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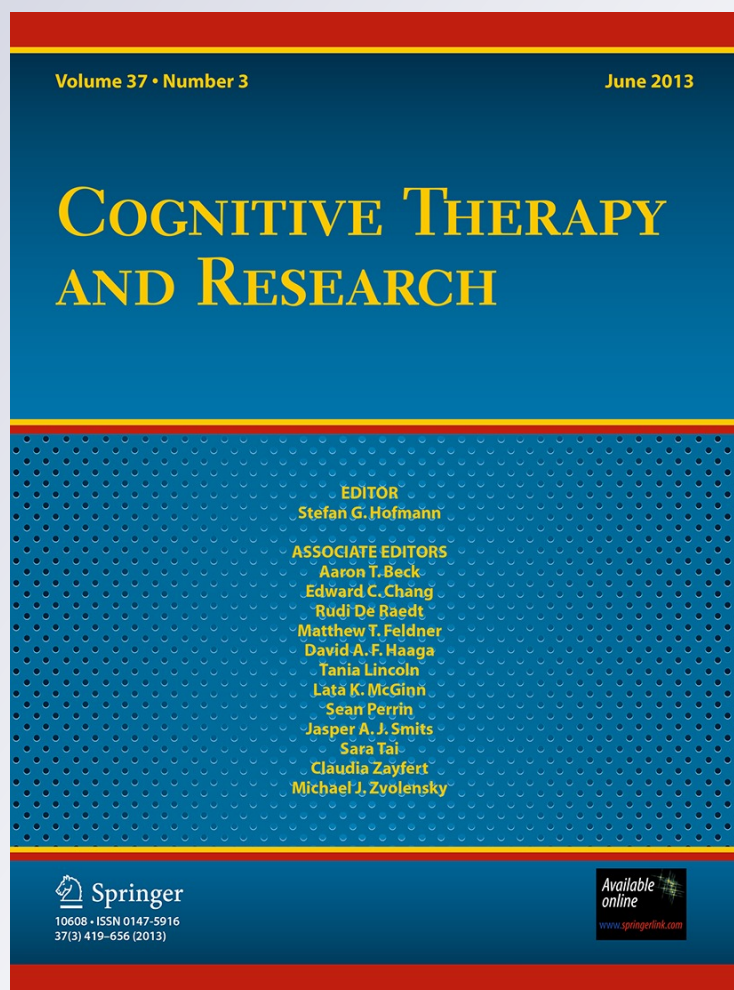ORIGINAL ARTICLE

Accurate but Pathological: Social Anxiety and Ensemble Coding of Emotion

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Abstract The current study examined whether social anxiety is associated with a biased perception of the overall emotional impression of facial crowds. Participants were presented with facial crowds that consisted of 6, 12, or 24 faces expressing either happiness or anger, after which they were asked to judge whether the crowds were positive or negative. We estimated each participant's point of subjective equality (PSE) and precision when judging the overall emotion of facial crowds to be negative. The participants' social anxiety levels were negatively associated with their PSEs to perceive the overall emotion of the crowds as negative. In contrast, there was no significant relation between social anxiety and the degree of precision in the participants' judgments of facial crowds. These findings indicate that socially anxious individuals lack the positive biases that are present in non-anxious individuals and, thereby, perceive the overall emotion of crowds more negatively compared with their less anxious counterparts.

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Keywords Social anxiety · Facial expressions · Ensemble perception · Emotion

Introduction

Face perception is crucial in understanding the intents, thoughts, and emotions of one's interacting partner(s). Receiving negative evaluations from other people, which often are conveyed by and inferred from facial expressions, is the basic fear in socially anxious individuals (APA 2000). Therefore, dysfunctional facial processing may be associated with social anxiety (e.g., Hofmann 2007). Although previous research mainly has focused on the processing of individually presented facial expressions (e.g., Yoon and Zinbarg 2007, 2008), people commonly interact with more than one person at a time or process multiple faces present in a background. Furthermore, appearing before a group of people is one of the most anxiety-provoking and avoided social situations for socially anxious individuals (Pinto-Gouveia et al. 2003). Therefore, a task that requires a person to form an overall impression of a group of faces could contribute to a better understanding of social anxiety.

Despite the importance of examining how socially anxious individuals perceive the overall emotion of facial crowds, we are aware of only three published studies, which yielded inconsistent findings. In one study, socially anxious individuals rated moderately disapproving crowds more negatively than did control participants (Gilboa-Schechtman et al. 2005). Another study, however, failed to obtain such anxiety-related group differences on explicit ratings, despite the fact that socially anxious individuals avoided crowds with angry faces on an implicit measure (Lange et al. 2008). Similarly, socially anxious participants

did not rate the crowds more negatively than the control participants, despite exhibiting more frequent gaze fixations on angry faces (Lange et al. 2011).

Previous research (Gilboa-Schechtman et al. 2005; Lange et al. 2008, 2011) has focused on examining whether there are any anxiety-related differences in overall emotional judgments of facial crowds. However, two different factors can lead to group differences: (a) individual differences in biases and (b) individual differences in sensitivity (i.e., precision in distinguishing facial crowds that are objectively negative from positive). Socially anxious individuals may differ from their counterparts on only one of these factors. Previous tasks may have differentially tapped into each of these factors, which could have contributed to inconsistent findings. Distinguishing individual differences in biases versus precision could help us better understand the processing of facial crowds in social anxiety.

To investigate how socially anxious individuals perceive the overall emotion of facial crowds, we examined two indices: the point of subjective equality (PSE, Fig. 1a) and the standard deviation (SD, Fig. 1b) (see Data Analysis for more information). The PSE indicates the degree of bias because it is the point at which a participant subjectively perceived crowds to portray a balanced emotion (i.e., perceived facial crowds to consist of half angry and half happy faces). The SD of each fitted function indicates the degree of precision in emotion judgments. Using these psychophysical methods, previous research has established that statistical descriptors are efficiently computed from a set of items. For example, observers can accurately extract the mean size from a set of circles (e.g., Chong and Treisman 2003, 2005). Furthermore, people can accurately extract the mean emotion from a set of morphed faces varying in emotionality (Haberman and Whitney 2007, 2009). We employed similar psychophysical methods to investigate the relation between levels of social anxiety and the perception of the overall emotion of facial crowds. Examining the PSEs and the SDs could result in a better understanding of whether socially anxious individuals' perceptions of the overall emotion of facial crowds are due to the differences in their biases (i.e., the PSE), sensitivity (i.e., SDs), or both.

Previous studies (Haberman and Whitney 2007, 2009) constructed each picture set using pictures of the same person that varied in emotionality (e.g., morphed pictures spanning happy to sad). In our everyday lives, however, we rarely encounter an opportunity to judge one person's various emotional expressions *at the same time*. Rather, it is important to judge the overall emotion of a crowd based on multiple individuals' emotional expressions. We used facial crowds with pictures of different people rather than using morphed pictures of one person. To minimize participants fixating on a particular face in facial crowds, we
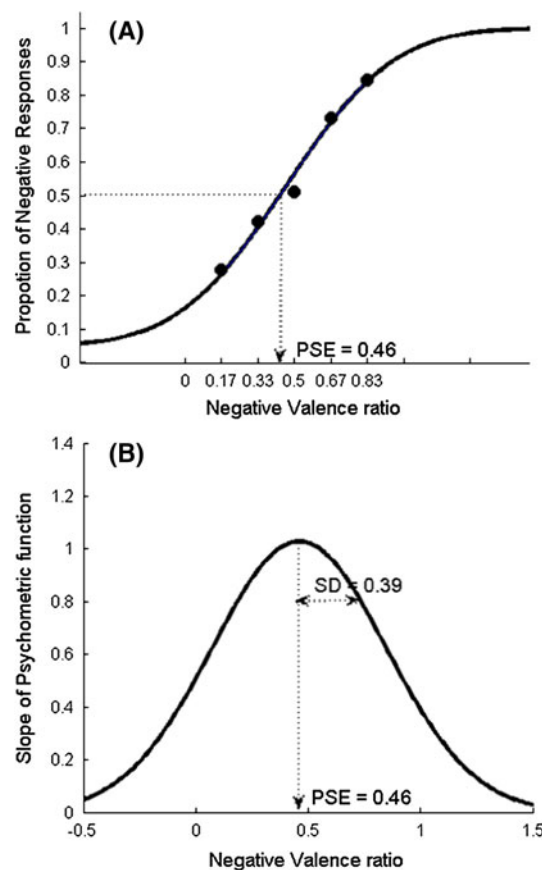

Fig. 1 An example psychometric function of one participant. **a** When 50 % of a participant's responses are "negative", the value on the abscissa corresponding to this value is the point of subjective equality (PSE) (i.e., where the arrow meets the abscissa). **b** The SD of the cumulative Gaussian function depicted in the *panel (A)*

used a categorization task during which participants judged the overall emotion of crowds presented for 100 ms (Mayfrank et al. 1987). In addition to preventing fixations on one stimulus, the short presentation time allows us to assess automatic, online processes that often characterize anxiety-related biases (e.g., Hirsch and Clark 2004). It was hypothesized that high levels of social anxiety are associated with the tendency to perceive facial crowds more negatively. More specifically, we investigated whether high levels of social anxiety are associated with bias (i.e., a lower PSE) and/or decreased precision (i.e., a larger SD), leading individuals with high levels of social anxiety to perceive facial crowds more negatively.

Method

Participants

Ninety-seven Korean undergraduate psychology students (62 females, 35 males; mean age = 21.55 years)

participated in the study in exchange for course credits. They had normal or corrected-to-normal vision. One participant did not complete the questionnaire, another participant's data was not stored, and two additional participants did not properly respond to the display (i.e., pressed only one key throughout the task). Final analyses were based on the remaining 93 participants.

Measure

The Social Interaction Anxiety Scale (SIAS; Mattick and Clarke 1998) was used to assess participants' levels of social anxiety. Participants indicated the degree to which each statement described themselves on a 5-point Likert-type scale ranging from 0 (not at all characteristic or true of me) to 4 (extremely characteristic or true of me). The optimum cutoff score of 37 has been suggested (Peters 2000). The SIAS has been translated into Korean and has demonstrated good reliability (Cronbach's $\alpha = .92$; Kim 2001). Although a specific cutoff score has not been established in Korean samples, a clinical sample in Korea demonstrated comparable SIAS scores ($M = 51.75$; Chung and Kwon 2006) to those reported in Peters (2000; $M = 55.24$). In the current study, Cronbach's α was .95, and the participants' mean SIAS score was 26.12 (SD = 13.33).

Task

Each trial started with a 500 ms fixation point, followed by a group of facial pictures presented for 100 ms. On the next display, participants were prompted to indicate whether the facial crowd was positive or negative as a whole by pressing an appropriate response key. Angry and happy faces were obtained from a well-validated Korean face database (Lee et al. 2006). Thirty-two models (16 female and 16 male) posed for each facial affect, resulting in a total of 64 different stimuli. Each picture was resized to 40 mm × 55 mm. Using these pictures, facial crowds were constructed to vary in terms of the size of the set (i.e., 6, 12, or 24 faces) and the degree of negativity expressed by the crowds. To vary the degree of negativity expressed by each crowd, the ratio of angry to happy pictures in the crowd was manipulated. Five different valence ratios were used: 1:5 (i.e., one angry and five happy faces; very positive), 2:4, 3:3 (balanced), 4:2, and 5:1 (very negative). Facial pictures in each crowd were randomly selected with two constraints: (1) an equal number of male and female models were presented in each crowd, and (2) no two pictures in each crowd were of the same model. There were 15 practice trials and 450 experimental trials (3 set sizes × 5 ratios × 30 blocks). The task was written using

MATLAB (Mathworks, MA) in conjunction with the Psychophysics Toolbox (Brainard 1997; Pelli 1997).

Procedure

Participants were tested in groups of two to three people. After providing informed consent, participants completed the SIAS. Next, the participants were introduced to the main task. Previous research suggests that threat or stress induction may be necessary to elicit cognitive biases in analogue samples (e.g., Mathews and MacLeod 1994). Therefore, the participants were instructed to imagine that they were giving a speech and that the facial pictures presented on the screen represented their audience. They were asked to indicate whether the audience (i.e., facial crowds) expressed a positive or a negative emotion. Once participants understood the instruction, they completed the task by themselves in separate cubicles. All aspects of the study were approved by the local Institutional Review Board.

Data Analysis

First, we plotted the proportions of "negative" responses as a function of the negativity (i.e., valence ratio) of the facial crowds, which ranged from 0.17 (negative: positive = 1:5) to 0.83 (negative: positive = 5:1). The data were then fitted with two-parameter (i.e., mean and SD) cumulative Gaussian functions. This psychometric function $\psi (\chi)$ can be defined as follows: $\psi(\chi) = \Upsilon + (1 - \Upsilon - \lambda)f(\chi; \alpha, \beta)$. Here, $f(\chi)$ is a cumulative Gaussian function in which α and β are constants associated with the mean and the SD of the function. Υ and λ are also constants that indicate the lower and upper bounds of the function, respectively. We used the Psignifit toolbox (Wichmann and Hill 2001a, b) to find each participant's cumulative Gaussian function and computed the PSE (bias) and the SD (precision) for each individual.

The position of the curves can be quantified by the PSE, which is the mean of the cumulative Gaussian functions. The PSE is the level of negativity of facial crowds where a participant's responses were 50 % negative and 50 % positive. Thus, the PSE indicates the negativity (or the valence ratio) of facial crowds that each participant perceived subjectively as portraying balanced emotion. As the dashed lines in Fig. 1a show, when $\psi (\chi)$ is equal to 0.5 (i.e., when 50 % of a participant's responses are "negative"), the χ value on the abscissa corresponding to this value is the PSE. A PSE that is lower than 0.5 indicates that a participant viewed facial crowds with more positive than negative faces as portraying balanced emotion, suggesting the presence of negative bias.

The SD (reflecting uncertainty) of a cumulative Gaussian function provides precision thresholds. To illustrate the idea of the SD of the psychometric function presented in Fig. 1a, we expressed the SD in a normal distribution function by finding derivatives of the cumulative Gaussian function (Fig. 1b). The SD of this normal distribution is identical to the value of β and inversely proportional to the maximum slope point of the psychometric function presented in Fig. 1a. In addition, the mean of this normal distribution is identical to the value of α (i.e., the PSE).

To better understand the significant relation between the levels of social anxiety and the PSEs, participants whose SIAS scores were 1 SD above or below the group mean were grouped into the high ($N = 18$, SIAS $M = 46.94$, SD $= 5.57$) or low ($N = 15$, SIAS $M = 9.13$, SD $= 2.45$) social anxiety groups. We then conducted appropriate t-tests. It is important to note that the patterns of results remained the same no matter how the two social anxiety groups were formed (e.g., a median split, the top and the bottom quartile, etc.).

Results

As a preliminary analysis, we first conducted a Set Size × Ratio × Social Anxiety General Linear Model (GLM), which allows the continuous nature of social anxiety to be preserved. The proportion of trials during which the participants indicated the crowds as negative served as a dependent variable. As expected, the main effect of ratio was significant, Greenhouse-Geisser corrected $F(2.78, 253.03) = 3.45, p < .001, \eta_p^2 = .71$. The main effect of social anxiety was also significant, $F(1, 91) = 7.19, p = .009, \eta_p^2 = .07$, indicating that socially anxious individuals were more likely to indicate the facial crowds as negative. No other effects were significant.

The main aim of the current study was to examine the relation between the levels of social anxiety and the processing of emotion expressed in facial crowds using two indices: (a) the PSEs (i.e., bias) and (b) the SDs (i.e., precision). Given that none of the effects involving the set size were significant in the GLM results reported above, we collapsed the data across three set size conditions to increase the reliability of the fitting.

The average PSE was 0.54 and the average SD was 0.49. The average PSE was significantly higher than 0.50, $t(92) = 3.13, p = .002, d = 0.33$, suggesting the presence of positive biases in the entire sample. Although the participants showed significant positive bias, it was only 4 % on average. More importantly, the levels of social anxiety were significantly associated with the PSEs, $r = -.25$, $p = .014, d = -0.52$. That is, higher levels of social anxiety were associated with the tendency to perceive

facial crowds as negative at a lower PSE. In contrast, the levels of social anxiety were not associated with the degree of precision (i.e., SD) in the extraction of the overall emotion, $r = -.10, p = .35, d = -0.2$. In sum, the levels of social anxiety are associated with the degree of biases, but not with their precision, in extracting information about the overall emotion of the group.

To understand the nature of the negative correlation between the levels of social anxiety and PSEs (bias), we examined the PSEs in the two extreme groups. The PSEs of the high social anxiety group ($M = 0.51$, SD $= 0.13$) did not significantly differ from the veridical ratio of 0.5 ($t(17) = .16, p = .88, d = 0.08$). In contrast, the PSEs of the low anxiety group ($M = 0.59$, SD $= 0.15$) were significantly higher than 0.5 ($t(14) = 2.29, p = .038$, $d = 0.6$). These results indicate the presence of positive bias among non-socially anxious individuals. Socially anxious individuals did not show negative bias when processing facial crowds; instead, they lacked the positive bias normally present in non-anxious individuals.

Discussion

The present study investigated the processing of facial crowds in socially anxious individuals. Consistent with our hypothesis, participants' tendencies to indicate facial crowds as negative increased as their levels of social anxiety increased. In contrast, the levels of social anxiety were not associated with the degree of precision in judgments of overall emotion of crowds. The current study extended previous findings of accurate mean emotion computations (Haberman and Whitney 2007, 2009) by demonstrating the presence of individual differences in the processing of the overall emotion of facial crowds consisting of different individuals. Consistent with previous research conducted by Haberman and Whitney, participants were able to extract the overall emotion in groups of faces quite accurately; there was only 4 % bias on average.

Interestingly, socially anxious individuals' perceptions of facial crowds and the actual emotional composition of the crowds were closely aligned, whereas non-anxious individuals perceived facial crowds more positively than the objective level of emotionality conveyed by the facial crowds. Socially anxious individuals perceived the crowds more negatively compared to their less anxious counterparts only because the non-anxious individuals exhibited positive bias. It is non-anxious individuals who are "biased in favor of nonthreatening or positive interpretations" (p. 706, Hirsch and Mathews 2000) when processing emotionally ambiguous information. Regardless of their social anxiety levels, however, participants were able to discern objectively positive from objectively negative

facial crowds with similar levels of sensitivity. Therefore, the more "accurate" perception of socially anxious individuals reflects not their greater sensitivity to negative facial expressions but their lack of positive bias. These results parallel strikingly the presence of positive bias among low socially anxious individuals and the lack of such positive bias in socially anxious individuals, when estimating their communication effectiveness (Fay et al. 2008). Furthermore, low and high socially anxious individuals were equally able to discriminate communication success from failure, mirroring the current findings on the lack of a significant association between social anxiety and precision (i.e., SDs).

What might account for the current findings? It has been argued that healthy individuals have overly positive views of themselves (Taylor and Brown 1988) and a tendency for self-favoring (De Jong 2002). This tendency is likely self-protective and adaptive (e.g., Johnson and Fowler 2011), which may have led non-anxious individuals to view the crowds as more positive (i.e., perceive that audience members are responding more favorably to their speech than they really are). If this protective mechanism is absent in socially anxious individuals (e.g., Hirsch and Mathews 2000), their overall emotional impressions of facial crowds will likely reflect the actual composition of facial crowds. The lack of positive bias (processing facial crowds more accurately in this study) among socially anxious individuals may contribute to the maintenance of a vicious cycle in social anxiety. That is, being "too realistic" may lead them to notice unfavorable reactions from others that may go unnoticed by their less anxious counterparts, which in turn may confirm their negative beliefs (e.g., "I'm incompetent."). More accurate, yet comparatively more negative, perceptions of social information could lead socially anxious individuals to feel more defensive and uncomfortable in social situations. In turn, they may feel less confident and even withdraw from social situations.

Along these lines, it is important to consider similar findings in the depression literature that appear to support the view of "depressive realism" (Alloy and Abramson 1988). For example, self-perceptions of dysphoric participants (vs. controls) aligned better to judgments made about them by independent observers (e.g., Kistner et al. 2001). Recent findings, however, suggest that depressive realism may be limited to non-clinical, dysphoric samples and that individuals diagnosed with depression exhibit negative biases (Carson et al. 2010; Fu et al. 2012). Similar to depressive realism, our findings may be limited to non-clinical samples with elevated levels of social anxiety, and individuals diagnosed with social anxiety disorder may demonstrate negative bias when processing a group of faces. In this regard, it is important to note that everyone in the high social anxiety group scored above the cutoff score

of 37 suggested by Peters (2000). Nevertheless, generalizing the current findings to a clinical population should be cautioned.

Another limitation of the current study is the use of prototypical, full-blown facial expressions. In real life, we are more likely to encounter faces with less intensive facial expressions. Future studies should examine individual differences in the overall emotion extraction from facial crowds consisting of facial expressions of varying intensities.

To prevent fixation of attention on a particular face in a facial crowd, we used a relatively short presentation time (i.e., 100 ms). Thus, the results are based on participants' initial perceptions of facial crowds and are not contaminated by the later more strategic processes (e.g., reflection about the information, the influence of previous social interactions). The current results reflect automatic processes when a person has to detect the mood of a crowd at a glance. In reality, there are times when a person interacts with a group of people for a longer period of time. In these situations, assessing the average mood of a group will not only be influenced by automatic, on-line processes, but also by later strategic processes. Furthermore, a longer presentation time could allow socially anxious individuals to focus on faces expressing negative emotions (i.e., selective attention to negative facial expressions; see Heinrichs and Hofmann, 2001 for review). Fixating on a few negative facial expressions in a facial crowd will likely lead socially anxious individuals to exhibit negative bias. Future studies should investigate whether socially anxious individuals still exhibit a lack of positive bias as opposed to the presence of negative bias when facial crowds are presented for a longer period of time.

Research on bias modification training has successfully demonstrated that anxious individuals' biases can be effectively reversed, leading to a reduction in anxiety and distress (see Hallion and Ruscio 2011; Hertel and Mathews 2011, for review). Repetitively exposing socially anxious individuals to a group in which positive facial expressions are the majority (e.g., a group with a valence ratio of 1:5 in the current study) could induce positive biases that characterize non-anxious individuals. The induction of positive biases, in turn, may reduce levels of social anxiety (e.g., Amir and Taylor 2012). This speculation should be investigated in the future.

We have successfully demonstrated the presence of individual differences in extracting the overall emotion in groups of faces. Specifically, non-anxious individuals exhibited positive biases when processing facial crowds with mixed emotional expressions, whereas socially anxious individuals lacked such positive biases. Ambiguity is prevalent in our everyday social interactions, and accurate processing, ironically, can be dysfunctional and pathological.

If socially anxious individuals process social information veridically but in a comparatively more negative manner than less anxious individuals, it could negatively impact their social interactions (e.g., avoiding or not enjoying social interactions).

Conflict of interest We declare that we have no conflict of interest.

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