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Facial attractiveness modulates early and late event-related brain potentials

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Abstract

Facial attractiveness is of high importance for human interaction and communication, and everyday experience suggests that the mere aspect of a face elicits spontaneous appraisal of attractiveness. However, little is known about the time course of brain responses related to this process. In the present study, event-related brain potentials were recorded during attractiveness classification of facial portraits that were standardized with respect to facial expression. The faces were either preceded by another face of high or low attractiveness or by an affectively neutral object. Attractive as opposed to non-attractive target faces elicited an early posterior negativity (EPN; ~250 ms) and a late parietal positivity (LPC; 400–600 ms), which were not modulated by affectively congruent prime faces. Elevated LPC activity had previously been shown in response to attractive versus non-attractive faces, possibly reflecting task-related evaluative processes. An enhanced EPN had been reported for faces with emotional compared to neutral emotional expression, and related to facilitated selection of emotional information. Extending these findings, our study is the first to report an attractiveness-related ERP modulation prior to the LPC, suggesting that appraising facial attractiveness starts already at processing stages associated with stimulus selection.

Keywords: Emotion; Beauty; Faces; Priming; ERPs

1. Introduction

Facial attractiveness is a feature of crucial importance for human communication and interaction, as evidenced by several lines of research. Research in social and personality psychology has shown that judgments of attractiveness are substantially correlated with inferences about personality characteristics (Dion et al., 1972). Facial attractiveness is considered as a key feature for selecting mates or peers (Johnston, 2006). Correspondingly, within the past 20 years, a large body of evidence has been accumulated regarding the physical characteristics that render a face attractive. Suggested key factors are the averageness of the face, symmetry, and hormone-dependent facial features (see Thornhill and Gangestad, 1999, for a review). Only recently, research on facial attractiveness has also begun to consider the beholder's perspective. Neuroimaging studies found several brain areas to be differentially responsive to attractive as opposed to non-attractive faces. Although the exact brain systems involved are somewhat variable, typically reward- and emotion-related areas such as the orbitofrontal cortex, basal ganglia, and amygdala have been shown to be responsive to facial attractiveness, independent of the gender of the beholders or the persons depicted (Aharon et al., 2001; Kampe et al., 2001; Kranz and Ishai, 2006; Nakamura et al., 1998; O'Doherty et al., 2003). In addition to these purely aesthetic aspects of facial beauty, a component of attractiveness due to sexual attraction or reproductive fitness has been suggested (e.g. Senior, 2003). However, the brain areas specifically responding to the attractiveness of faces of potential mates are varying across studies, ranging from superior temporal sulcus (O'Doherty et al., 2003) over the basal ganglia (Aharon et al., 2001) to medial orbitofrontal cortex (Kranz and Ishai, 2006).

Less is known about the time course of processing facial attractiveness in the brain. Owing to their excellent time resolution, event-related potentials (ERPs) appear as an appropriate method to investigate the temporal characteristics of appraising facial attractiveness. However, to date there are but few studies addressing this topic. Johnston and coworkers

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conducted two studies involving the presentation of facial portraits of varying attractiveness (Johnston and Oliver-Rodriguez, 1997; Oliver-Rodriguez et al., 1999). Faces rated as attractive elicited larger amplitudes of the parietocentral 'late positive complex' (LPC) between 400 and 600 ms after target onset. This finding is in line with ERP studies employing other types of emotional stimuli. LPC increases have also been demonstrated for affectively connotated compared to neutral words (Naumann et al., 1997) and or for emotional compared to neutral scenic pictures (Cuthbert et al., 2001; Schupp et al., 2003). The LPC, also termed P3b, is characterized by a sustained parietocentral distribution and has been related to the intensity of subjective stimulus evaluation (Johnson, 1986; Polich and Kok, 1995).

Several lines of evidence do, however, suggest that processing facial attractiveness may start already prior to the LPC time window, thus in time periods that are rather related to stimulus-driven than to evaluative processes. In the above-mentioned paper by Johnston and Oliver-Rodriguez (1997), an ERP effect around 250 ms was observable at electrode Pz in Figure 5, but it was neither mentioned nor considered in the ERP analysis. Other studies have reported even earlier ERP effects in perception-related time periods as reflected in N170 or P100 components. Pizzagalli et al. (1999) reported an ERP modulation between 100 and 160 ms in response to faces from the Szondi portrait collection that were considered as 'likable' versus 'non-likable' by the participants. In a later study using magnetencephalography, Pizzagalli et al. (2002) identified activity of the fusiform gyrus around 160 ms in response to likable compared to neutral and non-likable Szondi portraits. Other studies have reported ERP modulations around 100 ms post-target when comparing faces of varying emotional expression (Braeutigam et al., 2001; Eger et al., 2003) or faces that were either graphically manipulated (Halit et al., 2000). However, none of these studies investigated facial attractiveness. Further, the stimuli employed in these studies were not only varying in emotional significance but also in facial configuration or face typicality. Thus, the reported early ERP effects may have not only reflected processing of emotional stimulus aspects but also the detection of deviant perceptual features or facial configurations. Our study aimed to control for these possible influencing factors by employing stimuli that differed in attractiveness, but were standardized with respect to emotional expression and were free from any atypical features. Using this type of stimuli, we expected to obtain the LPC elevation for attractive faces, in accordance to previous research. Further, based on the literature reviewed above, we predicted an additional ERP effect prior to the LPC. The fact that our stimuli were standardized with respect to perceptual differences would allow for a more conclusive interpretation of these early effects as elicited by emotional significance.

The priming technique was employed as a further approach to investigate the electrophysiological correlates of facial attractiveness. This approach was based on earlier behavioral research that had provided evidence for affective priming effects, i.e., accelerated reaction times following emotionally congruent as opposed to incongruent word pairs (Fazio et al., 1986; Hermans et al., 2001; Klauer et al., 1997). These findings indicate that processing of an emotional stimulus may be facilitated by similar processing of its precursor. Event-related potentials appeared well-suited for investigating such implicit facilitation, as they allow to determine the exact processing stages in which brain potentials following primed stimuli are facilitated and thus diverging from unprimed ones (Pfütze et al., 2002; Schweinberger and Burton, 2003). We recently adapted the priming technique to the investigation of emotional face processing (Werheid et al., 2005). Comparing ERPs elicited by sequentially presented face pairs that were congruent or incongruent with respect to facial expression, we found both early (100–200 ms) and late (400–600) ERP priming effects.

In the present study, we aimed to extend the ERP priming approach on a further dimension of affective face processing, namely the appraisal of facial attractiveness. For this purpose, ERPs were recorded during the presentation of attractive and non-attractive faces that were either preceded by a congruent or by an incongruent prime. The participants were asked to judge the target faces for facial attractiveness, and reaction times were measured to investigate possible behavioral priming effects. We hypothesized that if the appraisal of facial attractiveness could be primed, then priming would enhance the amplitude differences in exactly those time periods that were sensitive for facial attractiveness, consistent with previous research on repetition priming using face recognition tasks (e.g., Schweinberger et al., 1995).

Taken together, the present study had two main purposes. First, we wished to compare ERPs in response to attractive and non-attractive faces in order to determine which time periods were sensitive to the appraisal of facial attractiveness. Second, we aimed to investigate if priming effects would occur in those time periods that were sensitive to the processing of facial attractiveness. For this purpose, target faces were preceded by faces that were either attractive or non-attractive faces or everyday objects, the latter being intended as a neutral baseline against which putative priming effects were to be gauged.

2. Materials and methods

2.1. Participants

The data from 18 participants (11 females, mean age 25.5 ± 5.7 years) were included in the analysis. Two further data sets had to be discarded because of excessive ERP artifacts. All participants were right-handed, and reported normal or corrected to normal vision. The study was conducted in accordance with the Declaration of Helsinki, and all participants gave informed consent to study participation.

2.2. Stimulus materials and stimulus selection

Thirty-two frontal-view color portraits of different persons (16 females) were employed, taken from the Purdue University database (Martinez and Benavente, 1998), from the Karolinska database (Lundqvist et al., 1998), or from our own database. A set of 24 pictures of everyday objects (e.g., chair, spoon) taken from print media served as neutral primes. All pictures were edited