



Will they like me? Neural and behavioral responses to social-evaluative peer feedback in socially and non-socially anxious females



Melle J.W. van der Molen^{a,b,*}, Anita Harrewijn^{a,b}, P. Michiel Westenberg^{a,b}

^a Institute of Psychology, Faculty of Social and Behavioral Sciences, Leiden University, Leiden, the Netherlands

^b Leiden Institute for Brain and Cognition, Leiden University, Leiden, the Netherlands

ARTICLE INFO

Keywords:

EEG
Feedback
P3
Social anxiety
Social evaluation
Theta power

ABSTRACT

The current study examined neural and behavioral responses to social-evaluative feedback processing in social anxiety. Twenty-two non-socially and 17 socially anxious females (mean age = 19.57 years) participated in a Social Judgment Paradigm in which they received peer acceptance/rejection feedback that was either congruent or incongruent with their prior predictions. Results indicated that socially anxious participants believed they would receive less social acceptance feedback than non-socially anxious participants. EEG results demonstrated that unexpected social rejection feedback elicited a significant increase in theta (4–8 Hz) power relative to other feedback conditions. This theta response was only observed in non-socially anxious individuals. Together, results corroborate cognitive-behavioral studies demonstrating a negative expectancy bias in socially anxiety with respect to social evaluation. Furthermore, the present findings highlight a functional role for theta oscillatory dynamics in processing cues that convey social-evaluative threat, and this social threat-monitoring mechanism seems less sensitive in socially anxious females.

1. Introduction

Fear of negative social evaluation is a core symptom of social anxiety disorder (Clark & Wells, 1995), a prevalent anxiety disorder with a chronic course of development and a precursor of other mental health problems (e.g., depression, substance abuse) (Blanco, Nissenson, & Liebowitz, 2001; Wittchen, 2000). Theoretical models have specified a variety of information processing biases that contribute to the maintenance of social anxiety, such as attentional biases (e.g., self-focused attention and increased focus on external threat), as well as anticipatory and post-event processing biases (Clark & McManus, 2002). It has been argued that these information processing biases are expressed based on the level of threat that is assigned to social-evaluative stimuli that convey judgment to important aspects of self-identity (Dickerson, Gruenewald, & Kemeny, 2004) – a concept recently coined as the *social-evaluative threat principle* (Wong & Rapee, 2016). A large body of work has examined responsivity to lower-order social-evaluative threat stimuli (e.g., behavioral and psychophysiological responsivity to facial expressions), and this work has contributed to the characterization of information processing biases in socially anxious individuals (e.g., initial hypervigilance to threat) (Clark & McManus, 2002; Mogg & Bradley, 2002). However, the neural mechanisms implicated in processing social-evaluative threat stimuli associated with higher-order

social concepts (e.g., social rejection cues from peers) remain poorly understood. The goal of the current study is to offer a detailed examination of the behavioral, as well as electrocortical responses to social-evaluative peer feedback in subclinical socially anxious vs. non-socially anxious females.

Due to the chronicity of a negative-expectancy bias in social anxiety, research has focused to delineate the cognitive mechanisms that instantiate this belief to be scrutinized by others in social situations. By employing paradigms that simulate social-evaluative threat it has been shown that socially anxious individuals predict to be socially rejected more often than non-socially anxious individuals. For example, using the Chatroom task, socially anxious participants believed that a larger proportion of peers would not be interested in chatting with them (Caouette et al., 2015). A similar negative expectancy bias was found using the Island Getaway task. In this paradigm, participants vote to accept or reject co-players from staying on a virtual island, while also receiving similar information from the co-players. Cao, Gu, Bi, Zhu, and Wu (2015) found that participants with social anxiety had lower-peer acceptance expectancies than healthy controls. Recent computational-modeling evidence underscores this negative expectancy bias and highlights a prominent inability to learn from positive feedback in socially anxious individuals (Koban et al., 2017). These authors postulated that socially anxious individuals are less attentive and influenced

* Corresponding author at: Institute of Psychology, Faculty of Social and Behavioral Sciences, Leiden University, Leiden, the Netherlands.
E-mail address: m.j.w.van.der.molen@fsw.leidenuniv.nl (M.J.W. van der Molen).

by positive feedback. These alleged misconceptions about social evaluation might not be easily corrected, which in turn could instantiate the negative expectancy bias and maintain social anxiety symptoms (Koban et al., 2017).

To date, it remains unclear how this negative expectancy bias in socially anxious individuals relates to the processing of social-evaluative feedback in the brain. According to the social-evaluative threat principle (Wong & Rapee, 2016), socially anxious individuals should display heightened reactivity to social-evaluative feedback (e.g., social rejection), since such stimuli would convey a significant threat to the individual's well-being (Baumeister & Leary, 1995; Eisenberger & Lieberman, 2004). In contrast, the cognitive-behavioral model on social anxiety of Clark and Wells (1995) suggests a reduced processing of external social-evaluative threat cues, most likely due to enhanced self-focused attention in socially anxious individuals (Bögels & Mansell, 2004). For example, in anticipation or in response to a social-evaluative stressor, attentional resources in a socially anxious individual can be directed internally (i.e., to physiological cues of arousal, such as elevated heart rate or blushing), or to their behavior and thoughts. Self-focused attention to internal self-relevant stimuli is argued to result in reduced attentional resources to external cues, and limits the processing of external social-evaluative threat (Clark & Wells, 1995; Rapee & Heimberg, 1997). This interpretation meshes with the idea that socially anxious individuals display increased interoceptive awareness to bodily sensations when they are confronted with a social-evaluative stressor (Durlak, Brown, & Tsakiris, 2014). Heightened interoceptive awareness dedicates increased attentional resources to somatic perception and the inherent subjective perception of anxiety (Critchley, Wiens, Rotshtein, Ohman, & Dolan, 2004), which might limit available resources to reorient attentional focus to external stressors in social anxiety (Terasawa, Shibata, Moriguchi, & Umeda, 2013). As a consequence, the enhanced self-focused attention might result in decreased sensitivity to social-evaluative threat.

Neural reactivity associated with processing social-evaluative feedback can offer an objective estimate of whether socially anxious individuals show increased or decreased sensitivity to social-evaluative threat. However, few studies exist on this topic and their results are mixed. The available studies examined reactivity of the feedback-related negativity (FRN), a brain potential belonging to a class ERPs generated by the medial prefrontal cortex, and the anterior cingulate cortex (ACC) in particular (van Noordt & Segalowitz, 2012). The FRN is sensitive to feedback communicating an unexpected outcome or indicating that behavior was incorrect (Holroyd & Coles, 2002; Miltner, Braun, & Coles, 1997). Using the Island Getaway task, Kujawa, Arfer, Klein, and Proudfit (2014) found that socially anxious teenagers were more sensitive to social rejection feedback vs. acceptance feedback as indexed by the FRN. In contrast, using a similar paradigm, Cao et al. (2015) found that patients with social anxiety disorder displayed a significantly larger FRN to social acceptance vs. rejection feedback. These inconsistent results might be related to the different participant samples used in these studies (e.g., socially anxious teenagers vs. adults with and without social anxiety disorder). Furthermore, both studies examined the FRN in response to social acceptance vs. rejection feedback without taking into account participants' trial-by-trial a-priori predictions about the social-evaluative outcome. It is known from myriad of performance monitoring studies that feedback-related brain activity is sensitive to prediction error (for a review, see Walsh & Anderson, 2012). With respect to the apparent negative expectancy bias in social anxiety, prediction error might be an important factor moderating brain activity to social-evaluative feedback.

A paradigm that allows for examining the effect of expectancies about social evaluation is the Social Judgment Paradigm (SJP), developed by Somerville, Heatherton, and Kelley (2006). In this paradigm, participants are led to believe that they were evaluated by a group of peers based a portrait photograph of the participant. Peers were supposedly asked to indicate whether they would like or dislike the

participant based on their first impressions. During the testing session, the participant is shown portrait photographs of these peers and has to predict whether each peer liked or disliked the participant. Thereafter, peer feedback is provided communicating social acceptance or rejection, and is either congruent or incongruent with participants' prior predictions. At the behavioral level, participants are generally optimistic about the social-evaluative outcome, as they predict higher proportions of social acceptance feedback (Dekkers, van der Molen, Gunther Moor, van der Veen, & van der Molen, 2015; van der Molen et al., 2014; van der Veen, van der Molen, van der Molen, & Franken, 2016). At the neural level, ERP studies using this paradigm have found that the FRN is sensitive to unexpected social-evaluative feedback (regardless of valence) and the P3 seems sensitive to expected social acceptance feedback, suggesting reward sensitivity (van der Veen, van der Molen, Sahibdin, & Franken, 2014).

In addition, recent evidence suggests that frontal midline (FM) theta (4–8 Hz) reactivity seems particularly enhanced during processing of unexpected social rejection feedback (van der Molen, Dekkers, Westenberg, van der Veen, & van der Molen, 2017). Source-localization methods revealed that this FM theta response could be localized to a broad cingulate network, with prominent activity observed in the dorsal ACC (van der Molen et al., 2017). A vast majority of source-localization studies have identified the dorsal ACC as a main generator of FM theta activity (Asada, Fukuda, Tsunoda, Yamaguchi, & Tonoike, 1999; Ishii et al., 2014; Onton, Delorme, & Makeig, 2005; Young & McNaughton, 2009), and the dorsal ACC and seems to play an important role in a broad neural network – including medial prefrontal cortex and mid/posterior cingulate cortex – that governs FM theta oscillations (Cavanagh & Shackman, 2015; Ishii et al., 2014). Theoretical accounts suggest that FM theta oscillations reflect a general mechanism implicated in cognitive control operations, for example when behavioral adjustment is required after errors or when facing uncertain outcomes (Cavanagh & Frank, 2014; Cavanagh, Zambrano-Vazquez, & Allen, 2012; Shackman et al., 2011). It has been shown that these FM theta-dependent control efforts are not restricted to cognitive processes, but also extend to situations that elicit anxiety (Cavanagh & Shackman, 2015). In this regard, FM theta reactivity to social-evaluative feedback might constitute a neural mechanism of social-evaluative threat processing in the socially anxious brain.

In the current study, we will employ the SJP to examine behavioral and electrocortical responses to social-evaluative feedback processing in socially and non-socially anxious females. We focused on females since they have been shown to be more sensitive to social rejection than men (Benenson et al., 2013; Guyer, McClure-Tone, Shiffrin, Pine, & Nelson, 2009). Also, focusing on females reduces inter-individual variability and allows for better comparison which previous studies on neural correlates of social-evaluative feedback processing (Dekkers et al., 2015; van der Molen et al., 2017; van der Molen et al., 2014). In addition to prior studies that have used this paradigm, we will ask participants to provide an estimation about the social-evaluative outcome *prior* to the experiment. This should offer an index of a possible negative expectancy bias in socially anxious participants. Also, we asked participants after the experiment to recall how they thought they were evaluated by peers (e.g., generally positively or negatively), to test for a possible recall bias in socially anxious females (Glazier & Alden, 2017). With respect to the trial-to-trial behavior on the SJP, we hypothesized that non-socially anxious females would be more optimistic about the social-evaluative outcome than socially anxious females (for example, see Dekkers et al., 2015; van der Veen et al., 2016). With respect to neural reactivity to social-evaluative feedback we expected that unexpected social rejection feedback would elicit the strongest theta power response (van der Molen et al., 2017). In addition, we performed source-localization analyses on the theta response to unexpected social rejection feedback, and expected the dorsal ACC to be an important generator of FM theta (see van der Molen et al., 2017). Regarding social anxiety status, two competing hypotheses were tested:

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