
Eye Avoidance in Young Children With Autism Spectrum Disorder Is Modulated by Emotional Facial Expressions

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Autism spectrum disorder (ASD) is a pervasive neurodevelopmental disorder characterized by impairments in social interaction and communication, as well as by the presence of repetitive or stereotypical behaviors (American Psychiatric Association, 2013). Along with these social deficits, individuals with ASD have been found to have impairments in facial identity discrimination (Weigelt, Koldewyn, & Kanwisher, 2012) and emotion recognition (Rump, Giovannelli, Minshew, & Strauss, 2009; Uljarevic & Hamilton, 2013). People with ASD also exhibit atypical neural responses to faces (Dalton et al., 2005; Pierce, Müller, Ambrose, Allen, & Courchesne, 2001) and atypical face-scanning patterns (for a review, see Falck-Ytter & von Hofsten, 2011). Particularly, eye-tracking studies have repeatedly found that people with ASD spend less time looking at others' eyes than typically developing (TD) counterparts (e.g., Jones & Klin, 2013; Pelphrey et al., 2002; Yi et al., 2013). This is referred to as the "eye avoidance" looking pattern in ASD (Tanaka & Sung, 2016). These findings are consistent with clinical observations that individuals with ASD have limited eye contact with others (Adrien et al., 1993; however, see later).

The mechanisms underlying this atypical eye-gaze in ASD have attracted increased research interest in the past decade. Some researchers have proposed that individuals with ASD perceive direct eye contact as socially threatening, and thus actively avoid looking at others' eyes to relieve the uncomfortable feelings elicited by direct eye gaze (e.g., Hutt & Ounsted, 1966; Kliemann, Dziobek, Hatri, Steimke, & Heekeren, 2010; Tanaka & Sung, 2016).

with time. The former would indicate a strong, consistent form of eye avoidance, suggesting that children with ASD cannot habituate to social threats, and thus continue to avoid looking at the eyes. The latter, on the other hand, would suggest a mild form of eye avoidance, perhaps representing their habituation to the threat over time. We expected to see different eye-avoidance patterns when children with ASD were processing faces with different facial expressions—more specifically, we expected stronger forms of eye avoidance in more threatening facial expressions (e.g., anger). The temporal-course analysis was intended to reveal the nuances in children’s responses to different facial expressions over time, which is of importance to our understanding of emotional face processing in ASD. Such nuanced responses to different facial expressions could also distinguish ASD from other disorders (e.g., social anxiety), and might have implications for the development of training programs targeted at improving eye contact in individuals with ASD.

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We recruited thirty 2- to 5-year-old Chinese children with ASD, who were diagnosed by pediatric psychiatrists according to the diagnostic criteria for ASD in the

included; e.g.,

for each cluster until none of the maximum values in any cluster is significant.

The two temporal-course analyses are described in more detail in the [online supplementary material](#).

Results

Total Time Looking at the Whole Face

We first examined group differences regarding total looking time on the whole face using a 2 Group (ASD and TD groups) \times 4 Expression (Angry, Neutral, Happy, and Sad) repeated-measures ANOVA. As shown in [Figure 2](#) and [Table S3](#), only the main effect of Expression was significant, $F(3, 165) = 31.99, p < .001, \eta_p^2 = .37, 90\% \text{ CI } [.26, .44]$. Post hoc pairwise t tests (after FDR correction) revealed that children looked longer at angry than neutral, happy, and sad faces, $t(57) = 4.43, p < .001, \text{Cohen's } d = 0.58, 95\% \text{ CI } [0.30, 0.86]$; $t(57) = 7.05, p < .001, \text{Cohen's } d = 0.93, 95\% \text{ CI } [0.61, 1.23]$; $t(56) = 7.48, p < .001, \text{Cohen's } d = 0.99, 95\% \text{ CI } [0.67, 1.31]$, respectively. Children also looked longer at neutral faces than happy and sad faces, $t(57) = 3.51, p = .001, \text{Cohen's } d = 0.46, 95\% \text{ CI } [0.19, 0.73]$; $t(56) = 4.53, p < .001, \text{Cohen's } d = 0.60, 95\% \text{ CI } [0.32, 0.88]$, respectively. The difference in face-looking time between happy and sad faces was not significant, $t(56) = 1.87, p = .067, \text{Cohen's } d = 0.25, 95\% \text{ CI } [-0.02, 0.51]$. There was no significant main effect of group, $F(1, 55) = 0.22, p = .64, \eta_p^2 < .01, 90\% \text{ CI } [.00, .07]$, or the Group \times Expression interaction, $F(3, 165) = 2.31, p = .087, \eta_p^2 = .04, 90\% \text{ CI } [.00, .09]$, indicating a similar amount of time looking at the whole face for the two groups. The same analyses were applied to the total time spent looking at the screen, and results were very similar to those of total time spent looking at the whole face (see [Table S3](#) and [Figure S2](#) for more details).

Proportional Time Looking at the Eyes

We examined whether the ASD and TD groups showed different proportional looking time focused on the eyes for F11Tfs5

and neutral versus sad, $t(30) = -2.20$, $p = .07$, Cohen's $d = 0.40$,
95% CI [0.03, 0.76].

Our comparative findings, in which the ASD group showed reduced proportional eye-looking time of angry faces, but not of sad faces, suggest that the eye avoidance of ASD has a greater likelihood of being associated with more socially threatening stimuli, rather than with negativity as a whole. Further evidence came from the analyses that compared the face-scanning patterns between different expressions for each group. The TD children looked at the eyes of the angry and sad faces more than those of the happy faces. Considering that expressive information of negative expressions is, for the most part, conveyed by the upper half of the face (Eisenbarth & Alpers, 2011; Schurgin et al., 2014; Smith, Cottrell, Gosselin, & Schyns, 2005), our finding suggests that TD children are very sensitive to this nuance among expressions. However, such sensitivity was absent in the children with ASD, who looked at the eyes of the angry faces less than the neutral, happy, and sad faces, further suggesting that eye avoidance in ASD is specific to socially threatening expressions. These interexpression comparisons also suggest that the decreased eye-looking time of children with ASD for angry faces is due to their atypical face processing, but not to their decreased physical salience

for the eyes of angry faces, given that the TD children spent the most time looking at the eyes of angry faces.

Despite their eye avoidance responses toward angry faces, the children with ASD, similar to TD children, looked more at the whole faces with threatening emotional expressions than those with non-threatening expressions, which is consistent with several previous studies (Hall, Hutton, & Morgan, 2012; Perez-Edgar et al., 2017). Faces displaying threatening emotional expressions, such as anger and fear, have been described to evoke vigilance responses from individuals (Green, Williams, & Davidson, 2003), leading to longer looking time for these faces. In fact, infants as young as 7 months already show difficulty in disengaging from threatening faces (Peltola, Lepänen, Vogel-Farley, Hietanen, & Nelson, 2009). It should be noted that although the children with ASD paid more attention to the angry faces than to the nonthreatening faces, they looked less at the inner features of the faces (especially the eyes). That is, the children with



Figure 5. Change-point analysis. Change-points are marked by square for the ASD group and diamond for the TD group. Average proportional eye-looking time before, after, or between change points are marked by dash line for the ASD group and dot line for the TD group. The solid lines represent proportional eye-looking time across time. See the online article for the color version of this figure.

cating a complete avoidance of the core facial features specific to angry faces. This looking style might be a combination of vigilance to threatening faces and avoidance to the core features of such faces, especially the eyes, which convey the most social and threatening information (Eisenbarth & Alpers, 2011; Farabee, Holcom, Ramsey, & Cole, 1993; Smith et al., 2005; Wieser, Pauli, Alpers, et al., 2009). While further research is certainly needed, such a special attentional style is obviously meaningful to people with ASD. For example, being more vigilant to threatening faces can help people with ASD detect important social cues; also, avoiding eye contact can alleviate discomfort elicited by threatening facial expressions. Notably, this looking pattern reflects a *spatial* distribution of visual attention, and is different from the vigilance-avoidance looking pattern found in people with social anxiety (Holas et al., 2014; Wieser, Pauli, Weyers, et al., 2009), which, revealed by the temporal-course analyses, represents a *temporal* change of looking pattern toward social threat (initially enhanced and then subsequently reduced looking time).

With regard to the temporal-course analysis, as expected, the children with ASD demonstrated a strong form of eye avoidance by

showing eye avoidance for the threatening facial expression (anger) persistently over the presentation time. For the neutral faces, although the group difference of the overall eye-looking time was not significant, the temporal-course analysis revealed that eye avoidance did appear between 1,000 ms and 2,900 ms after the face onset. After that, the group difference disappeared, due to both increased eye-looking time of the ASD group and decreased eye-looking time of the TD group. This eye-avoidance pattern confirms the mild form of eye avoidance in line with our hypothesis. Neutral expressions are often found to be confused with negative and threatening faces by both TD participants and participants with ASD (Eack, Mazefsky, & Minschew, 2015; Juth, Lundqvist, Karlsson, & Ohman, 2005; Lee, Kang, Park, Kim, & An, 2008). Thus, the decreased eye-looking with neutral faces in children with ASD may still reflect their tendency to avoid the threat-elicited discomfort posed by the eyes of neutral facial expressions. Given the lower degree of threat of neutral faces relative to angry faces, children with ASD showed a mild form of the eye-avoidance pattern that eclipsed over time. This can be attributed to

their habituation or their reduced perception of the threat of neutral faces over time.

Our temporal-course analysis has additional implications. First, most previous research measured gazing behavior across the whole stimulus-presenting time without evaluating the exact temporal course of attention allocation to the eyes (e.g., [De Wit et al., 2008](#)

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