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Impairment of unconscious, but not conscious, gaze-triggered attention orienting in Asperger's disorder

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ABSTRACT

Impairment of joint attention represents the core clinical features of pervasive developmental disorders (PDDs), including autism and Asperger's disorder. However, experimental studies reported intact gaze-triggered attentional orienting in PDD. Since all previous studies employed supraliminal presentation of gaze stimuli, we hypothesized that individuals with PDD may be impaired not in conscious but in unconscious gaze-triggered attention shift. We tested the hypothesis in a group of Asperger's disorder ($N = 12$) and age- and gender-matched controls ($N = 13$), using a cueing paradigm with supraliminal and subliminal presentation of gaze cues. Under supraliminal conditions, the gaze cueing effect was evident in both groups. Under subliminal conditions, the Asperger group, unlike the control group, did not show the gaze cueing effect. These results indicate the impairment of unconscious, but not conscious, joint attention in Asperger's disorder, which may underlie some clinical findings of social malfunction in PDD.

1. Introduction

Individuals with pervasive developmental disorders (PDDs), including autism and Asperger's disorder, are characterized primarily by qualitative impairments of social interaction (American Psychiatric Association, 2000; Matson, Compton, & Sevin, 1991). One of the most evident features of their social impairment is the deficit in joint attention (Mundy, Sigman, & Kasari, 1994). For example, when the attending physician suddenly averts his gaze to look at environmental objects during a clinical interview, an individual with PDD fails to follow his gaze direction (Okada, Sato, Murai, Kubota, & Toichi, 2003).

In contrast to such obvious clinical evidence of impaired joint attention, several experimental studies have found a normal ability to shift attention with another's gaze reflexively in PDD (Chawarska, Klin, & Volkmar, 2003; Johnson et al., 2005; Kylliainen & Hietanen, 2004; Okada et al., 2003; Senju, Tojo, Dairoku, & Hasegawa, 2004; Swettenham, Condie, Campbell, Milne, & Coleman, 2003; Vlamings, Stauder, van Son, & Mottron, 2005; for a review see Nation & Penny, 2008). The studies have used Posner's (1980) cueing paradigm to examine joint attention (c.f., Frischen, Bayliss, & Tipper, 2007). For example, Okada et al. (2003) presented a face with eyes directed left or right to individuals with PDD, and to controls with no developmental disorder. Then, a target appeared to the right or left side of the face. The reaction time (RT) to detect the target

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was shorter at a validly cued location than at an invalidly cued location in both PDD and control participants. These results suggest that computerized experiments using a conventional gaze cueing paradigm cannot reveal the impaired joint attention in PDD.

Experimental social psychological studies have revealed that our social interactions are full of adaptive unconscious processes (Wilson, 2002). A recent study revealed that gaze-triggered attention could even occur unconsciously (Sato, Okada, & Toichi, 2007). Based on these data, we hypothesized it would be unconscious, rather than conscious, gaze-triggered attention shift that is impaired in PDD. Here we tested this hypothesis in a group of Asperger's disorder and age- and gender-matched typically developing controls. We used the same cueing paradigm with supraliminally or subliminally presented gaze cues, as in a previous study (Sato et al., 2007).

2. Methods

2.1. Participants

The Asperger group (3 females, 9 males; mean $\pm$ *SD* age = 17.2 $\pm$ 6.3 years) consisted of 11 (2 females, 9 males) with Asperger's disorder and 1(female) with PDD not otherwise specified (PDD-NOS), who did not satisfy all the diagnostic criteria for Asperger's disorder but exhibited mild symptoms of PDD. The diagnoses, based on the DSM-IV-TR (American Psychiatric Association, 2000), were made by psychiatrists with expertise in developmental disorders. Neurological and psychiatric problems other than those associated with PDD were ruled out. Participants were taking no medication. The Full-scale IQ, measured by the WAIS-R or WISC-R, of all participants in the Asperger group scored in the normal range (Full-scale IQ = 106.8 $\pm$ 9.3; Verbal IQ = 106.4 $\pm$ 13.1; Performance IQ = 104.2 $\pm$ 10.0). Participants in the control group (3 females, 10 males; mean $\pm$ *SD* age = 19.7 $\pm$ 1.9 years) were matched for age and gender with the Asperger group. All participants had normal or corrected-to-normal visual acuity. After the procedure and purpose of the study were explained fully and before testing, written informed consent was obtained from the participants or their parents.

2.2. Experimental design

The experiment was constructed as a two-factorial mixed randomized-repeated design, with group (Asperger or control) as the randomized factor, and presentation condition (subliminal or supraliminal) as the repeated factor.

2.3. Apparatus

The events were controlled by SuperLab Pro 2.0 (Cedrus) and implemented on a Windows computer (MA55J, NEC). The stimuli were presented on a 19-in. CRT monitor (GDM-F400, Sony) with a refresh rate of 100 Hz and a resolution of 1024 $\times$ 768 pixels. The participants' responses were recorded using a response box (RB-400, Cedrus).

2.4. Stimuli

The gaze cues consisted of schematic faces in which the eye gaze was directed toward either the left or right. Masks were mosaic patterns that covered all of the facial features of the cue stimuli. The cues and masks subtended 6.5° vertically $\times$ 6.5° horizontally. The target was an open circle subtending 1.0° vertically $\times$ 1.0° horizontally. These stimuli consisted of a black line drawing on a white background.

2.5. Procedure

The procedure was identical to that of a previous study (Sato et al., 2007). The experiments were conducted individually in a small room. The participant was seated comfortably with her/his head supported by a chin-and-forehead rest located 0.57 m from the screen.

A threshold assessment session was first conducted. The stimulus onset asynchrony (SOA) between the target and mask was manipulated. To assess the upper limit of SOA for subliminal presentation in each participant, blocks of 20 subliminal cue presentation trials, i.e., 10 each for the left and right gaze directions, were prepared. In each trial, after the presentation of a fixation point, i.e., a small black "+" lasting 680 ms, the gaze cue was presented in the center of the monitor, after which the mask was presented in the same location. The presentation time of the mask was adjusted so that the total presentation period of the gaze cue and the mask was 200 ms. The order of gaze direction was randomized. The participant was asked to orally answer the question, "Did you see the gaze? If so, report the direction of the gaze." They were also asked not to guess at answers. The participants responded either "Yes" or "No," and in the case of the former, they then reported the gaze direction that they had seen. Starting with 10 ms, the SOA was prolonged by 10 ms increments. After the participants finished each block, the performance was investigated. If the participant correctly recognized at least 1 of the 20 stimuli, the corresponding SOA was regarded as the lower limit of conscious awareness for the cue for that participant, and an SOA 10 ms shorter than that limit was used in the trial session. The mean ($\pm$*SD*) SOA was as 19.2 $\pm$ 10.9 and 14.7 $\pm$ 7.8 ms for the Asperger and control groups, respectively (two-tailed *t*-test, $t(23) = 1.21$, *n.s.*).