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Brain & Development 33 (2011) 494–503

BRAIN & DEVELOPMENT
Official Journal of the Japanese Society of Child Neurology

www.elsevier.com/locate/braindev

Original article

Self-face recognition in children with autism spectrum disorders: A near-infrared spectroscopy study

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Received 25 July 2010; received in revised form 15 November 2010; accepted 21 November 2010

Abstract

It is assumed that children with autism spectrum disorders (ASD) have specificities for self-face recognition, which is known to be a basic cognitive ability for social development. In the present study, we investigated neurological substrates and potentially influential factors for self-face recognition of ASD patients using near-infrared spectroscopy (NIRS). The subjects were 11 healthy adult men, 13 normally developing boys, and 10 boys with ASD. Their hemodynamic activities in the frontal area and their scanning strategies (eye-movement) were examined during self-face recognition. Other factors such as ASD severities and self-consciousness were also evaluated by parents and patients, respectively. Oxygenated hemoglobin levels were higher in the regions corresponding to the right inferior frontal gyrus than in those corresponding to the left inferior frontal gyrus. In two groups of children these activities reflected ASD severities, such that the more serious ASD characteristics corresponded with lower activity levels. Moreover, higher levels of public self-consciousness intensified the activities, which were not influenced by the scanning strategies. These findings suggest that dysfunction in the right inferior frontal gyrus areas responsible for self-face recognition is one of the crucial neural substrates underlying ASD characteristics, which could potentially be used to evaluate psychological aspects such as public self-consciousness.

Keywords: Autism spectrum disorders (ASD); Self-face recognition; Inferior frontal gyrus; Near-infrared spectroscopy (NIRS); Eye-movement; ASD severity; Self-consciousness

1. Introduction

Children with autism spectrum disorders (ASD) have social impairments (e.g., [1,2]) which might be partly from abnormality in self-other distinction [3]. This abnormality was pointed as some behavioral characteristics during self-face recognition, which is known to be a basic cognitive ability for social development [4]. Still, their brain functions for self-face recognition have not been unresolved.

Only two noninvasive neuroimaging techniques have been employed to investigate their self-face recognition. An event-related potential (ERP) study showed atypical patterns for self-other distinction in children with pervasive developmental disorders (PDD) compared with the control group [5]. On the other hand, a functional magnetic resonance imaging (fMRI) study revealed that ASD children showed fewer characteristics of hemodynamic activation in response to self-face recognition in

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0387-7604/$ - see front matter
doi:10.1016/j.braindev.2010.11.007

the right inferior frontal gyrus (R-IFG) [6], which is well known as a self-recognition-related region in normal adults and children [7,8]. These findings seem to be inconsistent, and thus, further study is needed to resolve how potential factors affect neural substrate for self-face recognition in ASD children.

One of the factors possibly influencing the neural substrate is the severity of ASD. ASD is a 'spectrum' disorder ranging from mild to severe symptoms [2]. As long as self-face recognition contributes to social development, the cognitive specificities might be reflected in ASD severities. For example, Wang et al. [9] indicated that degrees of social impairments were significantly correlated with activation levels in the prefrontal area. Their tasks were relevant to social behaviors as well as self-face recognition, and it is necessary to take into consideration the influences of ASD severity on recognition as it relates to activity in the frontal area.

Self-consciousness is also assumed to involve self-face recognition. When individuals consider self-information, i.e., face and body, they are conscious of self from other's viewpoint [10]. The levels of consciousness might also influence self-face recognition. A fMRI study using a self-evaluation task in which subjects saw several self-face images showed that higher levels of self-consciousness intensified activities in the right prefrontal cortex [11]. Since this study lacked data for ASD and normal children, the relationships between consciousness and recognition in young subjects warrant further investigation.

There is another angle from which to consider self-face recognition. During face recognition, ASD children tend to use specific scanning strategies to fixate on the mouth area rather than the eyes [12]. Dalton et al. [13] demonstrated that fixation on the eyes was significantly correlated with activation in the fusiform gyrus, which is associated with structural encoding of face recognition. However, they did not focused on activation in the inferior frontal gyrus (IFG) and the effect of the scanning strategy on self-face recognition remains unresolved.

Here we investigated the neural substrates for self-face recognition in children with ASD and healthy controls, focusing on the IFG. Taking into consideration the issues noted above, we also evaluated ASD severity, self-consciousness, and scanning strategy. Function in the frontal area was measured using near-infrared spectroscopy (NIRS), which does not result in undue stress on subjects, making it applicable for use in children [14]. It is well known that NIRS can evaluate hemodynamic activities correlated with blood oxygen level dependent (BOLD) responses detected by fMRI studies [15,16].

2. Materials and methods

2.1. Subjects

The ASD group consisted of ten boys (mean age ± standard deviation, 10.2 ± 1.1 years; all right-handed) with Asperger's syndrome or high functioning autism (Table 1). They were recruited from the National Center Hospital of Neurology and Psychiatry (Kodaira, Japan) and Tokyo Gakugei University (Koganei, Japan). Two pediatric neurologists and a child psychiatrist

Table 1
Subject profiles.

	ADL	TDC	ASD	Comparison of TDC and ASD group
N	11	13	10	
Age	21.9 ± 1.2 (20 – 24)	10.9 ± 1.0 (9 – 12)	10.2 ± 1.1 (9 – 12)	$p = 0.11$
RCPM	34.7 ± 1.3 (32 – 36)	31.8 ± 1.7 (28 – 34)	30.2 ± 4.0 (24 – 34)	$p = 0.27$
SC private	28.6 ± 3.6 (21 – 32)	24.3 ± 4.7 (17 – 33)	20.5 ± 7.2 (9 – 33)	$p = 0.14$
SC public	30.1 ± 5.8 (21 – 38)	20.8 ± 6.7 (10 – 31)	19.9 ± 7.1 (10 – 31)	$p = 0.77$
PARS infant	N/A	0.9 ± 1.1 (0 – 3)	21.1 ± 9.2 (9 – 34)	$p < 0.001$
PARS present	N/A	1.6 ± 2.0 (0 – 6)	22.1 ± 6.1 (13 – 30)	$p < 0.001$
AQ	17.1 ± 7.5 (5 – 28)	N/A	N/A	
WISC-III FIQ	N/A	N/A	98.3 ± 9.1 (88 – 117)	

Each number shows mean scores and standard deviations. Numbers in parentheses show score ranges. Comparisons of TDC and ASD group were performed with Student's *t*-test (two-tailed unpaired). RCPM, Raven's Coloured Progressive Matrices; SC, Self-Consciousness scale; PARS, Pervasive Developmental Disorders Autism Society Japan Rating Scale; AQ, Autism-Spectrum Quotient; WISC-III, Wechsler Intelligence Scale for Children Third Edition; FIQ, full intelligence quotient; N/A, not available.