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Social anxiety and interpretation biases for facial displays of emotion: Emotion detection and ratings of social cost

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Abstract

The current study assessed the processing of facial displays of emotion (Happy, Disgust, and Neutral) of varying emotional intensities in participants with high vs. low social anxiety. Use of facial expressions of varying intensities allowed for strong external validity and a fine-grained analysis of interpretation biases. Sensitivity to perceiving negative evaluation in faces (i.e., emotion detection) was assessed at both long (unlimited) and brief (60 ms) stimulus durations. In addition, ratings of perceived social cost were made indicating what participants judged it would be like to have a social interaction with a person exhibiting the stimulus emotion. Results suggest that high social anxiety participants did not demonstrate biases in their sensitivity to perceiving negative evaluation (i.e. disgust) in facial expressions. However, high social anxiety participants did estimate the perceived cost of interacting with someone showing disgust to be significantly greater than low social anxiety participants, regardless of the intensity of the disgust expression. These results are consistent with a specific type of interpretation bias in which participants with social anxiety have elevated ratings of the social cost of interacting with individuals displaying negative evaluation.

Keywords: Social anxiety; Social phobia; Interpretation; Bias; Faces; Emotion; Happy; Disgust

Introduction

Theoretical models of social phobia suggest that biased information processing contributes to the etiology and maintenance of social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997). These models posit that individuals with elevated social anxiety tend to demonstrate negative biases in processing social cues that are indicative of negative evaluation. Data have largely supported theoretical claims that these individuals demonstrate perceptual and processing biases, such as biased attention to social threat (Mogg & Bradley, 2002; Mogg, Philippot, & Bradley, 2004), excessive attention to internal physiological cues (Bogels & Mansell, 2004), and negative interpretations of ambiguous social events (Amir, Foa, & Coles, 1998; Foa, Franklin, Perry, & Herbert, 1996). Additional research supports the importance of these biases in maintaining symptoms, given that interpretation biases have been shown to be reduced following effective treatment

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(Foa et al., 1996; McManus, Clark, & Hackmann, 2000; Wilson & Rapee, 2005). Thus, further clarifying the nature of these biases will contribute to better understanding the etiology and maintenance of social anxiety, and may further inform treatment.

Traditionally, the investigation of interpretation biases has focused primarily on the assessment of potential threat (e.g., whether the stimulus/scenario is negative, likelihood of a negative outcome). Studies of this type of interpretation bias have repeatedly revealed that individuals with social anxiety interpret ambiguous social scenarios more negatively than do controls (Amir et al., 1998; Constans, Penn, Ihen, & Hope, 1999; Stopa & Clark, 2000). For example, individuals who are socially anxious may be more likely to interpret the scenario "you walk into the break-room at work and the conversation stops" as reflecting something negative about them in contrast to a neutral or positive interpretation (e.g., "the conversation had reached its natural end" or "they were looking forward to hearing what you had to say"). Similarly, negative interpretation biases have been demonstrated for mildly negative (Lucock & Salkovskis, 1988; Vassilopoulos, 2006), as well as positive (Vassilopoulos, 2006), social events. Clearly, given the ambiguous nature of the majority of social cues one encounters in daily life (e.g., a friend's distracted glance could indicate either that they are either preoccupied [non-threat] or disinterested [threat]), biases to negatively misinterpret social cues can serve to maintain anxiety related to interacting with the social world.

In addition to the estimate of *perceived threat* of social cues, the interpretation process also involves estimates of the extent of *emotional cost* associated with these social cues (i.e., the perceived impact of the social event on the individual). Existing data suggest that individuals with social phobia estimate the cost of ambiguous (Foa et al., 1996) and negative (McManus et al., 2000; Vassilopoulos, 2006) social events to be greater (i.e., more negative) than non-anxious individuals. Thus, anxiety may be further maintained by the interpretation that even mild (or unclear) social disapproval is ruinous. Research examining mediators of treatment change in social phobia supports the utility of distinguishing between estimates of probability of negative outcomes and the cost of negative outcomes (e.g., Foa et al., 1996; McManus et al., 2000), although *which* indicator is more important for change still remains unclear. Therefore, to fully understand the role of interpretation biases in social anxiety it is important to assess both the interpretation of the valence of the social stimuli *and* the emotional cost of such stimuli for that individual.

Although early research on interpretation in social anxiety focused primarily on the interpretation of social scenarios presented as text (e.g., Amir et al., 1998; Constans et al., 1999; Foa et al., 1996; Stopa & Clark, 2000), more recent work has extended this line of research to studying the interpretation of emotional facial expressions (e.g., Mullins & Duke, 2004; Philippot & Douilliez, 2005; Richards et al., 2002; Winton, Clark, & Edelmann, 1995). Understanding the interpretation of facial expressions is important for understanding social anxiety given that facial expressions convey essential social information (Darwin, 1872; Ekman, 2003). Further, accurate decoding of emotional expressions is related to relationship well being. For example, Carton, Kessler, and Pape (1999) demonstrated that errors in decoding emotional expressions in faces were significantly correlated with low-relationship well-being and symptoms of depression.

To date, the literature on processing of facial expressions in social anxiety is sparse. On a basic level, Mullins and Duke (2004) found that social anxiety was not associated with errors in decoding facial expressions (labeling faces as happy, angry, fearful or sad), regardless of state anxiety. Further, these results were demonstrated for both intense and subtle displays of emotion. Using facial stimuli displaying intense emotional expressions, Winton et al. (1995) did not find evidence for differences between individuals that were high and low in social anxiety in their ability to discriminate negative vs. neutral facial expressions (label angry, sad, disgust, contempt, fear and neutral faces as either "negative" or "neutral"). However, their results showed that individuals with elevated social anxiety exhibited a response bias to report that all facial expressions were "negative." In another study conducted by Richards et al. (2002), participants viewed facial expressions representing a mixture of two emotions (e.g., 10% anger and 90% disgust; 30% fear and 70% sadness, etc.). Participants were then asked to label the emotional expression. The authors concluded that when fear was one of the two component emotions in the face, participants with elevated social anxiety classified more of the faces along the continuum as expressing fear relative to low-anxious controls. However, there was not a significant interaction of anxiety level with the percentage of fear displayed in the face. These results show that when presented with faces representing a mixture of fear and surprise or fear and sadness, individuals with elevated social anxiety are more likely to label the faces as fear. The authors argue that the results were not the result of an overall response bias to label emotional expressions as fearful as group differences were not found for the likelihood of labeling faces representing mixtures of disgust/anger, anger/happiness, happiness/surprise, or sadness/disgust as representing fear. Importantly, although this study addresses the recognition of emotional expressions, the stimuli employed in the study were blends of two different emotions (e.g., surprise/fear, anger/happiness) rather than nuances of pure emotional expressions. Thus, this study fails to address the impact of subtle emotional cues, such as low-intensity negative expressions. Utilizing such ambiguous indicators of negative evaluation (e.g., low-intensity expressions of threat) is particularly relevant to understanding interpretation biases in social anxiety. Importantly, the impact of such subtle emotional cues was investigated by Philippot and Douilliez (2005). This study employed morphed facial expressions of varying intensities, morphing between neutral expressions to emotional expressions, thereby assessing the impact of subtle emotional cues (0%, 30%, 70%, and 100% emotion). Results did not show group differences among individuals with social phobia, individuals with other anxiety disorders, and non-anxious controls on decoding accuracy (which emotion received the highest intensity rating on continuous emotion scales). Philippot and Douilliez (2005) speculated that despite a lack of an explicit evaluative bias, these biases may manifest in implicit or automatic processing as well as ratings of the potential importance (or meaning) of the stimuli to oneself (i.e., perceived emotional cost).

Therefore, the primary goal of the current study was to further the understanding of the interpretation of facial expressions conveying negative evaluation in social anxiety. Building from previous data and existing theory, three tasks were utilized to: examine perceptions of negative evaluation in facial expressions (tasks 1 and 2) and perceived cost (task 3) of these facial expressions, and examine the perception of negative evaluation at both long (unlimited presentation time; task 1) and brief (60 ms, task 2), stimulus durations. Given the aim of addressing interpretation of emotional facial expressions, and the fact that intense facial expressions leave less room for interpretation, stimuli were created for the current study representing a range of emotional intensities. Disgust and happy facial expressions were morphed with neutral expressions to create stimuli of varying intensities (e.g., 20%, 30%, 40% disgust, etc.). Disgust expressions were used in the current study for numerous reasons. First, as noted by Amir et al. (2005) disgust expressions are particularly relevant to social anxiety as they convey rejection. Indeed, disgust expressions provide a strong match to cognitive–behavioral models regarding factors that elicit social anxiety. That is, disgust expressions can be seen as ‘‘external indicators of negative evaluation’’ which are a core component of the theoretical model by Rapee and Heimberg (1997). Finally, results of a recent imaging study documented that social phobia participants displayed differential neural activation when processing disgust facial expressions in comparison to matched controls (Amir et al., 2005).[1] Happy expressions were also included to determine whether any interpretation bias detected would be specific to disgust or would be evident for a positive emotion as well.

Based on theoretical models of social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997) and the existing literature on interpretation biases that has used text (Amir et al., 1998; Constans et al., 1999; Foa et al., 1996; Stopa & Clark, 2000), we hypothesized that individuals with elevated social anxiety would show a bias to label faces as portraying disgust at a lower intensity than individuals with low social anxiety (i.e., show a heightened sensitivity to threat). This said, recent findings (Philippot & Douilliez, 2005) suggest that group differences may only emerge when participants are tested using brief stimulus durations (task 2) rather than at long stimulus durations (task 1). Finally, we hypothesized that individuals with elevated social anxiety would rate disgust faces (regardless of intensity) as more costly to interact with than would individuals with low social anxiety. As suggested above, happy faces were used as an emotion control; no specific predictions were made regarding potential group differences for the happy faces.

[1]Given that previous studies of information processing in social anxiety have used a wide range of emotions (e.g., disgust, fear, anger, sadness), we considered the benefits and drawbacks of each emotion type. Disgust expressions were chosen for the reasons articulated herein and the opinion that although individuals with elevated social anxiety may show biases towards other potential negative emotions (e.g., anger and fear), it is difficult to argue that they provide a better conceptual match to the core feature of social phobia. Of further note, some research has utilized contempt expressions in studying social anxiety. However, research using contempt expressions may be hindered by low reliability ratings for identifying this emotion (Matsumoto & Ekman, 1988), a finding consistent with the exclusion of contempt in many contemporary models of the basic emotional expressions (see for example, Richards et al., 2002; Young et al., 1997). Ultimately, additional research comparing different negative emotions within a theoretical framework may be beneficial.

Method

Participants

Participants for this study were 100 undergraduates who received research credit in introductory psychology courses for participation. Potential participants were identified via the psychology department's mass testing sessions. High social anxiety and low social anxiety groups were identified from this screening sample ($n = 697$) based on quartile scores on the Brief Fear of Negative Evaluation (BFNE) scale (Leary, 1983). Individuals who scored in the top 25% (BFNE total $\geqslant 40$) were recruited as "High Social Anxiety" participants ($n = 49$) and individuals who scored in the bottom 25% (BFNE total $\leqslant 28$) were recruited as "Low Social Anxiety" participants ($n = 51$).[2] Research has indicated that using such analogue groups based on social phobia measures is a viable means for studying processes present in social phobia (Stopa & Clark, 2001). Demographic information for the two groups is presented in Table 1.

Materials

Prototype images of faces were chosen from Matsumoto and Ekman's (1988) Japanese and Caucasian Facial Expressions of Emotion (JACFEE) and Japanese and Caucasian Neutral Faces (JACNEUF) stimuli sets. Because this research project was conducted with a primarily Caucasian sample only Caucasian facial stimuli were used. This decision was made based on evidence suggesting that ethnicity impacts facial discrimination, such that participants more effectively discriminate faces from their own race than other races (Walker & Tanaka, 2003). The JACFEE/JACNEUF facial stimuli sets are widely used, facilitating comparisons to other research, and the JACFEE/JACNEUF sets have demonstrated reliability in cross-national samples for identifying the emotions displayed (Biehl et al., 1997). The stimuli consist of 112 total color photos (half male, half female) of individuals displaying seven basic emotions (e.g., happy, sad, fearful, angry, disgust, surprise and contempt; JACFEE) or neutral facial expressions (JACNEUF). Happy expressions were included as an emotion control. The prototype facial stimuli from the JACFEE and JACNEUF sets were used to create morphed images (using *Morpheus* software[3]). The Morpheus program allows the user to generate a linear continuum of images given two endpoint images. Eight pairs of facial expressions were selected to serve as the endpoint images, with each pair containing a neutral expression and an emotional expression: either happy or disgust. Each emotion was represented by 4 continua (2 male and 2 female actors), for a total of 8 continua. To create the morphed transformation, a total of 113 points were used for each face to define the pertinent face areas to be morphed (10 on each eyebrow, 15 on each eye, 5 on nose, 20 on mouth and 38 on outline of face/clothing/etc.).[4] Nine morphed images were saved from each continuum, representing 10% increments of the two emotions (e.g., 90% Neutral, 10% Happy; 80% Neutral, 20% Happy, and so on). Prototype images (e.g., 100% Neutral or 100% Happy) were not presented to equate the images for naturalness. Therefore, there were a total of 72 morphed facial stimuli.

Measures

The BFNE (Leary, 1983) is a 12-item self-report measure of fear of negative evaluation by others. Each item is rated on a 5-point Likert-type scale (1 = not at all characteristic of me; 5 = extremely characteristic of me) indicating the extent to which the respondent agrees with the item based on their experiences. The BFNE has demonstrated strong convergent validity with other measures of social anxiety and with the previous longer version of this scale (the FNE; Leary, 1983; Westra & Stewart, 2001). In addition, the BFNE has demonstrated strong internal consistency in a sample of social phobia and panic disorder patients (Collins,

[2]Participants were administered the BFNE at mass testing and again when they participated in the current three tasks. Quartiles were established based on scores from mass testing and only participants whose BFNE scores remained consistent across the two administrations were included in the current study. Therefore, of 34 of 134 participants that completed the mass testing questionnaires were dropped for inconsistent BFNE scores, yielding the current sample of 100.

[3]For more information regarding the software program, readers are referred to the company's website—www.morpheussoftware.net.

[4]Further detail regarding the morphing process available upon request.

Table 1
Demographics and questionnaire data

	Social anxiety	
	Low	High
Gender (% female)	52.9%	75.5%
Race (% Caucasian)	94.1%	95.9%
	M (SD)	M (SD)
Age	18.92 (1.6)	18.45 (1.2)
Education	12.47 (.9)	12.47 (1.0)
BFNE	22.73 (5.0)	46.67 (7.2)
SIAS	11.27 (8.3)	33.83 (14.33)
SPS	4.6 (4.7)	23.48 (13.54)
SAI	12.73 (17.44)	23.39 (18.1)

Note: BFNE, Brief Fear of Negative Evaluation; SIAS, Social Interaction Anxiety Scale, SPS, Social Phobia Scale; SAI, State Anxiety Inventory.

Westra, Dozois, & Stewart, 2005). Similarly, the BFNE exhibited strong internal consistency in the current sample ($\alpha = 0.96$).

The Social Interaction Anxiety Scale (SIAS) and the Social Phobia Scale (SPS) (Mattick & Clarke, 1998) are companion measures assessing anxiety related to initiating and maintaining social interactions, and anxiety related to performing tasks while being observed by others, respectively. There is strong support for the convergent validity of the SIAS and SPS (Osman, Gutierrez, Barrios, Kopper, & Chiros, 1998; Peters, 2000) and both scales have demonstrated good internal consistency (Osman et al., 1998). Further, these measures have been shown to discriminate between social phobia and other anxiety disorders (Brown et al., 1997; Peters, 2000). Finally, both scales demonstrated strong internal consistency in the current sample (α's = 0.94 and 0.95, respectively).

State Anxiety was assessed using a visual analogue scale ranging from 0 to 100 (0 = "not really experiencing anxiety" to 100 = "the highest anxiety you've experienced or can imagine experiencing." Participants were asked to indicate, on the scale, how anxious they felt at that time.

Procedure

Participants were tested individually and provided informed consent before participation. Prior to the experimental tasks, they completed the state anxiety visual analogue measure. The participants then completed three experimental tasks. Within each experimental task, faces were displayed individually in a randomized order using E-Prime Software (Schneider, Eschman, & Zuccolotto, 2002). Upon completion of the experimental tasks, each participant completed the BFNE scale, as well as the SIAS and the SPS.

The first two experimental tasks assessed participant's labeling of facial expressions of varying degrees of ambiguity. Participants were instructed to look at each facial expression and "identify what emotion the face is displaying" by selecting one of the keys on the keyboard labeled with the response options "Neutral," "Happy," or "Disgust." Each trial began with a fixation cross-presented in the center of the screen for 250 ms, followed by a 250 ms blank screen. For the first experimental task, the facial stimuli were then presented and remained on the screen until the participant logged a response via the keyboard. For the second experimental task the facial stimuli were presented for 60 ms and then replaced by a blank screen. For each of the two experimental tasks, the 72 stimuli were presented 4 times for a total of 288 trials per task.

The third experimental task assessed participants' construal of the emotional cost of the emotional facial expressions of varying intensity. Each of the 72 stimuli were presented one at a time, and participants were asked to look at the facial expression and identify "what it would be like to interact with" the individual looking at them that way. Ratings were made from −3 "it would be very bad for me to interact with someone looking at me this way" to +3 "it would be very good for me to interact with someone looking at me this way.'' This language was adapted from a study conducted by Foa et al. (1996) on probability and cost of social and non-social events. The Foa et al. (1996) study asked participants to make cost ratings by assigning scores to hypothetical events based on a Likert-type scale with the anchors ''not at all bad'' to ''extremely bad.'' Given that the current study included both objectively positive (happy expressions) and objectively negative (disgust expressions) stimuli, the scale was modified to include both positive and negative cost ratings (i.e., ''very good for me'' to ''very bad for me''). Participants were encouraged to use the full range of the scale.

Analysis plan

To measure participants' identification of facial expressions, two-level hierarchical linear modeling was employed using HLM 6 (Raudenbush, Bryk, Cheong, Congdon, & duToit, 2004). This method of analysis increases statistical power by modeling both within-person and between-person variability simultaneously. For this study, analyses were conducted on each emotion separately to examine whether social anxiety impacted the interpretation of either positive (happy) or negative (disgust) facial expressions of emotion. In these analyses, the Level 1 (within-subjects) model included the within subject factor of morph level (emotion intensity). The Level 2 (between-subjects) model included group (high or low social anxiety) and subject sex.

The basic Level 1 (within-subject) model used to test the processing of emotional expressions in these studies was

$$\text{Accuracy}_{ij} = \beta_{0j} + \beta_{1j}(\text{Morph}_{\text{linear}}) + \beta_{2j}(\text{Morph}_{\text{quadratic}}) + \beta_{3j}(\text{Morph}_{\text{cubic}}) + r_{ij}.$$

In this model, Accuracy_{tij} represents the proportion of faces correctly classified as being part of the disgust or happy continuum at morph level i for participant j. β_{0j} represents the intercept term and β_{1j}, β_{2j}, and β_{3j} represent the slopes for the linear, quadratic, and cubic, respectively, trends in facial morph level.

The Level 2 (between-subject) model used to test the processing of emotional expressions in these studies was

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{Participant sex}) + \gamma_{02}(\text{Group}) + \gamma_{03}(\text{Participant sex} \times \text{group}) + u_{0j},$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{Participant sex}) + \gamma_{12}(\text{Group}) + \gamma_{13}(\text{Participant sex} \times \text{group}) + u_{1j},$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}(\text{Participant sex}) + \gamma_{22}(\text{Group}) + \gamma_{23}(\text{Participant sex} \times \text{group}) + u_{2j},$$

$$\beta_{3j} = \gamma_{30} + \gamma_{31}(\text{Participant sex}) + \gamma_{32}(\text{Group}) + \gamma_{33}(\text{Participant sex} \times \text{group}) + u_{3j}.$$

At this level of the model, γ_{00}–γ_{30} represent the intercepts for their respective equations, γ_{01}–γ_{31} represent the cross-level interaction of participant sex (male vs. female), γ_{02}–γ_{32} represents the cross-level interaction for group (high vs. low social anxiety), and γ_{03}–γ_{33} represents the three-way interaction of participant sex $\times$ group $\times$ the respective Level 1 variable. Finally, u_{0j}–u_{3j} represent the error terms for their respective equations.

Results

Means and standard deviations for the demographic variables are presented in Table 1. There were no significant differences between the high and low social anxiety groups in terms of age [$t(98) = 1.66$, $p = 0.10$, $r_{\text{effect size}} = 0.17$] or ethnicity (Caucasian vs. non-Caucasian) [χ^2 $(1, N = 100) = 0.17$, $p = 0.68$, $r_{\text{effect size}} = 0.04$].[5] There was, however, a significant between-group sex difference [χ^2 $(1, N = 101) = 5.53$, $p = 0.02$, $r_{\text{effect size}} = 0.24$], with the high social anxiety group having a significantly higher proportion of female participants than the low social anxiety group. Given this, participant sex was included in all analyses both as a main effect as well as to determine whether it moderated any group effects observed.

[5]Effect sizes were calculated for all significance tests using $r_{\text{effectsize}}$ (see Rosenthal, Rosnow, & Rubin, 2000). General guidelines for interpreting the size of $r_{\text{effectsize}}$ are as follows: small = 0.10, medium = 0.30 and large = 0.50.

The questionnaire data validated our analogue group assignment (see Table 1). Specifically, the high social anxiety group scored significantly higher on measures of fear of negative evaluation, social interaction anxiety, and social performance anxiety, than did the low social anxiety group [BFNE: $t\ (98) = 20.06$, $p < 0.001$, $r_{\text{effect size}} = 0.89$; SIAS: $t(94) = 9.44$, $p < 0.001$, $r_{\text{effect size}} = 0.70$); SPS: $t(96) = 9.29$, $p < 0.001$, $r_{\text{effect size}} = 0.69$]. Lastly, although neither group reported notable state anxiety, the high social anxiety group reported significantly higher state anxiety than the low social anxiety group, at the time of the experiment [see Table 1; $t(98) = 3.00$, $p = 0.003$, $r_{\text{effect size}} = 0.29$].

Experimental task one

Results of task one revealed that, as would be expected, as the intensity of emotional expression increased, both groups increasingly labeled faces as either happy or disgust as opposed to neutral (p's for all morph intercepts < 0.001; see Table 2 and Figs. 1 and 2). However, contrary to our hypothesis, none of the Level 2 variables (participant sex, group, participant sex × group) were significantly related to the morph slopes (linear, quadratic, or cubic) for either Disgust or Happy expressions (lowest $p = 0.21$). These findings, therefore, fail to support our hypothesis that high social anxiety participants are more sensitive than individuals with low social anxiety in perceiving threat in facial expressions (i.e., demonstrate a bias to identify disgust facial expressions at a lower level of emotional intensity). Further, no between-group differences were found for the interpretation of happy facial expressions.

Table 2
Summary of Task 1 results: long stimulus presentation

Fixed effect	Happy faces					Disgust faces				
	Coefficient	SE	t	p	r_{es}	Coefficient	SE	t	p	r_{es}
Accuracy$_{\text{intercept}}$ (π_0)										
Intercept (β_{00})	0.87	0.01	63.00	0.00	0.99	0.84	0.01	86.10	0.00	0.99
Participant sex (β_{01})	0.00	0.01	0.22	0.83	0.02	0.00	0.01	0.44	0.66	0.04
Group (β_{02})	0.00	0.01	0.24	0.81	0.02	0.00	0.01	−0.01	0.99	0.00
Participant sex × group (β_{03})	−0.02	0.01	−1.27	0.21	0.13	0.00	0.01	−0.34	0.73	0.03
Morph$_{\text{linear}}$ (π_1)										
Intercept (β_{10})	0.09	0.01	14.67	0.00	0.83	0.16	0.01	25.23	0.00	0.93
Participant sex (β_{11})	0.01	0.01	1.14	0.26	0.12	0.00	0.01	0.25	0.80	0.03
Group (β_{12})	0.00	0.01	0.64	0.52	0.07	0.00	0.01	−0.41	0.68	0.04
Participant sex × group (β_{13})	0.01	0.01	1.18	0.24	0.12	0.00	0.01	0.68	0.50	0.07
Morph$_{\text{quadratic}}$ (π_2)										
Intercept (β_{20})	−0.02	0.00	−25.97	0.00	0.94	0.02	0.00	−39.53	0.00	0.97
Participant sex (β_{21})	0.00	0.00	0.00	0.99	0.00	0.00	0.00	−0.82	0.42	0.08
Group (β_{22})	0.00	0.00	−0.23	0.82	0.02	0.00	0.00	0.56	0.58	0.06
Participant sex × group (β_{23})	0.00	0.00	0.21	0.83	0.02	0.00	0.00	0.07	0.94	0.01
Morph$_{\text{cubic}}$ (π_3)										
Intercept (β_{30})	0.00	0.00	2.78	0.01	0.27	0.00	0.00	−6.37	0.00	0.55
Participant sex (β_{31})	0.00	0.00	−1.47	0.15	0.15	0.00	0.00	−0.07	0.95	0.01
Group (β_{32})	0.00	0.00	−0.56	0.58	0.06	0.00	0.00	0.17	0.86	0.02
Participant sex × group (β_{33})	0.00	0.00	−1.01	0.32	0.10	0.00	0.00	−0.63	0.53	0.06
Random effect	Variance component	df	χ^2	p		Variance component	df	χ^2	p	
Intercept	0.02	96.00	406.01	0.00		0.01	96.00	330.33	0.00	
Linear slope	0.00	96.00	180.18	0.00		0.00	96.00	315.91	0.00	
Quadratic slope	0.00	96.00	95.84	>0.50		0.00	96.00	81.36	>0.50	
Cubic slope	0.00	96.00	95.31	>0.50		0.00	96.00	183.43	0.00	
Level-1 error	0.04					0.02				

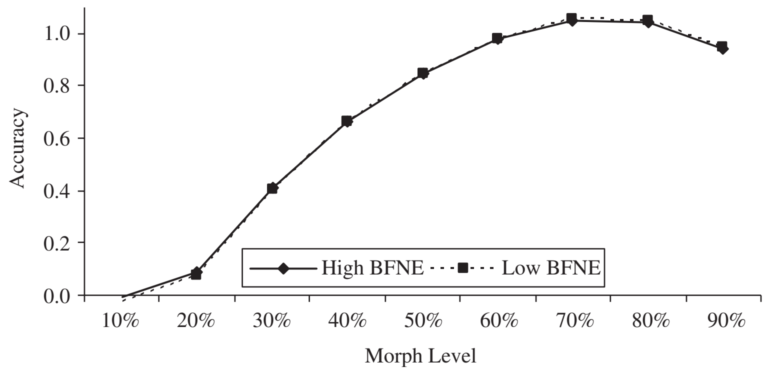

Fig. 1. Task 1: Mean emotion identification accuracy for disgust faces as a function of emotion intensity (morph level).

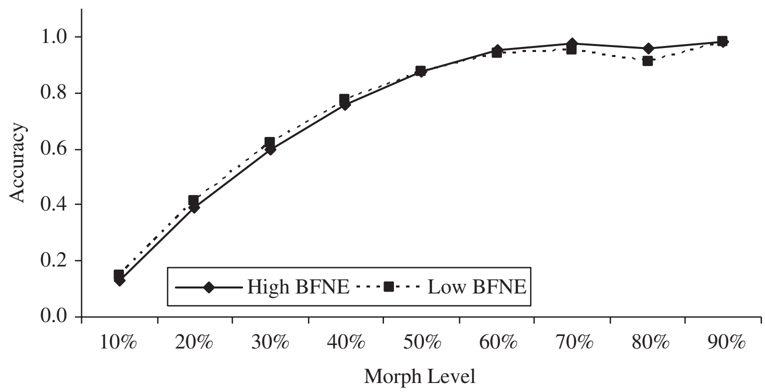

Fig. 2. Task 1: Mean emotion identification accuracy for happy faces as a function of emotion intensity (morph level).

Experimental task two

Results from task two, using a 60 ms stimulus presentation, replicated the findings from task one in that both groups were again more likely to label the faces as displaying the appropriate emotion (Happy/Disgust) as the intensity of emotional expression increased (*p*'s for all morph intercepts <0.001; see Table 3). Further, results for Happy expressions again showed that none of the Level 2 variables (participant sex, group, participant sex $\times$ group) reached significance. Focusing on Disgust expressions, although there were no significant differences involving group (social anxiety level), there was a significant sex difference for the Disgust accuracy intercept, and participant sex moderated the quadratic morph level effect on Disgust accuracy. Graphing these data revealed that at this brief stimulus duration, males labeled the emotional expressions as displaying disgust at a lower threshold than females (regardless of level of social anxiety[6]).

Experimental task three

Focusing next on participants' cost ratings, we found that as would be expected, cost ratings for both groups were stronger as the emotional intensity of the faces increased (e.g., as the faces displayed stronger expressions of disgust the ratings of emotional cost were increasingly negative and as they displayed more intense happiness the ratings of emotional cost were increasingly positive; *p*'s for all morph intercepts <0.001; see Table 4). Further, results for Disgust expressions revealed that individuals with high social anxiety rated the anticipated cost of an interaction with the individuals displaying Disgust expressions (regardless of morph

[6]This figure is available upon request.

Table 3
Summary of Task 2 results: long stimulus duration

Fixed effect	Happy faces					Disgust faces				
	Coefficient	SE	t	p	r_{es}	Coefficient	SE	t	p	r_{es}
Accuracy$_{intercept}$ (π_0)										
Intercept (β_{00})	0.93	0.01	65.74	0.00	0.99	0.75	0.01	63.85	0.00	0.99
Participant sex (β_{01})	0.00	0.01	0.08	0.93	0.01	0.03	0.01	2.27	0.03	0.23
Group (β_{02})	0.00	0.01	−0.17	0.86	0.02	0.00	0.01	−0.39	0.70	0.04
Participant sex × group (β_{03})	0.02	0.01	−1.26	0.21	0.13	0.01	0.01	−1.14	0.26	0.12
Morph$_{linear}$ (π_1)										
Intercept (β_{10})	0.04	0.01	6.24	0.00	0.54	0.16	0.01	28.00	0.00	0.94
Participant sex (β_{11})	0.01	0.01	1.29	0.20	0.13	0.00	0.01	−0.10	0.92	0.01
Group (β_{12})	0.01	0.01	1.14	0.26	0.12	0.01	0.01	0.96	0.34	0.10
Participant sex × group (β_{13})	0.01	0.01	0.90	0.37	0.09	0.00	0.01	−0.23	0.82	0.02
Morph$_{quadratic}$ (π_2)										
Intercept (β_{20})	0.02	0.00	−23.46	0.00	0.92	0.02	0.00	−22.71	0.00	0.92
Participant sex (β_{21})	0.00	0.00	−0.22	0.82	0.02	0.00	0.00	−2.46	0.02	0.24
Group (β_{22})	0.00	0.00	−0.61	0.54	0.06	0.00	0.00	−0.29	0.78	0.03
Participant sex × group (β_{23})	0.00	0.00	−0.23	0.82	0.02	0.00	0.00	1.52	0.13	0.15
Morph$_{cubic}$ (π_3)										
Intercept (β_{30})	0.00	0.00	7.91	0.00	0.39	0.00	0.00	−0.78	0.00	0.08
Participant sex (β_{31})	0.00	0.00	−1.20	0.23	0.12	0.00	0.00	0.71	0.48	0.07
Group (β_{32})	0.00	0.00	−0.62	0.53	0.06	0.00	0.00	−1.31	0.19	0.13
Participant sex × group (β_{33})	0.00	0.00	−0.33	0.74	0.03	0.00	0.00	0.43	0.67	0.04
Random effect	Variance component	df	χ^2	p		Variance component	df	χ^2	p	
Intercept	0.01	96.00	360.68	0.00		0.01	96.00	457.00	0.00	
Linear slope	0.00	96.00	172.60	0.00		0.00	96.00	251.10	0.00	
Quadratic slope	0.00	96.00	100.77	0.35		0.00	96.00	124.00	0.03	
Cubic slope	0.00	96.00	111.58	0.13		0.00	96.00	120.45	0.05	
Level-1 error	0.03					0.02				

level) more negatively than low social anxiety participants ($p = 0.03$, see Fig. 3). Turning to Happy expressions, we found a significant group × linear morph level interaction ($p = 0.03$; see Table 4). The analyses also revealed a significant participant sex × group interaction for the Happy accuracy intercept as well as a significant participant gender × group × quadratic morph level interaction (p's $= 0.02$ and 0.03, respectively). Given this interaction, the data were split by sex and the analyses were run separately for males and females. These results revealed that, for males there was a significant between-group difference for both the linear trend ($p = 0.003$) and the cubic trend ($p = 0.01$). Pairwise comparisons between groups at each morph level reveal that between-group differences were significant for males at the morph intensities of 50% $t(34) = -2.10$, $p = 0.04$, $r_{effect\ size} = 0.34$, and 70% $t(33) = -2.64$, $p = 0.01$, $r_{es} = 0.41$ (all other p's > 0.12). For females, between-group differences were found at the intercept ($p = 0.02$) and for the quadratic trend ($p = 0.008$). Pairwise comparisons reveal significant between-group differences at morph intensities of 20% $t(61) = 2.46$, $p = 0.02$, $r_{es} = 0.30$, and 30% $t(61) = 2.28$, $p = 0.03$, $r_{es} = 0.28$ for female participants (all other p's > 0.18). The nature of these effects is shown in Figs. 4 and 5.

Discussion

Findings from tasks one and two failed to provide support for differences between individuals with high and low social anxiety in regards to their perceptions of negative evaluation in facial expressions (i.e., in faces portraying disgust). Specifically, the two groups were not found to differ significantly in their likelihood to

Table 4
Summary of Task 3 results: ratings of emotional cost

Fixed effect	Happy faces					Disgust faces				
	Coefficient	SE	t	p	r_{es}	Coefficient	SE	t	p	r_{es}
Cost$_{intercept}$ (π_0)										
Intercept (β_{00})	7.04	0.05	142.51	0.00	1.01	3.05	0.05	56.00	0.00	0.99
Participant sex (β_{01})	0.04	0.05	0.78	0.44	0.08	−0.04	0.05	−0.79	0.43	0.08
Group (β_{02})	0.06	0.05	1.17	0.25	0.12	−0.11	0.05	−2.25	0.03	0.22
Participant sex × group (β_{03})	−0.12	0.05	−2.42	0.02	0.24	0.04	0.05	0.71	0.48	0.07
Morph$_{linear}$ (π_1)										
Intercept (β_{10})	0.32	0.02	19.42	0.00	0.89	−0.40	0.02	−21.88	0.00	0.91
Participant sex (β_{11})	0.00	0.02	−0.04	0.97	0.00	0.01	0.02	0.81	0.42	0.08
Group (β_{12})	0.04	0.02	2.27	0.03	0.23	0.00	0.02	0.05	0.96	0.01
Participant sex × group (β_{13})	0.02	0.02	1.36	0.18	0.14	0.02	0.02	0.83	0.41	0.08
Morph$_{quadratic}$ (π_2)										
Intercept (β_{20})	−0.03	0.00	−12.94	0.00	0.80	0.03	0.00	12.28	0.00	0.78
Participant sex (β_{21})	0.00	0.00	−0.47	0.64	0.05	0.00	0.00	0.65	0.52	0.07
Group (β_{22})	0.00	0.00	−1.89	0.06	0.19	0.00	0.00	0.38	0.71	0.04
Participant sex × group (β_{23})	0.01	0.00	2.15	0.03	0.21	0.00	0.00	−0.09	0.93	0.01
Morph$_{cubic}$ (π_3)										
Intercept (β_{30})	0.00	0.00	−0.54	0.59	0.06	0.02	0.00	6.16	0.00	0.53
Participant sex (β_{31})	0.00	0.00	0.61	0.55	0.06	0.00	0.00	−0.59	0.56	0.06
Group (β_{32})	0.00	0.00	−1.56	0.12	0.16	0.00	0.00	0.03	0.97	0.00
Participant sex × group (β_{33})	0.00	0.00	−1.36	0.18	0.14	0.00	0.00	−0.83	0.41	0.07
Random effect	Variance component	df	χ^2	p		Variance component	df	χ^2	p	
Intercept	0.22	94.00	585.40	0.00		0.22	94.00	603.35	0.00	
Linear slope	0.01	94.00	123.80	0.02		0.02	94.00	154.17	0.00	
Quadratic slope	0.00	94.00	111.10	0.11		0.00	94.00	133.94	0.01	
Cubic slope	0.00	94.00	69.16	>0.50		0.00	94.00	75.46	>0.50	
Level-1 error	0.30					0.31				

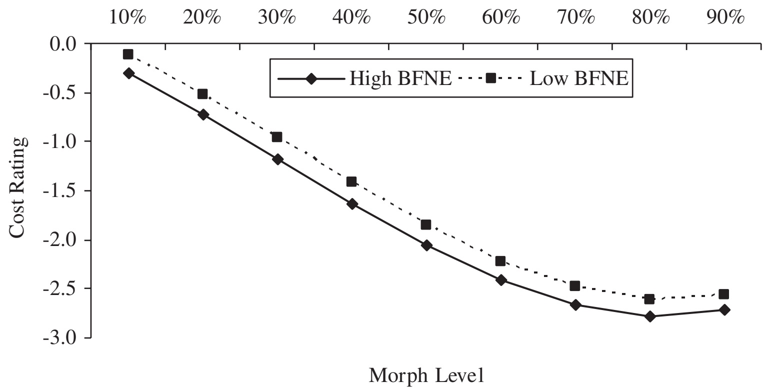

Fig. 3. Task 3: Mean cost ratings for disgust expressions as a function of emotion intensity (morph level).

label disgust expressions of varying intensities as ‘‘disgust’’. Further, the same pattern of results was found for both unlimited and brief (60 ms) stimulus presentation times and for both face types (Happy and Disgust). In contrast, however, individuals with high social anxiety showed a specific interpretation bias regarding estimates of the *perceived cost* of social interactions. When the stimuli displayed disgust expressions,

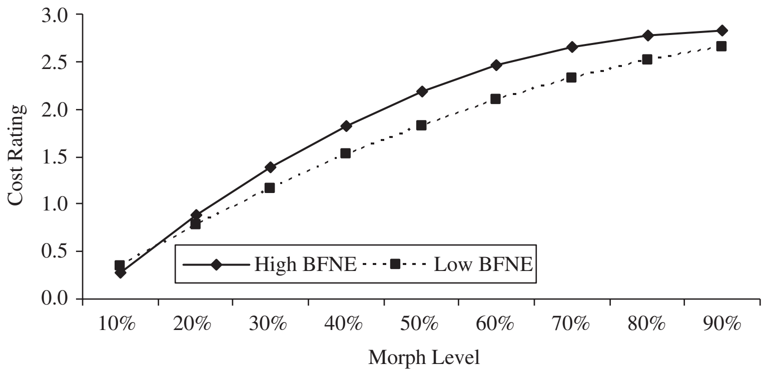

Fig. 4. Task 3: Mean cost ratings of male participants for happy expressions as a function of emotion intensity (morph level).

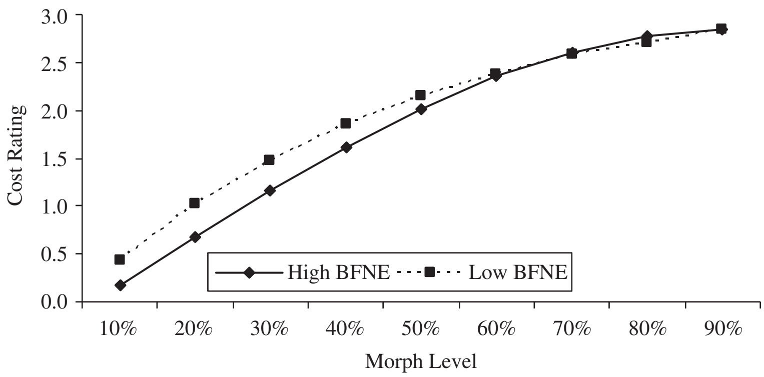

Fig. 5. Task 3: Mean cost ratings of female participants for happy expressions as a function of emotion intensity (morph level).

individuals with elevated social anxiety, compared to those with low social anxiety, estimated that a social interaction with the person would be more negative, regardless of how intense the expression was. Finally, this bias was not moderated by participant sex suggesting that if an individual shows any degree of disgust, both males and females with elevated social anxiety are biased to predict a negative interaction with that person. In contrast to these findings for disgust, our results showed that differences between individuals with high and low social anxiety regarding cost rating for happy expressions were moderated by participant sex. Specifically, females with high social anxiety rated ambiguously happy expressions less positively than low social anxiety females, and these differences were particularly notable at low-intensity expressions (20–30% emotion). These findings suggest that socially anxious women may be less optimistic about social interactions with individuals displaying positive (but subtle) emotional expressions. This pattern appeared different for the male participants in the current study. That is, socially anxious males in this study rated happy facial expressions (particularly those of moderate to high intensity) more positively than their low social anxiety counterparts, suggesting that males with social anxiety may be more optimistic than controls about social interactions with individuals displaying positive emotional expressions. These initial findings are intriguing in the context of previous evidence for gender differences in the decoding/labeling of emotional facial expressions in general samples (e.g., Montague, Kessels, de Haan, & Perret, 2005). However, given the relatively small number of subjects per cell when the sample is divided by both by anxiety level and gender (n's = 12–37), as well as a lack of previous data looking at potential gender moderation related to interpretation biases in social anxiety, further research is warranted.

Taken together, the results from these three tasks provide evidence for a specific type of interpretation bias in relation to the processing of emotional expressions in individuals with elevated social anxiety. That is, despite evaluating the emotional content of facial expressions similarly to non-anxious individuals (tasks 1 and 2), participants with elevated social anxiety perceive the emotional, or social, cost of hypothetical social interactions to be more negative when the stimuli display any level of negative emotion (task 3). The findings of this study in combination with those of Philippot and Douilliez (2005) provide further evidence for the hypothesis that a biased sensitivity to *perceive* (or decode) threat information in facial expressions is unlikely to play a significant role in the maintenance of social anxiety. However, these results suggest that biases may occur at a later stage in the interpretation process when judgments of the perceived social impact or cost are made. Specifically, although individuals with elevated levels of social anxiety may not be more likely to interpret an ambiguous facial expression as representing a negative emotion, they may be more likely to predict a negative social interaction with individuals expressing any degree of negativity. This specific form of interpretation bias is likely to increase avoidance behavior, thereby maintaining symptoms (Rapee & Heimberg, 1997), and is consistent with clinical observations that one of the most common forms of cognitive distortions in social anxiety is fortune telling (predicting that something negative is going to happen, as though one had a crystal ball; Hope, Heimberg, & Turk, 2006).

The results of the current study are broadly consistent with past studies of the interpretation of facial expressions in social anxiety. The first two tasks (threat detection) are most parallel to the existing emotion interpretation literature. Similar to the findings of both Mullins and Duke (2004) and Philippot and Douilliez (2005), participants with high social anxiety in the current study did not differ from those with low social anxiety in how they identified emotional expressions, regardless of the intensity of the emotional expression. However, the findings from the second task (where stimuli were presented briefly) appear to contradict those of Winton et al. (1995) who found that high social anxiety participants exhibited a response bias to label facial expressions negatively when stimuli were presented briefly. However, this apparent difference in findings may be explained by differences in the stimuli used (extreme vs. morphed emotional expressions) and the dependent variables analyzed (in Winton et al.'s study, participants categorized faces as either "negative" or "neutral").

Building from the interpretation literature that has utilized text (e.g., social scenarios described in writing to participants; Amir et al., 1998; Constans et al., 1999; Foa et al., 1996), we anticipated that individuals with elevated social anxiety would be more sensitive to perceive negative evaluation in disgust expressions. However, results of tasks 1 and 2 from the current study did not provide evidence for this bias. Furthermore, the effect sizes obtained from these two experiments were small, and power analyses using these effect sizes suggested that samples of over 800 participants would be required to obtain a significant effect. Failure to observe differences on these tasks may have been influenced by the "impersonal" nature of the tasks. These tasks did not put the stimuli into the context of a social interaction, and did not instruct participants to report on how they *personally* would perceive the stimuli (e.g., ask the participants to label what emotion they would see in the face in contrast to the "correct" answer of what emotion is displayed). Indeed, biases that have been observed using text-based tasks have been for scenarios that involve the individual placing themselves in a social interaction (see for example Amir et al., 1998). Further, previous research suggests that when individuals with elevated social anxiety made ratings for a "typical person" as opposed to themselves, the biases to demonstrate heightened estimates of negative outcomes were not observed (Amir et al., 1998). Thus, the nature of the first two tasks of the current study may not have been "social" and "personal" enough to tap potential biases.

The current study has a number of notable strengths. First, the study has a clear basis in cognitive–behavioral theories of social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997). Further, the experimental design was built from existing literature, and extended this literature by providing a more comprehensive assessment of potential biases in interpretation (e.g., assessed two components of interpretation, utilized both short and long stimulus durations). However, limitations of the research presented herein should be also considered. First, the use of only one type of negative emotion (disgust) necessarily limits the ability to generalize to negative emotions broadly, or to compare processing between different types of negative emotions. However, given the significant group differences on task 3 in combination with previous findings also using disgust expressions (Amir et al., 2005), disgust expressions are clearly relevant for social anxiety. Future studies can utilize the methods developed herein to further examine the specificity of biases to particular types of negative emotional expressions. The nature of the current sample also presents limitations. First, although our high-anxiety students had self-reported social anxiety scores comparable to samples of individuals diagnosed with social phobia (mean B-FNE scores in our sample: 46. 7

(SD = 7.2) compared to 46.9 (SD = 9.3) for a patient sample; see Weeks et al., 2005), the nature of our participants' symptoms are not necessarily comparable to patients with social phobia. For example, given that participants in the current study were predominantly freshman, reported social anxiety may have been impacted by this transition to a new lifestyle, social network, and academic institution. Further, information regarding the impact of this social anxiety (interference and distress) was not available. Importantly, although information processing biases established in analogue samples have repeatedly been replicated in clinical samples, the generalizability of the findings of the current study to a clinical population remains to be seen. Third, as mentioned above, future research may benefit from examining potential sex moderation on interpretation of emotional expressions.

In closing, the current study advances our understanding of the interpretation of facial expressions in social anxiety. Our results suggest that although individuals with elevated social anxiety do not appear to be more sensitive to negative evaluation in facial expressions, they do appear to have a bias to overestimate the perceived social cost of an interaction with the person. Taken together, the findings from the three experimental tasks provide support for the importance of partialling interpretation biases into perceived threat and cost, and suggest that future research further delineating processing of facial expressions in social anxiety is warranted.

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