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Face processing biases in social anxiety: An electrophysiological study

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Abstract

Studies of information processing biases in social anxiety suggest abnormal processing of negative and positive social stimuli. To further investigate these biases, behavioral performance and event-related brain potentials (ERPs) were measured, while high- and low-socially anxious individuals performed a modified version of the Erikson flanker task comprised of negative and positive facial expressions. While no group differences emerged on behavioral measures, ERP results revealed the presence of a negative face bias in socially anxious subjects as indexed by the parietally maximal attention- and memory-related P3/late positive potential. Additionally, non-anxious subjects evidenced the presence of a positive face bias as reflected in the centrally maximal early attention- and emotion-modulated P2 and the frontally maximal response monitoring-related correct response negativity. These results demonstrate the sensitivity of different processing stages to different biases in high- versus low-socially anxious individuals that may prove important in advancing models of anxious pathology.

Keywords: Social anxiety; Information processing biases; Event-related potentials; Attention; Response monitoring

Current accounts of social anxiety suggest that it is characterized by abnormal processing of social threat information (see Heinrichs and Hofmann, 2001 for a review) as well as social safety and acceptance signals (see Kashdan, 2007 for a review). These two abnormalities or unique tendencies – typically referred to as 'biases' – in information processing manifest such that socially anxious individuals display a bias toward negative social stimuli (e.g., angry faces) whereas they *fail* to show the normal bias toward positive social stimuli (e.g., praising words). Better understanding the nature of information processing biases in social anxiety is essential to elucidating its conceptualization and treatment.

Several lines of research support the idea that social anxiety is characterized by a bias towards social threat information. These studies show that while socially anxious individuals demonstrate preferential processing of (i.e., a bias toward) social threat, normal controls do not seem to show any bias at all (cf. Bar-Haim et al., 2007). For instance, behavioral studies have demonstrated facilitated response times (RT) to task-relevant stimuli that replace negative faces in dot probe tasks (Mogg and Bradley, 2002; Mogg et al., 2004), faster detection of negative faces during visual search (Eastwood et al., 2005) and pop out (Gilboa-Schechtman et al., 1999), as well as slower disengagement from threat words in a Posner task (e.g., Amir et al., 2003) in socially anxious subjects. Further support for this notion comes from functional neuroimaging studies that have demonstrated hyperactive amygdala, extrastriate visual cortex and insula activation to negatively valenced facial stimuli in socially anxious subjects (Stein et al., 2002; Straube et al., 2005).

Evidence for socially anxious individuals' failure to show a bias towards positive social stimuli is less robust, but still spans a number of different paradigms. Whereas the negative bias reviewed above is evident in *the presence of* preferential processing of threat information in socially anxious subjects and *the lack of* preferential processing in normal controls, the lack of positive bias is evident in *the lack of* preferential processing of positive social information in socially anxious subjects and *the presence of* preferential processing of positive social stimuli in normal controls. Socially anxious individuals, for example, fail to evince the faster RT advantage to words that complete ambiguous passages in a positive manner (Hirsch and Mathews, 2000), to positive words that are associated with self-referential words (Tanner et al., 2006), to positive faces (Silvia

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et al., 2006) that normal controls do. Additionally, socially anxious subjects fail to show the bias to associate positive outcomes with positive facial expressions that normal controls do (Garner et al., 2006).

Thus, the behavioral and neuroimaging data reviewed above suggest that socially anxious subjects show a bias toward threat information, while normal controls do not, and normal controls show a bias toward positive information, while socially anxious subjects do not. However, it is unclear whether both biases can occur in a given experiment, as it seems that when a negative bias is shown, a lack of positive bias is not, and vice versa. One possible reason why the studies reviewed above demonstrate different biases is because the experimental paradigms employed might, in fact, tap into different processes. Another possible reason why studies show different biases is because of the measures typically employed, namely RT and hemodynamic activity. Both RT and hemodynamic activity reflect an amalgam of processes and might therefore be less sensitive to detecting multiple biases or biases reflected in multiple processes in the context of a given experiment.

Event-related brain potentials (ERPs), on the other hand, are electrophysiological signals that allow for the examination of the sequence of constituent operations involved in processing and acting on incoming information on the order of milliseconds. Specifically, the ERP waveform represents multiple neural processes by discrete changes in voltage observed at the scalp – i.e., components – that offers several opportunities at detecting processing biases. Therefore, ERPs might be more sensitive to detecting the presence of biases. Consistent with this notion, several studies have demonstrated ERP differences between negative affective (anxious and depressed) and control groups in the face of comparable behavioral performance (Fallgatter et al., 2004; Hajcak et al., 2003, 2004a,b; Hajcak and Simons, 2002; Shestyuk et al., 2005). To our knowledge, only two recent studies have examined ERP correlates of information processing biases in social anxiety, however. First, Kolassa and Miltner (2006) reported somewhat larger occipito-temporal N170s to angry faces in socially anxious patients during an emotion identification task. More recently, Rossingol et al. (2007) found that high-socially anxious subjects evinced abnormal processing of anger and disgust faces as reflected in the N2b component (with 10 subjects in each group). Although preliminary, these studies suggest that ERPs can detect biases in the processing of facial expressions in social anxiety.

In the current study, we intended to extend these recent findings by examining modulations of stimulus- *and* response-locked ERPs to negative *and* positive face categorization. We chose facial stimuli because the core feature of social anxiety is fear of negative social evaluation and rejection, and faces convey significant social information (cf. Adolphs, 2002; Bradley et al., 1997; Ekman, 1993; Izard, 1971; Ohman et al., 2001). Additionally, we used negative *and* positive facial expressions, as it allowed us to examine biases in the processing of negative and positive social information that *both* appear to differentiate socially anxious from non-anxious subjects. By measuring both stimulus- and response-locked ERPs, we were able to examine whether socially anxious or non-anxious subjects showed (or lacked) a negative or positive bias at multiple points during information processing. Specifically, we examined the fronto-central P2 and N2 and parietal P3 of the stimulus-locked ERP and the fronto-central correct response negativity (CRN) of the response-locked ERP.

Electrophysiological activity in the time window of the P2 and N2 seems to be a good candidate for studying information processing biases in social anxiety, as a recent review of the literature by Eimer and Holmes (2007) showed that emotional facial expressions elicit an enhanced fronto-central positive shift beginning around 150–200 ms post-stimulus. Eimer and Holmes suggested that the fronto-central modulations by facial expressions may reflect rapid representation of emotional significance in prefrontal regions. Additionally, the previously mentioned reports by Kolassa and Miltner (2006) and Rossingol et al. (2007) suggest that ERPs in this time window can detect information processing biases in social anxiety.

Following the above-mentioned processes, the brain engages in more detailed analysis of visual information as reflected by the P3/late positive potential (LPP). The P3/LPP is a positive ERP component observed at parietal recording sites between 200 and 800 ms post-stimulus. The P3/LPP also seems to be a good candidate for studying information processing biases in social anxiety, as a large body of literature indicates that it is a neural index of attentional, perceptual and memory updating processes facilitated by motivationally relevant stimuli (Donchin, 1981; Donchin and Coles, 1988; Nieuwenhuis et al., 2005; Schupp et al., 2000). The P3/LPP was also shown to be responsive to emotional facial expressions in Eimer and Holmes's (2007) review. In addition, the P3/LPP has been reliably responsive to fear-relevant stimuli in PTSD patients (Attias et al., 1996), panic patients (Pauli et al., 1997), spider phobic patients (Kolassa et al., 2005) and animal phobic students (Miltner et al., 2005). At the same time, a reduction in the P3/LPP to flanker stimuli (i.e., fear-irrelevant, task-relevant stimuli) was found when spider phobic subjects were exposed to a spider challenge (i.e., a fear-relevant, task-irrelevant stimulus; Moser et al., 2005). Taken together, it seems that the P3/LPP is a rather robust measure of emotional processing and information processing biases in anxiety.

Response-locked ERPs reflect processes that occur around response execution that are essential to the monitoring and control of behavior. ERPs therefore allow for the differentiation of stimulus- and response-related processes that are confounded in RT measures. The CRN is one such ERP that indexes response-related processes and is typically observed as a negative deflection that peaks at fronto-central recording sites approximately 50–100 ms after a correct response is made in a two-choice speeded reaction time task (Bartholow et al., 2005; Vidal et al., 2000, 2003). More specifically, the CRN is part of a class of mediofrontal negativities believed to reflect action monitoring activity of the anterior cingulate cortex (ACC; Bartholow et al., 2005; Vidal et al., 2000, 2003). The CRN has been shown to be sensitive to response and strategy conflict (Bartholow et al., 2005), as well as the combination of cognitive conflict and affective context (Simon-Thomas and Knight,