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Yongyi Wang April 7, 2023

Social Visual Engagement in Children With and Without Autism: Classroom and Lab Observations

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Abstract

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By Yongyi Wang

Autism Spectrum Disorder (ASD) is a genetic disorder that causes significant social impairments. Twin studies of typically developing infants suggest that Social Visual Engagement (SVE), the time children spend looking at faces in social stimuli, is highly heritable and genetic. However, children with ASD show atypical patterns of SVE. In the lab, researchers conducted eye-tracking studies to investigate children's social attention, frequently with two types of dynamic social stimuli: First-person and Third-person interaction stimuli. In naturalistic environments, researchers measure children's social attention by recording children's active engagement through behavioral coding. This study adapts two classroom observational measures used by Siller et al. (2022) that measure children's attention to faces in the classroom: Face-looking and Onlooking. However, few studies have compared eye-tracking measures in lab and classroom observational measures directly to examine if similar constructs of social attention were captured. This study explored correlations between the First-person and Third-person interaction stimuli and Face-looking and Onlooking. We found a significant positive correlation between Third-person interaction stimuli and Face-looking, suggesting children who spent more time looking at the eye region in Third-person interaction stimuli received a higher score of Face-looking in the classroom. The significant correlation between eye-tracking and classroom observations on children's social attention provides guidance on assessing autistic children's readiness for inclusion programs and designing intervention programs to scaffold children's social attention in the classroom.

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Introduction

Infants and young children rely heavily on social engagement with caregivers and others to develop language skills and intersubjective knowledge (Wimpory et al., 2002; Koegel et al., 2012). One behavioral indicator of social engagement is the degree to which children attend visually to socially relevant information in their surroundings. Children with Autism Spectrum Disorder (ASD), a neurodevelopmental disorder, present with characteristic deficits in social attention (Dawson et al., 1998; Rochat & Striano, 1999). According to the social orientation hypothesis of autism, deficits in social attention underlie broader impairments in social communication and engagement with peers and adults (Dawson et al., 2004; Siller & Sigman, 2002).

Eye Tracking Measures of Social Visual Engagement (SVE)

Eye tracking has been used widely to evaluate children's social visual engagement (SVE). Results from this research have shown (a) children with ASD have characteristic deficits in SVE and (b) the deficits in SVE have been linked to subsequent developmental outcomes (Norbury et al., 2009; Shic et al., 2011; Speer et al., 2007; Rice et al., 2012; Jones et al., 2008). Further, twin studies that compared SVE patterns in monozygotic and dizygotic twins found that typically developing monozygotic twins show stronger correlations in the preferential attention to eyes and mouths, establishing the heritability of SVE (Constantino et al., 2017). The same study suggests that children with autism show atypical face-scanning patterns compared to typically developing twins with a diminished interest in eyes and mouths (Constantino et al., 2017). When evaluating SVE, eye-tracking studies used a broad range of stimuli (Mastergeorge et al. 2021; Papagiannopoulou et al., 2014), including static images and dynamic videos. Further, dynamic videos often include either first-person interaction stimuli (video recordings of one

actor talking into the camera) or third-person interaction stimuli (video recordings of social interactions between two or more people). While researchers have investigated differences between SVE in images and dynamic videos, few studies have compared First-person interaction stimuli and Third-person interaction stimuli directly.

Eye Tracking Research Using Third-person Interaction Stimuli

Third-person interaction stimuli are recorded videos that contain two or more individuals engaging in social interaction within the same frame. The individuals do not try to engage the viewer as a social partner, and the children would watch the videos passively. In general, children with autism show a gaze pattern that is incongruent with the storyline or the context of the conversation; on the other hand, typically developing children are able to shift and follow their gaze with the active speaker in the interaction (Hosozawa et al., 2012). Children with autism fixated more on the inanimate background than people, while typically developing children look more at people in social interactions (Rice et al., 2012; Shic et al., 2011). A preferential viewing of bodies over heads was also noticed in children with autism (Klin et al, 2002; Speer et al., 2007; Shic et al., 2011). When children with autism did attend to the head area of people, they spent less time looking at the eyes and more time looking at the mouth regions compared to the viewing patterns of typically developing peers (Shic et al., 2011; Speer et al., 2007). However, this preferential viewing of the mouth region over the eye region is inconsistent as Norbury and colleagues found no group difference in the fixation on the mouth between teenagers with and without autism; they argue the inconsistency of finding might be due to different levels of complexity of the social scenes in the Third-person interaction stimuli (Norbury et al., 2009).

Eye-tracking studies using Third-person interaction stimuli found inconsistent associations between the gaze patterns of children with autism and their social developmental outcomes. Researchers seem to agree on the associations between the fixation patterns on nonsocial objects and social development and found different results about fixation patterns on the face area. Increased fixation on the background was associated with greater social disability (Rice et al., 2012; Shic et al., 2011). While some researchers argued that the length of fixation on eyes positively predicted social responsiveness (Speer et al., 2007), others found that fixation on eyes in children with autism was not associated with social outcomes (Klin et al., 2002; Norbury et al., 2009). Across the autism spectrum, they found the fixation on the eyes was negatively associated with communicative competence; on the other hand, increased fixation on the mouth regions was positively associated with communicative and social competence (Klin et al., 2002; Norbury et al., 2009).

Eye Tracking Research Using First-person Interaction Stimuli

Caregiving stimuli are recorded videos that involve one individual looking into the camera and engaging the viewer through child-directed speech, games, or activities. Caregiving stimuli usually feature one single actor whose face region is large enough for researchers to discriminate the eyes and mouth regions reliably (Hosozawa et al., 2012). Generally, researchers found that infants who were later diagnosed with autism showed decreased interest in the social scene and increased interest in nonsocial elements compared to typically developing infants (Chawarska et al., 2013; Nakano et al., 2010). Interestingly, Chawarska and colleagues found that the decreased attention to social elements was not accompanied by enhanced attention to objects (2013). When children with autism did attend to social scenes, they showed a more scattered pattern of eye gaze, while the control group focused their gaze on faces (Nakano et al.,

2010). Compared to typically developing peers, infants who were later diagnosed with autism and children with autism both show shorter fixation length in the face area; on the other hand, they attended more to the mouth region (Chawarska et al., 2013; Nakano et al., 2010; Jones et al., 2008). There were fewer eye-tracking studies done with the First-person interaction stimuli, and only Jones and colleagues investigated the associations between the fixation patterns and the social development outcome in children with autism. They found that increased fixation on eyes predicted less severe social disability (Jones et al., 2008).

Observations of Social Attention in Preschool Classrooms

Classroom observations are effective tools to measure children's developmental progress because the method contextualizes children's learning by designing coding schemes that rate children's interactions with peers and teachers within preschool classrooms (Downer et al., 2010). Earlier research assessed children's interactions within the classroom by mainly measuring teaching quality (i.e. the Classroom Assessment Scoring System, Pianta, La Paro, & Hamre, 2008; Child-Caregiver Interaction Scale, Carl, 2007) rather than the individual child's experience (Sandilos & DiPerna, 2014; Williford et al., 2013). Recent classroom observation studies highlight the importance of evaluating children's active engagement in class, which reflects children's individual differences in responding to classroom demands (Johnson et al., 2021). In the literature of classroom observation studies for both typically developing and children with autism, active engagement was coded through live or recorded observational sessions by dividing active engagement into subcategories based on social partners (i.e. engaging with adults, peers, and tasks) or based on situations (i.e. instances that display engagement through social communication or play) (Fitzpatrick, 2012; Johnson et al., 2021; Rice et al., 2016; Vitiello & Williford, 2016; Boyd et al., 2018). Research has found that children's task

orientation during preschool is associated with self-regulation, social skills, and later achievement in formal schooling (Fitzpatrick, 2012; Vitiello & Williford, 2016). In an inclusive classroom setting, research suggests that children with autism were less likely to initiate coordinated joint attention with adults compared to their typically developing peers (Rice et al., 2016). Obtaining data on children's engagement in a naturalistic setting helps researchers draft realistic developmental patterns and challenges and design practical interventions accordingly (Rice et al., 2016).

Most literature investigated children's active engagement in the classroom in terms of on-task behaviors and joint attention, but few studies explored children's spontaneous social attention. Observations of social attention in preschool classrooms provide an opportunity to evaluate social attention in real-life situations, where children have the opportunity to both, passively observe others' social interactions (similar to SVE measures using Third-person Stimuli) and actively engage others in interaction (similar to SVE measures using First-person Stimuli). Observational measures often leverage classroom videos to allow detailed coding of children's gaze direction. For the current study, we will distinguish two types of social attention: Face-looking and Onlooking (Siller et al., 2022). Face-looking measures children's attention to faces, and Onlooking measures children's general attention and interest in others' actions.

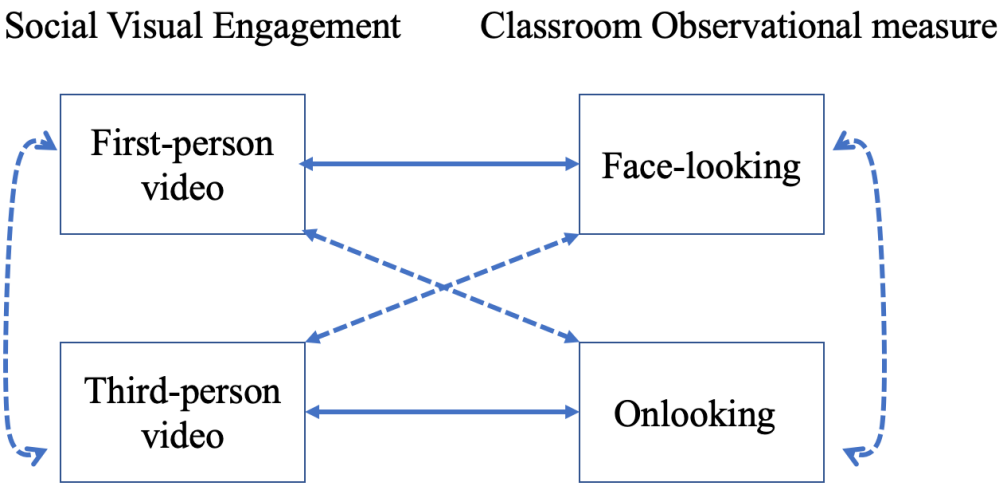
The Current Study

Previous research has established various measures to explore children's social attention in lab settings and in naturalistic social settings. However, very few studies have investigated the relationships between these measures. This current study was conducted across three classrooms of an inclusive preschool program focused on autism, attempting to explore whether similar

constructs of social attention were captured in eye-tracking measures and classroom observations.

We used two types of eye-tracking stimuli to evaluate children's SVE: First-person and Third-person interaction stimuli. In addition, we collected classroom videos to evaluate children's social attention (Face-Looking, Onlooking). We hypothesized that SVE eye-tracking measures using Third-person Stimuli would be correlated with observational classroom measures capturing children's Onlooking behaviors. Conversely, we hypothesized that SVE eye-tracking measures using First-person Stimuli would be correlated with observational classroom measures capturing children's Face-Looking. Figure 1 shows a path diagram illustrating the predicted associations. Throughout, we also evaluated whether observational and eye-tracking measures are associated with autism diagnoses (categorical measure) and symptom severity (continuous measure). Building from the differences in eye-fixations regarding the regions of interest between children with and without autism highlighted by eye-tracking studies (Rice et al., 2012; Shic et al., 2011; Klin et al, 2002; Speer et al., 2007; Chawarska et al., 2013; Nakano et al., 2010), and the decreased interest in establishing intersubjectivity and joint attention during in-person social interactions (Rochat & Striano, 1999; Rice et al., 2016), we hoped to explore correlations between controlled eye-tracking measures and children's social attention in vivo. By investigating correlations between two measures (eye-tracking and observational) that attempt to capture similar aspects of social engagement, we hope to validate the eye-tracking scores against children's classroom behavior.

Figure 1. Predicted associations between the study variables (SVE and Classroom Observations)



Note. Solid lines indicate predicted associations; dashed lines indicate exploratory associations.

Method

Setting & Participants

The data was collected in the Fall of 2019 and the Spring of 2021. The sample was 48 children (14 female, 34 male) in total recruited from the Louise and Brett Samsky Preschool, an inclusive and university-based lab school for 2- to 5-year-old children with and without ASD. There were 18 children who had been diagnosed with ASD and 30 typically developing children. The mean age for the samples was 47.4 months. The average age for children with autism was 41.0 months, and the average age was 50.1 months for typically developing children. The average age for children with and without autism was comparable with an insignificant group difference (t (46) = 2.054). The mean score of SRS of all participants was 51.13, with a mean score of 59.59 for children with autism and 46 for children without autism; there was a significant group difference in SRS score variability (t (43) = -5.47, $p < .001$). The participants consisted of 6 Hispanic children and 42 non-Hispanic children. There were 30 White American

children, 2 Asian American children, 12 African American children, and 4 children who specified other race. While the sample represented a diverse range of socioeconomic backgrounds, the majority of the children came from higher-income households (60.4%).

Table 1. Descriptive statistics about participant characteristics ($N = 48$)

	Mean ± SD (range)	Number (%)
Age	47.7 ± 11.96	
SRS total score	51.13 ± 10.40	
Gender		
Female		14 (29.2)
Male		34 (70.8)
ASD Diagnosis		
Children with autism		18 (37.5)
Children without autism		30 (62.5)
Ethnicity		
Hispanic		6 (12.5)
Non-Hispanic		42 (87.5)
Race		
Asian American		2 (4.2)
African American		12 (25.0)
White American		30 (62.5)
Other		4 (8.3)
Family income		
20k – 50k		6 (12.5)
50.001k – 80k		4 (8.3)
80.001k – 120k		8 (16.7)
Above 120k		29 (60.4)
Missing		1 (2.1)

Note. ASD = (Autism Spectrum Disorder); SRS-2 = (Social Responsiveness Scale)

Procedures

Participants in this study attended the Louise and Brett Samsky Preschool daily. Children participated in eye-tracking sessions. In addition, day-long classroom videos were collected once per week for five weeks. Finally, parents completed the Social Responsiveness Scale (SRS-2, Constantino & Gruber, 2012). Parents provided informed consent in accordance with a protocol approved by Emory University's Institutional Review Board.

Measures

Eye-tracking

SVE was measured via eye-tracking devices in a lab setting. The procedures of the eye-tracking sessions were similar to the methods used by Constantino et al. (2017). Children were tested sitting in a car seat and supported by a familiar teacher as necessary. Children watched videos with two different dynamic social stimuli, during which their eye movement and fixation on facial regions are recorded with a video-based, dark pupil/corneal reflection technique with hardware and software by ISCAN, Inc. The child participating in the session could not see the eye-tracking system as it was mounted in a panel beneath the stimuli presentation monitor. The monitor was a 20-inch computer monitor with a refresh rate of 60 Hz. Sound was played through a set of hidden speakers. The lighting in the room was dimmed so that children would attend to the monitor. All children view the monitor from a standardized distance. The experimenter sat behind a curtain and could observe the child through a live video feed.

The presentation order of videos was randomized. Children started watching after calibration. The videos were categorized into two groups based on the stimulus presented in the social interaction. One group involves dyadic cues from a caregiver figure talking into the camera (First-person); the other involves triadic peer interactions (Third-person).

The fixation data was performed with software written in MATLAB (MathWorks) (Constantino et al., 2017). The eye-tracking device identified children's eye movements into fixation data of eyes, mouths, bodies, and objects for videos with First-person and Third-person stimuli. The regions of interest were identified and hand-traced by the experimenters frame-by-frame for all videos. Additional fixation data on faces was collected for videos with First-person stimuli, which was a composite score of the fixation lengths on eyes and mouths. The percentage of time fixating on each region of interest was calculated by the time child spent fixating on a specific region (eyes, mouth, body, or object) divided by the total time of the child's eye fixation on the video.

Social Visual Engagement (First-person). The videos involve actresses playing the role of caregivers and looking directly into the camera. The actresses gave visual and audio cues to engage the children when they played childhood games on video.

Social Visual Engagement (Third-person). The materials were videos of toddlers playing at a playground. There were no visual or audio cues to scaffold children's attention in the video.

Classroom Observations & Coding

Classroom observations are coded from recordings of class activities at the Louise and Brett Samsky Preschool in Fall 2019 and Spring 2021. Five Go-Pro cameras are mounted to the five sides of classroom walls: the classrooms are shaped irregularly (a rectangle with an extra corner). Each angle focuses on one area of the classroom. Class activities were recorded once per week for five weeks at the beginning and the end of the school year during center time, a free-play period where children can choose to wander among various play centers in the classroom. During Center Time, a random 5-minute period was selected for each child. This was repeated

for each day of the recording. Children either engage in teacher-facilitated activities, peer interactions, or both at play centers. Coding groups that were unaware of the purposes of the study watched the recordings in the lab and scored children's classroom behavior in two categories: Face-looking and Onlooking. Coding groups consist of student interns trained at the Educational Science Research Core Lab of Marcus Autism Center. Coders coded the classroom recordings with Noldus The Observer XT, a behavioral coding software. The inter-observer agreement was established by comparing scores from two coders, and the agreement was acceptable.

This study uses classroom observations to operationalize the broader abstract concept of children's attention in a social context into two observable constructs: Face-looking and Onlooking. Face-looking captures children's visual attention to the faces of peers or teachers. Onlooking captures children's attention to other people's actions.

Face-looking. For a behavior to be coded as Face-looking, a child looked at the faces of their peers or teacher while in close physical proximity. A brief glance for Face-looking was less than 2 seconds. A sustained gaze for Face-looking was longer than 2 seconds. It was coded on a scale from 1 to 4, with 1 representing little to no social attention with less or equal to two brief glances and no sustained gaze, 2 representing some social attention with one to two sustained gazes or more than two brief glances, 3 representing clear and sustained social attention with three to four sustained gazes or two sustained gazes and more than two glances, and 4 representing high and sustained social attention with at least five sustained gazes.

Onlooking. For a behavior to be coded as Onlooking, the child paid sustained attention to an interaction either from a distance or in close proximity but did not attend to the individual's face. A sustained gaze for onlooking was longer than 5 seconds. It was coded on a scale from 1

to 4, with 1 representing none or little onlooking with less or equal to two sustained gazes, 2 representing some onlooking with three to four sustained gazes, 3 representing clear and sustained onlooking with five to seven sustained gazes, 4 representing high and sustained onlooking with at least eight sustained gazes.

Each child received 5 Face-looking scores and 5 Onlooking scores across the five points of data collection. These 5 scores were averaged into a mean Face-looking score and a mean Onlooking score.

Social Responsiveness Scale

The total score of SRS-2 measures social ability and impairments specific to children with ASD or at risk for ASD (SRS-2, Constantino & Gruber, 2012). Higher scores of SRS-2 indicate more severe impairment in social interactions. Among all participants, the mean SRS-2 score was 51.13, with a minimum score of 35 and a maximum score of 77. The mean SRS-2 score of children with ASD was 59.59. The mean SRS-2 score of typically developing children was 51.13 (See Table 1).

Statistical Analysis

Preliminary analyses were completed to inspect data for inconsistencies and non-normality (e.g., skew, outliers). Descriptive statistics (means, standard deviations, percentage scores, ranges) were computed for all variables. Associations between variables were computed using Pearson correlations for continuous variables (e.g., SVE, observational coding, SRS-2) or independent sample t-tests for categorical variables (e.g., diagnostic classifications). Statistical analyses were completed using SPSS (version 28.0.1.0).

Results

Descriptive Analyses

Descriptive information of the two SVE eye-tracking measures (First-person, Third-person) and the two observational measures (Face-looking and Onlooking) is presented in Table 2.

Table 2. Descriptive statistics for study variables

	n	Mean	SD	Minimum-Maximum
SVE – First-person	43	.360	.204	0 – 1
SVE – Third-person	48	.139	.080	.025 – .361
Classroom – Face-looking	48	2.36	.573	1.2 – 3.5
Classroom – Onlooking	48	1.95	.591	1 – 3.5

Note. SVE = Social Visual Engagement

Preliminary Analyses

Preliminary analyses were completed to investigate whether the two SVE eye-tracking measures (First-person, Third-person) and the two observational measures (Face-looking and Onlooking) were associated with parent-rated measures of social impairment (SRS-2). Results are presented in Table 3. Findings show that children's Face-looking in the classroom is significantly and negatively correlated with their parents' rating of social impairment. We ran a linear regression analysis to further explore this significant correlation between SRS total score and Face-looking. The result shows that children's SRS total score reliably predicts their Face-looking (b = -.02, $s.e.$ = .008, p = .012). As a higher SRS total score indicates more severe impairments in social interactions, this negative relationship suggests that children with lower SRS total scores and less severe autism symptoms are more likely to have higher Face-looking scores in the classroom.

Table 3. Correlations between SRS total score and study variables

	SVE – First-person	SVE – Third-person	Classroom – Face-looking	Classroom – Onlooking
SRS total score	.033	-.172	-.370*	-.038

*. Correlation is significant at the 0.05 level (2-tailed).

Note. SVE = Social Visual Engagement; SRS = Social Responsiveness Scale.

Similarly, preliminary analyses were completed to investigate whether the two SVE eye-tracking measures (First-person, Third-person) and the two observational measures (Face-looking and Onlooking) were associated with categorical measures of children's ASD diagnoses. Results from independent t-tests show that the difference in Face-looking scores between children without autism (M = 2.55; SD = .52) and children with autism (M = 2.04; SD = .52) was significant (t (46) = 3.261; p = .002). We ran a regression analysis to further explore this significant group difference and found Children's ASD diagnosis significantly predicts the differences in children's Face-looking (b = -.572, *s.e.* = .195, p = .005). Since children's ASD diagnosis was coded as a categorical variable with 0 as typically developing children and 1 as children with autism, the negative relationship suggests that typically developing children are more likely to have higher Face-looking scores.

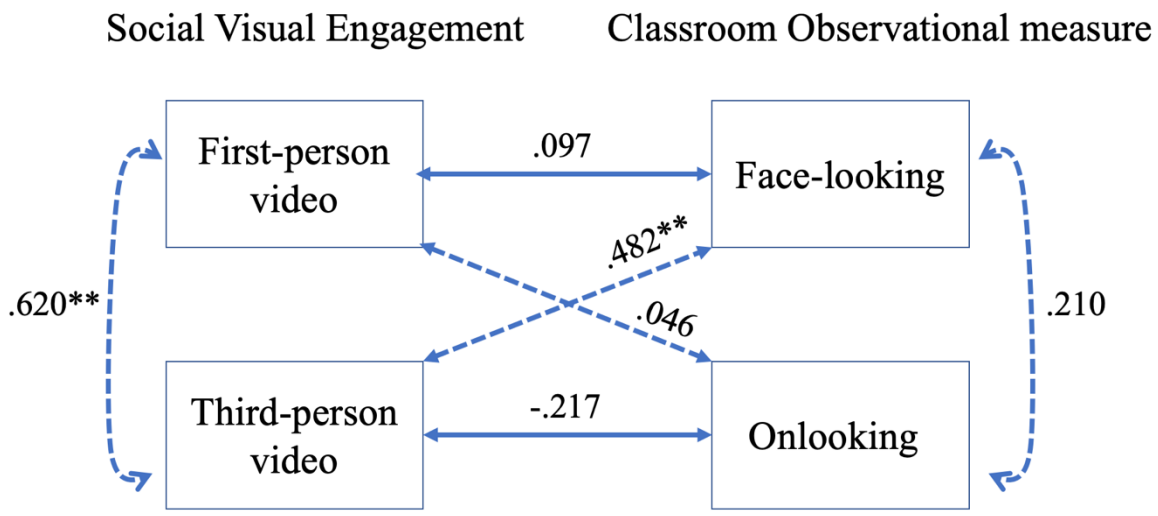
Finally, we completed preliminary analyses to investigate whether SRS-2 scores differed by diagnosis. Results from an independent t-test show that the difference in SRS-2 scores between children without autism (M = 46; SD = 7.15) and children with autism (M = 59.59; SD = 9.44) was significant (t (43) = -5.471; p < .001). Children with an ASD diagnosis were more likely to receive higher SRS-2 scores, indicating more severe autism symptoms.

Correlations Between SVE Scores and Classroom Observation Measures

While examining the correlations between the SVE measurements and the classroom observation measures, it is also important to examine the correlation between the eye-tracking

measures and the correlation between the two classroom observations to evaluate whether they measure similar or different constructs of social attention. We found that SVE scores for Third-person stimuli are significantly and positively correlated with SVE scores for First-person stimuli (r = .620, p < .001), which means that increased time fixating on the eyes region while watching videos of other peer interactions is correlated with increased eye-fixation time while watching dyadic interaction with the caregiver. Surprisingly, Face-looking and Onlooking are not significantly correlated with each other, suggesting that these two classroom observation measures might target different aspects of social attention. Among the four correlations between the eye-tracking scores and classroom observation measures, there is only one significant positive correlation SVE scores for Third-person stimuli have a significant positive correlation with Face-looking (r =. 482, p < .001). This suggests that longer fixation on the eye regions while watching peer interactions is correlated with a higher score of Face-looking in the classroom.

Figure 2. Correlations between study variables



**. Correlation is significant at the 0.01 level (2-tailed).

Exploratory Follow-up Analyses

We ran a regression analysis to further explore the significant correlation between the SVE scores and children's Face-looking in the classroom. SVE scores of Third-person videos reliably predict children's Face-looking when controlling for the effects of SVE scores of First-person videos ($b = 4.891$, $s.e. = .680$, $p < .001$).

Discussion

The current study examines the correlations between SVE eye-tracking measures derived from two types of stimuli (First-person and Third-person) and the two classroom observation measures of children's social attention in preschool settings (Face-looking and Onlooking). Two hypotheses were proposed: 1) the SVE of viewing Third-person stimuli would be significantly correlated with children's Onlooking scores; 2) the SVE of viewing First-person stimuli would be significantly correlated with children's Face-looking scores. This study attempted to validate the two eye-tracking stimuli, widely used in the autism literature to investigate children's social attention, against the two classroom observation measurements.

Neither of the two hypotheses was supported: 1) there was not a significant correlation between the Third-person SVE and Onlooking; 2) there was not a significant correlation between the First-person SVE and Face-looking. Instead, there was a significant correlation between the Third-person SVE and Face-looking in the classroom. We did not expect such a correlation since the Third-person SVE measures children's social attention in observing others' interaction, whereas Face-looking measures children's active engagement in interactions through looking at faces. This correlation suggests that children who pay more attention to others' eyes during passive observations are more likely to actively engage in social interactions themselves.

This study explores associations between eye-tracking measures and children's social attention behaviors in the classroom. Although we failed to reject the null hypotheses, this is the first study that found eye-tracking measures predict classroom behaviors in an inclusive preschool setting. The association between Third-person interaction stimuli and Face-looking behavior could be explained as both measures are group-based measures. While observing the Third-person interaction stimuli, children pay attention to multiple social actors, engage in turn-taking conversation, and attend to face regions, especially eyes, for underlying social information (Rice et al., 2012). During an active engagement episode in the classroom, children also need to attend to other group members' actions and language to understand the social context and their roles within the social interaction (Rice et al., 2016). Similar to observing others' group interactions, face-looking is also an effective demonstration of social skills while children are involved in group interactions. Finding that the Third-person SVE stimuli predict children's Face-looking suggests that eye-tracking measures might be an indicator of autistic children's social interest and the likelihood of active engagement in the classroom. This could be a useful indicator that suggests autistic children's readiness for inclusion programs since active engagement is a central element in the Preschool Education Lab's programming and a preferred criterion of the admission decision into an inclusion program (Siller et al., 2020).

The significant correlation between Third-person SVE stimuli and Face-looking also suggests new directions in designing intervention programs in a clinical or naturalistic setting. Previous intervention programs for children with autism focused on children's general active engagement in the classroom, which includes on-task behaviors, social-communication and play behaviors, and emotional regulation skills (Vitiello & Williford, 2016; Boyd et al., 2018; Morgan et al., 2018). Our finding proposes the possibility of designing an intervention program that

specifically focuses on improving face-looking in social interactions within a group context for children with low SVE scores. Future research could use a longitudinal design to find out if increased face-looking in the classroom contributes to increased SVE scores after the intervention program.

The failure to reject both null hypotheses suggests inaccuracy in our hypotheses. As discussed above, the Third-person SVE stimuli and Face-looking are both group-based measures. On the other hand, the First-person SVE stimuli focus on one-on-one interactions when one caregiver talks to the camera, trying to engage the viewing child (Hosozawa et al., 2012). Research studying one-on-one interactions, such as mother-child interactions, in children with and without autism suggests that children with autism produce fewer conventional-interactive and showing gestures (Mastrogiuseppe et al., 2015), and mothers of autistic children show a higher tendency of using physical contact than verbal communication compared to mothers of typically developing children (Doussard-Roosevelt et al., 2003). Future research could explore the association between First-person SVE stimuli and real-life mother-child interaction to see if First-person eye-tracking can predict children's engagement in dyadic social interactions.

The failure in finding significant correlations between all other variables (the 2 SVE measures and Face-looking) and Onlooking could suggest that Onlooking might capture a different aspect of social attention, which is not comparable to the rest study variables. When children engage in Onlooking, they not only attend to other social partners but also the objects others are engaging with. Therefore, Onlooking is not purely a social measure that evaluates children's social interest in the eyes in particular. Since previous eye-tracking literature suggested that children with autism show increased attention to bodies and nonsocial objects (Rice et al., 2012; Shic et al., 2011; Klin et al, 2002; Speer et al., 2007), future research should

investigate the associations between Onlooking and children's social visual engagement with bodies or objects to find out if those measures capture similar aspects of social interest.

Limitations

This study had a sample size of 48, which consisted of six classes in a university-based lab school over two semesters. The sample size might not have been adequate to detect a statistically significant effect size.

The observational coding intervals used in this study were only 5 minutes long in duration, which might not have been representative enough for a typical episode of center time. Also, the children with autism who participated in the study were enrolled in the university-based lab school after a careful evaluation of their eligibility for an inclusion program. Therefore, the extent to which findings generalize to other inclusive programs or preschools in general is unknown.

The cross-sectional design of the study used an average score of children's Face-looking and Onlooking across 5 points of data collection. Since the curriculum at the inclusive preschool is designed as an intervention to promote social interactions, it would be helpful for this study to adopt a longitudinal approach and examine if there were improvements in scores across time points, especially in children with autism diagnoses.

The Face-looking and Onlooking classroom measures were coded on a scale from 1 to 4 based on the number of instances observed within the 5-minute interval. On the other hand, the eye-tracking scores were calculated as a percentage by dividing the looking time on the eye region by the children's total looking time. For future studies, it is important to examine the comparability between the observational coding scales and the calculation of eye-tracking to make sure the scoring of both measures represents similar levels of social attention.

This study coded children's Face-looking and Onlooking regardless of their social partners. However, classroom observation studies suggest that differences exist between children's active engagement with adults and peers (Downer et al., 2010; Johnson et al., 2021). Future research could benefit from dividing the coding schemes into social attention directed toward peers or teachers, which could provide a more detailed description of children's classroom behavior during free play.

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