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Original article

Event-related potentials of self-face recognition in children with pervasive developmental disorders

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Abstract

Patients with pervasive developmental disorders (PDD) often have difficulty reading facial expressions and deciphering their implied meaning. We focused on semantic encoding related to face cognition to investigate event-related potentials (ERPs) to the subject's own face and familiar faces in children with and without PDD. Eight children with PDD (seven boys and one girl; aged 10.8 ± 2.9 years; one left-handed) and nine age-matched typically developing children (four boys and five girls; aged 11.3 ± 2.3 years; one left-handed) participated in this study. The stimuli consisted of three face images (self, familiar, and unfamiliar faces), one scrambled face image, and one object image (e.g., cup) with gray scale. We confirmed three major components: N170 and early posterior negativity (EPN) in the occipito-temporal regions (T5 and T6) and P300 in the parietal region (Pz). An enhanced N170 was observed as a face-specific response in all subjects. However, semantic encoding of each face might be unrelated to N170 because the amplitude and latency were not significantly different among the face conditions. On the other hand, an additional component after N170, EPN which was calculated in each subtracted waveform (self vs. familiar and familiar vs. unfamiliar), indicated self-awareness and familiarity with respect to face cognition in the control adults and children. Furthermore, the P300 amplitude in the control adults was significantly greater in the self-face condition than in the familiar-face condition. However, no significant differences in the EPN and P300 components were observed among the self-, familiar-, and unfamiliar-face conditions in the PDD children. The results suggest a deficit of semantic encoding of faces in children with PDD, which may be implicated in their delay in social communication.

Keywords: PDD, pervasive developmental disorders; AD, autistic disorders; Children; Face; Self-awareness; N170; EPN, early posterior negativity; P300; MNS, mirror neuron system

1. Introduction

Pervasive developmental disorders (PDD) are characterized by a unique behavior in communication. Persons with PDD often have difficulty reading facial expressions and deciphering their implied meaning. PDD may cause developmental deficits in theory of mind (ToM), mind-reading, and empathy underlying social interaction and communication skills [1–5]. They are probably related to face cognition, because in many cases the face information can help us understand others' feelings and recognize the communication situation.

Recently, noninvasive neuroimaging techniques have found dysfunctions in the brain domain related to perception of the face, eye gaze, and facial expression in persons with PDD [6–10]. Some studies showed that

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face-structural analysis contributed to fusiform gyrus. Other studies showed that eye gaze, emotion, and person identity corresponded to the inferior frontal cortex (IFC), amygdala, limbic system, and superior temporal sulcus (STS) [11,12]. These areas are partly referred as mirror neuron system (MNS), which is associated with execution and observation of actions by oneself and/or others [13,14]. In other words, the MNS affects social cognition significantly [15,16]. Hence, we hypothesized that self-awareness and familiarity of a face also correspond to the MNS because both processes mutually affect social skills and communicative abilities. Indeed, the areas IFC and STS showed strong activity during self-face cognition [7,17–20]. Such a neurophysiological approach would help to define the etiology of autistic disorders (ADs) in PDD and to improve poor social skills; however, such studies are rare.

Many studies have evaluated the developmental stages of cognitive function following visual and auditory perception using event-related potentials (ERPs) [9,21–23]. This technique is advantageous for clinical application, because ERP can be measured noninvasively and repeatedly, even in children. Analysis of the P300 component is especially effective for checking developmental stage and symptom severity because this component influences discrimination ability of stimulus features i.e., frequency, size, shape, and familiarity [21]. In the present study, we measured P300 followed by the face-specific response N170, and compared among the responses to one's own face, a familiar face and an unfamiliar face. This may be the first study based on neurological evidence to explore person identity nodes in face cognition in AD.

2. Methods

2.1. Subjects

The PDD group consisted of eight children (seven boys and one girl) with Asperger's syndrome (AS) or high function autism (HFA) aged 10.8 ± 2.9 years, one of whom was left-handed (FIQ: 97 ± 12; VIQ: 102 ± 15; PIQ: 92 ± 11). The subjects were recruited from National Center Hospital of Neurology and Psychiatry (Kodaira, Japan), and their diagnosis was based on DSM-IV criteria (American Psychiatric Association, 1994) by two pediatric neurology specialists [24]. The subjects' intelligence quotients were evaluated on the basis of the Wechsler Intelligence Scale for Children-Third Edition (WISC-III) (Wechsler, 1991; Japanese translated and adapted version, Azuma et al., 1998) [25,26]. The control groups consisted of healthy adults without AD (Adult group: six men and five women; aged 26.9 ± 5.6 years; two left-handed) and typically developing children (Children group: four boys and five girls; aged 11.3 ± 2.3 years; one left-handed). None of the subjects had a neurological disorder.

Informed consent to participate in the experiment was obtained from the mother of each subject in the PDD group, from each subject in the Adult group, and from both the subject and his or her mother in the Children group. The present study was approved by the Ethics Commission of National Center of Neurology and Psychiatry.

2.2. Tasks

Subjects were instructed to view stimuli, which consisted of monochromatic photographs of three facial images (self, familiar, and unfamiliar faces), one scrambled-face image, and some object images while sitting on a chair. The comparison of each stimulus condition was supposed to reveal self-awareness, familiarity, and face cognition, respectively (Table 1). The facial images and the scrambled-face image were individually created from photographs taken with a digital camera. For the self-face condition (Self), a mirror image of the subject's own face was used. For the familiar-face condition (Fam), an image of the face of each subject's mother was used in the PDD and Children groups. In the Adults group, an image of the face of a gender- and age-matched familiar person, such as a friend in the subject's school or office, was used in the familiar-face condition because the subjects rarely saw their mothers. Three unfamiliar-face (Unfam) images were respectively morphed from facial photographs of seven young women (22–30 years old), four young men (22–24 years old), and 11 middle-aged women (35–46 years old) who were unknown people to the subjects and were gender- and age-matched to the familiar-face condition using Software for Facial Image Processing System for Human-like "Kansei" Agent (Information-technology Promotion Agency, IPA, Japan) and an extension tool (Harashima-Naemura Laboratory, University of Tokyo, Tokyo, Japan). The scrambled-face image (Scram) was created by randomly rearranging the self-face image for each subject. The subjects were instructed to press a key when an object image (Target) was presented. To keep the subjects' attention and the vigilance level

Table 1
Stimuli

Condition	Factor		
	Self-awareness	Familiarity	Face perception
Self-face (Self)	○	○	○
Familiar-face (Fam)	×	○	○
Unfamiliar-face (Unfam)	×	×	○
Scrambled-face (Scram)	×	×	×
Object (Target)	×	×	×