

Gender and parental status affect the visual cortical response to infant facial expression[☆]

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Abstract

This study sought to determine the influence of gender and parental status on the brain potentials elicited by viewing infant facial expressions. We used ERP recording during a judgement task of infant happy/distressed expression to investigate if viewer gender or parental status affects the visual cortical response at various stages of perceptual processing. ERPs were recorded in 38 adults (male/female, parents/non-parents) during processing of infant facial expressions that varied in valence and intensity. All infants were unfamiliar to viewers. The lateral occipital P110 response was much larger in women than in men, regardless of facial expression, thus indicating a gender difference in early visual processing. The occipitotemporal N160 response provided the first evidence of discrimination of expressions of discomfort and distress and demonstrated a significant gender difference within the parent group, thus suggesting a strong interactive influence of genetic predisposition and parental status on the responsivity of visual brain areas. The N245 component exhibited complete coding of the intensity of facial expression, including positive expressions. At this processing stage the cerebral responses of female and male non-parents were significantly smaller than those of parents and insensitive to differences in the intensity of infant suffering. Smaller P300 amplitudes were elicited in mothers versus fathers, especially with infant expressions of suffering. No major group differences were observed in cerebral responses to happy or comfortable expressions. These findings suggest that mere familiarity with infant faces does not explain group differences.

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1. Introduction

Newborn babies and infants communicate their needs or physiological states (such as pain) mainly through crying and facial expression. Thus, infant facial expression represents an important means of non-verbal communication between parents and their infants. It is well known that facial expression processing is carried out by means of a network of occipitotemporal regions within the ventral visual stream (e.g., Haxby, Hoffman, & Gobbini, 2000; Kanwisher, McDermott, & Chun, 1997; Puce, Allison, Asgari, Gore, & McCarthy, 1996). However, until now little knowledge was available regarding how biological or cul-

tural factors (such as gender or parental status) and cerebral plasticity may affect these structures' responsiveness to facial expression.

Several recent studies have investigated the brain responses of mothers and fathers to familiar and unfamiliar children's cries. In one interesting study (Purhonen et al., 2001a; Purhonen, Paakkonen, Ypparila, Lehtonen, & Karhu, 2001b), auditory ERPs evoked by emotional and neutral auditory stimuli were recorded in a group of mothers 2–5 days after childbirth and in control women who were not in the state of early motherhood. Infant cries were used as the emotional stimulus, for the experimental women the cry of their own infant and for the control women the cry of an unknown infant. The auditory N1 response to both emotional and neutral stimuli was significantly higher in the recent mothers than in control women, suggesting an overall increase in arousal for women who had given birth in the last few days. However, cry familiarity or emotional valence did

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not produce any effect. Seifritz et al. (2003) also reported interesting fMRI data on differences in brain activation among men and women (parents or not parents) when listening to familiar and unfamiliar infants crying and laughing. Results showed an effect of both gender and parental status. Infant cries evoked stronger activation in the amygdala and interconnected limbic regions in parents versus non-parents. However, women but not men (irrespective of parental status) showed a deactivation in the anterior cingulate cortex in response to both infant crying and laughing. This gender effect was interpreted as a reflection of women's preference for certain sensory stimuli, in this case infant vocalizations. On the other hand, the parental status effect was interpreted as an indication of neuroplastic changes in the brain as a result of parenting experience, likely to subservise the biological need for parental care.

Other recent neuroimaging studies (Bartles & Zeki, 2004; Leibenluft, Gobbi, Harrison, & Hexby, 2004; Nitschke et al., 2004) have recorded brain activation in mothers viewing pictures of their own children (which is thought to elicit so-called "maternal love"). The results show activation of brain areas linked to affect (amygdala) and in particular positive emotion (orbitofrontal cortex and connected regions belonging to the pleasure/reward circuitry such as the periaqueductal gray). A few studies have investigated adult judgements of the emotional valence of expressions of unfamiliar and unrelated infants. However, no study has investigated brain responses evoked by viewing unfamiliar infants, responses that are thought to be instinctual and tied to species preservation.

The overall aim of the present study was to investigate the cerebral response (synchronized bioelectrical activity using recording of electroencephalogram [EEG] and ERPs) of adults viewing pictures of infants with emotional facial expressions. We sought to characterize this response in a variety of ways. First, we sought to determine its sensitivity to sexual gender and parental status of the viewer. This information in turn would help to differentiate between a genetic and experience-dependent effect on the responsiveness of visual brain areas to infant facial expression. Any impact of parental status on visual processing during the initial perceptual decoding stages (within the first 100–200 ms) would suggest experience-dependent neuroplasticity, even if biologically regulated ("parental behaviour", e.g., Ramirez, Bardi, French, & Brent, 2004). On the other hand, an influence of gender would suggest a pre-existing (genetically induced although culturally modulated) difference across individuals. We also predicted that if gender or parental status influenced the neural response to viewing of an unknown infant's face, this would be observed first as a difference in the amplitude (or latency) of the occipitotemporal N1 component of the evoked response potentials (ERPs), but possibly as a difference in earlier visual responses.

Previous ERP and magnetoencephalography (MEG) studies provide evidence that the N1 response is associated with structural encoding of faces (Bentin, Deouell, & Soroker, 1999; Halgren, Raj, Marinkovic, Jousmaki, & Hari, 2000; Liu, Higuchi, Marantz, & Kanwisher, 2000; Sagiv & Bentin, 2001; Pizzagalli et al., 2002; Rossion et al., 2000; Watanabe, Kakigi, Koyama, & Kirino, 1999). The N1 response shows a specific

sensitivity to face inversion, suggesting holistic processing of this complex visual pattern (e.g., Rossion et al., 2000; Rossion, Joyce, Cottrell, & Tarr, 2003; Rousselet, Mace, & Fabre-Thorpe, 2004; Sagiv & Bentin, 2001). Functional neuroimaging studies have identified an area of the ventral occipitotemporal cortex around the lateral fusiform gyrus, a possible face perception area, as the possible generator of N1 (e.g., Henson et al., 2003; Itier & Taylor, 2004; Kanwisher et al., 1997). This region seems to respond preferentially to faces (Haxby et al., 1999, 2000; Puce et al., 1996) and to be sensitive to face inversion and even viewpoint effects (frontal versus three-quarter view) (Pourtois, Schwartz, Seghier, Lazeyras, & Vuilleumier, 2005b). However, there is not a general agreement on the notion that FFA would be specifically devoted to face processing. For example, Gauthier, Tarr, Anderson, Skudlarski, and Gore (1999) compared fMRI activation during perception of upright versus inverted faces and greebles and found activation of the fusiform face area (FFA) for both stimuli; activation increased with expertise. Therefore, they concluded that FFA is activated during object recognition as a function of expertise with visual stimuli, not just in relation to face processing. Haxby et al. (2000), Haxby, Hoffman, and Gobbi (2002), on the basis of available literature and their own fMRI studies, described the face perception mechanism as a distributed but hierarchically organized network of occipitotemporal regions. The core system consists of the extrastriate visual cortex, mediating the visual analysis of face structure, and the superior temporal sulcus (STS), mediating the analysis of changeable face characteristics such as gaze, expression, and lip movements. The interconnection of STS and the amygdala nucleus may be crucial for the emotional evaluation of face expressions.

Overall, face processing seems to elicit a stronger activation in the right hemisphere, as suggested by human (Hsiao, Hsieh, Lin, & Chang, 2005; Pegna, Khateb, Michel, & Landis, 2004; Rossion et al., 2003) and animal studies (Pinsk, DeSimone, Moore, Gross, & Kastner, 2005).

Analysis of the emotional content of faces seems to take place concurrently with rather than subsequent to completion of the structural encoding of faces (as predicted by the Bruce and Young (1986). In fact, many ERP and MEG studies have found that affective information modulates the brain's response to human faces as early as 120–150 ms after the stimulus (Batty & Taylor, 2003; Halgren et al., 2000; Pizzagalli, Lehmann, Koenig, REGARD, & Pascual-Marqui, 2000; Pizzagalli et al., 2002). Furthermore, neuroimaging studies have shown increased activation of the fusiform gyrus during processing of emotional versus neutral faces (e.g., Ganel, Valyear, Goshen-Gottstein, & Goodale, 2005; Hariri, Bookheimer, & Mazziotta, 2000), which supports the hypothesis that the emotional coding of expression occurs during processing of structural face information. During later processing (230–240 ms) the coding of emotional facial expression becomes more sophisticated, distinguishing not only positive versus negative expressions but specific emotions such as fear, happiness, and disgust, as evidenced by differences in the amplitude of the N230–250 visual response (Batty & Taylor, 2003; Liddell, Williams, Rathjen, Shevrin, & Gordon, 2004; Streit, Wolwer, Brinkmeyer, Ihl, & Gaebel, 2000).

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