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Maternal face processing in Mosuo preschool children

Junqiang Dai[a], Hongchang Zhai[a,**], Haiyan Wu[c], Suyong Yang[d], John T. Cacioppo[e], Stephanie Cacioppo[f], Yue-jia Luo[b,*]

[a] Educational College of Guangzhou University, China
[b] Institute of Affective and Social Neuroscience, Shenzhen University, China
[c] Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Sciences, China
[d] Key Laboratory of Exercise and Health Sciences of Ministry of Education, Shanghai University of Sport, China
[e] Center for Cognitive and Social Neuroscience, University of Chicago, United States
[f] High-Performance Electrical NeuroImaging Laboratory, University of Chicago, United States

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ABSTRACT

Instinctively responding to maternal face is an evolutionary function of enhancing survival and development. However, because of the confounding nature of familiarity, little is known concerning the neural mechanism involved in maternal face recognition. We had a rare opportunity to examine Mosuo preschool children who were raised in a matrilineal society in which mothers and aunts represent equally familiar faces to the children. The participants were exposed to photographs of their mother's face, aunt's face, and an unfamiliar female's faces during electroencephalography (EEG) recording. The EEG results showed that the mother's face elicited a more negative N1 component, a larger left N170 component, and a larger P300 component; both the mother's and aunt's faces elicited a larger right N170 component. These results suggest that the emotional attachment between mother and child has neural ramifications across three successive face processing stages that are distinguished from the neural effects of facial familiarity.

1. Introduction

Maternal caretaking plays a quintessential role in the lives of social species and in the evolutionary function of enhancing survival, development and health; the maternal bond established at childbirth typically grows into a more conceptual, abstract and mental representation throughout a child's development (Broad, Curley and Keverne, 2006; Mousseau and Fox, 1998a, 1998b). A mother's face, which constitutes an important source of information for the child (see Bruce and Young, 1986; Vico, Guerra, Robles, Vila and Anllo-Vento, 2010 for review), elicits a preferential response in human newborns who are several hours old (Cecchini et al., 2011), even when olfactory information is strictly controlled (Bushnell et al., 1989).

A growing body of neuroimaging research on pair-bonding and maternal face processing has investigated love in general and maternal love in particular (Bartels and Zeki, 2004; Cacioppo, Bianchi Demicheli, Frum, Pfaus and Lewis, 2012; Guerra, Sánchez-Adam, Anllo-Vento, Ramírez and Vila, 2012; Leibenluft, Gobbini, Harrison and Haxby, 2004; Nitschke et al., 2004; Noriuchi, Kikuchi and Senoo, 2008; Ortigue, Bianchi Demicheli, Patel, Frum and Lewis, 2010; Quirin et al., 2012). To date, the majority of the neuroimaging studies recorded brain activity from mothers as they looked at their babies' faces, although two neuroimaging studies investigated the brain activity of adults as they looked at their mothers' faces. The two neuroimaging studies of adults support the view that a mother's face elicits a broader range of brain areas associated with face processing than the faces of strangers (e.g., bilateral fusiform gyri, inferior frontal gyri and thalamus; right superior temporal gyrus, right lingual gyrus, right angular gyrus, right inferior parietal lobule and right middle frontal gyrus as well as the left cuneus; Arsalidou, Barbeau, Bayless and Taylor, 2010; Guerra et al., 2012). The two regions involved in processing the mother's face are the inferior frontal and the middle temporal gyri, which suggests the existence of a significant overlap between the mother and self-related processing that complements the distributed brain network models for face processing (Gobbini and Haxby, 2007; Ishai, Schmidt and Boesiger, 2005). This work, therefore, has the potential for extending the standard models of face processing (Arsalidou,

* Corresponding author at: Institute of Affective and Social Neuroscience, Shenzhen University, Shenzhen 518060, China.
** Corresponding author.
E-mail address: luoyj@bnu.edu.cn (Y.-j. Luo).

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Barbeau, Bayless and Taylor, 2010; Cacioppo, Bianchi Demicheli, Hatfield and Rapson, 2012).

The chronoarchitecture of processing familiar faces of loved ones has also been investigated (Başar, Schmiedt-Fehr, Öniz and Başar-Eroğlu, 2008; Bobes, Quinonez, Perez, Leon and Valdes-Sosa, 2007; Grasso, Moser, Dozier and Simons, 2009; Herzmann, Schweinberger, Sommer and Jentzsch, 2004; Langeslag, Jansma, Franken and Van Strien, 2007; Vico et al., 2010). Research on face perception has focused on two early electrophysiological potentials, the N1 and N170, and a later component, the P300 or LPP. Studies of the N1 component suggest that this component reflects early attentional allocation during face processing (Antal, Kéri, Kovács, Janka and Benedek, 2000; Hopf, Vogel, Woodman, Heinze and Luck, 2002; Vogel and Luck, 2000), whereas studies of the N170 component, which is predominantly distributed over the right occipito-temporal region, varies as a function of facial familiarity (Caharel et al., 2002 Caharel, Courtay, Bernard, Lalonde and Rebaï, 2005; Caharel, d'Arripe, Ramon, Jacques, & Rossion, 2009; Rossion & Jacques, 2008). This right lateralized N170 has been interpreted to reflect encoding of structural information from the face, as proposed by Bruce and Young, 1986. A left lateralized N170 component has also been reported when face processing emphasizes specific features of the face rather than the holistic configuration (Hillger and Koenig, 1991; Posamentier and Abdi, 2003; Rossion et al., 2000). Finally, the P300 component, with a centroparietal distribution, is modulated by task relevance, emotional relevance, explicit memory, and evaluative distinctiveness in various versions of the oddball paradigm (Cacioppo, Crites Jr, Berntson and Coles, 1993; Ito and Cacioppo, 2000; Langeslag, Franken and Van Strien, 2008; Picton, 1992; Schlaghecken, StÜrmer and Eimer, 2000; Schupp et al., 2004; Voss and Paller, 2006, 2007). For instance, the study of female college students by Vico et al., 2010 showed that pictures of loved ones (romantic partners, parents, and siblings) elicited a larger P300 component compared with pictures of unfamiliar persons.

The vast majority of neuroimaging studies of maternal face processing has focused on adults rather than children. A serious limitation in most of these studies is that the faces of mothers are more familiar than are the faces of the control stimuli (Grasso & Simons, 2010; Guerra et al., 2011; Langeslag et al., 2007; Kringelbach, 2008). Familiarity was characterized by the length of time spent with someone or the information collected concerning someone (Guerra et al., 2011; Kringelbach et al., 2008; Langeslag et al., 2007; Vico et al., 2010). Two studies that addressed this confounding effect used more familiar faces, such as the faces of fathers; however, including paternal faces introduced differences in the gender of the faces (Arsalidou et al., 2010; Guerra et al., 2012). In the present study, we had a rare opportunity to investigate the spatio-temporal brain dynamics of maternal face processing in Mosuo preschool children who were raised in a matrilineal society of Yunnan Province in China. Contrary to typical families, Mosuo children live with their mother, maternal aunt, uncle and grandmother from birth. Mosuo mothers and aunts are both regarded as "Ami" and they raise their children together. The mother and aunt, therefore, represent equally familiar faces to the Mosuo children (Dashi, 2006; see also http://en.wikipedia.org/wiki/Mosuo). This matriarchal population represented a rare opportunity to study maternal face processing using a control stimulus that was matched for gender, age, and familiarity. Considering the extensive processing of maternal faces found in previous studies (Arsalidou et al., 2010; Guerra et al., 2012), as well as its profound role and evolutionary function for social species (Broad, Curley and Keverne, 2006; Mousseau and Fox, 1998a, 1998b), the maternal face would expectedly trigger greater responses at various processing stages marked by the electrophysiological potentials.

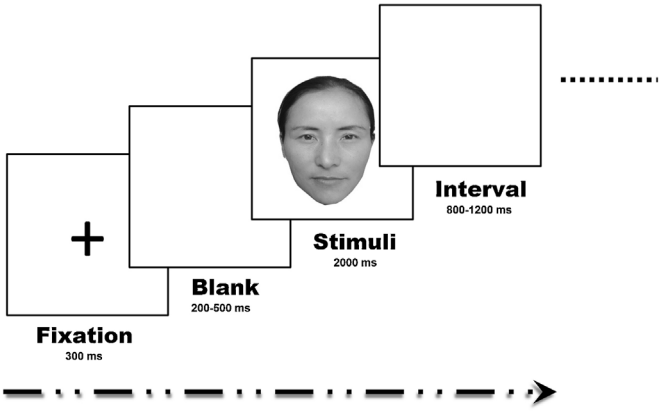

Fig. 1. Overview of the recording procedure and the sample of facial stimuli. The females whose photographs are presented here have provided written informed consent, permitting us to publish, reuse and reprint their photographs.

2. Methods

2.1. Participants

The final sample included 13 Mosuo children (7 females and 6 males; mean age, 5.8 years) who were recruited through flyers and verbal appeals to groups by local guides and experimenters. The EEGs from six additional participants were not analyzed because of excessive eye blinks and movement artifacts, and the EEG data from two additional participants were lost due to technical problems during data collection. All of the participants were right handed, had normal vision and no psychiatric disorders, received no medications, and reported that they had lived with their mothers and aunts since birth. Moreover, neither these children's mothers nor their aunts reported that they had ever worked outside of the village for a period of time (i.e., there was uninterrupted exposure to or bonding with their children). The participants were tested using the *Chinese-Binet Scale* before the experiment to ensure that they had normal cognitive abilities (Score: $M = 95.38$, $SD = 5.65$). The participants' guardians signed the informed consent before the experiment, and the participants received gifts after their participation.

2.2. Stimuli

Color photographs were taken from the neck up of the mother, aunt, and an unfamiliar female of similar age and ethnicity against a light gray background. All of the women assumed a neutral expression for the photograph and wore the same gray scarf to obscure the neckline and clothing; earrings and other jewelry were removed. To avoid the perceptual information generated by skin color that could affect the participants' behavioral and neurophysiological responses, the photographs were presented on-screen in grayscale (Fig. 1). Adobe Photoshop CS Version 5.0 was used to control the size, color and luminance (50.5 cd/m^2) of the facial stimuli.

The Mosuo children tested in the present study came from several villages; thus, the faces of several mothers and aunts were used as unfamiliar faces for other children. All of the faces were matched for age, and all of the participants were asked to ensure whether they had any knowledge of the unfamiliar female before beginning the experiment.

2.3. Procedure

A modified oddball paradigm was used in the present study because the oddball paradigm is well studied, and the potentials elicited in this paradigm are known to reflect specific aspects of attention, expectancy violation, face perception, and motivational relevance (Halgren & Marinkovic, 1995; Li, Yuan and Lin, 2008; Mejias et al., 2005). In the paradigm of the present study, the photographs of the mother and aunt served as targets, whereas the photographs of the unfamiliar female served as non-targets. In a counterbalanced order, the participants were instructed to press the F key (placed under their left index finger) when a photograph of the mother (aunt) appeared, press the J key (placed under their right index finger) when a photograph of their aunt (mother) appeared, and not respond when a photograph of an unfamiliar person appeared.

The participants sat in front of a table approximately 75 cm from a 15.6-in. (38.5 cm × 25.5 cm) Hewlett-Packard video monitor that delivered the stimulus, with a vertical visual angle of 5.3° and a horizontal visual angle of 3.6°. The experiment consisted of 420 trials that were separated into 5 blocks of 84 trials each. The stimulus order was randomized in each block; the photographs of the mother and the aunt were presented 12 times each (14.29%) within each block; and the photographs of the unfamiliar female's face was presented 60 times (71.43%) per block; each of the photographs of the five unfamiliar females appeared 12 times per block. The photographs of five unfamiliar females were used to avoid neural adaptation to