

Original article

# A group of very preterm children characterized by atypical gaze patterns

Mariko Sekigawa-Hosozawa<sup>a,\*</sup>, Kyoko Tanaka<sup>a,b</sup>, Toshiaki Shimizu<sup>a</sup>,  
Tamami Nakano<sup>c,d</sup>, Shigeru Kitazawa<sup>c,d</sup>

<sup>a</sup> Department of Pediatrics and Adolescent Medicine, Juntendo University Faculty of Medicine, Tokyo, Japan

<sup>b</sup> Division of Adolescent Mental Health, Department of Psychosocial Medicine, National Center for Child Health and Development, Tokyo, Japan

<sup>c</sup> Dynamic Brain Network Laboratory, Graduate School of Frontier Biosciences, Osaka University, Osaka, Japan

<sup>d</sup> Department of Brain Physiology, Graduate School of Medicine, Osaka University, Osaka, Japan

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## Abstract

**Objective:** Very preterm (VP) children are at risk for social difficulties, including autism spectrum disorder (ASD). This study used eye tracking to determine viewing behaviors that may reflect these difficulties.

**Design:** The gaze patterns of 47 VP (mean gestational age: 28 weeks, mean birth weight: 948 g, and mean chronological age: 49 months) were assessed while viewing dynamic social scenes and compared with those of 25 typically developing (TD) and 25 children with ASD. The temporo-spatial gaze patterns were summarized on a two-dimensional plane using multidimensional scaling (MDS) and the median of the TD children was used to characterize the gazes of the VP children. Time spent viewing the face was also compared.

**Results:** The VP children formed two clusters: one had a mean MDS distance comparable to that of TD group ( $n = 32$ ; VP-small), and the other had a larger mean distance comparable to that of ASD group ( $n = 15$ ; VP-large). The VP-large were similar to the ASD group by spending significantly less time viewing the face. Their performance was comparable to the TD during the initial 1 s, but they could not remain focused on the face thereafter.

**Conclusions:** The VP children were objectively classified into two groups based on gaze behaviors. One group was comparable to TD children, whereas the other had difficulty maintaining attention and exhibited atypical viewing behaviors similar to those of the ASD group. Our method may be useful in identifying VP children at higher risk for experiencing social difficulties.

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**Keywords:** Very preterm; Autism spectrum disorder; Social competence difficulties; Social cognition; Eye tracking

## 1. Introduction

Very preterm (VP) children tend to show poorer social competence such as peer rejection and social with-

drawal, and are at increased risk of being diagnosed with autism spectrum disorder (ASD) [1–6]. However, the biological mechanisms underlying this increase and the most effective method with which to identify those at most risk remain unclear. Recent studies examining the spontaneous monitoring of dynamic social scenes by individuals with ASD identified atypical viewing behaviors that are related to social disabilities [7–9]

\* Corresponding author at: Department of Pediatrics and Adolescent Medicine, Juntendo University Faculty of Medicine, 2-1-1 Hongo, Bunkyo-ku, Tokyo 113-8421, Japan. Fax: +81 3 5800 0216.

E-mail address: [m-seki@juntendo.ac.jp](mailto:m-seki@juntendo.ac.jp) (M. Sekigawa-Hosozawa).

and later diagnoses of ASD [10,11]. These findings suggest that viewing behaviors during the observation of dynamic social scenes that represent everyday life may be used to better understand the clinical features of those at risk for social difficulties and how to screen for them.

Prospective studies of preterm children using static facial stimuli have reported atypical face processing [12,13] or decreased visual sensitivity to point-light biological motion in those with periventricular white matter lesions [14,15]. Williamson and Jakobson [16] asked subjects to interpret dynamic social scenes and found that VP children have difficulties processing nonverbal cues and correctly identifying the emotions of characters. However, because this study required verbal explanations, it was limited to children older than 8 years of age, and differences in linguistic ability may have influenced the results.

A study from our research group used dynamic social scenes and multidimensional scaling (MDS; [17]) to characterize gaze patterns and found that adults and children with ASD exhibit atypical gaze behaviors compared with those displayed by children with typical development (TD, [8]). The same experimental approach applied in children with specific language impairments revealed that their overall gaze patterns were similar to those of TD children but different from those of ASD group [18]. Thus, this non-verbal experimental method is useful for quantitative comparisons of overall social viewing behaviors across a wide range of ages [8,18].

The present study used this method to investigate how VP children view dynamic social scenes and compared the findings with data from ASD and TD children. This study aimed to determine gaze behaviors that may underlie social difficulties in VP children without ostensive neurological impairments and possibly to identify VP children at higher risk for social difficulties.

## 2. Methods

### 2.1. Subjects

The present study was performed in the Faculty of Medicine at Juntendo University and assessed 97 participants: 47 VP children (mean chronological age  $\pm$  SD,  $49 \pm 25$  months, range: 15–120 months), 25 children with ASD ( $59 \pm 21$  months, 31–108 months), and 25 TD children ( $37 \pm 23$  month, 14–93 months).

The ASD and TD subjects were the same as those used in a previous study by Nakano et al. [8]; the detailed characteristics of the children are included in that article. Briefly, participants with ASD were diagnosed by two experienced clinicians in our institute, using DSM4-TR criteria. 16 were assigned as autism, 2 as high functioning ASD, and 5 as pervasive developmental disorders -not otherwise specified. The TD chil-

dren were selected on the basis of chronological age: under the assumption that their developmental ages were consistent with their chronological ages, they were matched with the developmental ages of the ASD group. None of the children in the TD group had a family history of ASD or a history of developmental delay.

The VP children were recruited from our outpatient follow-up program, which regularly follows up with all surviving children born in our hospital who weighed <1500 g at birth until 9–10 years of age. The developmental status of each VP child was assessed using the Bayley Scales of Infant and Toddler Development, 3rd Edition (BSID-3; [19]) for children younger than 42 months. To adjust for prematurity, corrected age was used to calculate the scores of children younger than 24 months, and the average of the BSID-3 cognitive and language scores was used to evaluate their developmental quotient (DQ). For children older than 42 months, the Kaufman Assessment Battery for Children (K-ABC; [20]) was used to evaluate full scale intelligence quotient (IQ). Social and emotional behaviors were assessed using the Japanese version of the parent-rated Strength and Difficulties Questionnaire (SDQ; [21]).

This study recruited children who visited our outpatient clinic between March 2010 and April 2015. All children participated on voluntary basis and met the following criteria: birth weight <1500 g, gestational age <32 weeks, aged between 12 months (corrected age) and 10 years old, no known genetic disorders, normal vision or could see a screen without glasses, and no auditory impairments. Additionally, children with neurodevelopmental delays (IQ/DQ < 70) were excluded to avoid any influence of developmental delays on the study results. Of the 126 children who met these criteria, 54 had dropped out of the follow-up program at the time of this study, and the parents of 20 children refused to participate. Of the remaining 52 children, data from five children were excluded because their total valid viewing time did not reach a cut-off point of 35 s (45%). Thus, 47 VP children were included in the final analyses.

The 47 VP children had a mean gestational age of  $28 \pm 2$  weeks (mean  $\pm$  SD; range: 24–32 weeks), mean birth weight of  $948 \pm 302$  g (range: 471–1490 g), and mean chronological age of  $49 \pm 25$  months (range: 15–120 months); when adjusted for prematurity for children up to 24 months, the mean corrected age was  $49 \pm 26$  months (range: 12–120 months). The mean IQ/DQ of the VP children was  $99 \pm 11$ , and the mean developmental ages for the VP, ASD, and TD children were  $49 \pm 26$  months (range: 13–125 months),  $37 \pm 22$  months (range: 16–90 months), and  $37 \pm 23$  months (range: 14–93 months), respectively; the developmental age of the TD children was assumed to be their chronological age. The mean developmental age of the VP children was 12 months older than those

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