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Trait anxiety and involuntary processing of facial emotions

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ABSTRACT

There is suggestion that trait anxiety influences the processing of threat-related information. To test this hypothesis we recorded ERPs in response to subliminally presented and backward masked fearful and neutral faces, and non-face objects, in the preselected low- and high-anxious individuals. The amplitude of N170 was found to be larger when elicited by faces in comparison to non-faces, however it was not found to be emotion-sensitive or modulated by anxiety level. Differences between low- and high-anxious individuals appeared in a time window of the P1 component. At later stages, within the EPN component, stronger negativity specific for fearful faces was recorded exclusively in the low-anxious participants. Our findings indicate that anxiety level modulates early stages of information processing, as reflected in the P1 component. This leads to anxiety-related differences in involuntary emotional expression detection at later stages (EPN component).

1. Introduction

Emotional functioning determines important evolutionary adaptations involved in the control of behavior in complex social environments. Among other sources of social information, faces are salient stimuli conveying essential nonverbal signals. For that reason they are assumed to be the best direct indicator of current affective dispositions and attitudes, both positive and negative. Specifically, due to their biological and social significance, information about emotional states derived from faces should be processed very rapidly to be available for the immediate regulation of behavior.

Research on the brain structures relevant to perception and analysis of emotionally significant information has been conducted with the application of several complementary methods, such as electrophysiological recordings, functional brain imaging or neuropsychological investigation of focal brain damage. Recent findings suggest a separate brain module critically involved in face processing, located in the fusiform gyrus and in the superior temporal gyrus (Allison et al., 2000; Haxby et al., 2000). Moreover, brain regions generally engaged in the processing of faces are strongly activated during the processing of facial emotions. The initial perceptual analysis takes place in the inferior occipital cortex (Rossion et al., 2003) and in the lateral fusiform gyrus (Kanwisher et al., 1997) for invariant aspects of faces which determine face identity (Haxby et al., 2000). The superior temporal sulcus is involved in the processing of changeable aspects of faces, such as facial expression, eye and mouth movements (Allison et al., 2000). It has been moreover suggested that the amygdala and the orbitofrontal cortex mediate a rapid, preattentive evaluation of the emotional and motivational significance of facial expression (Sprengelmeyer et al., 1998), while the anterior cingulate, the prefrontal cortex and somatosensory areas are linked with forming conscious representations of facial emotional expressions (Adolphs, 2003).

Recent studies have indicated that a stimulus can be categorized as a face much earlier than other objects (Liu et al., 2002). Larger amplitudes of the N170 component of the ERP have been regularly obtained to faces when compared to non-face objects. The onset of the face effect has been observed remarkably early, between 140 and 200 ms poststimulus from occipito-temporal locations (Batty and Taylor, 2003; Bentin et al., 1996; Eimer, 2000; Eimer and Kiss, 2010; Itier and Taylor, 2004). Similarly, M170, the magnetic counterpart of the N170 scalp potential, is also face-sensitive, as revealed by Halgren et al. (2000).

There are also a number of studies in which the amplitude of N170 recorded in response to emotional faces has been found to be more pronounced than for neutral faces (Batty and Taylor, 2003; Blau et al., 2007; Miyoshi et al., 2004; Rigato et al., 2010; Vlamings et al., 2009). However, in our previous study (Wronka and Walentowska, 2011), the N170 modulation has been obtained exclusively in a task demanding emotional expression categorization, which suggests voluntary facial emotion processing at this stage of analysis. At later stages, authors have reported increased activity of the visual system elicited by facial emotions in comparison to neutral faces. This effect has been termed the Early Posterior Negativity (EPN; Sato et al., 2001; Schupp et al., 2004b; Wronka and Walentowska, 2011). In this case, the enhanced negativity elicited by emotional expressions was obtained about 200 ms after the stimulus onset. Recently, it has been suggested that the EPN reflects the activation of temporo-

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parieto-occipital areas engaged in the visual information processing, when stimuli of high evolutionary significance are presented (Schupp et al., 2003a, 2004a).

Numerous emotion-specific effects have been obtained in experiments with relatively long, supraliminal face presentations. However, affectively salient facial stimuli can capture attention and evoke specific electrophysiological responses even without reaching the level of conscious awareness. It has been suggested that subliminal processing of expressive facial cues may be mediated *via* a 'short' retino-thalamic-amygdala neural pathway (see Pessoa, 2005 for discussion). Experimental evidence that facial threat is privileged in the processing comes mostly from studies where backward masking procedure has been used. With this technique, Whalen et al. (1998) have found stronger activity of the amygdala to fearful faces relative to happy ones. From the other hand, results obtained by Pessoa et al. (2006) suggest that the amygdala activity in response to fearful faces is probably related to the objectively assessed visibility of masked stimuli. However, fMRI technique with its rather low millisecond resolution does not provide information about the temporal characteristics of information processing. This can be obtained using electrophysiological recordings. In recent ERP studies authors report fear-specific patterns of brain activity in response to subliminal processing of backward masked facial stimuli (Eimer et al., 2008; Kiss and Eimer, 2008). Both experiments, conducted by the same group of researchers, have revealed no effects recorded in the time window of the N170 component. In contrast, Pegna et al. (2008) have found that subliminally presented fearful faces elicited larger N170 amplitudes than non-fearful (happy and neutral) faces. What should be noticed, this early effect has been obtained in a task demanding active detection of fearful faces, which can be related to voluntary attention involvement. Nevertheless, although all these experiments successfully explore the topic of subliminal processing of facial emotions, at least one imperfection can be found in the experimental procedures, which is the type of the mask. Eimer et al. (2008) and Pegna et al. (2008) used images of neutral faces as the masking stimuli. Kiss and Eimer (2008) used scrambled neutral faces, although the images probably still resulted in oval-shaped and face-similar masking objects. In this context it should be emphasized that the probability that brain responses to subliminally presented faces can interfere with responses to masking facial stimuli is relatively high and may serve to disrupt the analyses.

The general consensus comes from both ERP and neuroimaging studies that emotionally salient faces have a special status in capturing visual attention, even involuntarily, however still little is known about the emotionally rooted temperamental traits which influence information processing from the perspective of the subjects. Specifically, it has been suggested that the cognitive system of anxious individuals, characterized by the state or trait of apprehension, may be distinctively sensitive and may bias the processing of threat-related stimuli. Whalen (1998) suggests that fearful stimuli in comparison to angry ones evoke stronger brain responses due to their ambiguity. In the light of anxiety-related hypervigilance, perception of stimuli requiring more information to be interpreted may result in stronger activation of the anxious individuals. Generally, to study this issue more thoroughly, both clinical populations (displaying diverse anxiety disorders) and subclinical subjects (reporting high levels of trait anxiety in the State-Trait Anxiety Inventory; Spielberger et al., 1983) have been employed. It has been assumed that in high-anxious individuals threat-related information can rapidly capture attention (Bar-Haim et al., 2007; Mathews and Mackintosh, 1998; Mathews and MacLeod, 2002) even without conscious processing of the stimuli (Mogg and Bradley, 1998). Numerous neuroimaging studies confirm these results showing increased amygdala activity in highly trait anxious individuals during unconscious processing of fearful stimuli (Bishop, 2007; Etkin et al., 2004) when compared with low-anxious individuals. Consistent with these results, Ewbank et al. (2009) have obtained a significant positive correlation between the level of anxiety and the left amygdala activity in response to fearful expressions in condition when they were task-irrelevant and, due to attentional modulation, their processing was involuntary. Furthermore, early attentional orienting to threatening stimuli in high-anxious individuals has been shown in numerous electrophysiological studies suggesting privileged threat evaluation at initial stages (Fox et al., 2008; Li et al., 2005). One of the recent ERP studies in anxious individuals has aimed to examine the automaticity in facial emotion processing in tasks with different cognitive load (Holmes et al., 2009). Among others, the authors have revealed the modulation of P1 and EPN components specific for emotional faces. Notably, the EPN differentiation was more apparent within low-anxious group, while the P1 modulation was not influenced by the level of anxiety. Therefore, anxiety-related effects can be observed starting about 100 ms after the stimulus onset, which is consistent with the hypothesis that high level of anxiety can be linked with the hypervigilant processing of emotional information.

Our procedure was aimed to investigate the differences between brain responses to subliminally presented faces and non-face objects, as they have been extensively studied with supraliminally displayed stimuli, where the systematic face effect within the latency of N170 component has been observed. However, the open question is whether similar pattern of results can be recorded with very brief stimuli presentations. Moreover, the second aim of the current study was to investigate the course of involuntary face processing and facial emotion processing with respect to the level of self-reported trait anxiety. To address this issue, participants were briefly (for 16 ms) shown images of faces (fearful, neutral) and non-face objects, immediately masked by an abstract image, and they were asked to categorize masking stimuli. Backward masking procedure was used to limit the access of the masked objects to conscious awareness. In addition, we assumed that this procedure would successfully solve the problematic issue of the facial masking stimulus together with forced-choice discrimination of the target stimulus.

We hypothesized that if there is a qualitative difference between face and non-face processing, the amplitude of the occipito-temporal, face-specific N170 component would be larger in response to faces when compared to non-face objects, as it was previously revealed by researchers using longer stimuli presentations (Batty and Taylor, 2003; Bentin et al., 1996; Eimer, 2000; Eimer and Kiss, 2010; Itier and Taylor, 2004). To investigate the emotional expression effects, we anticipated that brain activity would be different in response to emotional and neutral faces. We predicted that faces with emotional expressions would modulate ERP waveforms over occipital sites starting from 100 ms after the stimulus onset, as this early modulation has been so far investigated with supraliminal face presentations (Holmes et al., 2008, 2009; Pourtois et al., 2005). Larger amplitudes of the N170 elicited by fearful relative to neutral faces can also be expected, relying on previous results (Batty and Taylor, 2003; Blau et al., 2007; Miyoshi et al., 2004; Rigato et al., 2010; Vlamings et al., 2009). At later stages, we expected facial threat to elicit stronger negativity of the emotion-specific EPN component in comparison to facial neutrality, which also has been shown using supraliminal presentations (Sato et al., 2001; Schupp et al., 2004b; Wronka and Walentowska, 2011). Notably, we also supposed that the emotional expression effects would be influenced by the level of subjects' trait anxiety. Results from the previous studies let us expect the differences in the course of facial emotion processing between low- and high-anxious subjects starting from 100 ms post-stimulus, overlapping with the P1 and EPN components.

2. Materials and methods

2.1. Participants

Thirty six volunteers were selected from a large pool of first-year psychology students who had previously completed the trait scale