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Social Communication as an Early Indicator of Autism in High-Risk Infant Populations

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Social communication is the capacity for reciprocal nonverbal and verbal communication using speech, gestures, and eye contact to meaningfully engage with others (Salley, Miller, & Bell, 2013). Generally, the complexity of social communication skills follows a general developmental trajectory in which acquisition and mastery of preverbal communication, such as joint attention (JA), during the first two years of life impact later language skills and understanding of social situations (Schietecatte, Roeyers, & Warreyn, 2012). The development of social communication, particularly JA, is associated with later language and social outcomes for typically developing (TD) children (Poon, Watson, Baranek, & Poe, 2012; Beuker, Rommelse, Donders, & Buitelaar, 2013). Joint attention is a nonverbal social communicative behavior used to share attention of an external object or event with another person (Poon et al., 2012). Mastery of JA is significant to later development, because it requires children to be aware of their social environment, recognize others' bids for attention, and understand how to direct someone else to share attention of some object or event. Gaze shifts and gestures are two forms of JA used prior to the acquisition of verbal communication.

Gaze shifts used for JA are defined as nonverbal social communication in the form of three-point shifts in eye contact to share attention of an object with another person. This behavior follows a developmental trajectory in which infants learn how to respond to and then later initiate JA gaze shifts. Responding JA is the ability to follow another person's gaze shifts by looking at the object or event the person wants to share attention of (Cassel et al., 2007). Generally, TD children develop the ability to respond to JA around 6 to 11 months old (Schietecatte et al., 2012; Bedford et al., 2012). After responding JA has been developed, initiating JA (IJA) gaze typically emerges. Initiating JA gaze is shifts initiated by a child to direct someone else's attention to an object the child is interested in (Cassel et al., 2007). Serving as a precursor to language, IJA gaze can stand alone or be paired with other behaviors, such as using showing gestures or vocalizations, to indicate a desire to share attention of an object (Winder, Wozniak, Parlade, & Iverson, 2012).

Gestures used for JA are defined as nonverbal communication using intentional hand movements to share attention of an object or event with another person. Gestures are categorized into three groups based on the purpose of communication: social interaction, behavior regulation and JA (Bruner, 1981). Social interaction gestures are primarily used to direct another person's attention to oneself (e.g., waving) and behavior regulation gestures serve as a method of controlling another person's behavior (e.g., shaking one's head to indicate stopping an activity). Joint attention gestures, similar to IJA gaze, use coordination of attention to direct another person to focus on a mutual object. Research on typical development suggests that JA gestures emerge in social communication as early as 9 months of age with mastery of these gestures being achieved within the first two years (Crais, Douglas, & Campbell, 2004; Winder et al., 2012; Watson, Crais, Baranek, Dykstra, & Wilson, 2013). Furthermore, JA gesture use, specifically the use of showing, pointing, giving, and requesting, has been found to be a reliable predictor of later language and developmental outcomes in TD children (Kuhn et al., 2014) making the gestures important behaviors to analyze in the context of disorders affecting language and social development, such as autism spectrum disorder (ASD).

Autism spectrum disorder is a developmental disorder defined by the Diagnostic Statistical Manual Fifth Edition (DSM-5) as having persistent deficits in social communication and interaction, restricted interests, and the presence of repetitive and stereotyped behaviors (American Psychiatric Association, 2013). ASD affects about one in 68 children (CDC, 2014); however, there is a gender disparity in ASD prevalence rates, with males being affected at a much higher rate of about one in 42 boys compared to one in 189 girls (CDC, 2014). Children with ASD typically have impairments in attention, social interactions, and cognition; therefore, early interventions focusing on behaviors that influence later development in these areas can increase positive outcomes for children.

Research on the social communicative profile of ASD reveals that children with ASD tend to have poorer IJA gaze and JA gesture use compared to their TD peers (Veness, Prior, Eadie, Bavin, & Reilly, 2014). During the second year of life, children later diagnosed with ASD used significantly less IJA gaze than TD children (Charman and Swettenham, 1997; Ibanez, Grantz, & Messinger, 2013) and are slower to use IJA gaze than TD peers (Cornew et al., 2012). A study analyzing children with early and late ASD diagnoses (14 months versus 18-36 months) found that both groups of children with ASD had fewer frequencies of IJA gaze than TD children at 14 months, although children with early diagnoses had even fewer IJA gaze shifts than their late diagnosis peers (Landa, Gross, Stuart, & Faherty, 2013). In terms of JA gesture research, children later diagnosed with ASD exhibited lower frequencies of showing and pointing to initiate JA at 21-24 months (Cassel et al., 2007; Winder et al., 2012; Wetherby, Watt, Morgan, & Shumway, 2007). In their research on predictors of ASD, Barbaro and Dissanayake (2013) distinguished social communication including pointing and showing gestures used by children at 24 months as strong predictors of a later ASD diagnosis. Overall, researchers have also identified that deficits in JA behaviors at 18 months are associated with later impaired language and social functioning for children with ASD (Poon et al., 2012). This research suggests that there are distinct differences in the social communicative profiles of children with ASD and JA specific behaviors that are indicative of later outcomes evident in the second year of life.

Although there is not a known genetic cause of ASD, some groups of children are at a higher risk due to an unknown familial influence or comorbidity. The younger siblings of children already diagnosed with ASD (ASIBs) are at higher risk of ASD than typical children without siblings diagnosed with ASD. Although underlying causes of the higher risk are unknown, prevalence rates of ASD for ASIBs are reported to range from 2-28% of the ASIB population with most studies indicating a risk of ~18% (CDC, 2014; Messinger et al., 2015; Gronborg, Schendel, & Parner, 2013). Furthermore, while some research studies consider ASIBs as a high-risk group regardless of diagnostic outcomes, other studies categorize ASIBs by their later outcomes of having ASD, having developmental delays or broader autism phenotype, or having typical development. The present study focuses on ASIBs as a high-risk group regardless of their diagnostic outcomes.

Research has shown that ASIBs score significantly lower in social communication abilities, including responding to social interaction, IJA, and requesting behaviors at 15 months than TD children but did not significantly differ from children already diagnosed with ASD (Goldberg et al., 2005). Those who were later diagnosed with ASD at 36 months were also found to utilize a smaller inventory of gestures at 14 months and fewer JA behaviors than their non-ASD peers (Landa, Holman, & Garrett-Mayer, 2007; Rozga et al., 2011), and a slower rate of growth in IJA gaze and gesture use between 15 and 24 months (Yoder et al., 2009). Gangi, Ibanez, & Messinger (2014) concluded that IJA also served as the best predictor of later severity of ASD-related characteristics for ASIBs. These findings suggest that there is a need to distinguish the profile of ASIBs without ASD and ASIBs with ASD by analyzing more specific social communication behaviors for both groups.

Children with fragile X syndrome (FXS) are also at a higher risk of ASD than TD children. FXS is the most common inheritable genetic cause of intellectual disability and affects approximately one in 3500 males (McDuffie et al., 2016). The syndrome is caused by a mutation on the FMR1 gene that causes abnormal brain structure and function, including impaired production of fragile X mental retardation protein. The syndrome presents itself either as FXS (and generally larger deficits) or as the FXS premutation in which there is less impairment of the gene and generally less cognitive deficits (McCary & Roberts, 2013; McDuffie et al., 2016). There is high comorbidity of FXS and ASD with about 50-75% of children with FXS meeting criteria of ASD (Abbeduto, McDuffie, & Thurman, 2014; Clifford et al., 2007).

In regards to the comorbid FXS and ASD profile, Rogers, Wehner, and Hagerman (2001) found that children with FXS and ASD had similar profiles to other non-FXS children with ASD for JA, imitation, and object play at 21-48 months. Their results suggest that the FXS and ASD profile is similar in terms of JA and social communication to other children with ASD alone. Children with both FXS and ASD also tend to have poorer social communication skills, including a lack of response to responding JA and fewer pointing gestures, and greater cognitive impairments at two years old than children with FXS alone (Brock & Hatton, 2010; Flenthrope & Brady, 2010). However, understanding of the underlying mechanisms for the perceived comorbidity of ASD and FXS is controversial with some scholars hypothesizing that ASD symptoms in children with FXS are due to different mechanisms than those found in children with ASD alone (Hall, Lightbody, Hirt, Rezvani, & Reiss, 2010; McDuffie et al., 2014). McDuffie et al. (2014) discovered that boys with FXS and ASD had fewer deficits in showing gestures, directing attention, and less severe ASD symptoms than boys with ASD alone aged four to ten years, suggesting that the two profiles have behaviorally different characteristics. More research is needed to distinguish the profiles of children with ASD alone, children with FXS alone, and children with FXS and ASD to further the understanding of ASD causes and symptoms in these developmental conditions.

There is a consensus that early identification of ASD and intervention lead to improved outcomes for children diagnosed with ASD (National Research Council, 2001). Despite clinicians having the ability to reliably diagnose ASD at two years old, ASD is still generally not diagnosed until children are at least three or four years old (CDC, 2014; Charman & Baird, 2002; Shattuck et al., 2009). The increased risk of ASD for children with FXS or ASIBs and the delay in diagnosis suggest that more research is needed to determine social communicative behaviors that could be identified early as indicators of a later ASD diagnosis. There are also limited studies that compare the social communicative profiles of children with FXS to children with FXS and ASD, as well as no studies analyzing differences in JA behaviors for children with FXS and ASIBS. Analyzing behaviors across these groups compared to TD children can add to the understanding of profiles specific to each group. Moreover, much of the literature on JA as a form of social communication focuses on behaviors present during the second half of the second year of life (Veness et al., 2014; Rogers et al., 2001; Cassel et al., 2007; Winder et al., 2012; Wetherby et al., 2007), thus leaving a gap in the literature on JA abilities prior to 18 months in relation to at-risk groups for ASD.

The present study analyzes the frequency of IJA gaze and JA gesture behaviors within two high-risk ASD groups, ASIBs and children with FXS, compared to TD controls to add to the social communication profiles for both high-risk groups. The study also focuses on JA skills at 12 months of age in order to fill the gap in literature on IJA gaze and JA gesture abilities for high-risk groups at an earlier age than usually studied. Lastly, the study aims to distinguish if IJA gaze and JA gestures at 12 months are indicative of a later ASD diagnosis at 24 months for the same high-risk infant populations. Based on the findings of previous research stated above, it is hypothesized that children with FXS and ASIBs will have lower frequencies of IJA gaze and JA gestures than TD controls, due to their higher risk of ASD. It is also hypothesized that children with FXS will have lower frequencies than ASIBs due to their higher risk (18% versus 50-75%). Lastly, it is hypothesized that the frequencies of each of the behaviors at 12 months will predict a later ASD diagnosis at 24 months for ASIB and FXS groups.

Method

Participants

Participants were recruited as a part of a larger longitudinal study at the University of South Carolina (USC) focusing on biomarkers and behavioral measures as early indicators of ASD in high-risk infant populations. Mothers of the infants participating in the longitudinal study were recruited using list serves, flyers, and word of mouth. Families were paid for their time and reimbursed for any travel expenses.

Forty-nine 12-month-old males participated in this study (M=12.59, SD=0.87). The control group was comprised of TD infants characterized as having little-to-no ASD symptoms, falling within the average range for developmental level (e.g., a score of 85 or greater), and having no history of developmental concerns or family history of autism per parent report. Sixteen infants were categorized as the TD group after ten TD infants were excluded from the analyses due to either presenting with high autism symptoms as measured on a semi-structured clinical instrument within the larger longitudinal study (n=6) or having a developmental level score lower than 85 (n=4) . Twelve infants were categorized as the FXS group for having a FXS diagnosis. The remaining twenty-one infants made up the second high-risk experimental group of ASIBs, thus having an older sibling being previously diagnosed with ASD. For descriptive statistics, see Table 1.

Measures

The Laboratory Temperament Assessment Battery (Lab-TAB; Goldsmith & Rothbart, 1996) is a standardized assessment used to observe differences in temperament in everyday situations by having participants engage in a variety of tasks. The present study focused on IJA gaze and JA gesture behaviors using an unstructured play task during which the participant is given a set of plastic, noise-making keys to play with independently for three minutes. The examiner and infant's mother are seated at the same table as the participant for the task and remain neutral for the three minutes. A second examiner videotapes the entire task for later offline behavioral coding. Although the original aim of the play-based task is to study attention, it was expanded to look at IJA gaze and JA gestures for the present study.

IJA Gaze. Initiating JA gaze was defined as nonverbal communication in which the infant uses three-point gaze shifts to direct another person's attention to an object. The initiation of the three-point gaze shifts must begin with the infant looking at an object (e.g., the keys in the Lab-TAB play task), then shifting his gaze to make eye contact with another person (e.g. the examiner or parent in the room), and returning his gaze back to the same object in under two seconds (Clifford & Dissanayake, 2008). The behavior was broken down into two categories that defined whether the child focused on the parent or examiner to initiate JA of the object. Of the 49 participants, 78% used at least one IJA gaze shift in the entire three-minute Lab-TAB video with 75% using at least one examiner-directed IJA gaze shift and 10% using at least one parent-directed IJA gaze shift. The large difference between examiner-directed and parent-directed gaze could be explained by the set-up of the Lab-TAB task; most participants sit in their parents' laps, making it difficult to look at the parent without excessive shifting in their seat.

JA Gesture Use: Joint attention gestures were defined using the Communication and Symbolic Behavior Scales (CSBS; Wetherby & Prizant, 2002), a developmental measure that assesses social communication behaviors, particularly JA gesture use in young children. Gestures are nonverbal communication using hand signals or manipulation of an object to direct another person's attention to an object. Joint attention gestures were classified into four subcategories using the CSBS:

a) *Show*: The participant presents an object to another person by extending it in the direction of that person. To exclude nonsocial behaviors such as peering, the showing gesture must also be accompanied by gaze directed towards the person whom is being shown the object.

b) *Give*: The participant pushes, hands, or throws the toy towards another person in an effort to give away the object. Gaze is not required; however, the participant must fully let go of the object and place it in the direction of the examiner or parent to qualify as giving. Due to the set-up of the Lab-TAB task in which the participant often cannot reach the examiner to hand off the toy, the giving definition was adapted from the CSBS to include throwing or pushing the object toward the examiner.

c) *Point*: The participant uses his/her index finger with a closed fist to point at an object to direct attention to it. To exclude nonsocial behaviors such as merely touching the object, only pointing behavior in which the participant does not touch the object is considered pointing.

d) *Reach/Request*: The participant reaches for an object by extending his/her arm and opening his/her palm. The object must be out of the participant's reach even with extended arms to be coded as requesting to exclude nonsocial instances of the participant simply reaching to grab an object.

Of the 49 participants, 71% used at least one gesture in the entire three-minute Lab-TAB video, with 39% demonstrating showing, 35% demonstrating giving, and 18% demonstrating requesting. None of the participants demonstrated a pointing gesture during the task.

All occurrences of IJA gaze and JA gestures were coded using the computer-based coding software Noldus Observer XT 10.5. To establish reliability with coding for IJA gaze shifts and JA gestures in the task, two researchers coded videos together and then separately until a ≥ 80 percent inter-rater agreement on three consecutive videos was achieved. Reliability was maintained through a master coder who coded 20 percent of the videos with a Cohen's kappa coefficient of 0.90 across all codes.

ASD Severity. A subset of FXS and ASIB participants with 12 month and 24 month data were utilized to answer the second research question on whether IJA gaze and JA gestures were indicative of a later ASD diagnosis. Autism symptom severity scores were collected for this subset using the Autism Diagnosis Observation Scale - Second Edition (ADOS-2; Lord, Rutter, DiLavore, & Risi, 2001) at the participants 24 month assessments. The ADOS-2 is a semi-structured assessment of communication, social interaction, and play in children that calculates severity of ASD symptoms and is used to diagnose ASD in children. The ADOS-2 has five modules to meet a variety of developmental and language levels. Module 1 is intended for developmentally younger children without language (Luyster et al., 2009) and was used with five participants. The Toddler Module is intended for children with mental ages of 12 to 30 months (Luyster et al., 2009) and was used with 27 of the participants. To ensure uniformity of severity scores across the two measures, raw scores from each module were converted into calibrated severity scores (CSS; Gotham, Pickles, & Lord, 2009). The CSS has been found to have stronger validity and stability in measuring the severity of ASD symptoms in comparison to raw scores provided across the different modules (Shumway et al., 2012). The CSS were compared to the frequencies of IJA gaze and JA gestures behaviors coded using the Lab-TAB. The CSS were also utilized to define the TD group by excluding infants from the group if they had scores of four or higher (n=6).

Developmental Level. The Mullen Scales of Early Learning (MSEL; Mullen, 1995) is a standardized assessment of cognitive and motor skills for young children aged birth to 68 months. A combination of scores from the visual reception, fine motor, expressive language, and receptive language domains yield an early learning composite (ELC) score that measures general intelligence. The ELC collected at each participant's 12 month assessment was used in this study to control for the developmental level of infants across groups due to potential influences varying levels of intelligence might have on group differences in IJA gaze and JA gestures.

Procedure

The MSEL, Lab-TAB, and ADOS measures were administered and scored by trained examiners as part of a larger longitudinal study. Participants' families traveled to USC's Columbia campus for their 12 month assessments where the MSEL and Lab-TAB were administered as part of a larger battery. The Lab-TAB was later coded offline by trained research assistants. The ADOS-2 was obtained in the participants' homes at 24 months of age as part of a larger battery.

Data Analysis. Preliminary analyses were conducted to examine outliers, nonnormality, linearity, and homogeneity of residuals. All data were transformed to z-scores to make sure the variables were standardized. A series of ANCOVA's were used to analyze differences in the frequency of IJA gaze shifts and JA gestures at 12 months for FXS, ASIB, and TD groups, controlling for developmental level using the ELC from the MSEL. Regression analyses were used to analyze the relationships of the frequency of IJA gaze shifts and JA gestures on later ASD severity for a subsample of the FXS and ASIB participants.

Results

Correlations Across and Between Groups

Analyses were run to see how IJA gaze and JA gestures collapsed across the groups related to MSEL ELC scores for participants. Small correlations were found, 0.24 and 0.13 respectively. See Table 2 for data on correlations across groups. Correlation analyses were also conducted to analyze if MSEL ELC scores related to IJA gaze and JA gestures within each group. The ELC was only significantly correlated with IJA gaze for the FXS group, r=0.61, p=0.03. See Table 3 for data on correlations within groups.

Frequency of IJA Gaze Between Groups

A one-way independent groups ANCOVA was conducted to analyze the difference between three groups of infants on frequency of IJA gaze shifts during a three-minute play task. No significant difference was found, $F(2, 45)=0.18$, $p=.84$. This indicates that the FXS ($M=2.20$, SD=3.23), ASIB ($M=2.24$, $SD=2.10$), and TD ($M=2.94$, $SD=2.29$) groups did not have significantly different frequencies of IJA gaze during the play task.

Frequency of Gestures Between Groups

A one-way independent groups ANCOVA was conducted to analyze the difference between the three groups of infants on frequency of JA gestures used during the Lab-TAB play task. No significant difference was found, $F(2, 45)=0.51$, $p=.60$. This indicates that the FXS ($M=1.60$, $SD=1.68$), ASIB ($M=2.62$, $SD=2.48$), and TD ($M=2.69$, $SD=3.80$) groups did not significantly differ in the frequency of JA gestures used during the play task.

Frequency of IJA Gaze as Indicator of ASD

Regression analyses were used to analyze whether the frequency of IJA gaze at 12 months is predictive of later ASD symptom severity at 24 months using a subset of FXS and ASIB participants with 24 month ADOS-2 scores collapsed into one group. No significant effect of IJA gaze (ß=-0.15, $SE=0.19$, $t=-0.83$) on ASD symptom severity ($F(2, 29)=1.50$, $p=0.24$, $R^2=0.09$) was found controlling for developmental level. No significant main effects were found for frequency of IJA gaze (ß =0.56, $SE=0.61$, $t=0.93$) or study groups (ß =1.94, $SE=1.67$, $t=1.16$).

Regression analyses were also utilized to analyze whether the frequency of IJA gaze at 12 months is predictive of later ASD symptom severity within each of the FXS and ASIB groups. No significant interaction of IJA gaze and group (ß=-0.57, $SE=0.38$, $t=-0.97$) on ASD symptom severity ($F(4, 29)=0.96$, $p=0.45$, $R^2=0.12$) was found while controlling for developmental level. No significant main effects were found for frequency of IJA gaze (ß=0.41, $SE=0.62$, $t=0.67$) or study groups (ß=0.03, $SE=0.53$, $t=0.12$).

Frequency of Gestures as Indicator of ASD

Regression analyses were used to analyze whether the frequency of JA gestures at 12 months is predictive of later ASD symptom severity at 24 months using the subset of FXS and ASIB participants with 24 month ADOS-2 scores. No significant interaction of JA gestures (ß =-0.14, $SE=0.54$, $t=-0.26$) on ASD symptom severity ($F(2, 29)=2.01$, $p=0.15$, $R^2=0.12$) was found controlling for developmental level. No significant main effects were found for frequency of JA gestures (ß=-0.22, $SE=0.22$, $t=-1.28$) or study group (ß =1.37, $SE=1.77$, $t=0.78$).

Regression analyses were also utilized to analyze whether the frequency of JA gestures at 12 months is predictive of later ASD symptom severity within each of the FXS and ASIB groups. No significant interaction of JA gestures and group (ß=0.96, *SE*=0.67, *t*=0.99) on ASD symptom severity ($F(4, 27)=1.33$, $p=0.28$, $R^2=0.17$) was found while controlling for developmental level. No significant main effects were found for frequency of JA gestures (ß=-1.22, *SE*=1.26, *t*=-1.25) or study groups (ß=0.21, *SE*=0.54, *t*=0.79).

Discussion

The present study aimed to differentiate between two high-risk groups for ASD, as well as compare those profiles of high-risk groups to TD children to determine if there were differences in the use of JA behaviors at 12 months. Contrary to our hypotheses, there were no group differences found in the frequency of both IJA and JA gestures with no relationship of either of these JA behaviors with later ASD outcomes. The lack of differences in frequencies of either IJA gaze shifts or JA gestures in the present study across groups suggests that high-risk infants may not experience deficits in JA behaviors at 12 months. This finding is interesting, because much of the JA literature on high-risk infant groups indicates differences in JA compared to TD children throughout the second year of life (Veness et al., 2014; Cassel et al., 2007; Winder et al., 2012). Although they were also not significantly different from the TD group, the lack of significant differences in IJA gaze shifts and JA gestures for children with FXS and ASIBs adds an interesting component to the discussion on whether ASD in children with FXS is the same phenotype as non-FXS children with ASD, particularly because it supports the hypothesis that the behavior profiles for ASD in FXS and ASIB are the same. However, further research is needed to examine JA and other early behaviors for ASIB and children with FXS in a longitudinal context.

The second element of the present study was to determine if IJA gaze and JA gestures at 12 months were early indicators of later ASD severity at 24 months. The results suggest that the use of these two JA behaviors at 12 months is not indicative of ASD severity, despite contradictory evidence in the literature identifying impairments of IJA gaze shifts and JA gesture use in the second year of life as strong indicators of ASD (Barbaro & Dissanayake, 2013; Ibanez, Grantz, & Messinger, 2013; Winder et al., 2012). Few studies have researched the presence and indicative quality of these two behaviors earlier than 18 months and the present study suggests that due to the lack of distinctive differences across groups, 12 months may be too early to notice differences in IJA gaze shifts and JA gestures or serve as predictors of later ASD symptoms within these high-risk groups. The mixed findings of this study and other research highlight the need for further exploration of JA in the context of ASD severity.

Due to the nature of the study, there were a few limitations that could have affected the results. One such limitation is the small sample size of infants, particularly infants who are later diagnosed with ASD. Infants are recruited as early as 6 months old for the larger USC study and tracked longitudinally throughout early childhood as opposed to recruiting children with ASD and using retrospective data to analyze development. Statistically, this means that about 20% of the participants will go on to have ASD, 40% who will have developmental delays, and the last 40% will be typical, making it difficult to identify findings in these groups without knowing the outcome of their later diagnoses. In addition, the larger longitudinal study in which the participants were recruited from is still ongoing; therefore, there was a limited amount of participants who had data for both 12 months and 24 months of age. However, the present study is focused on high-risk infants, particularly children with FXS and how their social communicative profiles compare to TD and ASIBs rather than solely focusing on ASD outcomes; therefore, although there is a limited amount of participants who ultimately receive ASD diagnoses, the sample size of children with FXS is quite good considering the challenges to recruiting infants with FXS. Regardless, increasing the sample size, which would naturally increase the number of children who are later diagnosed with ASD, could increase the strength of the study.

Another limitation of the study was the Lab-TAB play-based task used to measure frequencies of IJA gaze shifts and JA gestures at 12 months. The primary focus of the Lab-TAB task is to analyze the infants' attention to an object within an experiment in which the examiner and parent were asked not to promote social engagement; therefore, the infants' initiated behaviors are captured in a relatively asocial context, which is important to understanding the results. Using a task with a wider range of materials for participants to play and interact with may be more ideal to capture their initiation of social bids with others in their environment. Furthermore, the play task is only three minutes. Analyzing frequencies in the short time frame might explain the low numbers of IJA gaze shifts and JA gestures across groups; therefore, if a longer task was used, there might be more noticeable differences in the amounts of JA behaviors in the groups.

The findings of the present study and the limited and mixed literature on the FXS with ASD profile suggest that further studies on FXS compared to other high-risk groups is necessary to fully understand the FXS and ASD phenotype. Based on the limitations of the present study, future directions on this research include increasing the sample size of the FXS and ASIB groups and investigating IJA gaze shifts and JA gestures in a different play-based measure. Due to the lack of documented differences in the present study for JA behaviors at 12 months, future studies could analyze these behaviors at a different age to determine if they differentiate between groups at an earlier or later age. Furthermore, utilizing longitudinal models to examine trajectories of IJA gaze shifts and JA gestures to pinpoint when impairments in each begin to surface would also add to the understanding of IJA gaze and JA gestures in high-risk groups. Additionally, analyzing a higher level of JA in which infants use coordination of JA behaviors (combination of gaze shift and gesture) in order to direct and share attention with others might add to the understanding of JA within FXS and ASIB groups.

Initiating JA gaze shifts and JA gestures at 12 months were not found to be significant predictors of later ASD severity groups for participants in the present study, contrasting previous literature that found JA behaviors during the second year of life to be strong predictors of ASD severity. However, JA is shown to play an important role in later language, social, and even cognitive development (Poon et al., 2012; Beuker et al., 2013); therefore, future directions for JA research include examining additional outcomes that IJA gaze shifts and JA gestures may significantly predict in development as early as 12 months. In terms of early predictors of ASD, future longitudinal research on the trajectories of gaze shifts and gestures would further clarify if JA behaviors are actually indicative of ASD severity and at what age they begin to be indicative. Distinguishing this point in development will enhance clinicians' understanding of what behaviors should be targeted at certain age points to maximize intervention strategies and provide better outcomes for children at risk of ASD.

Regardless of the ability to reliably and validly diagnose ASD at 24 months, most children do not receive an official diagnosis of ASD until 36 months or later. The disconnect in points at which ASD can be clearly recognized and point of diagnosis (and thus therapeutic efforts) creates a large gap of time in which children could be receiving services to reduce future deficits and impairments in functioning. Future research on early indicators of ASD in the first two years of life is needed to address this gap in services and provide better strategies to target behaviors that are identified as problem behaviors in early development. Additionally, understanding the ASD profile in children with FXS and distinguishing whether it is comparative to or different from the ASD profile in non-FXS and high-risk children is important to determine how therapeutic services should be directed to children with FXS and ASD to maximize positive outcomes.

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Table 1

Descriptive Statistics of FXS and TD Variables

Variable	FXS		ASIB		TD	
	n	Mean (SD)	*n*	Mean (SD)	*n*	Mean (SD)
Chronological Age (months)	12	12.72 (1.07)	21	12.78 (0.94)	16	12.26 (0.33)
Frequency of IJA Gaze	12	1.83 (2.66)	21	2.24 (2.10)	16	2.94 (2.29)
Frequency of Gestures	12	1.42 (1.38)	21	2.62 (2.48)	16	2.69 (3.80)
MSEL Early Learning Composite	12	68.92 (14.71)	21	95.67 (13.52)	16	106.50 (7.51)
ADOS-2 Score	12	5.17 (3.09)	20	4.20 (2.71)	13	1.39 (0.65)

Note. FXS is children with fragile X syndrome; ASIB is younger siblings of children with ASD; TD is typically developing controls; MSEL is the Mullen Scale of Early Learning; ADOS-2 is Autism Diagnosis Observation Scale Second Edition

Table 2

Correlations: Between MSEL ELC Scores and IJA Gaze and JA Gestures

Measure	1	2	3
1. MSEL ELC	–	0.24	0.28
2. IJA Gaze	0.24	–	0.28
3. JA Gesture	0.13	0.28	–

Table 3

Correlations: Between MSEL ELC Scores and IJA Gaze and JA Gestures within Groups

Measure			
FXS Group	1	2	3
1. MSEL ELC	–	0.61	0.19
2. IJA Gaze	0.61	–	0.77
3. JA Gesture	0.19	0.77	–
ASIB Group	1	2	3
1. MSEL ELC	–	0.14	-0.25
2. IJA Gaze	0.14	–	0.50
3. JA Gesture	-0.25	0.50	–
TD Group	1	2	3
1. MSEL ELC	–	-0.43	0.19
2. IJA Gaze	-0.43	–	-0.05
3. JA Gesture	0.19	-0.05	–