Biological Psychology 92 (2013) 114–124

Contents lists available at SciVerse ScienceDirect

Biological Psychology

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

N170 response to facial expressions is modulated by the affective congruency between the emotional expression and preceding affective picture

Jari K. Hietanen[a,*], Piia Astikainen[b]

[a] Human Information Processing Laboratory, School of Social Sciences and Humanities, 33014 University of Tampere, Tampere, Finland
[b] Department of Psychology, PO Box 35, 40014 University of Jyväskylä, Jyväskylä, Finland

ARTICLE INFO

Article history:
Received 8 May 2012
Accepted 22 October 2012
Available online 3 November 2012

Keywords:
Affective priming
Event-related potential (ERP)
Face
Recognition accuracy
Response time

ABSTRACT

Does contextual affective information influence the processing of facial expressions already at the relatively early stages of face processing? We measured event-related brain potentials to happy and sad facial expressions primed by preceding pictures with affectively positive and negative scenes. The face-sensitive N170 response amplitudes showed a clear affective priming effect: N170 amplitudes to happy faces were larger when presented after positive vs. negative primes, whereas the N170 amplitudes to sad faces were larger when presented after negative vs. positive primes. Priming effects were also observed on later brain responses. The results support an early integration in processing of contextual and facial affective information. The results also provide neurophysiological support for theories suggesting that behavioral affective priming effects are based, at least in part, on facilitation of encoding of incoming affective information.

1. Introduction

Facial expressions are of utmost importance for social interaction as they convey information about other individuals' emotions and social intentions (Fridlund, 1991; Keltner et al., 2003; Russell et al., 2003). In the laboratory, perception of facial expressions is typically investigated by presenting isolated pictures of faces to the participants. However, in every-day life, an individual's face is usually not perceived in isolation. Instead, it appears in rich context of information emanating from other people and the physical environment surrounding the expressor as well as multichannel information from the expressor herself. This influence can be significant for the perception of facial expressions, especially when the context information contains affective meaning. Indeed, the expressor's own emotional expressions in the vocal prosody (de Gelder and Vroomen, 2000; Hietanen et al., 2004; Massaro and Egan, 1996; Vroomen et al., 2001), body posture (Meeren et al., 2005), and hand movements (Hietanen and Leppänen, 2008) modulate the recognition of his/her facial expressions. Also, surrounding people's facial expressions (Masuda et al., 2008), emotion provoking stories (Carroll and Russell, 1996), film clips (Niedenthal et al., 2000), visual affective scenes (Aviezer et al., 2008; Righart and de Gelder, 2008b), and odors (Leppänen and Hietanen, 2003) influence the facial expression recognition. A typical finding in these studies is that facial expression recognition is faster and more accurate when the context is affectively congruent rather than incongruent with the facial expression (affective congruency effect). The contextual effects are observed even when the participants are explicitly asked to attend on the facial expressions and ignore the context information. These findings give evidence for the automatic nature of processing of affective information from all available sources and integrating it with the face processing.

From cognitive neuroscience viewpoint an interesting issue relates to the stage of processing where the contextual information starts to interact with the processing of facial expressions. Is it an early (automatic) or a late (more controlled) process? Because of its excellent temporal resolution, measuring of event-related potentials (ERPs) is a potentially useful method to study this issue. Visual ERP studies have identified a specific ERP response which has been proposed to be particularly sensitive to faces (Bentin et al., 1996; Itier and Taylor, 2004; Rossion and Jacques, 2008). This component, known as N170, is recorded over occipitotemporal regions peaking between 140 and 200 ms after stimulus onset, and characterized by a bilateral temporal negative deflection. The N170 response is considered to reflect the early visual processing of structural, configurally represented information in the face (Bentin et al., 1996; Eimer, 2000; Itier and Taylor, 2004). Importantly for the present study, the N170 response (or its magnetoencephalographic counterpart, M170) may also be sensitive to facial emotional expressions (Batty and Taylor, 2003; Blau et al., 2007; Caharel et al., 2005; Eger et al., 2003; Japee et al., 2009; Leppänen et al., 2007; Williams et al., 2006; Vlamings et al., 2009; Wronka and Walentowska, 2011), although there are some previous studies lacking to show this effect

* Corresponding author. Tel.: +358 40 190 1384; fax: +358 3 3551 7345.
E-mail addresses: jari.hietanen@uta.fi (J.K. Hietanen), piia.astikainen@psyka.jyu.fi (P. Astikainen).

0301-0511/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.biopsycho.2012.10.005

(e.g., Eimer and Holmes, 2002; Eimer et al., 2003; Holmes et al., 2003). However, these differences could be related to attentional effects, e.g., whether the faces were presented to the attentional focus, and whether the task specifically required processing of facial expressions. In all the studies where faces were centrally presented *and* the participants were instructed to direct their attention to facial expressions, modulation of N170 amplitude by facial expressions has been observed (Caharel et al., 2005; Japee et al., 2009; Leppänen et al., 2007; Wronka and Walentowska, 2011).

There are a couple of previous studies which have investigated whether the integration of facial expressions and other types of affective information is reflected in the early visual ERP responses. Meeren et al. (2005) showed face–body compound stimuli in which the face and body components were expressing fear or anger, either congruently or incongruently. The P1 response (peaking on average at 115 ms) was sensitive to the affective congruency between the body and face stimuli: the P1 was larger for incongruent vs. congruent face–body compound stimuli. However, the authors themselves suggested that the enhanced P1 responses to incongruent compound stimuli could be related to the deviation from the normal face–body composition in the incongruent cases, and that this anomalous conflict between facial and bodily expression could have attracted more attention than emotion-congruent stimuli prompting more elaborate analysis in early visual areas. Moreover, it is debatable whether the P1 response reflects processing of a high-level percept of a face at all, but rather some low-level features (Rossion and Caharel, 2011; Rossion and Jacques, 2008). No effect of affective congruency between the face and body components was found for the amplitude of the N170 in the study by Meeren and colleagues. Righart and de Gelder (2006) presented fearful and neutral faces overlaid on pictures of fearful and neutral natural scenes. The results gave evidence for the context effect on N170 responses: N170 was larger in the context of fearful than neutral scenes. However, although this enhancement was larger for fearful than neutral expressions, it was observed for both fearful and neutral faces. Thus, this result can be considered to provide only partial support for a congruency effect. In a following study, Righart and de Gelder (2008a) presented again face–context compound stimuli to the participants. This time the scenes were fearful, happy or neutral, the faces were fearful or happy. Again, the electrophysiological results replicated the previous ones: the N170 response was larger for both expressions in the context of fearful vs. other scenes, although this enhancement seemed to be larger for fearful than happy faces. There was no effect of affective context on the P1 responses in either of these studies. In sum, despite the strong behavioral evidence of emotional context information influencing the recognition of facial expressions, previous studies have not been able to show a clear affective congruency effect on the face-sensitive N170 response.

In the above-mentioned visual ERP studies, the stimulus faces were presented simultaneously with and embedded in the affective context information. In the present study, we decided to use another well-known paradigm for investigating the affective context effect: affective priming. In affective priming, an affective target is presented after (e.g., 300 ms) an affective prime. The results typically show that affectively congruent prime–target pairs result in shorter response times to targets (e.g., positive/negative evaluative decisions) than affectively incongruent prime–target pairs (for reviews, see Fazio, 2001; Klauer and Musch, 2003). There are a few previous studies which have measured ERPs to facial expressions in affective priming paradigms. However, in these studies the focus has been on investigating the affective congruency effects on longer latency ERPs, especially on N400 and LPP (late positive potential) responses, which are known to show congruency effects also in classic semantic priming studies (Besson et al., 1992). And indeed, these studies have shown enhanced N400 and LPP responses to emotionally incongruent prime–target pairs (Krombholz et al., 2007; Paulmann and Pell, 2010; Werheid et al., 2005). Krombholz et al. (2007) also investigated affective congruency effect specifically on N170 responses to facial expressions (primed by emotion words "anger" and "happiness") but no effect was found. Paulmann and Pell (2010) primed facial expressions by emotional prosody vocalizations. No effect of affective congruency on N170 responses was found in this study either (see Fig. 4, in Paulmann and Pell, 2010). In Werheid et al. study, the target faces (primed by another expressive face) did not evoke a typical N170 response at all.

To sum up, we investigated whether the early face-sensitive N170 response is modulated by the affective congruency between the emotional expression displayed on the face (target) and the affective content of a preceding natural scene (prime). The primes were pictures with complex, emotional scenes evaluated as emotionally positive or negative. The target stimuli were facial expressions of happiness and sadness. The prime–target stimulus-onset-asynchrony (SOA) was 300 ms. The presentation of the prime and target stimuli was combined in such a way that half of the trials were affectively congruent and another half emotionally incongruent. The participants' task was to categorize the faces as happy or sad. We measured both behavioral (reaction time and recognition accuracy) and ERP responses. Recognition accuracies were expected to be higher and response times shorter for facial expressions preceded by affectively congruent vs. incongruent primes. More importantly, we expected the N170 responses to be larger in amplitude for facial expressions preceded by affectively congruent vs. incongruent primes. The hypothesis for N170 response *enhancement* for affectively congruent stimuli was based on previous findings from studies of affective context effects on N170 amplitudes (e.g., Righart and de Gelder, 2006, 2008a) and on findings from studies showing that, for example, as a function of the facial expression intensity, the N170 amplitudes (Sprengelmeyer and Jentzsch, 2006) as well as the recognition accuracy (e.g., Hoffmann et al., 2010) are enhanced.

2. Methods

2.1. Subjects

Twenty-seven participants (20 females, age range 20–58 years, mean 39.8 years) took part in the experiment. The participants were volunteers recruited by a newspaper advertisement. The age range of the participants was wide because the participants served as healthy controls to another ongoing study investigating the effects of depression on affective information processing. All participants were right-handed and reported normal or corrected-to-normal vision. They were unaware of the purpose of the experiment. An informed, written consent was obtained from each participant. The experiment was undertaken in accordance with the Declaration of Helsinki. The ethical committee of the University of Jyväskylä approved the research protocol. From the original 27 participants, we decided to reject those participants whose recognition accuracy was only 50% or lower in any of the experimental conditions. This criterion led to rejection of 7 participants. In all of these participants, the recognition accuracy was low in the (incongruent) positive prime followed by a sad face–condition. A low recognition accuracy in an incongruent condition is, of course, expected, and by rejecting these participants we were likely, in fact, to decrease the affective congruency effect, at least on recognition accuracy data. However, had we included these participants in our analyses, the number of trials with correct responses would have been very unequal between different conditions. In the final sample of 20 participants, we had 6 males and 14 females (age range 20–56 years, mean 37.1 years). Comparison of the included and excluded participants revealed, in fact, that the excluded participants tended to be, on average, 10 years older than the included ones ($M_{\text{excluded}} = 47.3$ vs. $M_{\text{included}} = 37.1$), $t(25) = 1.85$, $p < .08$. The recognition of both facially and vocally expressed emotions has been shown to decline as a function of age, and this is especially true for recognition of sadness (Mill et al., 2009). For the remaining, included participants, age was not correlating with the recognition accuracy ($r = -.03$, $p > .8$) or the recognition times ($r = .20$, $p > .3$). It should be noted that we also analyzed the data including all 27 participants, and all the main results remained unchanged.

2.2. Stimuli and procedure

The prime stimuli were color pictures of natural scenes from the International Affective Picture System (IAPS) (Lang et al., 1999). There were 16 pictures with