Biological Psychology 99 (2014) 183–192

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

ERP evidence for an early emotional bias towards happy faces in trait anxiety

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ARTICLE INFO

Article history:
Received 30 October 2013
Accepted 24 March 2014
Available online 4 April 2014

Keywords:
Anxiety
Emotion
Attention
Face
Event-related potentials
P1

ABSTRACT

The present study examined the influence of trait anxiety on the early stages of emotional face processing. In order to test if such early effect of anxiety could appear in response to positive as well as to negative stimuli, we recorded event-related potentials in response to both happy and fearful faces – contrasted with neutral faces – during a task where attention was explicitly directed to the emotion, in two groups differing by their anxiety level. We observed an amplification of the occipital P1 peak (90–120 ms) in response to happy compared to neutral faces in high trait anxious participants but not in the low trait anxious ones. Additionally, the N170 and EPN components were enhanced for the negative (fearful) faces, with no impact of trait anxiety. Our results provide evidence for an early bias towards positive stimuli in trait anxiety.

1. Introduction

Among the thousands of stimuli processed during an ordinary day life, affective stimuli have proven to attract attention and facilitate sensory processing (for a review see Pourtois, Schettino, & Vuilleumier, 2013). Experimental evidence for this emotional facilitation initially came from behavioural studies that showed enhanced and shortened detection for emotional compared to neutral information (e.g. Anderson & Phelps, 2001; Eastwood, Smilek, & Merikle, 2001; Fox, Russo, & Dutton, 2002; Ohman, Lundqvist, & Esteves, 2001). In the same line, neuroimaging studies have found enhanced visual activations in response to emotional material, including face stimuli (e.g. Junghofer et al., 2006; Lang et al., 1998; Vuilleumier, Richardson, Armony, Driver, & Dolan, 2004). Event-related potential (ERP) studies have revealed emotional amplifications at several stages of face processing time course, from perceptual to higher cognitive levels (for reviews see Eimer & Holmes, 2007; George, 2013). In particular, a growing number of studies have shown effects of emotion at early stages of face processing (90–120 ms) over occipito-parietal regions (on the so-called P1 component), prior to the full visual categorization stage indexed by the face-specific N170 component (Bentin, Allison, Puce, Perez, & McCarthy, 1996; George, Evans, Fiori, Davidoff, & Renault, 1996). These early emotional modulations have been observed in response to both negative – in particular fearful – (Bar-Haim, Lamy, & Glickman, 2005; Chammat, Foucher, Nadel, & Dubal, 2010; Eger, Jedynak, Iwaki, & Skrandies, 2003; Holmes, Vuilleumier, & Eimer, 2003; Pourtois, Thut, Grave de Peralta, Michel, & Vuilleumier, 2005; Righart & de Gelder, 2006; see also Pizzagalli, Regard, & Lehmann, 1999; Vlamings, Goffaux, & Kemner, 2009; Williams et al., 2007) and positive facial expressions (i.e. happy; Batty & Taylor, 2003; Brosch, Sander, Pourtois, & Scherer, 2008; Dubal, Foucher, Jouvent, & Nadel, 2011; Esslen, Pascual-Marqui, Hell, Kochi, & Lehmann, 2004; Fichtenholtz et al., 2004; see also Halgren, Raij, Marinkovic, Jousmaki, & Hari, 2000). Moreover, the N170 has also been shown to be enhanced in response to faces expressing different emotions, including fear and happiness (Ashley, Vuilleumier, & Swick, 2004; Batty & Taylor, 2003; Blau, Maurer, Tottenham, & McCandliss, 2007; Eger et al., 2003; Kolassa & Miltner, 2006; Kolassa, Kolassa, Musial, & Miltner, 2007; Williams, Palmer, Liddell, Song, & Gordon, 2006), suggesting that these early

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http://dx.doi.org/10.1016/j.biopsycho.2014.03.011
0301-0511/

perceptual stages may be sensitive to emotional cues in general and not only to negatively valenced emotions.

The processing of emotional stimuli may be further modulated by interpersonal differences, notably by anxiety. Anxiety is depicted as an aversive emotional state occurring in threatening circumstances. Decades of literature have reported an attentional bias towards threatening relative to neutral stimuli in anxiety (for reviews see Armstrong & Olatunji, 2012; Cisler & Koster, 2010). According to the hypervigilance-avoidance models (Eysenck, 1992; Mogg & Marden, 1990), this bias is explained by a rapid orientation of attentional resources towards aversive stimuli, allowing their fast detection, followed by allocation of attention away from the location of threat. A second but non-exclusive model, the maintenance hypothesis puts forward a difficulty in disengaging attention from threat, as threatening stimuli capture attention longer in anxious individuals (Fox, Russo, Bowles, & Dutton, 2001; see also Armstrong & Olatunji, 2012). Experimental studies that confirmed anxious biases mostly reported anxiety effects in favour of negative stimuli. For instance, an anxiety-related attentional bias for threatening faces has been reported in probe position and probe classification tasks (e.g. Bradley, Mogg, White, Groom, & de Bono, 1999) and threatening cues have been shown to have a strong impact on the disengagement of attention in anxious subjects (e.g. Fox et al., 2001). Moreover, this has been observed in different types of anxious populations: individuals with clinical disorders such as generalized anxiety disorders (GAD), social phobia or post-traumatic stress disorders (PTSD), but also subclinical high anxious individuals (for a meta-analysis, see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007).

The fact that anxious individuals show abnormal attention allocation mechanisms suggests that anxiety impacts the early stages of emotional information processing. Indeed, attention is known to modulate the very first stages of stimulus processing, in particular the P1 component (Hillyard & Anllo-Vento, 1998; Luck, Heinze, Mangun, & Hillyard, 1990). In line with this assumption, there is growing evidence for anxiety-related effects on this early-component (Bar-Haim et al., 2005; Felmingham, Bryant, & Gordon, 2003; Frenkel & Bar-Haim, 2011; Holmes, Nielsen, & Green, 2008; Kolassa, Buchmann, et al., 2007; Kolassa, Kolassa, et al., 2007; Kolassa et al., 2009; Li, Zinbarg, Boehm, & Paller, 2008; Mueller et al., 2009; Muhlberger et al., 2009; Rossignol, Philippot, Bissot, Rigoulot, & Campanella, 2012b; Walentowska & Wronka, 2012; Williams et al., 2007; see also McTeague, Shumen, Wieser, Lang, & Keil, 2012) and a few recent studies have even reported early differential activations in response to emotional vs. neutral faces according to the level of anxiety (Felmingham et al., 2003; Holmes et al., 2008; Li et al., 2008; McTeague et al., 2012; Mueller et al., 2009; Rossignol et al., 2012a; Williams et al., 2007). However, these studies differed greatly according to their design, to the nature of the task, and to the type of anxiety examined. The early anxiety-related effects seemed more consistently reported when the processing of emotion was not task-relevant, although such effects have also been recently reported in studies that used emotion-classification tasks (Kolassa et al., 2009; Rossignol et al., 2012a; for a review see Schulz, Mothes-Lasch, & Straube, 2013). Furthermore, most of the evidence for differential emotional modulation of the P1 according to anxiety stemmed from research on Social Anxiety (for a review see Schulz et al., 2013); the existence of similar early emotional influence in trait-anxiety is still a matter of debate (Holmes et al., 2008; Mogg & Bradley, 2002; Rossignol et al., 2012b). Thus, a first aim of the present study was to check if trait anxiety may also impact on the early stages of emotional face processing, namely on the P1.

Additionally, most studies on anxiety were conducted in the theoretical framework of the negative attentional bias and they have either focused on threatening stimuli (e.g. Bishop, Duncan, & Lawrence, 2004; Dickie & Armony, 2008) or confirmed the bias towards negative emotions when positive emotions were also examined (Bar-Haim et al., 2005). However, there is behavioural and neuroimaging evidence that this bias may not be specific to threat but to emotional material in general (e.g. Bradley et al., 1999; Martin, Williams, & Clark, 1991; Mogg & Marden, 1990; Somerville, Kim, Johnstone, Alexander, & Whalen, 2004; Straube, Mentzel, & Miltner, 2005). In other words, according to the emotionality hypothesis, the pattern of hypervigilance towards emotional stimuli in anxiety may also be observed in response to positive stimuli. Thus, a second aim of the present study was to test if an early (P1) anxiety-related emotional bias could be observed in response to happy faces. To date, most ERP studies including positive faces have failed to report early anxiety-related emotional facilitation for these stimuli, at the level of the P1 component (Bar-Haim et al., 2005; Carretie, Mercado, Hinojosa, Martin-Loeches, & Sotillo, 2004; Compton et al., 2007; Holmes et al., 2008; Holmes, Nielsen, Tipper, & Green, 2009; Kolassa & Miltner, 2006; Kolassa, Kolassa, et al., 2007; Mercado, Carretie, Tapia, & Gomez-Jarabo, 2006; Mueller et al., 2009; Muhlberger et al., 2009; Rossignol, Philippot, Douilliez, Crommelinck, & Campanella, 2005; Rossignol, Philippot, Crommelinck, & Campanella, 2008; Rossignol et al., 2012b). More precisely, some studies reported no effect of anxiety on the P1, while others reported an effect specific of the negative expressions, confirming the negative attentional bias theory. Yet, a few recent studies have reported a generalized enhancement of the P1 in response to faces regardless of expression (i.e. to both emotional and neutral faces; Kolassa, Kolassa, et al., 2007; Muhlberger et al., 2009; Peschard, Philippot, Joassin, & Rossignol, 2013; Rossignol et al., 2012b), in line with the hypothesis of a generalized sensory amplification in anxious individuals. Moreover, early anxiety-related emotional modulations in response to positive emotions have been reported in the P1 time-range, when considering non-face stimuli (Sass et al., 2009; Weinberg & Hajcak, 2011), or sustained Steady-State Visual Evoked Potential (SSVEP) activity (McTeague et al., 2012). Furthermore, a recent study has revealed enhanced P1 response to emotional (including happy) vs. neutral faces in a paradigm with high socially anxious individuals (Rossignol et al., 2012a). Thus, we wanted to determine if trait anxiety may impact on the early stages of emotional face processing, in the form of an emotional amplification of the P1 in response to both happy and fearful faces relative to neutral faces.

To shed light on anxiety-related P1 amplifications towards positive as well as negative emotional stimuli, some task parameters may be important to consider (Peschard et al., 2013, for a review see Schulz et al., 2013). Indeed, most studies with happy stimuli presented them intermingled with fearful stimuli and did not require the participants to focus explicitly on the emotional content of the stimuli; altogether this may have tamed any effect of the happy stimuli. Here we presented happy faces and fearful faces in different blocks of stimuli to avoid any emotional contamination or interference between the different emotions. Moreover, we used an explicit emotional detection task to direct the participants' attention to the emotional content of the faces.

Overall, the main goal of our study was to explore the impact of trait anxiety on the early stages of face processing, namely on the P1. For this, we recorded ERPs to happy and fearful (vs. neutral) faces that were presented in separate blocks and during an emotional detection task, in two groups that differed by their trait anxiety level. In line with the emotionality hypothesis (Mogg & Marden, 1990), we expected to observe an anxiety-related emotional amplification of the P1 for the positive (and not only the negative) faces as compared to the neutral faces. In addition, we examined the N170 component that may be sensitive to emotional facial processing (for a review see George, 2013). In contrast to the P1, the N170 was not expected to be modulated by anxiety, in line with the absence of such effect reported by the majority of