Developmental Cognitive Neuroscience 19 (2016) 115–121

Contents lists available at ScienceDirect

Developmental Cognitive Neuroscience

journal homepage: http://www.elsevier.com/locate/dcn

Putting the face in context: Body expressions impact facial emotion processing in human infants

Purva Rajhans[a,*], Sarah Jessen[a], Manuela Missana[a], Tobias Grossmann[a,b,**]

[a] Early Social Development Group, Max Planck Institute for Human Cognitive and Brain Sciences, Stephanstrasse 1A, 04103 Leipzig, Germany
[b] Department of Psychology, University of Virginia, 103 Gilmer Hall, PO Box 400400, Charlottesville, VA 22904, USA

ARTICLE INFO

Article history:
Received 10 June 2015
Received in revised form 28 January 2016
Accepted 30 January 2016
Available online 17 February 2016

Keywords:
Emotion
Infants
Body expressions
Priming
ERP

ABSTRACT

Body expressions exert strong contextual effects on facial emotion perception in adults. Specifically, conflicting body cues hamper the recognition of emotion from faces, as evident on both the behavioral and neural level. We examined the developmental origins of the neural processes involved in emotion perception across body and face in 8-month-old infants by measuring event-related brain potentials (ERPs). We primed infants with body postures (fearful, happy) that were followed by either congruent or incongruent facial expressions. Our results revealed that body expressions impact facial emotion processing and that incongruent body cues impair the neural discrimination of emotional facial expressions. Priming effects were associated with attentional and recognition memory processes, as reflected in a modulation of the Nc and Pc evoked at anterior electrodes. These findings demonstrate that 8-month-old infants possess neural mechanisms that allow for the integration of emotion across body and face, providing evidence for the early developmental emergence of context-sensitive facial emotion perception.

1. Introduction

Responding to others' emotional expressions is a vital skill that helps us predict others' actions and guide our own behavior during social interactions (Frijda and Mesquita, 1994; Frith, 2009; Izard, 2007). The bulk of research investigating emotion perception has focused on facial expressions presented in isolation and been based on the standard view that specific facial patterns directly code for a set of basic emotions (Barrett et al., 2011). However, emotional face perception naturally occurs in context because during social interactions emotional information can be gleaned from multiple sources, including the body expression of a person (de Gelder, 2006; Heberlein and Atkinson, 2009; Van den Stock et al., 2008). Body expressions have been argued to be the most evolutionarily preserved and immediate means of conveying emotional information (de Gelder, 2006) and may provide potent contextual cues when viewing facial expressions during social interactions. For example, when body and face convey conflicting information then emotion recognition from the face is biased into the direction of the body expressions (Aviezer et al., 2012; de Gelder, 2006; Meeren et al., 2005). These findings indicate that emotional faces are interpreted in the context of body expressions. More generally, the notion that context plays an important role in the interpretation of facial expressions adds to the growing body of research which challenges predominant views that emphasize the encapsulated and independent nature of facial expression processing (for discussion, see Barrett et al., 2011).

With respect to the neural processes that underlie the impact of body expression on emotional face processing in adults, using face-body compound stimuli Meeren et al. (2005) presented evidence for a very rapid influence of emotional incongruence between face and body. Specifically, in this ERP study, incongruent compared to congruent body-face pairings evoked an enhanced P1 at occipital electrodes, suggesting that emotional incongruence between body and face affected the earliest stages of visual processing. The P1 is enhanced when attention is directed towards a certain stimulus location and has been shown to be generated in extrastriate visual areas (Clark and Hillyard, 1996; Di Russo et al., 2002; Hillyard and Anllo-Vento, 1998). This is in line with an increasing body of evidence suggesting that context influences early stages of visual processing. Meeren et al. (2005) also found that brain processes reflected in the N170 at electrodes over posterior temporal regions were not modulated by congruency between faces and bodies. The

* Corresponding author. Tel.: +49 341 9940 2472; fax: +49 341 9940 113.
** Corresponding author at: Max Planck Institute for Human Cognitive and Brain Sciences, Early Social Development Group, Stephanstrasse 1A, 04103 Leipzig, Germany. Tel.: +49 341 9940 2472; fax: +49 341 9940 113.
E-mail addresses: rajhans@cbs.mpg.de (P. Rajhans), grossman@cbs.mpg.de (T. Grossmann).

http://dx.doi.org/10.1016/j.dcn.2016.01.004
1878-9293/

absence of an effect on the N170 in adults was taken to indicate that the structural encoding of the face is not affected by conflicting emotional information from the body.

Critically, the existing work with adults leaves unclear whether the neural processes involved in emotion integration across body and face emerge early in human ontogeny and can therefore be considered a key feature of human social perceptual functioning. In the current study we thus examined the neural processing of emotional information across bodies and faces in infancy using ERPs. Similar to adults the main focus of emotion perception research in infancy has been on facial expressions (Leppänen and Nelson, 2009). This work has shown that (a) beginning around 7 months of age infants discriminate between positive and negative emotions (especially fear) and (b) at that age, emotional facial expressions modulate neural processes associated with the perceptual encoding of faces (N290 and P400) and the allocation of attentional resources (Nc) and recognition of stimulus (Pc) (Leppänen et al., 2007; Nelson and De Haan, 1996; Nelson et al., 1979; Peltola et al., 2009a,b; Webb et al., 2005). Only recently, research has begun to examine how the neural correlates of the ability to perceive and respond to others' emotional body expressions develops during infancy. In a first study, using dynamic point-light displays of emotional body expressions (Missana et al., 2015) reported that 8-month-olds, but not 4-month-olds, showed brain responses that distinguished between fearful and happy body expressions, suggesting that the ability to discriminate emotional body expressions develops during the first year of life. Furthermore, Missana et al. (2014) extended this line of work by showing that infants' ERP responses also distinguished between fearful and happy static emotional body postures at the age of 8 months.

Another line of work has looked at the neural correlates of infants' ability to integrate emotional information across modalities using ERPs. This work has shown that infants are able to match emotional information across face and voice (Grossmann et al., 2006; Vogel et al., 2012). Specifically, in 7-month-old infants detecting incongruent face-voice pairings resulted in an enhancement of the Nc component, indexing a greater allocation of attention, whereas detecting congruent face-voice pairings elicited an enhanced Pc, reflecting recognition of common emotion across face and voice (Grossmann et al., 2006). While this work has provided insights into the early development of cross-modal emotional integration processes, to date, the neural processes of integrating emotional information across body and face have not been studied in infancy.

The main goal of the current study was to examine whether and how emotional information conveyed through the body influences the neural processing of facial emotions. In order to investigate this question, we used a priming design in which we presented 8-month-old infants with emotional body expressions (fearful and happy) that were followed either by a matching or a mismatching facial expression. Priming has been shown to be a powerful method to elucidate implicit influences of context on social information processing in adults and children (see Stupica and Cassidy, 2014). However, despite its tremendous potential in studying how social information is represented in the brain of preverbal infants, to date there are only relatively few studies that have used priming designs to investigate the neural correlates of social information processing in infancy (Gliga and Dehaene-Lambertz, 2007; Peykarjou et al., 2014). Furthermore, 8-month-old infants were chosen because at this age infants have been shown to reliably detect and discriminate between fearful and happy expressions from faces (Nelson et al., 1979; Peltola et al., 2009) but also from bodies (Missana et al., 2014, 2015), which is an important prerequisite for the detection of congruency across body and face. We predicted that if infants are indeed sensitive to the congruency between body and facial expressions then their ERPs would show priming effects on components shown to reflect early visual processes similar to those identified in prior work with adults (Meeren et al., 2005). In addition, we expected priming effects on later attentional processes and recognition memory processes (Nc and Pc), which might be similar to the effects identified in prior infant work on face-voice emotion matching (Grossmann et al., 2006), in which incongruent face-voice pairings resulted in an enhanced Nc and congruent face-voice pairings elicited a greater Pc. However, based on prior work with adults showing more specific interaction (hampering) effects between emotional faces and bodies (Aviezer et al., 2012; Meeren et al., 2005), viewing mismatching body expressions might impede emotion discrimination from facial expressions in infants. We therefore examined whether infants' neural discrimination between emotional facial expressions (happy and fear) is impaired when they previously saw a mismatching body expression. Specifically, based on prior work with adults (Aviezer et al., 2012; Meeren et al., 2005), we hypothesized that ERPs (especially the Nc and Pc) would differ between facial expressions of emotion only when presented in the context of a congruent body expression but not when presented in the context of an incongruent body expression. Finally, we also examined face-sensitive ERP components (N290 and P400), but similar to prior work with adults (Meeren et al., 2005), we did not expect congruency effects on ERP responses associated with the structural encoding of faces.

2. Methods and materials

2.1. Participants

In the present study, the infants were recruited via the database of the Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany. The final sample consisted of 32 eight-month-old infants aged between 229 and 258 days (16 females, Median age = 245, Range = 29 days). An additional 18 eight-month-old infants were tested, but were excluded from the final sample due to fussiness ($n = 12$) or too many artifacts ($n = 6$). Note that an attrition rate at this level is within the normal range for an infant ERP study (DeBoer et al., 2007). The infants were born full-term (between 38 and 42 weeks) and had a normal birth weight (>2800 g). All parents provided informed consent prior to the study and were compensated financially for participation. The children were given a toy as a present after the session.

2.2. Stimuli

For the emotional body stimuli, we used full-light static body displays taken from previously validated stimulus set by Atkinson et al. (2004), see Fig. 1. For each emotion we presented body postures from 4 different actors (selected on the basis of high recognition rates) shown for these stimuli by a group of adults (Atkinson et al., 2004). The facial expressions that followed the emotional body postures were color photographs of happy and fearful facial expressions taken from the previously validated FACES database (Ebner et al., 2010). We selected photographs from four actresses (age 19 to 30, ID-numbers 54, 63, 85, 134). These actresses were selected on the basis of high recognition rates shown by a group of adult raters (Ebner et al., 2010). In order to keep the stimulus presentation protocol comparable with previous infant studies, we decided to include only pictures of women (Grossmann et al., 2007; Kobiella et al., 2008; Leppänen et al., 2007). The photographs were cropped so that only the face was visible within an oval shape. The body stimuli had a mean height of 12.52 cm and a mean width of 5.37 cm and the face stimuli had a mean height of 12 cm and a mean width of 9.3 cm.