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Atypical recognition of dynamic changes in facial expressions in autism spectrum disorders

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ABSTRACT

Previous studies have suggested that the processing of dynamic facial expressions is impaired in autism spectrum disorders (ASD). However, the specific component that is impaired in the processing of dynamic facial expressions has not been identified. We investigated the recognition of dynamic changes in facial expressions among individuals with ASD and age- and sex-matched typically developing controls. Morphing animations of facial expressions of six emotions were presented at four different changing speeds, and participants rated the naturalness of the expression changes. The correspondence between reduced speeds and decreased naturalness ratings was weaker in the ASD than in the control group. These results suggest that the atypical visual analysis of dynamic changes in facial expressions underlies the impairment in real-life social interaction among individuals with ASD.

1. Introduction

Individuals with autism spectrum disorders (ASD) are characterized primarily by qualitative impairments in social interaction (American Psychiatric Association (APA), 2000). One of the most evident features of their social impairment is deficient communication involving emotional facial expressions (Hobson, 1993). For example, previous studies reported that individuals with ASD exhibited attenuated emotional behaviors (Corona, Dissanayake, Arbelle, Wellington, & Sigman, 1998) and reduced and/or inappropriate facial reactions (Yirmiya, Kasari, Sigman, & Mundy, 1989) compared with typically developing individuals in response to the facial expressions of other individuals in social interactions.

However, previous experimental studies investigating emotional expression processing in ASD have reported inconsistent findings. For example, although some studies demonstrated impaired facial expression recognition in ASD (e.g., Braverman, Fein, Lucci, & Waterhouse, 1989; Celani, Battacchi, & Arcidiacono, 1999; Uono, Sato, & Toichi, 2011), other studies reported no such impairment (e.g., Adolphs, Sears, & Piven, 2001; Castelli, 2005; Grossman, Klin, Carter, & Volkmar, 2000). Almost all these studies, regardless of their findings, used photos of emotional facial expressions as stimuli.

In real-life social interactions, facial expressions are usually dynamic. Thus, normal facial expressions contain not only static form information but also dynamic motion information (cf. Matsumoto, Ekman, & Fridlund, 1991). Researchers who have observed facial expressions in real situations have described the rich dynamic information contained in emotional facial expressions (Darwin, 1872; Ekman & Friesen, 1975). Consistent with such observations, several experimental studies in typically developing individuals have found that participants showed sensitivity to the dynamic properties of facial

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expressions (Hoffmann, Traue, Bachmayr, & Kessler, 2010; Krumhuber & Kappas, 2005; Sato & Yoshikawa, 2004). For example, Sato and Yoshikawa (2004) tested the naturalness ratings of dynamic changes in facial expressions and found that expressions that changed too slowly were generally rated as unnatural. Additionally, the effects of changing speeds differed across emotions in that the fastest and slowest changing were seen as relatively natural for surprised and sad expressions, respectively. These data indicate that the dynamic properties of the stimuli affect the visual processing of facial expressions.

Because previous studies reporting impairments in social interactions tested real communication (e.g., Corona et al., 1998; Yirmiya et al., 1989), facial expressions were dynamic in those studies. Consistent with this notion, several recent studies have shown that dynamic presentations of facial stimuli more clearly elicited the abnormal behavioral patterns in individuals with ASD than did static presentations (Kessels, Spee, & Hendriks, 2010; Tardif, Lainé, Rodriguez, & Gepner, 2007; Uono, Sato, & Toichi, 2009). For example, Uono et al. (2009) reported that experiments using dynamic facial expressions as stimuli revealed the facilitative effect of emotional expression on automatic gaze-triggered attentional shifts in typically developing individuals and the impairment in this regard among individuals with ASD, although such effects were not found in response to static presentations (Hietanen & Leppänen, 2003). Several neuroimaging studies have also shown reduced activation of some social brain regions, such as the superior temporal sulcus (STS), in response to dynamic facial expressions in individuals with ASD (Pelphrey, Morris, McCarthy, & Labar, 2007; Rahko et al., 2012; Sato, Toichi, Uono, & Kochiyama, 2012).

Although these studies demonstrated that individuals with ASD suffer from impairment in the processing of dynamic facial expressions, the particular component that is impaired in the processing of dynamic facial expressions has remained unclear. Because neuroimaging studies have reported weak activation in the visual cortices during the processing of dynamic facial expressions by individuals with ASD (e.g., Pelphrey et al., 2007), we hypothesized that individuals with ASD may be impaired in their ability to analyze the dynamic properties of emotional facial expressions, which has been proposed as the earliest component in facial expression processing (Haxby, Hoffman, & Gobbini, 2000). To test this hypothesis, we used the experimental paradigm employed in a previous study with typically developing individuals (Sato & Yoshikawa, 2004). We presented dynamic facial expressions at different speeds and asked participants to rate the naturalness of the changing speeds of expressions. We predicted that individuals with ASD would be less sensitive to the dynamic changes in facial expressions than typically developing individuals would be.

2. Materials and methods

2.1. Participants

The ASD group consisted of sixteen individuals (two females, fourteen males; mean ± standard deviation (*SD*) age = 24.6 ± 11.9 years); eight (males) had Asperger's disorder and eight (two females, six males) had pervasive developmental disorder not otherwise specified (PDD-NOS). As defined by the Diagnostic and Statistical Manual-Fourth Edition-Text Revision (DSM-IV-TR) (APA, 2000), PDD-NOS includes heterogeneous subtypes of ASD ranging from so-called atypical autism to a subtype with milder symptoms than those typically associated with Asperger's disorder. In this study, only high-functioning participants with PDD-NOS (i.e., those with milder symptoms than those associated with Asperger's disorder) were included. The diagnoses were based on the DSM-IV-TR (APA, 2000) criteria and were made by psychiatrists with expertise in developmental disorders. Neurological and psychiatric problems other than those associated with PDD were ruled out. None of the participants was taking medication. The full-scale intelligence quotient, measured by the Wechsler Adult Intelligence Scale-Revised or the Wechsler Intelligence Scale for Children-Revised, of all participants in the ASD group was in the normal range. The control group consisted of sixteen participants (two females, fourteen males; mean ± *SD* age = 21.5 ± 1.1) who had been matched for age ($t(30) = 1.04$, $p > .1$) and sex with the ASD group. All participants had normal or corrected-to-normal visual acuity. After the procedure and purpose of the study were explained fully, all participants provided informed consent for participation in the study. This study was approved by the local institutional ethics committee.

2.2. Experimental design

The experiment was constructed as a three-factorial repeated-measures design, with group (ASD or control) as a between-participant factor and speed (260, 520, 1040, or 2080 ms/clip) and emotion (anger, disgust, fear, happiness, sadness, or surprise) as within-participant factors.

2.3. Apparatus

The events were controlled by a program written in Visual C++ 5.0 and implemented on a Windows computer. The stimuli were presented on a 19-in. flat CRT monitor (GDM-F400, Sony; refresh rate, 100 Hz) at a viewing distance of 0.57 m. Under this condition, the stimuli subtended a visual angle of 15.0° vertical × 10.0° horizontal.

2.4. Stimuli

With one exception, the stimuli were almost identical to those used in a previous study (Sato & Yoshikawa, 2004). Due to the limited refresh rate of the display device, the total frame number was decreased from 51 to 26. The stimuli were created