Evaluating Eye Contact in the Clinic and Language Behavior in the Home in Children With ASD

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Abstract

Autism spectrum disorder (ASD) is characterized by difficulties in social communication, verbal and nonverbal communication, and repetitive behaviors. Two of the core features of ASD are language impairment and atypical eye contact. Whether these two behaviors are correlated and whether the environment or social context has an impact on these behaviors in children in ASD is yet to be determined. This study attempts to answer if there is a significant difference in the amount of eye contact displayed in conversation versus play in the clinic and whether eye contact in play or conversation is predictive of verbal responses in the home of children with ASD. It was hypothesized that there would be a significant difference between eye contact in play versus conversation because different social contexts would cause subjects to react with different amounts of eye contact. Eye contact during play in the clinic was predicted to be correlated with verbal responses in natural settings because eye contact in play is associated with joint attention abilities, whereas eye contact in conversation requires less shared communicative reference. A paired samples t-test was created to determine if there was a significant difference between eye contact in play versus conversation, and a pairwise correlation was performed to determine whether there was an association between eye contact and verbal responses. It was concluded that there was a significant difference between eye contact displayed in conversation versus play, with more eye contact displayed during conversation. Furthermore, this study found no correlation between eye contact in either play or conversation with language in the home. This might indicate that the brain of an individual with ASD may regulate these behaviors in a different way than in a typically developing brain.

According to the Center for Disease Control and Prevention's Community Report on Autism (2014), there has been a ten-fold increase in the prevalence of autism spectrum disorder (ASD) in the U.S. over the past 40 years. Currently, 1 in 68 American children are diagnosed with ASD. ASD is characterized by difficulties in social communication, verbal and nonverbal communication, and repetitive behaviors. These difficulties in social communication are the key to understanding and distinguishing ASD from other disabilities (Vellonen, Karna, & Virnes, 2012). Unfortunately, the exact cause of ASD remains unknown, however it is clear that there isn't one direct cause of ASD since the disorder is so heterogeneous. In recent years, researchers have identified rare genetic mutations associated with ASD (one of the most famous being de novo mutations), some of which are sufficient to cause ASD alone. Regardless, it is believed that ASD is caused by a combination of genetic risk and environmental factors, some of the most common being events that take place before or during birth that influence early brain development.

One of the core features of ASD is language impairment, specifically limited use of language, and the inability to maintain conversations (Lord & Paul, 1997; American Psychiatric Association (DSM-V), 2013). However, there is considerable heterogeneity in language profiles in ASD (Tager-Flusberg & Joseph, 2003) as many children have other language impairments, such as a lack of vocabulary, grammatical errors, and difficulties with semantic abilities (Kjelgaard & Tager-Flusberg, 2001). These various types of delays in language development usually result in children receiving early intervention. The majority of positive outcomes in language abilities are also linked to improvements in social skills, adaptive behavior, autism symptomatology, and level of independence (Pasco et al., 2008; Szatmari et al., 2003). In this way, studying language development in children with ASD is important to achieving a greater understanding of the etiology and treatment of ASD.

There are other core deficits that characterize ASD which are closely related to language abilities and one of the most commonly studied is joint attention. Joint attention is the ability to coordinate attention with a social partner and involves sharing a common point of reference using gaze and gestures. Difficulties with joint-attention are one of the earliest signs of ASD, and are often one of the core behaviors targeted in early intervention programs (Charman, 2003). A wealth of studies conducted over the years (mostly using performance-based activities in the clinic) have shown that there is a positive correlation between joint attention and language.

For example, in a study by Sigmund and Ruskin (1999), it was found that high levels of joint-attention abilities correlated with long-term gains in expressive language at the age of 12. Likewise, Stone and Yonder (2001) also found a correlation between early joint-attention skills and later expressive language ability, but with children aging longitudinally from two to four years old.

Direct gaze plays a fundamental role in joint attention abilities. Joint attention involves following the direction of the gaze and gestures of others in order to share a common point of reference. In other words, joint attention is the use of gestures and eye contact to direct others' attention to objects, to events, and to one's self. However, atypical eye contact, meaning the lack of eye contact during conversation, is a diagnostic and widely reported feature of ASD (American Psychiatric Association 2013). In a study conducted by Akechi et al. (2014), it was found that typically developing adolescents detected faces with a direct gaze faster than faces with an averted gaze, indicating enhanced unconscious processing of eye contact. However, individuals with ASD aged 12–21 did not show different durations of perceptual suppression for faces with direct and averted gaze, suggesting that preferential unconscious processing of eye contact is absent. It was proposed that atypical processing of eye contact in individuals with ASD could therefore be related to a weaker initial, unconscious registration of eye contact. In a study by Von dem Hagen et al. (2014), it was shown that not only do individuals with ASD *not* prefer direct eye contact, but also that they *prefer* averted gaze. Typically developing individuals showed an increased response to direct gaze in different brain areas: the medial prefrontal cortex, temporoparietal junction, posterior superior temporal sulcus region, and amygdala. These same regions showed an increased response to averted gaze in individuals with ASD. Von dem Hagen et al.'s research suggested that while individuals with ASD recruited a similar neural circuit for processing gaze, it was in a different context (averted vs. direct), which may help to understand difficulties associated with eye contact and processing social scenarios in ASD.

Whether two of the main core deficits of autism—language and eye contact—are related in the autistic brain is not perfectly clear. However, studies of the amygdala have shown that there may be a connection between language and eye contact in the autistic brain. In a longitudinal MRI-scan study by Muson et al. (2006), researchers discovered that larger right amygdala volume was associated with more severe social and communication impairments at ages 3 and 4 years. Larger right amygdala volume also was predictive of poorer social and communication abilities at age 6 years. Nacewicz et al. (2006) conducted an eye-tracking MRI-scan study and found that individuals with autism ages 10–24 years who had the smallest amygdala showed the least fixation of eye regions and also exhibited the most severe social impairments in early childhood. The combined results of these studies could indicate that on a neurobiological level there is some sort of relationship between eye contact and language. This relationship is suggested since it is shown that the amygdala is involved with both verbal and nonverbal social communicative functioning, and that the volume of this brain region impacts an individual's social-communicative abilities. However, it is important to note that Nacewicz et al. (2006) did not study the correlations between eye fixation time (measured in percentage of viewing time spent on different aspects of the social scenes) and social impairments; it is therefore unclear whether this correlation persisted after early childhood. There is, however, support for this possibility from a study by Corden et al. (2008), which reported that among adults with ASD, less fixation on the eyes was related to impaired recognition of facial expressions of fear and greater levels of social anxiety.

Very few studies have examined the relationship between language and eye contact in individuals with ASD and those that do exist were not conducted in naturalistic settings and the results were varied. There are three foundational studies examining the relationship between eye contact and language. First, Klin et al. (2002) reported that fixation time towards the eyes during simulated naturalistic social situations (viewing videos that replicate social interactions) was not a strong predictor of social competence (standardized measures of daily social adjustment and degrees of autistic social symptoms, including language). However, fixation on the mouth region was associated with greater social adaption and lower social impairment. Klin et al. proposed that focusing on the mouth suggests that children with autism may follow an alternative path for learning language, possibly relying more on the association between the movement of the mouth and the sounds it makes to communicate verbally, rather than learning speech as a social communication tool. This theory has been supported by many other eye-tracking studies, such as a study conducted by Jones, Carr, and Klin (2008). A follow-up study by Norbury et al. (2009) examined individuals with ASD *without* language impairments and individuals with ASD *with* language impairments. Norbury and colleagues found no differences in viewing patterns between individuals with ASD with language impairments and typically developing peers. Eye movement paths were also not associated with social outcomes for children with ASD with or without language impairment. Higher fixations on the mouth were associated with higher communicative competence for both ASD groups. Norbury et al. suggest that this may be due to the fact that fixation time on eyes may not significantly disrupt social competence in daily interactions. The final study that has contributed to understanding whether there is a relationship between eye contact and language is by Kaartinen et al. (2012). This study determined if unconscious arousal during eye contact (measured by skin conductance responses) is related to social skills among children with ASD ages 8–16. The level of arousal to direct gaze in comparison to arousal to averted gaze or closed eyes was associated with impairments in social skills. The correlation was observed only among children with ASD; there was no indication of such correlation among the children without ASD. These results suggest that eye contact is related to general social disabilities found in ASD.

The majority of previous research studying the day-to-day experiences of individuals with ASD involves standardized testing, parent report, and structured interviews or task-based activities in clinical settings. These methods of data collection do not fully capture the influence or context of the daily experiences of subjects (Chen et al. 2014). Usually, standardized testing measures assess both receptive communicative-abilities (the ability to understand language heard or read) and expressive communicative-abilities (the ability to put thoughts into words in a way that makes sense), whereas spontaneous speech in naturalistic settings measures specifically expressive language. Since there is a range of abilities in ASD, it is important to use both standardized tests and natural language samples to accurately assess individuals (Condouris et al., 2003).

In one of the first naturalistic studies conducted in the field of ASD, Hart and Risley (1992) determined that the number of words per day at home collected in a longitudinal sample of children starting at 10 months of age predicted their cognitive scores at three years of age. This study was one of the first to demonstrate that collecting language in naturalistic settings can predict later cognitive development. Other studies have shown that spontaneous speech predicts language and communication competence 15 months later (Loucas et al., 2008), and that the study of spontaneous communication can be used to examine patterns in deficits of children with autism in everyday activities (Stone and Caro-Martinez, 1990). Collectively, these studies show that observational measures of communication in naturalistic environments are valuable assessment strategies for research and clinical practices.

Furthermore, naturalistic data may be more successful at identifying language impairment than data obtained in the clinic. In a study by Dunn et al. (1996), the sensitivity of standardized test measures were compared with measures derived from natural language samples for diagnosing specific language impairment. They found that natural language data—specifically mean length of utterance (MLU) and percentage of utterances that contained structural errors—were better at identifying language impairment than psychometric tests. In another study conducted by Conti-Ramsden et al. (1997), it was found that when standardizing psychometric tests to different language disorders, these tests were successful at identifying structural language impairment, but none of the tests could identify children with semantic/pragmatic language incapability; naturalistic sampling was better at identifying this disorder.

There is little research looking at the relationship between eye contact and language in children with ASD in naturalistic settings as compared to clinical settings. The current experiment addresses this gap. The first aim of this study was to determine if there was a relationship between eye contact and language in the clinic. Specifically, this study examined whether there was a difference in the amount of eye contact when a child was playing versus when they were engaged in a conversation. This study attempted to determine whether a difference in social activity would impact the duration of eye contact displayed by children with ASD. It was hypothesized that there would be a significant difference between the total duration of eye contact presented during play and eye contact presented during conversation because the change in social context would cause the children to react with different amounts of eye contact.

The second goal of this study was to test whether increased eye contact in play versus conversation in a clinical environment would predict the amount of communication (specifically verbal responses) in the home of children with ASD. It was hypothesized that eye contact during play in the clinic would predict verbal responses in natural settings because eye contact during play is associated with joint attention abilities which directly relate to language skills. It was predicted that eye contact during conversation in the clinic would not be associated with verbal responses, as it requires less shared communicative reference, or joint attention skills.

Clinic sessions for each participant were recorded using eyeglasses with an embedded video camera worn by clinicians, and the subjects' speech was recorded in their homes by a LENA DLP device. Eye contact during play in the clinic was compared to eye contact during conversation in the clinic as the child and clinician engaged in the BOSCC, a semi standardized 12-minute social interaction. Children were sent home with the LENA DLP device, which recorded an average of 90 minutes per day of language for 2-5 days during 1 week. Studying the relationship between eye contact and language is important to understand the behavioral presentation and development of ASD symptoms. Understanding if there is an association between eye contact and language could ultimately help clinicians improve interventions by tailoring interventions to better meet the social and everyday needs of those on the spectrum and may also help to predict developmental outcomes of interventions.

Methods

The data for this project is part of a one-week protocol from the "Advancing a Standardized Research Protocol to Study Treatment Effects in Autism" (IRB #1405015095A005), also referred to as the Change Study. Subjects came in for an initial visit at the clinic conducted at the Center for Autism and the Developing Brain (CADB) at Weill Cornell Medical School/New York Presbyterian Hospital in White Plains, NY or at Weill Cornell in New York, NY. Children were recruited for this study because they had already come to CADB as a clinic patient and had agreed to be contacted for future research studies. 12 children completed the procedures (11 males, one female), 5–17 years of age (average age 8 years and 9 months and SD = 4.5 years) and had *at least* 2 to 3 word phrases daily. Verbal, non-verbal, and full-scale IQ scores for each child were generated from scores on the Differential Abilities Scale (DAS). Small sample ASD populations under 20 are common because of difficulty of recruitment. Many previous studies in this field have had small sample sizes such as Charman (2003), Kaartinen et al. (2012), and Vellonen et al. (2012).

Participants completed the Brief Observation of Social Communication Change (BOSC-C), a 12-minute interaction between clinician and child at CADB. The BOSCC is divided into three segments. First, there is a five-minute play interaction with a series of standardized toys, in which the child is free to choose whatever toys they would like to play with. The second segment is a two-minute conversation about any topic. The final segment is a second five-minute play interaction with a second set of standardized toys.

The BOSCC was recorded with a camcorder handheld camera as well as pivot-head glasses (See Appendix A). Pivothead glasses have an embedded camera embedded between the eyes. Because the camera is positioned between the eyes, it is possible to tell when the child was making eye contact with a clinician based on if they were looking directly at the camera (See Appendix A).

During the clinic visit, caregivers were given a LENA Digital Language Processor (DLP) device and a T-shirt with a pocket for the device to be placed inside and parents were given instructions on how to operate the device in their homes. The researchers notified the parents that the LENA device was to stay inside the home and not be brought to school, after-school activities or in the car. Language was recorded on 2–5 days of the week, and the average total recording time at home was 390 minutes per subject, SD = 118 minutes. Parents returned the LENA DLP device to the clinic after 7 days. All data was de-identified and was collected as a part of an IRB-approved study at Weill Cornell Medical College.

Data Analysis:

The clinic visit videos were coded for eye contact frame by frame to the thousandth of a second using ELAN (a tool created by The Language Archive for the creation of complex annotations on video and audio resources). Proportions were generated for each subject by taking the total duration of eye contact that was displayed during conversation over the total conversation time and the total duration of eye contact during play over the total time during play. Research assistants transcribed the language recordings using Systematic Analysis of Language Transcripts (SALT) software. The SALT transcriptions were queried for the number of verbal responses (anytime a child responded to a comment or question). A proportion for each subject of the total number of verbal responses over the total time frame that the subject was recorded in the home was generated because each child was recorded for different amounts of time in their home. A paired samples *t*-test was performed to determine if there was a significant difference between eye contact shown in conversation versus eye contact shown in play, with respect to independent variables of age and IQ. A Bonferroni correction was then calculated for this t-test. Additionally, a pairwise correlation was performed to determine if there was a relationship between eye contact during play vs. conversation and verbal responses, with respect to independent variables of age and IQ. All statistical analyses were performed in SPSS Version 22.

Results

There was a significant difference between the duration of eye contact during play versus eye contact during conversation (play: M = .04, S = .04 conversation: M = .15, S = .16), ($t(11)$ =

2.580, $p = .026$). Paired samples t-tests with covariates of age and IQ, demonstrated no significant interaction between age and IQ ($p < .05$). Together the results show that there was a difference in the amount of eye contact in children with ASD in the clinic based upon what task they are performing. To control for the small sample size, a Bonferroni correction was performed. The p-value 0.05 was divided by the number of tests performed, which was one. The results were thus still significant, since the p-value remained the same after the correction. See Figure 1.

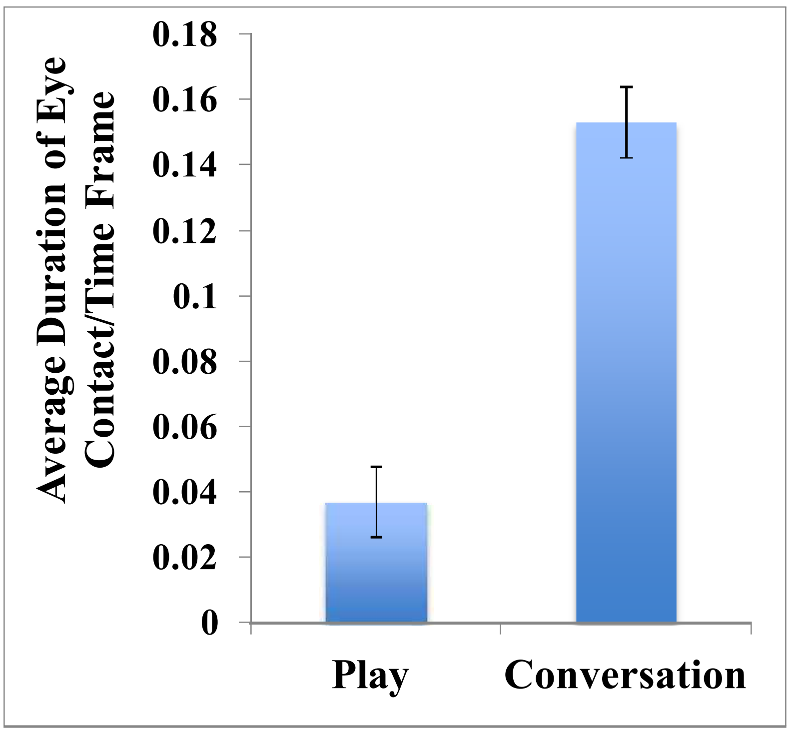

Figure 1. Is There A Significant Difference Between Eye Contact in Play vs. Conversation? This figure demonstrates that there is a greater amount of eye contact shown in conversation than in play in the initial clinic session.

The second set of analyses target whether there was a relationship between eye contact in the clinic versus spoken language in the home. There was no significant correlation between eye contact in play in the clinic and verbal responses at home, ($p = .627$), or eye contact in conversation in the clinic and verbal responses in the home ($p = .211$). There was no further relationship with age and IQ ($p < .05$). See Figures 2 and 3.

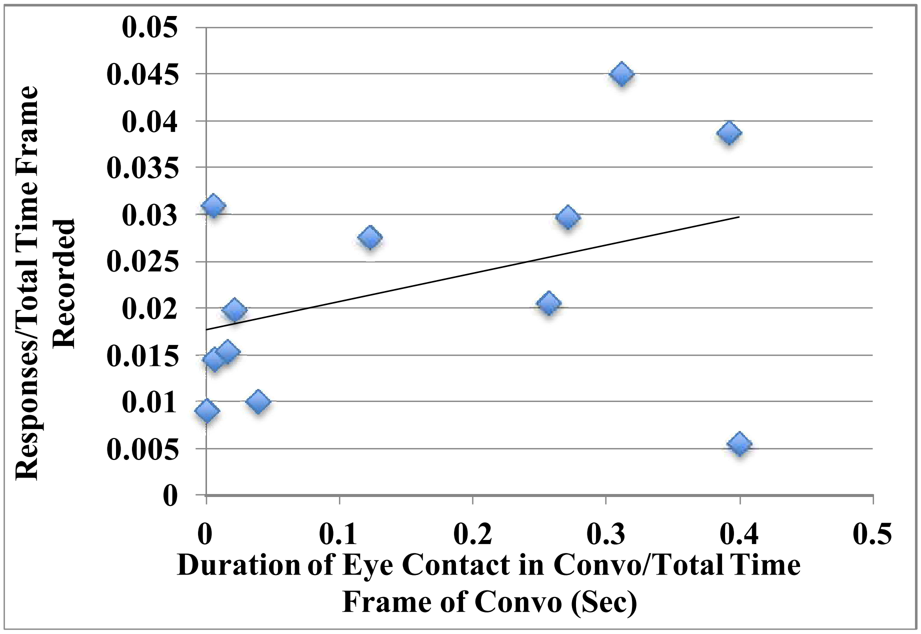

Figure 2. Is Eye Contact in Conversation Predictive of Verbal Responses? This figure displays the relationship between eye contact observed during conversation in the clinic and verbal responses recorded in the home.

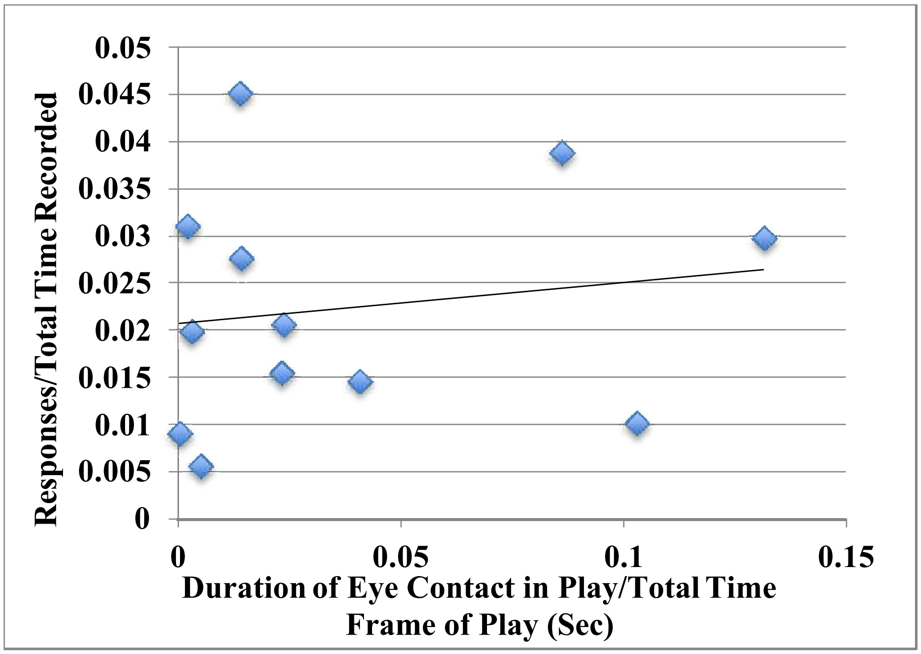

Figure 3. Is Eye Contact in Play Predictive of Verbal Responses? This figure displays the relationship between eye contact observed during play in the clinic and verbal responses recorded in the home.

Discussion

The first aim of this study was to determine if the type of social activity impacts eye contact displayed by children with ASD in the clinic. The results suggested a significant difference in the amount of eye contact displayed during play as compared to during a conversation. These findings suggest that the type of social activity affects the amount of eye contact displayed by children with ASD. During the experiment, children focused attention on toys that they were playing with rather than on the clinician who was playing with them. In comparison, when the children were instructed to stop playing with the toys and engage in a brief conversation, the children were more inclined to focus their attention on the clinician.

These findings of less eye contact during play versus conversation in children with ASD were initially surprising because the majority of individuals with ASD do not display an appropriate amount of eye contact during conversation, and lack of eye contact during social communication is a diagnostic characteristic for ASD (Freeth, Foulsham, and Kingstone, 2013). However, the results makes sense given that children with ASD focused on the objects that they were playing with and these findings are consistent with previous research showing individuals with ASD are often intensely focused or attached to certain objects. This fascination on objects seems to be linked to repetitive and restrictive behaviors displayed in ASD (National Institute of Mental Health, 2015). In this way, removing a toy from a social scene would then force a child to move his or her focus from the object to the person talking to them.

Another consideration for why there was more eye contact displayed during conversation versus play in children with ASD is prior research suggested there are certain aspects of conversation that stimulate higher amounts of eye contact in individuals with ASD. In a study conducted by Freeth, Foulsham, and Kingstone (2013), they demonstrated that higher functioning individuals with ASD, although they lacked an appropriate amount of eye contact, looked more frequently at the experimenter's face when being asked questions during conversation, which was also found to be the case in typically developing individuals. This coincides with data from the current study. When children were asked questions, they were more likely to make eye contact during both play and conversation tasks, but they were more frequently asked questions during conversation, which could explain why we found more eye contact. In general, there could have been more eye contact displayed during conversation in this sample because all subjects were verbal. Since these subjects displayed less autistic symptoms, it is possible that this is the reason this sample on average displayed eye contact that would be considered relatively close to that of typically developing individuals.

The second goal of this study was to ascertain if eye contact during play or conversation in the clinic related to verbal responses in the home. We found no correlation between eye contact in either play or conversation with verbal responses in the home. In other words, there was no correlation between eye contact and language in children with ASD across two different contexts. This coincides with the majority of previous research that has looked at eye contact and language of children with ASD in the clinic only. Since eye contact and language are linked in typically developing individuals (people look at one another when they are speaking), it makes sense that in children with ASD who are lacking in social communicative abilities, the opposite would be true. This may indicate that the brain of an individual with ASD may regulate these behaviors in a different way than in a typically developing brain. In general, a lack of eye contact in children with autism reflects an altered pattern of brain development (Jones, Carr, & Klin 2008). This atypical development in the brain could impact the nature of the relationship between eye contact and language functioning in children with ASD.

It is possible that as a result of atypical brain development in ASD, instead of eye contact being predictive of language, gazing at the mouth is positively correlated with language abilities. Klin et al. (2002) found that fixation time on the eyes was not associated with social adaption or social disability; however, fixation time on the mouth was associated with greater social adaption and lower social impairment. What's interesting about this finding is that although lacking in eye contact is a diagnostic for ASD, it was not a good predictor of other social deficits in ASD. However, this was also found to be true in a more recent study by Young et al. (2009), which found that gaze behavior at 6 months did not predict ASD. Young et al. also found that greater fixation time on the mother's mouth during live interaction predicted higher levels of expressive language, not only for children with ASD, but also with typically developing infants as well. This suggests that gaze directed at the mouth is useful in predicting individual differences in language development in all infants. This may indicate that looking at the mouth is positive for development, and is used as an alternative way to learn language. Looking at the movement of the mouth and associating it with the sounds it makes may help all children learn how to speak to a certain extent, however it is probably more commonly seen in ASD because this may need to be utilized more to make up for social and developmental deficits. Studying fixation on the mouth and eyes and how they are related to language could help identify what differences exist in the correlations between these skills in children with ASD versus typically developing children.

Future studies examining the relationship between eye contact and language across clinical and naturalistic settings could lead to more individualized intervention treatments for children with ASD. In general, studying these behaviors in natural settings is important because by observing subjects in social environments outside of the clinic, specialists would be better able to determine which areas subjects need to be working on in order to improve their level of functioning in the outside world. Interventions would be more successful at meeting the everyday needs of the individual if specialists get a sense of their patients' daily life. Comparing children with ASD's behaviors in the clinic versus the home could also help in identifying the difference in intervention that patients require in these different settings, and potentially help to aid parents in how they should be communicating with their child at home, possibly in a different way than specialists interact with their child in the clinic. Studying the differences in these behaviors across clinical and naturalistic settings may aid in discovering what environmental factors could be further stimulating these impairments.

Discovering the origins of language and eye contact deficits and the nature of their relationship would help to create better treatments to improve these behaviors. Knowing that these behaviors are most likely not directly correlated, these behaviors could be targeted in interventions in more specific ways, with improved strategies to target these behaviors simultaneously and also separately. It has already been shown through past research that deficits in language are most effectively treated by intervention that focuses on joint attention. Three different studies, (Rogers & Lewis 1989; Koegel, 2000; Lord, 2000) demonstrated that intervention focused on joint-attention and nonverbal social communicative skills often result in enhanced language and social development. Intervention focused on joint attention for improving language may also be effective in naturalistic settings, as joint attention has been shown to be predictive of language ability in children with ASD in naturalistic settings. In one study that looked at spontaneous communication (requests, drawing attention to oneself, and motoric forms of communication toward instructor) in 30 children with ASD, joint-attention deficits were observed and were found to be most severe in the subgroup of children who were not verbal (Stone and Caro-Martinez, 1990). Continuing with this research on the effectiveness of treatments and looking at how eye contact is related to language could help to determine if joint attention intervention is also effective in improving eye contact and if there are other methods that could be used for treating eye contact.

Future directions for this study would include continuing to look at the relationship between eye contact in the clinic and language in the home in the eight-week trial of The Change Study that was completed after the one-week protocol. This trial had a larger sample of children in addition to being conducted over a longer period of time. With this new data, it would be interesting to look at the quality of language during the BOSCC in addition to eye contact to see if eye contact in play or conversation is related to language spoken in the clinic. It would also be relevant to examine if there is a significant difference in language quality shown during play versus conversation. This could help to determine if language quality is one of the factors that causes the type of social activity to have an impact on the amount of eye contact displayed by children with ASD. Furthermore, with the eight-week trial, language in the clinic could be compared to language at home, which would further our understanding of the difference in behavior displayed by children in ASD in the clinic and at home.

Since The Change Study only involves recording speech in the home, an interesting follow-up study could involve having parents or guardians wear pivot-head glasses to film their children's eye contact in their home environment. This would allow for a comparison to be made between eye contact and language just in naturalistic settings. While there is ongoing research in the clinic, there is no comparison research being done on eye contact in the home in children with ASD. If this research was conducted, this could help to determine how the environment impacts eye contact and language behavior in ASD individuals. With this kind of follow-up study, duration of eye contact displayed in the clinic and duration of eye contact displayed at home could also be compared. As a whole, studying language and eye contact in children with ASD is important to achieving a greater understanding of the etiology and treatment of ASD.

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Appendix A

Note: This image shows the Pivothead glasses worn by clinicians during initial clinic visits. The camera is located in between the lenses, which records what the wearer sees directly in front of them. For this study, these glasses were used to track eye contact. Since the camera is located in between the eyes, if the child is looking directly at the camera, this indicates that they are making eye contact with the clinician.