Children with ASD Prefer Observing Social Scenarios from Third-Person Perspective

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Abstract. This study employed visual tracking technology to explore the effects of a third-person perspective on the fixation condition of social scenarioss in children with autism spectrum disorder (ASD). This study selected 24 ASD children and 24 psychologically age-matched typically developmenting (TD) children as control group, and used eprime 3.0 to present experiment image cosist of social stimuli (a person's smiling expression) and non-social stimuli (Circumscribed Interests, control objects) by pairing. The results reported that: first, children with autism spend significantly longer looking at the images of social scenarios in the third-person perspective than objects; second, children with autism spend significantly longer looking at image in the third-person perspective than in the first-person perspective; third, when the distractor is Circumscribed Interests, children with ASD spend shorter time to the first fixation of both social scenarios and objects than TD children in the first-person perspective.

Keywords: Autism spectrum disorder · Third-person perspective · Social information processing

1 Introduction

Autism Spectrum Disorders (ASD) is a neurodevelopmental disorder that has two core symptoms: social communication disorder and Restricted, Repetitive Behaviors and Interests (RRBIs) [1]. Some researchers reported that the fixation way of social information is attended to may be an important factor in their successful socialization and communication and that reduced social attention in individuals with ASD is strongly associated with their social disorder [2–4]. However, social motivation theory reported that individuals with ASD don't have a natural tendency to attend to social stimuli, and there is no consensus among researchers regarding this finding [5].

It has been found that typically developing (TD) individuals have an attentional bias for social scenarios, but children with ASD have reduced attentional allocation to social stimuli in many contexts [6–8]. For example, children with ASD have a lower tendency to observe and describe scenarioss of complex social interactions with faces

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and heads than TD or language-delayed peers [9]. It is well known that the eyes play a distinct important role in social interactions and communication of our real world, and individuals with TD are very sensitive to and show higher motivation for social messages conveyed by the eyes (e.g., emotions, attention, intentions) because of their perception of eye contact as beneficial [10]. In contrast, individuals with ASD are lessly insensitive to eyes [11], resulting in diminished motivation to look at eyes [10].

However, some other researchers have refuted the theory, which does not believe that social motivation theory can be used to generalize to explain the reduced fixtion at social information in individuals with ASD, and some studies have found no difference in the amount of face-gazing effort between children with ASD and control children [12]. Other studies have interpreted this from a cultural perspective, such as for Chinese, looking straightly in others' eyes is rude or impolite [13]. Others consider that children with ASD perceive the eyes are threated [14], so they draw on the contents of their peripheral vision to obtain eye information instead of loking eyes straightly, similar to a compensatory strategy.Wang compared the effects of different perspective orientations on the gaze of children with ASD, which model faces looking directly at children with ASD and controlling for the direction of the model's gaze, results found that the ASD group spent significantly less time looking at the eyes for the 0° perspective than for the 30° and 60° perspectives. The study found that children with ASD would avoid the gaze if a faces looking directly at them, but if not, children with ASD showed a decrease in eye avoidance [15]. In addition, it is important to emphasize that previous studies have used individual faces singally, and it has been reported that children with autism have a impairments in sociality that may result from attentional processes specific to social stimuli, specifically, differential allocation of attention to different components (e.g., reduced attention to the face but increased attention to the body) [8]. Social material just presenting faces singally can't objectively reflect the real-life cognitive processing of social information in children with ASD, and the gaze aversion hypothesis states that individuals with ASD actively avoid eyes to alleviate the discomfort caused by direct eye gaze [16]; therefore, future research should appropriately introduce information about characters rather than lonely faces to avoid excessive rejection of lonely face presentation by children with ASD.

However, previous studies have some shortcomings: first, previous studies have mostly studied only social deficits but not focusing on the relationship between social and nonsocial deficits. Althought some researchers have compared the influence of nonsocial information on social information without exploring the inner connection between the two in-depth. Second, most previous studies have examined the timing of eye gaze by children with ASD when seeing the faces of others from the first-person perspective, while less attention has been paid to the behavioral patterns of children with ASD when perspectiveing social scenarioss from the third-person perspective. Most of the faces used in previous studies were clear full faces [17], and these face images were all straightforward to the perspective of the child with ASD, but them have a major drawback is that it only measures focal vision, therefore, it can't detect the attention allocated to the edges of the visual field [18]. In the future, the gaze of children with ASD on social information should be explored from multiple angles and perspectives.Like making a possible real-life scenario, the third perspective, which is a image consist of two people talking to each other, when children with ASD are perspectiveing the social scenarios from a third-person perspective situation, enriches the research base of children with ASD gaze on social scenarioss. Therefore, this study hopes to initially explore the relationship between social and non-social deficits and the behavioral patterns of children with ASD perspectiveing social scenarioss from a third-person perspective.

Other studies have used non-social information to explore the effects of social attention in children with ASD, such as Circumscribed Interests (CI), to which individuals with ASD can show unusual attention and intense obsession [19], but in this area some researchers have suggested that the presence of CIs interferes with children with ASD's attention to social information, thereby reducing attention to social information [20]. Others believe that children with ASD don't pay attention to social information because they have no motivation to it [21]. And other researchers have compared biological movements to nonsocial movements [22], as well as the presentation of objects in static social images or geometric shapes, a decrease in social information gaze was also observed in children with ASD [23–25]. Despite the large number of studies reporting social attention deficits in children with ASD, little is known about the relationship between social and nonsocial processing gaze processing in children with ASD.

Based on this, this study aimed to investigate the effects of different perspectives (first-person perspective vs. third-person perspective) on social scenarios gaze patterns of children with ASD. This study adopted a visual preference paradigm to examine the gaze of children with ASD on social information characters (busts of pepole smiling faces taken in real scenarios) and non-social information objects (CI, control objects). We proposed two hypotheses in this study: **hypothesis 1**: children with ASD avoid social information and children with ASD will pay more attention to non-social information objects, especially CI; **hypothesis 2a**: based on social motivation theory, if children with ASD lack social motivation, then there is no difference between first-person and third-person perspective gaze; **hypothesis 2b**: based on the eye threat hypothesis, if children with ASD just avoid the first-person perspective, then in the third-person perspective, children with ASD would gaze more at social scenarios.

2 Methods

2.1 Subjects

Thirty-three children with ASD diagnosed by a tertiary care hospital were recruited from a special education school, and 33 children with TD were recruited from a kindergarten. Based on the subjects' cooperation and the completion of the experiment, a total of 48 valid subjects were finally screened, including 24 children with ASD (22 boys and 2 girls) and 24 children with TD (22 boys and 2 girls). All subjects had normal visual acuity or corrected visual acuity, and other diseases were excluded. The Peabody Picture Vocabulary Test (PPVT) was used to assess the intelligence level of the subjects, and the Childhood Autistic Rating Scale (CARS) was used to assess the autism level of the subjects. Details of the subjects' information are shown in Table 1.

Table 1. Basic information of subjects ($M \pm SD$)

Basic Information	ASD($n = 24$)	TD($n = 24$)	t
Physiological Age (years)	12.63 ± 2.3	3.46 ± 0.51	19.6^{***}
Score of PPVT	32.8 ± 23.1	31.3 ± 21	0.27
Score of CARS	31.7 ± 4.47	15.3 ± 0.48	17.64^{***}

2.2 Experimental Materials

Experimental materials were images of real scenarios containing objects and people, and pictures of people and objects were presented on both the left and right sides of the computer screen. The position (left and right) in which the objects and person pictures appeared on the screen, and the gender of the person were balanced. The objects stimulus pictures were CI and control object (CO), both from the photographic website (https://699pic.com/), and the CI selected for this study used the Cambridge University Obsessions Questionnaire (CUQQ).The CIs were assessed by parents or teachers of children with ASD, and the CIs were selected from computer, fan, and vehicle according to the high to low selection rate, and the COs were selected from dishes, sofa, and green plants according to the low to high selection rate. The pictures of people were taken by ourselves, and the expressions of people in the scenarios were happy, and the two environments of office and outdoor were chosen for the shooting scenarios. The object Scenarios and character Scenarios were matched out of 12 groups of pictures, 6 groups of pictures containing CI Scenarios and character Scenarios, and 6 groups of pictures containing CO Scenarios and character Scenarios, see Fig. 1. all pictures were processed by Photoshop and the size was 1024×768 pixels.

Fig. 1. Example of Experimental Image (A: a two-person scenario with CI; B: a two-person scenario with CO)

2.3 Experimental Design

2 (subject type: children with ASD, children with TD) $\times$ 2 (distractor type: CI, CO) $\times$ 2 (perspective type: third-person perspective, first-person perspective) $\times$ 2 (information type: social information, non-social information) mixed-factor design.

2.4 Experimental Procedures

Subjects were 60–70 cm away from the computer display. Using SMI RED500 eye-tracker to record the data of eye-tracking, and 5-point calibration was used, and the experiment began with the main subject explaining to the subject the instruction phrase: "XXX (subject's name) please look at the picture on the screen." When the subject was ready to start the experiment, there are two images of practiced trials from each of the various experimental conditions, and then the formal experiment was started, with each image presented 5 s, and then presented a "+" white screen 1s. A total of 12 groups of pictures (excluding practice trials) were presented, each experimental conditions has 6 groups, and each subject watched all images. The images were presented randomly for different experimental conditions. Subjects just expected to look the computer screen whithout any task. The procedure is shown in Fig. 2.

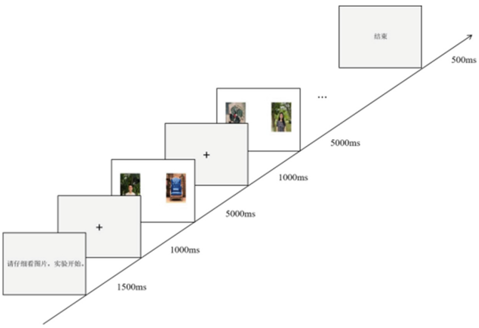

Fig. 2. Experimental flow chart

2.5 Experimental Apparatus

Subjects' gaze behavior was eye-tracked using an SMI RED500 eye-tracker with a sampling rate of 500 Hz. Stimulus material was presented using a 20-in. desktop computer display with a screen resolution of 1680 × 1050 pixels.

2.6 Areas of Interest and Analysis Metrics

Area of interest: left and right full image, object, head, body, and person. See Fig. 3 for details.

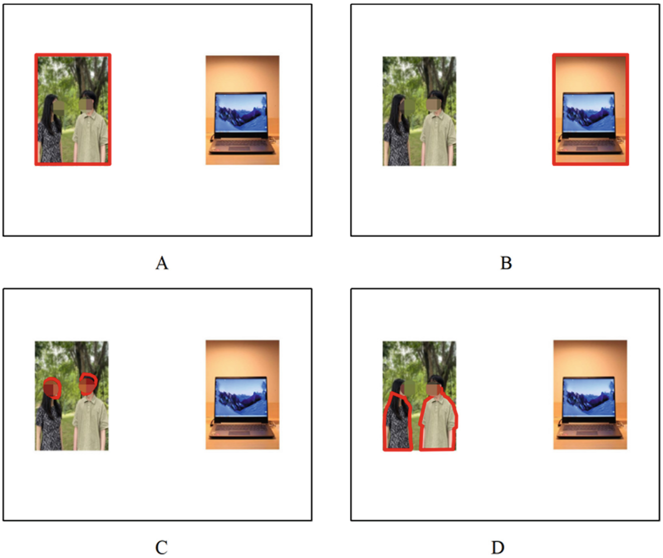

Fig. 3. Example of areas of interest (AOI) (A: full-image of people, B: full-image of object, C: head, D: body, the area except people is the background)

Analysis indexes: (1) gaze time: the sum of all gaze time and eye-hopping time between entering an area of interest and leaving this area of interest; (2) fixation count: the total number of gaze points falling on the area of interest; (3) dwell time ratio: the dwell time ratio of the full map area of interest is the ratio of the dwell time of the full map area of interest to the total dwell time presented in the full map; the dwell time ratio of the local area of interest is the ratio of the dwell time of the local area of interest to the dwell time of the full map area of interest, and because of the size difference between different areas of interest, the dwell time ratio is further area normalized, i.e., the dwell time ratio is then divided by the area ratio of the area of interest to the full map area of interest. (4) time to first fixation time (TFF): the time spent on the first fixation to the area.

3 Results

3.1 Analysis of Social Information, Non-social Information Full Map

A 2 (subject type: ASD, TD) × 2 (interferer type: CI, CO) × 2 (perspective type: third-person perspective, first-person perspective) × 2 (information type: social, non-social) repeated measures ANOVA was performed on the oculomotor metrics of the full figure, and the results are shown in Fig. 4.

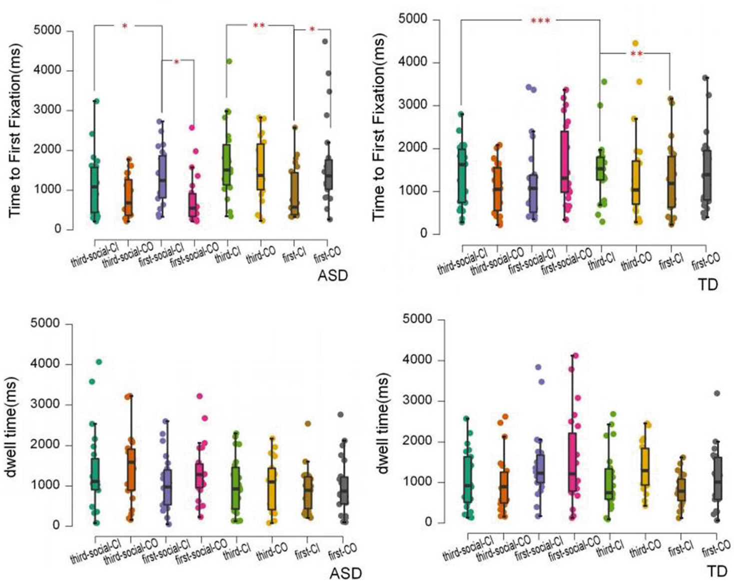

Fig. 4. Subjects' fixation condition on different types of pictures

(1) TFF

ANOVA revealed a significant subject type main effect, $F(1{,}41) = 4.49$, $p < 0.05$, $\eta_p{}^2 = 0.176$; and interactions for subject type, information type, perspective type, and distractor type, $F(1{,}41) = 7.21$, $p < 0.05$, $\eta_p{}^2 = 0.256$. All other main effects and interactions were not significant.

Further simple effects analysis revealed that under the first-person perspective, children with ASD had significantly shorter TFF for characters appearing simultaneously with CI than for characters appearing simultaneously with CO ($p = 0.044$), and children with ASD had significantly shorter TFF for characters appearing simultaneously with CI than children with TD ($p = 0.005$); children with ASD had significantly shorter TFF for CI than for CO ($p = 0.000$) and also perceived the CI significantly shorter than in the case of the third-person perspective ($p = 0.007$). In the third-person perspective, children with ASD had significantly shorter TFF for characters presented in pairs with CI than children with TD ($p = 0.027$) and also significantly shorter TFF for the first-person perspective ($p = 0.038$); children with TD had significantly shorter TFF for CI than for the first-person perspective ($p = 0.001$). children with ASD had significantly shorter TFF than children with TD.

(2) gaze time

ANOVA revealed a significant main effect of information type, $F(1{,}41) = 9.7$, $p < 0.01$, $\eta_p{}^2 = 0.316$; the interaction between subject type, information type, and perspective type was significant, $F(1{,}41) = 8.5$, $p < 0.01$, $\eta_p{}^2 = 0.288$. All other main effects and interactions were not significant.

Further simple effects analysis revealed that under the first-person perspective, TD children gaze time significantly longer at people ($p = 0.046$) and also significantly longer at objects ($p = 0.002$) than under the third-person perspective. Under the third-person perspective, children with ASD had significantly longer gaze time for people than children with TD ($p = 0.028$), children with ASD had significantly longer gaze time for people than objects ($p = 0.027$), and children with TD had significantly longer gaze time for objects than for the first-person perspective ($p = 0.026$). Subjects' gaze time was significantly longer for people than for objects.

3.2 Detailed Analysis of Social Information

A repeated-measures ANOVA was performed on the social information 2 (subject type: children with ASD, children with TD) × 2 (distractor type: CI, CO) × 2 (perspective: third-person perspective, first-person perspective) × 3 (AOI: background, body, head), and the results are shown in Fig. 5.

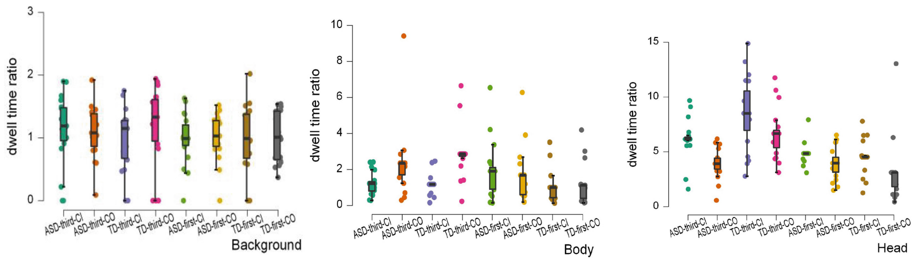

Fig. 5. Ratio of subjects' gaze time for different types of interest areas

On the gaze time ratio, the ANOVA results found a significant main effect of area of interest type, $F(1,36) = 313$, $p < 0.001$, $\eta_p{}^2 = 0.97$; main effect of perspective type, $F(1,36) = 44$, $p < 0.01$, $\eta_p{}^2 = 0.71$, interaction of subject type, perspective type, and area of interest, $F(1,36) = 11.6$, $p < 0.01$, $\eta_p{}^2 = 0.58$. All other main effects and interactions were not significant.

Further simple effect analysis revealed that the gaze time ratio for the body was significantly biger for ASD children than TD children in the first-person perspective ($p = 0.011$). Under the third-person perspective, TD children had a significantly biger gaze time ratio to the head than ASD children ($p = 0.000$); ASD children had a significantly biger gaze time ratio to the figure's head than in the first-person perspective ($p = 0.037$); TD children had a significantly biger gaze time ratio to the body, head than in the first-person perspective ($p = 0.000$). The subjects' gaze time ratios for the area of interest were ranked from largest to smallest: head, body, and background. Subjects' gaze time ratio for pictures in the third-person perspective was significantly biger than that of the first-person perspective.

4 Discussion

4.1 Early Processing of Social Scenarios by Children with ASD

The results of this study showed that children with ASD had significantly shorter TFF for characters in both the first-person and third-person perspectives than children with

TD. However, children with ASD also had significantly shorter TFF for CIs in the first-person perspective than children with TD, and this result did not occur in the third-person perspective. This suggests that children with ASD are able to perceive social information early, but shift their attention to CI when the model looks directly at the child with ASD (first-perspective condition). Some previous studies have supported the results of the present study, Hernandez found that individuals with ASD increased their face gaze time only in conditions where the actor's gaze was not direct [26]. Since the visual preference paradigm chosen for the present study, reported by Qi, such a presentation would allow subjects to engage in "forced selection," and the less gaze time on social stimuli in this condition could be due to avoidance of social stimuli by children with ASD, or it could be due to an over-preference for CIs over-preference [27]. Since TFF is an indicator of early processing stages [28], the results of this study found that children with ASD actively engage in the early processing of social information but avoid first-perspective social cognitive processing.

In addition, the present study found that in the first-perspective situation, children with ASD perceived people presented in pairs with CIs significantly shorter than those with COs, suggesting that the presence of CIs facilitates early processing of social information in children with ASD in the first-person perspective, which is similar to previous findings, Koegel found that CI objects improved social interactions between children and peers [29], and researchers also found significant activation of the amygdala and syrinx gyrus in the brain when individuals with ASD looked at CI objects [30]. It can be seen that CI can be appropriately introduced in future studies, especially in the case of children with ASD who have direct eye gaze, as a way to facilitate early processing of social information in children with ASD, but the present study did not find that children with ASD gaze more at CI-related social information on gaze duration indicators, which may be due to the fact that the CI objects selected for the present study were not specific to each child with ASD specifically assessed, but rather for this study group. The effect of CIs on children with ASD's attention to social scenarios could be further tested in the future by assessing CIs for each ASD subject.

4.2 Perspective Influences Children with ASD's Gaze on Social Scenarios

The results of this study found that children with ASD gazed at third-perspective characters for significantly more time than children with TD; and children with ASD gazed at people more often in the third-perspective rather than in the first-perspective condition. This indicates that children with ASD do not avoid social information in the third-perspective situation and actively engage in social cognitive processing. When the first-perspective situation, children with ASD and the model's eyes were in a reciprocal gaze, the gaze time ratio on the peoples' body was significantly biger for children with ASD than TD, whereas the gaze time ratio on the figure's head was significantly biger for children with ASD than TD in the third-perspective situation. The results of the present study showed that children with ASD did not gaze at reduced social information in all situations, especially the head, and since researchers usually consider the head to be the significant social information [31], Wang also found that children with ASD showed an increase in attention allocation to the eyes when performing an active task (facial identity judgment task) compared to a passive task (perspectiveing the same stimuli)

[15]. The results of the present study do not support the social motivation theory [5], the present study found that children with ASD do not avoid social information, direct eye avoidance of direct eye gaze, and that children with ASD gaze at social information is atypical, but does not mean that they lack social motivation, as the results of the present study show that in the third perspective, children with ASD not only attended to social information more than nonsocial information but also attended to the head of the salience area more than TD children, as shown in the present study. Therefore, it is hypothesized that children with ASD may perceive themselves as participating in this process in the third perspective, for example, in their daily lives, they watch their parents and teachers talking in the third perspective, and in addition, in this case, they do not need to make direct eye contact, so they do not avoid looking at the social Scenarios in the third perspective.

To sum up, future researchers should focus on the social processing function of children with ASD, especially the social processing function of the third perspective. In addition, special education teachers can also use the third perspective presentation of social information to teach or intervene with children with ASD, such as avoiding looking directly at the students during lectures or showing some instructional videos so that the social stimuli in the videos do not look directly at the students, which may promote children with ASD to pay more attention to social information and instructional content. Furthermore, the results of this study can be applied in the future in conjunction with artificial intelligence (AI), such as creating a humanoid robot that gradually evolves from a third-perspective to a first-perspective state of presenting instructional information, thereby promoting the development of socially relevant skills in children with ASD.

5 Conclusion

The following conclusions are drawn from this study: first, children with ASD will promote their fixation on people in the third-person perspective, which shows that the gaze time of ASD children on people is significantly longer than on objects in the third perspective; second, in the first perspective, CI It will promote ASD children to perceive social information earlier, and it is shown that in the first perspective, ASD children's perception time of people paired with CI is significantly shorter than that of people paired with CO.

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