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ORIGINAL PAPER

Increased Eye Contact During Conversation Compared to Play in Children With Autism

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Abstract Children with autism have atypical gaze behavior but it is unknown whether gaze differs during distinct types of reciprocal interactions. Typically developing children (N = 20) and children with autism (N = 20) (4–13 years) made similar amounts of eye contact with an examiner during a conversation. Surprisingly, there was minimal eye contact during interactive play in both groups. Gaze behavior was stable across 8 weeks in children with autism (N = 15). Lastly, gaze behavior during conversation but not play was associated with autism social affect severity scores (ADOS CSS SA) and the Social Responsiveness Scale (SRS-2). Together findings suggests that eye contact in typical and atypical development is influenced by subtle changes in context, which has implications for optimizing assessments of social communication skills.

Keywords Autism spectrum disorder (ASD) · Eye contact · Gaze · Context · Play · Naturalistic interactions

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Introduction

Atypical eye contact is a diagnostic hallmark of Autism Spectrum Disorder (ASD) (American Psychiatric Association 2012) and individuals with ASD have difficulty modulating gaze behavior during social interactions (Charman et al. 1997; Dawson et al. 2004; Mundy et al. 1986; Stone et al. 1997). While there is a substantial body of research documenting atypical use of gaze to regulate social behavior and abnormal processing of face stimuli in ASD (for a review see Senju and Johnson 2009), few studies to date have examined how contextual factors modulate gaze behavior in this population (Dawson et al. 1990; Nadig et al. 2010). The present study sought to determine whether the amount of eye contact with an unfamiliar examiner would differ during distinct aspects of social interactions, specifically interactions in the presence or absence of toys. Determining whether the amount of eye contact differs across distinct contexts in ASD may be important for interpreting social communication behavior in a clinical setting and assessing changes in response to behavioral or pharmacological treatments.

Examinations of how context influences the gaze behavior of children with ASD during real-time social interactions are limited. In one study, children with ASD spent less time looking at their caregiver, compared to children with developmental delays without ASD and TD children, during unstructured free play (Kasari et al. 1993). Interestingly, there were no group differences in gaze when caregivers were asked to actively engage the child (Kasari et al. 1993). Thus interactions facilitated by an adult increased looking behaviors in children with ASD such that their behavior did not differ from children without ASD. This finding echoed earlier research demonstrating that when children with ASD interact with an individual who is familiar (i.e. a caregiver) and scaffolds the interaction, they tend to look toward their caregiver's face as much as TD children (Dawson et al. 1990). It is unknown whether there are differences in gaze behavior in children with ASD during interactive play compared to interactions with an adult when no toys are present.

Dawson et al. (1990) studied children's gaze directed to their caregiver under conditions of low communication demands (free play with toys) and high communication demands (putting toys away and snack time) and found no differences between TD and ASD children in either of the conditions. Unfortunately, there were no direct comparisons between the two conditions (free play and putting toys away/snack time). Within conversation, Nadig and colleagues (Nadig et al. 2010) showed that when children with ASD and TD children engaged in a conversation about a topic of interest to them, they made more eye contact than when engaged in a conversation on a generic topic. Together, these studies begin to suggest that gaze of children with ASD is directly influenced by the level of engagement during a social interaction.

To date, no studies have explicitly examined the impact of the presence versus absence of toys on gaze in autism, nor contrasted how gaze differs during interactive play versus conversation. Understanding whether the presence of toys alone impacts gaze behavior is critical for optimizing the assessment of social behaviors in this population, and may have implications for assessing changes in eye gaze in response to treatments that target social communication skills. More broadly, directly contrasting how gaze differs during interactive play versus conversation is ultimately critical for understanding how social behavior differs across contexts in both typical and atypical development.

In this study we conducted three investigations with the goal of examining variability in eye gaze as a result of the social context in children with ASD and typically developing children. First we examined whether the duration and frequency of eye contact differed between interactive play with toys in comparison to a conversation when no toys were present. We hypothesized that children with ASD would make less eye contact with the examiner across play and conversation compared to TD children. Second, we assessed whether patterns of gaze behavior observed during interactive play versus conversation are constant across a short period of time (8 weeks) in children with ASD, in order to verify that any observed contextual effects were stable. We hypothesized that children with ASD would demonstrate consistency in their gaze behavior across the two time points. Finally, we examined associations between the amount of eye contact shown during these two interactions and standardized parent-report and clinician-rated measures of autism symptoms. We hypothesized greater amounts of eye contact during both interactive contexts would correspond to less severe ratings of autism symptoms on these measures.

Methods

Participants

Participants were drawn from ongoing studies at Weill Cornell, with approval from Weill Cornell Medicine's IRB. Parents gave written consent and children 7 years and older provided assent.

Sample 1

Twenty children with a diagnosis of Autism Spectrum Disorder (ASD) (4 females) and 20 Typically Developing (TD) children (6 females) were recruited through the Center for Autism and the Developing Brain (CADB) in White Plains, NY and the Sackler Institute for Developmental Psychobiology in Manhattan, NY at NewYork-Presbyterian/Weill Cornell Medicine. Participants were between 4 and 13 years of age (mean age = 7 years). The TD and ASD samples were age, gender and IQ matched (see Table 1 for participant demographics). Participants

Table 1 Sample demographics and descriptive statistics

	TD	ASD (sample 1)	ASD (sample 2)
N	20	20	15
Males	14	16	12
Age	7 (1.7)	7 (2.1)	8 (2.8)
VIQ	98.35 (18)	105.55 (18)	95.07 (26)
NVIQ	111.3 (19)	109.75 (25)	99.40 (29)
SRS-2 *t* score	47.9 (6)	67.9 (8)	70 (7)
CSS total	na	7.7 (1.5)	7.5 (1.7)
CSS SA	na	7.8 (1.4)	7.7 (1.7)
CSS RRB	na	6.7 (2.5)	6.9 (2.8)
Ethnicity			
Caucasian (%)	30	60	60
Hispanic (%)	30	10	7
Asian (%)	10	10	7
African American (%)	20	0	0
Biracial (%)	15	25	26

VIQ verbal IQ, *NVIQ* nonverbal IQ, *SRS-2* social responsiveness scale second edition, *CSS total* calibrated severity score from ADOS, *CSS SA* ADOS calibrated severity score for social affect, *CSS RRB* ADOS calibrated severity score for restricted and repetitive behaviors. Age, VIQ, NVIQ, and SRS-2 expressed as Mean (Standard Deviation)

Table 2 Rates per minute and percent durations of eye contact during conversation and interactive play

	Conversation	Interactive play
TD		
Duration	44.1 (17.9)	5.5 (4.7)
Rate	12.0 (1.4)	3.8 (0.7)
ASD (sample 1)		
Duration	33.7 (17.2)	5.5 (6.7)
Rate	10.5 (1.3)	2.8 (0.7)
ASD (sample 2): time 1		
Duration	28.5 (17.9)	3.9 (4.5)
Rate	10.7 (1.8)	3.0 (0.9)
ASD (sample 2): time 2		
Duration	27.8 (15.4)	4.2 (5.9)
Rate	10.9 (1.5)	3.0 (1.1)

All averages expressed as Mean (Standard Error)

completed play-based assessments during a single visit. TD participants also completed cognitive testing on the same day.

Sample 2

20 children with ASD were recruited through CADB to participate in a longitudinal 8-week study. Five participants were excluded from the sample due to technical problems with the video camera, severe behavioral problems that prevented the completion of the behavioral assessments, or the removal of an eye patch between the first and final visit. The final sample of 15 children (3 females) was between 5 and 13 years of age (mean age = 8 years) (see Table 1 for participant demographics). Seven of the participants were also included in sample 1. Participants completed play-based assessments during two visits that were 8 weeks apart (week 1:T1; week 8:T2). There was no specific treatment or intervention across the 8 weeks so there were no predictions that there would be significant changes in the child's behavior from T1 to T2.

Procedures

For ASD participants, diagnosis was confirmed prior to participation by a licensed clinical psychologist at CADB. A best estimate diagnosis was based upon information collected from the Autism Diagnostic Observation Schedule (ADOS) (Lord et al. 2012) and the Autism Diagnostic Interview-Revised (ADI-R) (Rutter et al. 2003). Calibrated severity scores (CSS) for Social Affect (SA) and for Restricted and Repetitive Behaviors (RRB) were derived from the ADOS on a scale from 1 to 10 (Hus et al. 2014). Full scale IQ as well as nonverbal and verbal IQ were calculated from the Differential Abilities Scales (DAS) (Elliott 2007), the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV) (Wechsler 2008), or the Wechsler Preschool and Primary Scales of Intelligence-Fourth Edition (WPPSI-III) (Wechsler 2012), depending on developmental level of the child.

All caregivers completed the Social Responsiveness Scales Second Edition (SRS-2) (Constantino 2012) to measure general autism symptoms and behavior difficulties, and to screen for presence of ASD symptoms in the TD control group (sample 1). The SRS was missing from one individual who was excluded only from analyses involving the SRS. Descriptive statistics for these measures in both samples can be found in Table 1.

Play and Conversation Interaction

All participants completed a modified version of the Brief Observation of Social Communication Change (BOSCC) (Grzadzinski et al. 2016), a 12-min examiner-subject interaction that consisted of two 5-min interactive play segments with standardized sets of toys, separated by a 2-min conversation segment. Unlike the standard BOSCC procedures that allow the child to move freely around the room (Grzadzinski et al. 2016), the examiner and participant were seated across from each other (face-to-face) at a small table. During the interactive-play, the child was given the option to choose a single toy from a variety of standardized options that were placed in a box. The set of toys presented varied from the first play segment to the second play segment. Within each play segment, the child was free to chose a new toy if they no longer wanted to play with the toy originally chosen. The child was free to play with each toy as he or she saw fit; the examiner joined the child's play but did not guide it, and maintained an amount and level of language commensurate with the child's. The transition to the conversation segment was signaled by the examiner stating that it was time to clean up and then introducing an open-ended conversation topic (e.g., "I went to the park this weekend"). During the conversation, no toys were present on the table. Thus, interactive play segments were defined as the two 5-min periods where materials were present and the examiner was available as an interactive partner, and conversation segments were defined as the 2-min periods without materials when only the examiner was available as a conversation partner. Three examiners (AH, CC, RJ) administered the BOSCC in sample 1 and two examiners (AH, CC) administered the BOSCC in sample 2. In sample 2, the same examiner completed the BOSCC at T1 and T2 with each subject, except for one case when the examiner changed between T1 and T2.

The BOSCC assessments were recorded with Pivothead Kudu camera glasses worn by the examiner. These glasses have an outward facing camera embedded in the bridge over the nose, and thus naturally captured the child's face and shifts in gaze toward the examiner.

Eye Gaze Coding

Videos recorded by the Pivothead glasses were manually coded by trained individuals for each instance the child looked directly into the camera, which—given that the camera's location in the bridge over the nose—served as an approximation for making eye contact with the examiner. Five coders used Mangold International's INTERACT video annotation software to flag frame-level onsets and offsets of the following: (1) each instance of eye contact with the examiner; (2) the play and conversation segments; (3) each toy that the child engaged with during free-play. Inter-rater reliability for segment and toy coding was calculated as percent agreement in overlap for each segment in time. Percent agreement across all pairwise comparisons of five coders across 9 sessions ranged from 91% to 99%. Inter-rater reliability for eye contact coding, assessed via an intraclass correlation coefficient, was 0.96 across the five coders.

Data Analysis

Because the duration of the interactive play and conversation segments varied across participants (242–351 s for play; 89–147 s for conversation), durations and frequencies of eye contact were expressed as proportions and rates, relative to the duration of the segment. The use of proportions and rates allowed for comparisons of eye contact across individuals who differed in the duration of their interactive play and conversation segments. The terms duration of eye contact and frequency of eye contact refer to these calculated proportions and rates.

Duration of eye contact in the first play segment did not differ from the duration of eye contact in the second play segment in sample 1 ($p = 0.9$) and across T1 and T2 in sample 2 (p's > 0.5). Similarly, the frequency of eye contact during the first play segment and the second play segment was no different in sample 1 ($p = 0.3$) or across T1 and T2 in sample 2 (p's > 0.2). Thus, for all analyses the duration and frequency of eye contact from the two play segments were averaged together.

In sample 1, the percent duration and rate of eye contact during interactive play and conversation were compared with separate repeated measures ANOVAs with context (play, conversation) as the repeated factor. Diagnosis (ASD versus TD) was included as a between subjects variable. In sample 2, the percent duration and rate of eye contact during interactive play and conversation across the two time points were compared in 2 (context: play, conversation) by 2 (time: T1, T2) repeated measures ANOVAs.

To determine whether autism symptom severity in the social and restricted and repetitive behavior domain differentially impacted the amount and frequency of eye contact across contexts, the ADOS CSS SA and CSS RRB were included as covariates together in a 2×1 repeated measures ANOVA as described above, with duration of eye contact as the dependent variable. A second ANOVA was performed with rate of eye contact as the dependent variable. Eye contact data was pooled across samples by taking the T1 data from sample 2 and combining it with sample 1. Post-hoc bivariate correlations were used to interrogate significant interactions between context and the CSS scores.

To understand whether general autism symptoms and problem behaviors differentially impacted the amount of eye contact across contexts, the SRS-2 T scores were included as a covariate in a 2×1 repeated measures ANOVA with percent duration of eye contact as the dependent variable. The SRS-2 scores were pooled across samples as described above. Post-hoc bivariate correlations were used to interrogate significant interactions between context and the SRS-2 scores. All analyses were performed in SPSS version 24. Following a Bonferroni correction for the multiple comparisons between duration and frequency of eye contact, p's < 0.025 were considered significant.

Exploratory analyses examined whether the type of toy impacted the amount of eye contact the child made with the examiner during interactive play. Because participants were free to select any of the 31 toys presented across the two boxes, we identified the six toys most frequently selected by ASD and TD participants. Analyses focused on the amount of eye contact made while playing with these toys, expressed as a proportion relative to the amount of time the child interacted with the toy. As all children did not play with the same toys, the data was analyzed for descriptive purposes only in order to demonstrate that children made different amounts of eye contact during play depending on the toy (see Supplementary Fig. 1).

Two control analyses were performed to test whether (1) different examiners influenced gaze behavior and (2) gender impacted gaze behavior. The identity of the examiner was included as a covariate in all analyses described above. There were no significant interactions, confirming that the BOSCC administrator didn't impact the results reported below. Second, we restricted our analyses to males only (as there were too few females to do a direct comparison) and found no differences in the reported findings, suggesting no effects of gender on our results.

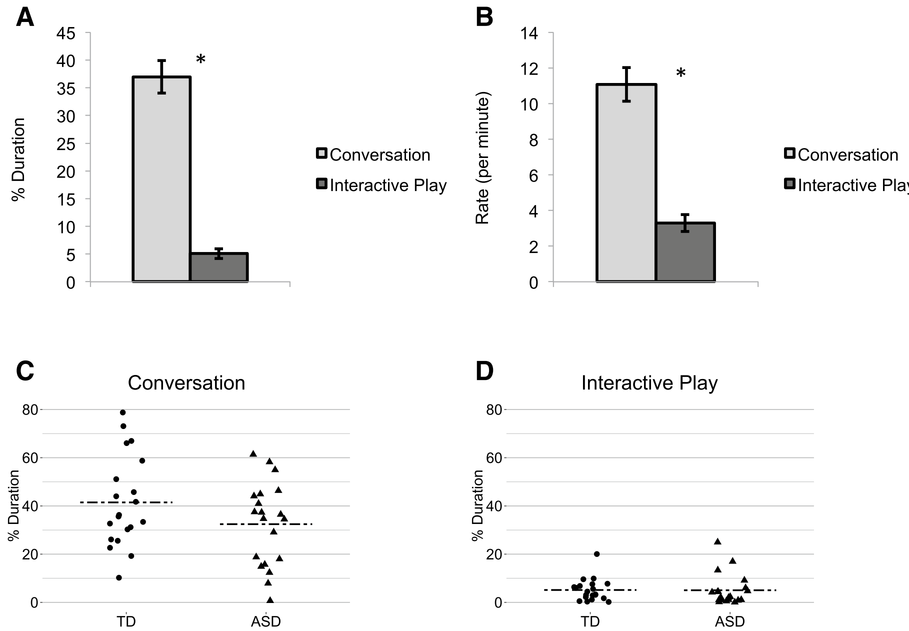

Fig. 1 Mean of the percent duration (**a**) and rate per minute (**b**) of eye contact during conversation and interactive play, averaged across the ASD and TD participants (*error bars* represent standard error of the mean). Individual means of percent duration of eye contact during conversation (**c**) and interactive play (**d**), presented separately for children in the ASD group and TD group

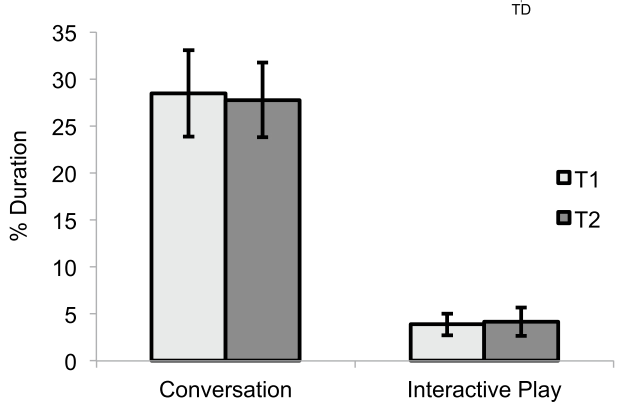

Fig. 2 Average duration of eye contact during conversation and interactive play in children with ASD in sample 2, measured at time 1 (week 1) and time 2 (week 8)

Results

Analysis of the matched sample of ASD and TD participants (sample 1) indicated that participants had a higher duration of eye contact with the examiner during conversation compared to free play ($F(1,38) = 151.5$, $p < 0.001$, $\eta_p^2 = 0.8$) (Fig. 1a) and made more frequent eye contact with the examiner during conversation versus free play ($F(1,38) = 98.9$, $p < 0.001$, $\eta_p^2 = 0.7$) (Fig. 1b). The interaction between context and diagnosis was not significant for the duration of eye contact ($p = 0.09$) nor for the frequency of eye contact ($p = 0.9$).

Analysis of longitudinal data from ASD participants (sample 2) indicated that the impact of context on duration and frequency of eye contact was consistent across the two time points. Similar to the findings from sample 1, there was a main effect of context (play versus conversation) for both duration of eye contact ($F(1,14) = 51.1$, $p < 0.001$, $\eta_p^2 = 0.8$) (Fig. 2) and frequency of eye contact ($F(1,14) = 31.3$, $p < 0.001$, $\eta_p^2 = 0.7$), but no significant effects of time (p's > 0.9) or interaction between time and context (p's > 0.7) (Table 2).

The duration of eye contact during play versus conversation was significantly associated with the severity of social affect symptoms on the ADOS (CSS SA), as evidenced by a significant interaction between severity and context, ($F(1,25) = 8.98$, $p < 0.01$, $\eta_p^2 = 0.3$). The interaction between severity of symptoms in the restricted and repetitive behavior domain and context was not significant ($p = 0.7$). Post-hoc analyses demonstrated that children with more severe social affect symptoms made less eye contact with an examiner during conversation compared to those who had less severe social affect symptoms ($r = -0.48$, $p < 0.02$) (Fig. 3a). There was no impact of severity of social symptoms and the amount of eye contact during play ($p = 0.9$) (Fig. 3b). There was no association between frequency of eye contact and severity of social affect symptoms or restricted and repetitive behavior symptoms (p's > 0.2).

The duration of eye contact during play versus conversation was significantly associated with scores on the SRS-2, as evidenced by a significant interaction between SRS scores and context ($F(1,45) = 7.4$, $p < 0.01$, $\eta_p^2 = 0.14$). Post-hoc analyses demonstrated that individuals with higher scores on the SRS (more severe autism-related behaviors) made less eye contact during conversation ($r = -0.4$, $p < 0.01$) (Fig. 3c). There was no association between the SRS and the amount of eye contact during play ($p = 0.24$) (Fig. 3d).

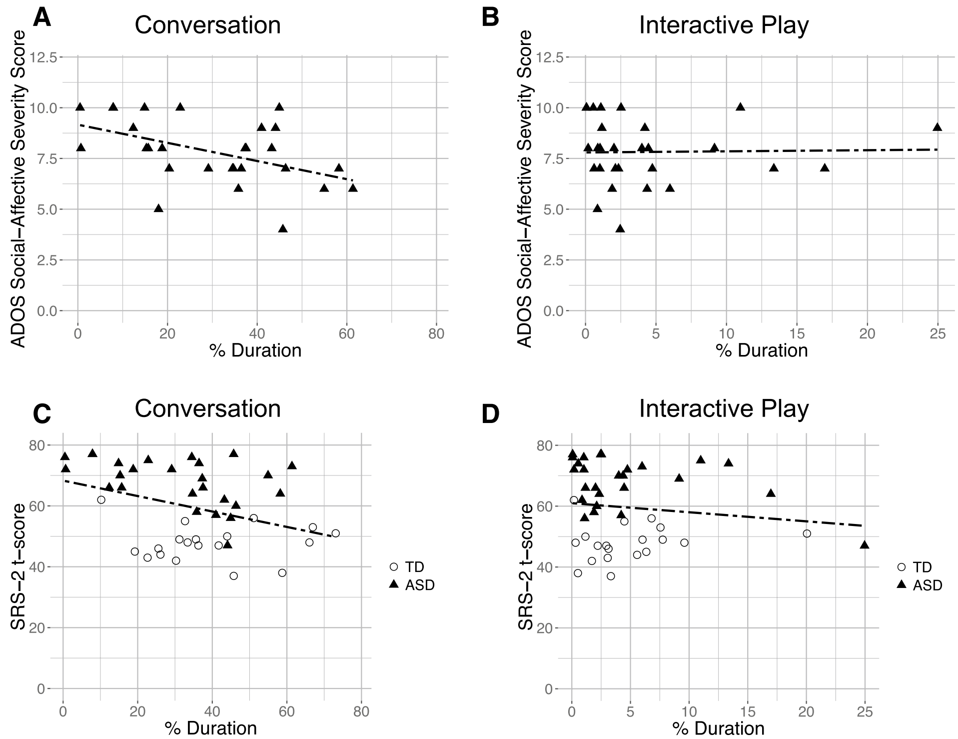

Fig. 3 Percent duration during conversation is associated with ADOS social affective severity score (CSS SA) (**a**) but percent duration during play is not associated with CSS SA (**b**). Percent duration during conversation (**c**) is associated with SRS-2 *T* scores but percent duration during play is not associated with SRS-2 T scores (**d**)

Discussion

The present study determined whether gaze behavior varied across distinct reciprocal social interactions in children with autism and typically developing children. Both groups made more frequent eye contact while engaging in a conversation in the absence of toys compared to interactive play with toys. Surprisingly, in contrast to conversation, there was minimal eye contact during interactive play in both ASD and TD groups. These findings suggest that gaze behavior in ASD should be probed across multiple contexts, including in the absence of toys, in order to elicit the greatest amount of eye contact. The gaze differences observed across contexts were stable over a short time period and the amount of eye contact during conversation was associated with common gold standard measures of autism behaviors, demonstrating the validity of these gaze measurements gathered during a brief clinical assessment. Together the results have clear implications for optimizing the content of assessments that measure gaze behavior in children with autism who are more cognitively able.

Children regardless of diagnosis made little eye contact during interactive play. The minimal eye contact during play was surprising, as toy-based interactions typically elicit shifts of gaze between objects and the social partner's face in young children, and there is evidence that children with autism make more eye contact when engaged in play activities of their choosing (Koegel et al. 1987). Currently, observational assessments of gaze and joint attention typically involve toy-based interactions (Mundy et al. 2003; Wetherby and Prizant 2002) and our findings could be interpreted as calling into question the nature of these assessments. Yet, the data should not be characterized as a reason to eliminate toy based assessments to probe for eye contact. Indeed, follow up analyses of the most frequently selected toys suggested that the amount of eye contact varied depending on the toy in both groups of children, such that certain toys elicited greater amounts of eye contact (e.g. wind up toys) compared to other types of toys (e.g. angry birds board game). Thus the data suggests that assessments that target gaze behavior in autism should present multiple toys, as certain toys may evoke more eye contact in children than other toys. In addition, assessments should include interactions where no toys are present, as it is likely the absence of toys may elicit more eye contact.

Contrary to our hypotheses, children with ASD did not differ from typically developing children in their gaze behavior across the two interactive contexts. Prior studies with somewhat younger and less cognitively able samples similarly reported no differences between TD children and children with ASD in attending to the face when interacting with their caregivers (Dawson et al. 1990; Kasari et al. 1993). We demonstrated a trend at $p = 0.09$, that TD children had longer durations of eye contact during conversations compared to those with ASD, relative to the durations of eye contact exhibited during play, which were strikingly similar across groups. In contrast, there was no evidence of a difference in the frequency of eye contact between TD and ASD in either context. Together, the findings paint a more nuanced picture of the nature of atypical eye contact in autism, suggesting that gaze may be qualitatively different (briefer) in ASD relative to TD children. Future studies that examine children with autism who are less cognitively able will aid in further understanding the impact that context has on gaze behavior as well as the similarities and differences across a range of children with atypical development compared to those who are typically developing.

Interactions in the absence of toys elicited greater amounts of eye contact relative to when toys were absent. These findings were somewhat surprising in the ASD group, as one might have predicted that the increased social demands during a conversation without toys may diminish eye contact in ASD. However, the findings are consistent with previous research demonstrating that both TD and children with ASD make more eye contact when motivated during a conversation (Nadig et al. 2010). Notably, in the current study, children with autism and TD children made similar amounts of eye contact in the absence of toys as reported in previously published findings on age-related trends in TD child–adult dyads (Levine and Sutton 1973). It is important to note that the children in this study were 4–13 years of age, and that children who are younger may be more influenced by the presence or absence of toys. In this study the examiner was an unfamiliar adult and previous research has suggested that familiar adults (i.e. caregivers) are more likely to engage the child and elicit greater amounts of eye contact (Dawson et al. 1990). Future studies will need to consider probing gaze behavior with familiar versus unfamiliar adults in the presence and absence of toys to fully flesh out how gaze behavior is modulated by these contextual factors, much as has been the case for eye tracking studies that have reported modulation of looking to eyes and faces based on varying stimulus characteristics, (e.g., static faces versus dynamic social scenes) (Senju and Johnson 2009).

The amount of eye contact during conversations was associated with severity of autism symptoms in the ASD group, as well as overall general autism symptoms and behavior difficulties across groups. These associations confirm that quantitative measures of amount of eye contact captured meaningful variation in social-communication symptoms in individuals with ASD. The lack of associations between ASD symptoms and the amount of eye contact during interactive play is intriguing, though likely attributable to the general lack of variability in gaze behavior in both groups. We also observed stability in the frequency and duration of eye contact across a short time period, highlighting the robustness of the findings. Together the individual differences and repeated measures findings across time highlight the validity and stability of the quantitative gaze behavior measures across context.

Limitations

In the current study, we targeted children with ASD who had sufficient language to engage in a dialogue with an examiner. While it will be important to replicate these findings with less cognitively able children with ASD, it is likely that the differences in eye gaze that were observed across contexts were not necessarily driven by the conversation per se, but simply the absence of toys. Future studies that explore whether the absence of toys without the support of verbal interaction increases eye contact will be important to further understand why gaze varies across contexts.

Conclusions

The present study demonstrated the importance of considering context when measuring eye gaze behavior in children with autism, highlighting subtle changes in environmental demands on a child can significantly influence the display of social communication behaviors. Clinical assessments for measuring social communication behaviors in autism should consider interactions with and without toys in order to maximize the amount of eye contact observed. From a methodological perspective, video-based coding of gaze behavior was facilitated by the unique viewpoint afforded by the Pivothead glasses. Specifically, the placement of the camera in the bridge over the nose readily captured moments of eye contact as looks directly into the camera. Ongoing work by our group that capitalizes on the unique viewpoint afforded by such Point-of-View (POV) cameras to develop automated measures of frequency and duration of gaze behavior (Ye et al. 2015) may reduce the time burden inherent in manual coding of video. Such advances may not only enable large scale, systematic explorations of the influence of multiple factors on gaze behavior in ASD, but may lead to scalable, standardized measures that could be utilized by clinical and research settings.

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Author Contributions RMJ, AH, CC, EK, JMR, CL and AR participated in the design of the study. RMJ, AH and CC collected the data. RMJ, AS, AH, CC, CB, SN, ES, EK, CW and AR participated in the data coding and analysis. RMJ, CW and AR performed the statistical analyses with the oversight of JMR and CL. RMJ and

AR drafted the manuscript. All authors read and approved the final manuscript.

Compliance with Ethical Standards

Conflict of interest Catherine Lord receives royalties from two measures that were used in this study (ADI-R, ADOS-2) and all proceeds related to this project were donated to charity. No other authors report conflicts of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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