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Too bad: Bias for angry faces in social anxiety interferes with identity processing

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A B S T R A C T

The recognition of faces across incidences is a complex function of the human brain and a crucial ability for communication and daily interactions. This first study on ERP correlates of emotional face learning in social anxiety disorder (SAD) investigates whether the known attentional bias for threatening faces leads to a corresponding memory bias. Therefore, 21 patients with SAD and 21 healthy controls (HCs) learned faces with emotional facial expressions (neutral, happy, and angry) and were later asked to recognize these out of novel identities all presented with a neutral facial expression. EEG was recorded throughout. Behaviorally, the faces' emotional expression modulated later recognition in terms of accuracy, response times, signal detection parameters and ratings of valence, but with better performance for happy than angry faces in HC as well as in SAD. In the learning phase, attention- and memory-associated event-related potentials (ERPs) P100, N170, P200, N250/EPN, and LPP indicated enhanced processing of angry faces, which was restricted to patients with SAD in N250/EPN and LPP. In the test phase, familiarity effects emerged in N250, FN400 and LPP. While N250 was affected by learned-angry faces, FN400 and LPP reflected image learning of neutral faces, which was restricted to SAD in LPP. We replicated the attentional bias to threatening faces, which was not restricted to early ERP components, but was prolonged to later stages of conscious processing, especially in SAD. In contrast to what had been expected, sustained hypervigilance to the emotional content seems to have *impaired* the processing of the facial identity, resulting in a happy face advantage at the behavioral level. This could be explained by prominent models assuming separate processing of facial emotion and identity. Hypervigilance in SAD might be a disadvantage in those studies focusing on other aspects of face processing than emotion.

1. Introduction

Human faces convey a lot of information not only on identity and other stable aspects of a person, but also on the emotional state and attentional focus, and therefore can be regarded as highly important for everyday interactions (Calder and Young, 2005; Leopold and Rhodes, 2010; Tsao and Livingstone, 2008). Such properties of the face itself (i.e., its saliency or distinctiveness; Itz et al., 2014; Schulz et al., 2012a, 2012), but also characteristics of the observer (e.g., individual differences, Kaufmann et al., 2013), influence how well we learn and recognize a given face. Face recognition requires successful face learning by the formation of a stable representation that allows identification across, e.g., different viewpoints and lighting (Eger et al., 2005; Zimmermann and Eimer, 2013).

Social anxiety disorder (SAD) is a highly frequent disorder with a life-time prevalence of up to 12.1% (Kessler et al., 2005). "Persistent fear of one or more social or performance situations in which the person is exposed to unfamiliar people or to possible scrutiny by others" and the fear to be embarrassed or humiliated are described as the main symptoms; such situations are commonly avoided or undergone with intense fear or distress (according to DSM-5, Diagnostic and statistical manual of mental disorders (5th ed.), 2013). The etiology and maintenance of the disorder might be explained by automatic cognitive biases in the processing of social information (Clark and Wells, 1995; Morrison and Heimberg, 2013). Hypervigilance-avoidance models describe hypervigilance in terms of an initial attentional bias to threatening stimuli, e.g. angry faces (Gilboa-Schechtman et al., 1999; Mogg et al., 2004), followed by avoidance of these (see Bögels and Mansell (2004)). Moreover, patients are more likely to interpret ambiguous stimuli negatively and underestimate the likelihood of upcoming positive events (for a review see Heinrichs and

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Hofmann (2001)); even positive feedback is associated with negative affect (Wallace and Alden, 1997).

Human faces are described as highly disorder-relevant stimuli and are often used in studies investigating SAD (Ohman and Mineka, 2001; Schulz et al., 2013; Staugaard, 2010). Faces are interpreted more negatively in general (Joormann and Gotlib, 2006; Yoon et al., 2009) and more attention is directed especially to angry faces (Gilboa-Schechtman et al., 1999; Mogg et al., 2004; Stevens et al., 2009). Studies on event-related potentials (ERPs) support hypervigilance to potentially threatening stimuli as indicated by larger P100 amplitudes in SAD (Mueller et al., 2009; Rossignol et al., 2012; Schmitz et al., 2012) – a component modulated by attention during the procession of visual information (Luck et al., 1990). P100 is enhanced in various anxiety disorders and seems to indicate hypervigilance to potentially threatening stimuli when anticipated (Michalowski et al., 2015). Another study found a positive correlation of social anxiety and overall P100 amplitudes, but no influence of the emotion of the presented faces on this component (Kolassa and Miltner, 2006), while the face-sensitive N170 (Bentin et al., 1996) was modulated in SAD, with higher amplitudes while looking at angry faces. A modulation of this component by emotion has also been found in healthy participants (Batty and Taylor, 2003; Blau et al., 2007; Caharel et al., 2005; Krombholz et al., 2007; Rellecke et al., 2012), however, not perfectly consistent with respect to the direction of the effect. The subsequent occipito-temporal P200 was enhanced in high compared to low socially anxious participants (Helfinstein et al., 2008; Rossignol et al., 2012), and for angry compared to fearful faces in participants with high fear of negative evaluation (Rossignol et al., 2013). This component has been associated with the processing of the perceived typicality of faces, with larger amplitudes to typical compared to less typical faces (Halit et al., 2000; Schulz et al., 2012a; Stahl et al., 2008, 2010). Altered processing in initial ERPs to faces supports the view of hypervigilance in SAD.

Some studies and cognitive models of SAD suggest conditioning and/or social learning to contribute to the development and maintenance of the disorder (Clark and Wells, 1995; Mineka and Zinbarg, 2006; Pejic et al., 2013). While altered initial attentional processing has been studied extensively, evidence concerning memory processes is still rare. Thus, the question arises whether there is also a memory bias, especially for those faces that carry the most salient information for participants with SAD, namely dismissive faces in terms of angry faces. While studies on verbal material do not support a memory bias in SAD (for review see Heinrichs and Hofmann (2001)), there are only a few studies on behavioral memory effects for faces, and these yield controversial data: in an incidental learning paradigm, participants with SAD recognized critical faces better than accepting faces, while healthy controls showed the opposite pattern (Coles and Heimberg, 2005; Lundh and Öst, 1996). However, participants with SAD showed worse recognition of angry faces after a supraliminal dot-probe task (Lemoult and Joormann, 2012). Other studies applied explicit learning paradigms. Foa and colleagues found generally better memory for same pictures of faces in SAD compared to healthy controls (HC), which was even more pronounced for negative faces (Foa et al., 2000). In an explicit learning study for facial identities by D'Argembeau and colleagues, participants learned emotional faces and were later asked to recognize the same and novel persons now showing a neutral facial expression. Low socially anxious participants had better memory for happy faces while there was no effect of facial expression in high socially anxious participants (D'Argembeau et al., 2003). These inconsistent findings may be explained by the very different designs used-mostly with a low number of facial identities as stimuli and rarely in an explicit identity-learning paradigm.

As yet, there are no studies on electrophysiological correlates of emotional face learning in SAD. In several studies on ERP correlates of face learning in the general population (Itz et al., 2014; Kaufmann et al., 2013; Kaufmann and Schweinberger, 2012; Schulz et al., 2012a, 2012), more salient (here: distinctive or caricatured) faces were learned and remembered better, which was accompanied by enhanced negativity in occipito-temporal ERPs (N170, P200, and N250) and larger positivity in the late positive potential (LPP). The N250(r) has been related to individual recognition of faces (Bindemann et al., 2008; Schweinberger et al., 1995, 2002), and to the acquisition of face representations and their activation during recognition (Gosling and Eimer, 2011; Kaufmann et al., 2009; Schweinberger and Burton, 2003; Tanaka et al., 2006; Tanaka and Pierce, 2009). During initial processing, it is enhanced not only by facial distinctiveness, but also by other-race faces (Wiese et al., 2013). The well-known early posterior negativity (EPN) is often analyzed in a very similar time range and at similar electrode sites for faces. The EPN is generally larger (i.e. more negative) to emotional compared to non-emotional pictures (Schupp et al., 2003) and to emotional compared to neutral faces, especially with an angry expression (Mühlberger et al., 2009; Rellecke et al., 2012). It is supposed to indicate tagging of particularly salient stimuli (Schupp et al., 2007). We will refer to this component as “N250/EPN” in our study as we are not able to disentangle the two in this paradigm. The N250 is generally the first component modulated by familiarity in face recognition paradigms, while the mid-frontal FN400 has been shown to discriminate between familiar and unfamiliar words and pictures (Curran, 2000; Curran and Cleary, 2003) as well as faces (Curran and Hancock, 2007; Righi et al., 2012). Higher amplitudes for emotional pictures have been shown in this component (Schaefer et al., 2011; Van Strien et al., 2009), but no studies have been performed in SAD. Finally, the centro-parietal late positive potential (LPP) or P3 is often larger for emotional compared to non-emotional stimuli (Schupp et al., 2003), including faces (Eimer and Holmes, 2007; Righi et al., 2012). In memory experiments, it is often larger when stimuli are encountered again, and thus may reflect stages of explicit episodic or semantic memory (Friedman and Johnson, 2000; Rugg et al., 1996), therefore sometimes also called parietal old/new effect. LPP is also present in face recognition (Bentin and Deouell, 2000; Schweinberger and Burton, 2003), in which it is sometimes called P600f (Eimer et al., 2012). Whether this component is influenced by clinical social anxiety is not yet clear. One study (Moser et al., 2008) found larger amplitudes in high socially anxious participants (HSA) for angry and disgusted faces, while other studies failed to find a modulation by facial expression besides generally enhanced amplitudes for HSA (Mühlberger et al., 2009).

In a learning study with emotional faces in healthy participants, Johansson et al. (2004) used positive, negative and neutral facial expressions in learning and test. In the absence of a behavioral effect, a larger parietal ERP old/new effect for negative compared to positive and neutral facial expressions emerged. An earlier frontal old/new effect was driven by the novel emotional faces. This shows that in designs with emotional faces in learning and test, it is impossible to disentangle effects of emotion originating from an attentional bias in the learning phase or from the processing of visible emotion during test. To solve this, another study (Righi et al., 2012) asked participants to learn faces with happy, fearful and neutral expressions and to identify these out of novel ones all showing a neutral facial expression. Identities presented with a fearful expression during learning were remembered better than neutral or happy ones. The N170 to the neutral test faces was affected by the emotion during learning in terms of less negative amplitudes for encoded-fearful faces. In the FN400 at frontal regions, encoded-fearful faces showed more positive amplitudes compared to encoded-neutral and happy faces. Also, the LPP