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Electrocortical Evidence of Enhanced Performance Monitoring in Social Anxiety

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Self-focused attention is thought to be a key feature of social anxiety disorder. Yet few studies have used event-related potentials (ERPs) to examine whether socially anxious individuals display greater monitoring of their performance and attention to their errors. Similarly, only a few studies have used ERPs to examine how social anxiety is related to processing of performance feedback. Individuals with high (n = 26) and low (n = 28) levels of social anxiety completed a trial-and-error learning task. Self-focus was manipulated using false heart-rate feedback during a random subset of trials. Performance feedback was given using emotional and neutral faces in a positive context (correct = happy face; incorrect = neutral face) and negative context (correct = neutral face; incorrect = disgust face) in order to investigate biased interpretation and attention to feedback. Socially anxious subjects displayed enhanced amplitude of the ERN and CRN, suggesting greater response monitoring, and enhanced Pe amplitude, suggesting greater processing of errors relative to the low social anxiety group. No group differences were observed with respect to feedback processing. Before learning stimulus–response mappings in the negative context, the FRN was larger for self-focus compared to standard trials and marginally larger for socially anxious subjects compared to controls. These findings support cognitive models and suggest avenues for future research.

Keywords: social anxiety; self-focus; ERP; ERN; Pe

SELF-FOCUSED ATTENTION IS THOUGHT to be a key process in maintaining social anxiety disorder (SAD; Clark & McManus, 2002; Heimberg, Brozovich, & Rapee, 2014). Specifically, socially anxious individuals monitor aspects of themselves which they believe may elicit rejection. This includes anxiety symptoms (e.g., increased heart rate) and other features of the self that are believed to lead to rejection if noticed by others. Theories propose that self-focus interferes with cognitive processes involved in social interaction and may affect processing of feedback in social situations (Clark & Wells, 1995; Rapee & Heimberg, 1997; Schultz & Heimberg, 2008). Only a few recent studies have explored the relationship between social anxiety and response monitoring, which may be conceptualized as a facet of self-focused attention. And studies have not examined how response monitoring and performance feedback may be affected by attention to somatic anxiety symptoms. The goal of this study was to address these gaps.

Research supports an excessive focus on somatic anxiety symptoms, particularly accelerated heart rate, in those who are socially anxious. For example, Mills, Grant, Judah, and White (2014) found that socially

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anxious individuals who were assigned to anticipate an upcoming social interaction showed an attentional bias for ostensible snapshots of their electrocardiogram (ECG) waves compared to sound waves. Other studies have used false heart-rate feedback to examine the effects of focus on anxiety symptoms in SAD (see Papageorgiou & Wells, 2002), including studies using event-related potentials (ERPs; Judah, Grant, Mills, & Lechner, 2013; Judah, Grant, & Carlisle, in press). Although such research has begun to document how focus on physiological symptoms plays a role in SAD, relatively little research has examined whether socially anxious individuals display increased monitoring of their performance. Social anxiety has been linked to perfectionism (Flett & Hewitt, 2014; Lundh & Öst, 1996), suggesting that research is needed to determine whether monitoring the "correctness" of one's behavior may be an aspect of self-focused attention in SAD. Errors in performance situations can be conceptualized as aspects of the self which invite negative evaluation. Hence, the hypothesis that socially anxious individuals may deploy greater cognitive resources for monitoring their performance is consistent with cognitive theories of SAD.

Several ERPs may be useful to assess performance monitoring in SAD. These ERPs are derived by averaging electrical activity at the scalp after a response or after feedback in performance tasks. Those occurring after a response include the error-related negativity (ERN), correct response negativity (CRN), and error positivity (Pe). The feedback-related negativity (FRN) occurs after feedback about performance.

The ERN (Falkenstein, Hohnsbein, Hoorman, & Blanke, 1990; Gehring, Coles, Meyer, & Donchin, 1990) occurs after incorrect responses, and the CRN (Bartholow et al., 2005; Vidal, Burle, Bonnet, Grapperon, & Hasbroucq, 2003) occurs after correct responses. Both have a fronto-central scalp distribution that is maximal within 100 ms of the response. The ERN and CRN are thought to represent activity of the anterior cingulate cortex as it detects conflict between behavioral impulses and recruits attention to learn contingencies and control future responses (Coles, Scheffers, & Holroyd, 2001; Falkenstein, Hoormann, Christ, & Hohnsbein, 2000; Holroyd & Coles, 2002; Moser, Moran, Schroder, Donnellan, & Yeung, 2013; Yeung, Botvinick, & Cohen, 2004). These components may represent suppression or correction of prepotent unintended motor response impulses (see Hochman, Orr, & Gehring, 2014). Research suggests that enhancement of the ERN may be a transdiagnostic feature of anxiety disorders, perhaps because worriers and anxious individuals perceive errors as threats (Proudfit, Inzlicht, & Mennin, 2013). Studies have found an enhanced ERN in GAD subjects (Weinberg, Olvet, & Hajcak, 2010) and high worriers relative to low worry controls (Meyer, Weinberg, Klein, & Hajcak, 2012; Moran, Taylor, & Moser, 2012).

Although many studies have found that anxiety is linked to the ERN and not the CRN (e.g., Aarts & Pourtois, 2010), other studies have found enhanced CRN and ERN in anxious individuals (Endrass et al., 2010; Endrass, Klawohn, Schuster, & Kathmann, 2008; Hajcak, McDonald, & Simons, 2004; Moser, Moran, & Jendusina, 2012). In the case of SAD, one study noted an enhanced ERN and CRN in SAD subjects relative to healthy controls (Endrass, Riesel, Kathmann, & Buhlmann, 2014). However, another study found a significant interaction between social anxiety group (i.e., high; low) and the CRN when observed by others versus when alone (Barker, Troller-Renfree, Pine, & Fox, 2015). Follow-up analyses were not significant, and the nature of the effect could not be determined. Research is needed to disentangle whether social anxiety is characterized by increases in monitoring errors in particular (i.e., enhanced ERN only) or performance more generally (i.e., enhanced ERN and CRN). Furthermore, most studies examining anxiety and the ERN and CRN have utilized the Eriksen flanker task, which assesses errors made when required to identify a target (e.g., >) with two congruent (e.g., > > > > >) or incongruent (e.g., < < > < <) flankers on each side. Because the ERN and CRN are modulated by learning (Holroyd & Coles, 2002), other tasks which incorporate trial and error learning may be important to advancing our understanding of psychological processes driving relationships between these ERPs and anxiety.

The error positivity (Pe) is characterized by centro-parietally distributed positive voltage that appears 200–400 ms after an incorrect response (see Olvet & Hajcak, 2009). Though its precise functional significance is unclear, research suggests that the Pe is associated with conscious awareness of errors (Falkenstein, 2004; Olvet & Hajcak, 2008; Orr & Carrasco, 2011; Overbeek, Nieuwenhuis, & Ridderinkhof, 2005). Thus, the Pe may be used to investigate whether socially anxious individuals display greater processing of known errors. Compared to ERN findings, research is less clear about the relationship between the Pe and anxiety (e.g., Endrass et al., 2008; Hajcak et al., 2004), including social anxiety (Barker et al., 2015; Endrass et al., 2014). More research is needed to examine possible relationships between social anxiety and processing of errors as indicated by the Pe.

In addition to response monitoring, processing of feedback is an important aspect of performance situations, in which socially anxious individuals may