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Attention in the Infant Siblings of Children with an Autism Spectrum Disorder

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ATTENTION IN THE INFANT SIBLINGS OF CHILDREN WITH AN AUTISM SPECTRUM DISORDER (ASD)

By

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Children with Autism Spectrum Disorders (ASDs) are impaired in visually disengaging attention in both social and non-social contexts, impairments that may, in subtler form, also affect the infant siblings of children with an ASD (ASD-sibs). I investigated patterns of visual attention (gazing) in six-month-old ASD-sibs (n = 17) and the siblings of typically developing children (COMP-sibs; n =17) during the Face-to-Face/Still-Face Protocol (FFSF). Also, I examined joint attention through the Early Social Communication Scales (ESCS) when ASD-sibs and COMP-sibs were eight months of age. The relationship between gazing and later joint attention was examined. Throughout the FFSF protocol, ASD-sibs shifted their gaze to and from their parents' faces less frequently than did COMP-sibs. The mean durations of ASD-sibs' gazes away from their parents' faces were longer than those of COMP-sibs. ASD-sibs and COMP-sibs did not differ in the mean durations of gazes at their parents' faces. Also, infants' shifts in gaze were positively correlated with initiating joint attention behaviors at eight months of age. In sum, ASD-sibs showed no deficits in visual interest to their parents' faces, but greater interest than COMP-sibs in non-face stimuli. Such differences may play an important role in the development of joint attention.

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Chapter 1: Introduction

In early childhood, the ability to engage and disengage attention is necessary to the development of social communication. Engaging attention involves sustaining visual attention on an object, while disengaging attention involves shifting visual attention from one object to re-engage on another. Children with Autism Spectrum Disorders (ASDs) are able to sustain attention, but appear overly focused and impaired in their ability to disengage and shift attention (Landry & Bryson, 2004; Lovaas & Schreibman, 1971; Rincover & Ducharme, 1987; Wainwright Sharp & Bryson, 1993; Wainwright & Bryson, 1996). The purpose of this study was to identify possible disengagement deficits and their relationship to joint attention within the first year of life by examining the at-risk infant siblings of ASD children (ASD-sibs).

ASDs are pervasive developmental disorders characterized by impairments in social functioning, communication, and the display of repetitive behaviors and/or stereotyped interests (APA, 2000). Males are at greater risk than females for developing an ASD (Fombonne, 1999). Some of the associated deficits are present, in the form of a broader phenotype, in the relatives of individuals with an ASD (Constantino et al., 2006; Dawson et al., 2004). The broader phenotype refers to milder deficits in at least one of the three affected domains in autism (Dawson et al., 2002; Yirmiya et al., 2006). While 3 to 9% of full-siblings exhibit deficits associated with an ASD diagnosis, as many as 20% of full-siblings may exhibit deficits in social and communicative functioning, indicative of the broader phenotype (Gamliel, Yirmiya, & Sigman, 2007; Landa & Garrett Mayer, 2006; Zwaigenbaum et al., 2005).

Although ASDs are usually not diagnosed before two years of age, 30-50% of parents report prior abnormalities in their child's behavior from before the time of diagnosis (Werner, Dawson, Osterling, & Dinno, 2000; Zwaigenbaum et al., 2005). Early orienting and gaze-related deficits in autism have been identified through retrospective studies using parent report and analysis of early home videos. In home videos of ASD and typically developing (TD) children at eight and ten months of age, Werner et al. (2000) found that children with an ASD oriented to their name half as often as TD children, and were less likely than TD children to coordinate smiling with gaze at another person's face. Other retrospective studies using parent report have found similar deficits in orienting (Gomez & Baird, 2005; Osterling & Dawson, 1994; Zakian, Malvy, Desombre, Roux, & Lenoir, 2000). Overall, children with ASDs oftentimes display impairments possibly associated with disengagement deficits within the first year of life. These deficits may underlie difficulties in coordinating communication behaviors.

Landry and Bryson (2004) compared the visual-spatial attention (e.g., ability to disengage) of children with an ASD, children with Down syndrome, and TD children using a visual orienting paradigm. Children with an ASD disengaged significantly more slowly and had significantly fewer "fast" (< 300 msec) reaction times than the other two groups. Similarly, Newell et al. (2007) found that children with an ASD were slower in shifting their attention when concurrent stimuli were present. These results indicate that children with an ASD have "sticky" visual attention which causes them to disengage more slowly or not disengage at all. This impaired disengagement may explain why individuals with an ASD display deficits in eye contact, orienting to name, and joint attention in early development.

Deficits in shifting gaze and orienting may be related to deficits in joint attention abilities, which are associated with important developmental outcomes such as language (Delgado et al., 2002; Delgado, & Yale, 2000; Markus, Mundy, Morales, Morales et al., 2000; Mundy et al., 2007; Mundy, Fox, & Card, 2003). Infants' ability to follow someone's gaze with their own visual attention has been predictive of their collaborative joint attention and emotional regulation strategies later in toddlerhood (Morales, Mundy, Crowson, Neal, & Delgado, 2005). The specific ability to initiate joint attention (IJA) requires the use of gestures and gaze to communicate about an object or event in the environment (Jones & Carr, 2004; Messinger & Fogel, 1998). The ability to respond to joint attention (RJA) requires following the joint attention (e.g. pointing) of another individual. In both circumstances, children need to be able to disengage from one object or event to either initiate joint attention or respond to joint attention bids. Deficits in IJA have been found in children with autism (Baranek, 1999; Jones & Carr, 2004) and ASD-sibs (Cassel et al., 2007; Goldberg et al., 2005).

Recently, prospective studies have compared ASD-sibs with the infant siblings of typically developing children (COMP-sibs) (Yirmiya et al., 2006; Zwaigenbaum et al., 2005; Cassel et al., 2007) as ASD-sibs are at greater risk for developing an ASD or showing deficits associated with the broader autism phenotype (Landa & Garrett Mayer, 2006; Zwaigenbaum et al., 2005). Some of these studies have investigated possible early deficits in disengaging visual attention. Yirmiya et al. (2006) examined gaze patterns in four-month-old ASD-sibs and COMP-sibs during the Face-to-Face/Still-Face Protocol (FFSF; Tronick et al., 1978; Adamson & Frick, 2003) with the parent. ASD-sibs did not significantly differ from COMP-sibs in the proportion of time spent gazing at their mothers' faces. Additionally, Zwaigenbaum et al. (2005) found that those ASD-sibs who went on to receive an ASD classification on the Autism Diagnostic Observation Schedule-Generic (ADOS-G; Lord, Rutter, DiLavore, & Risi, 1999) at 24 months of age, showed slowed disengagement at 12 months of age when compared to COMP-sibs. Using an eye tracking technique to examine gaze and visual fixation patterns, Merin, Young, Ozonoff and Rogers (2007) found that six-month-old ASD-sibs did not differ from controls in the amount of time they spent looking at their parents' faces versus away during the FFSF.

With respect to joint attention, Cassel et al. (2007) found that ASD-sibs had less IJA bids than COMP-sibs at 15 months of age. Although such deficits have not been as apparent in RJA, ASD-sibs have shown less RJA behaviors than COMP-sibs (Goldberg et al., 2005; Cassel et al., 2007). Sullivan et al. (2007) found some of the previously established relationships between joint attention and language in ASD-sibs, as joint attention behaviors at 14 months was predictive of later ASD classification and language ability.

The current study further investigated disengagement and joint attention by comparing six-month-old ASD-sibs' and COMP-sibs' gaze patterns at their parents' faces during the FFSF, and examining their joint attention bids during the Early Social Communication Scales (ESCS; Mundy, Hogan, & Doehring, 1996) at eight months of age. My goal was to examine infants' durations of engagement and disengagement at the parents' faces, and not simply overall time gazing at the parents' faces. I assessed visual attention through the FFSF, which has two periods of naturalistic interaction separated by a period of parental nonresponsivity. I assessed joint attention through the ESCS, which is an assessment that attempts to elicit early social communication, particularly joint attention, via an interaction between experimenter and infant.

I hypothesized that ASD-sibs would shift their gaze to and from their parents' faces less frequently, as well as have greater mean durations of gaze at and away from their parents' faces than COMP-sibs. Since the interactive episodes of the FFSF protocol are more social than experimental visual attention paradigms, I also examined the potential impact of parent behaviors, such as tickling, touching, and positive affect on infants' gaze patterns. The ability to disengage at six months of age during the FFSF was expected to positively correlate with IJA and RJA behaviors at eight months of age during the ESCS.

By examining infant ASD-sibs' gaze patterns and early joint attention, I could gain a better understanding of how early social communication deficits appear within the first year of life.

Chapter 2: Method

Participants

All infants were approximately six-months old (M = 6.12, SD =.37) when they participated in the FFSF. Infants in this study were part of a larger sample investigating the social, emotional, and cognitive development of ASD-sibs and COMP-sibs. The present study included a sample of 34 infant-parent dyads (32 infant-mother dyads, 2 infant-father dyads); two of the ASD-sibs female infants were monozygotic twins. See Table 1 for the gender breakdown of ASD-sibs and COMP-sibs. Infants were included in the ASD-sibs group if the parent reported that at least one older sibling was diagnosed with Autism, Asperger's Syndrome, or Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS), and diagnosis was confirmed through ADOS-G, Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & Couteur, 1994), and clinical impression. Infants were included in the COMP-sibs group if they had older sibling(s) not diagnosed with, and not showing any research evidence of, an ASD-related disorder (i.e. did not exceed cut off score of nine on the Social Communication Questionnaire (SCQ; Berument, Rutter, Lord, Pickles, & Bailey, 1999). Groups were comparable on gestational age (weeks), ethnicity, and socioeconomic status (SES) as measured by parent education (see Table 1). ASD-sibs, however, had significantly more male older siblings than COMP-sibs, $\chi^2 = 7.56$, $ps < .01$.

Face-to-Face/Still-Face Protocol

All six-month-olds participated in the FFSF Protocol (Tronick et al., 1978; Adamson & Frick, 2003), which consists of three episodes: the Face-to-Face (FF) episode, the Still-Face (SF) episode, and the Reunion (RE) episode. Parents were instructed to play with their infant (without toys) for three minutes (FF), then stop playing and hold a still-face for two minutes (SF), and resume play for another three minutes (RE). A two-second tone sounded at the beginning of each episode to notify the parents when a new episode had begun. The dyadic interaction was videotaped with a camera directed at the infant's face, a camera directed at the parent's face, and a camera that captured both infant and parent interacting. Infants were placed in a car seat and the parent was seated in a chair directly in front of the infant. FFSF episodes were terminated if the infant cried for more than 20 seconds or if the parent elected to terminate the episode. There were no group differences in the mean duration (minutes) of the FF (M = 3.00), SF (M = 1.97), and RE (M = 2.78). Twenty eight of the infant-parent dyads presented in the prospective study by Cassel et al. (2007) are included in the current study's sample. They found that during FFSF, six-month-old ASD-sibs smiled for a lower proportion of time than COMP-sibs.

Coding Gaze

Infants were coded as either gazing directly at the parent's face or not gazing at the parent's face. Thirty-eight percent of the video clips were randomly selected and coded by two coders (mean agreement = 90%; *kappa* = .75). The coders were blind to participant status.

Gaze patterns were examined using the overall frequency of gaze shifts and mean durations of gaze. The Frequency of Gaze Shifts was calculated as the sum of the frequency of shifts to and shifts away from the parent's face per minute. The Mean Duration of Gaze At Parent was calculated as the average time in seconds that the infant spent gazing at the parent's face per gaze within each episode. The Mean Duration of

Gaze Away was calculated as the average time in seconds that the infant spent gazing away from the parent's face within each episode. In exploratory analyses, I also calculated the Total Proportion of Gaze At Parent as the proportion of the number of frames in which the infant gazed directly at the parent's face out of the total number of frames.

Coding Parent Behaviors

Due to the interactive aspects of the FFSF, parent behaviors that could potentially influence infants' gaze, such as tickling, touching, and smiling were also coded. Parent smiling at their infant during the FFSF was coded by a coder certified in Facial Action Coding System (FACS; Ekman & Friesen, 1978). The onset of tickling occurred when the parent began moving their fingers while touching the infant. The offset of tickling occurred when the parent stopped moving their fingers and removed their hands from the child. Touch was coded when the parent made physical contact that did not involve tickling with the infant. Approximately 12% of the video clips were randomly selected and coded by two coders with a mean agreement of 88% (mean *kappa* = .81). The three types of parent behaviors were included as covariates in all repeated-measures ANOVAs.

Early Social Communication Scales[1]

Out of the 34 infants that participated in the FFSF at six months of age, 27 were administered the Early Social Communication Scales (ESCS; Mundy, Hogan, & Doehring, 1996) at eight months of age. The gender breakdown was more skewed for this sample than the FFSF sample as there were more male ASD-sibs than male COMP-sibs (see Table 2). This assessment elicits joint attention and behavioral requesting, and the sharing of positive affect with an examiner. The ESCS took approximately 15-25 minutes to administer, during which only the experimenter, and not the parent, interacted with the child.

Initiating Joint Attention (IJA) refers to a child's ability to share his or her interest or joy in an object. IJA was coded when infants made eye contact with the experimenter while manipulating a static or active toy, or alternated eye contact between a distal, active mechanical toy and the experimenter. If an infant alternated, his or her, eye contact after a mechanical toy became inactive, IJA episodes were only coded within two seconds of the time the toy became inactive. This ensured that the infant's behavior was indeed related to the object. Instances in which the experimenter's overt behaviors (e.g., talking or moving) may have elicited the infant's attention were not coded.

IJA is comprised of lower and higher level behaviors. Lower Level IJA behaviors included gazing at an examiner while watching or holding an active toy, or making eye contact while holding or touching an inactive toy. Higher Level IJA behaviors included pointing, with or without eye contact, at an object of interest or clearly holding up a toy and showing it to the examiner. I examined Total IJA, which combined both Lower Level and Higher Level IJA. All IJA variables were indicated as a rate per minute (rpm) with respect to the total duration of the ESCS.

Responding to Joint Attention (RJA) refers to the child's ability to follow the joint attention behavior (i.e., pointing) of the examiner. RJA was coded when infants followed the examiner's point combined with a vocalization (i.e., the child's name) to a distal stimulus. RJA was indicated as the number of correctly followed trials (out of 8 trials).

The ESCS behaviors were coded by two main coders and one reliability coder.

Approximately 20% of infants were coded by a reliability coder with mean intra-class correlations of $\geq$.70 for all behaviors coded.

Twenty-four of the infants presented in the prospective study by Cassel et al. (2007) are included in the current study's joint attention sample. They found no differences between eight-month-old ASD-sibs and COMP-sibs on their Lower Level or Higher Level IJA, Total IJA, or RJA.

A logarithmic transformation was performed to normalize the raw frequency of gaze shift, mean duration, and joint attention data. This transformation did not influence the results. The raw variables are presented in the figures and the logarithmically transformed variables were used in the statistical analyses.

Chapter 3: Results

Group Differences in Gaze

I compared the Frequency of Gaze Shifts (rate per minute) and the Mean Duration of Gaze Away and Gaze At Parent (seconds) of ASD-sibs (n = 17) and COMP-sibs (n = 17) across the FFSF. See Table 3 for the mean and standard deviations of these variables.

A 2 (group) x 3 (episode) x 2 (gender) repeated-measures ANOVA, controlling for parent behaviors, indicated that ASD-sibs shifted their gaze to and from their parents' faces less frequently than COMP-sibs, $F(1, 27) = 4.98$, $p = .03$, $\eta^2 = .16$ (see Figure 1). A non-significant interaction between group and gender indexed a tendency for female ASD-sibs to shift their gaze less frequently than female COMP-sibs, and male ASD- and COMP-sibs $F(1, 27) = 3.11$, $p = .08$, η2 = .11. Within-subjects contrasts indicated that infants, regardless of group, shifted their gaze at their parents' faces less frequently during the SF compared to the FF and RE, $F(1, 27) = 4.28$, $p = .05$, $\eta^2 = .14$. There was no interaction between episode and group, $F(2, 27) = .84$, $p = .41$. There were no gender main effects.

To follow-up on the group differences in the Frequency of Gaze Shifts, I examined group differences in Mean Duration of Gaze At Parent and Mean Duration of Gaze Away. First, I examined the association between these variables. The Mean Duration of Gaze Away was not correlated with Mean Duration of Gaze At Parent in any of the episodes in the FFSF (FF $r = -.20$; SF $r = -.21$; RE $r = -.18$). The Frequency of Gaze Shifts was negatively correlated with Mean Duration of Gaze Away in each episode of the FFSF (FF $r = -.57$; SF $r = -.93$; RE $r = -.62$), $ps < .01$, and with the Mean Duration of Gaze At Parent during the FF ($r = -.62$) and RE ($r = -.61$), ps < .01, but not the SF (r =

-.11). Thus there was not a one-to-one correspondence between these variables, although a higher Frequency of Gaze Shifts was associated with longer durations of individual gazes.

A 2 (group) x 3 (episode) x 2 (gender) repeated-measures ANOVA of Mean Duration of Gaze Away, controlling for parent behaviors, indicated that ASD-sibs had significantly longer Mean Duration of Gaze Away than COMP-sibs across the FFSF protocol, $F(1, 27) = 5.31$, $p = .03$, $\eta 2 = .16$ (see Figure 2). A non-significant interaction between group and gender indexed a tendency for female ASD-sibs to have longer Mean Duration of Gaze Away than female COMP-sibs, and male ASD- and COMP-sibs, $F(1, 27) = 3.23$, $p = .08$, $\eta 2 = .11$. There was no interaction between episode and group, $F(2, 27) = .56$, $p = .58$. There were no significant gender or episode main effects.

A 2 (group) x 3 (episode) x 2 (gender) repeated-measures ANOVA of Mean Duration of Gaze At Parent, controlling for parent behaviors, indicated that there were no group differences in Mean Duration of Gaze At across the FFSF protocol. There was no interaction between episode and group, $F(2, 27) = 1.20$, $p = .31$. There were no significant gender, episode, or interaction effects.

The Total Proportion of Gaze At Parent was, unsurprisingly, strongly positively correlated with Mean Duration of Gaze At in each episode of the FFSF (FF $r = .74$; SF $r = .65$; RE $r = .66$), $ps < .01$, and strongly negatively correlated with Mean Duration of Gaze Away (FF $r = -.75$; SF $r = -.86$; RE $r = -.80$), $ps < .01$. To increase comparability with previous reports, we, nevertheless, conducted a 2 (group) x 3 (episode) x 2 (gender) repeated-measures ANOVA of Total Proportion of Gaze At Parent, controlling for parent behaviors. There were no group differences in Total Proportion of Gaze At across the

FFSF protocol both when I controlled for covariates and when I did not.

Gaze and Joint Attention

Several Pearson's *r* correlations were conducted to examine the relationships between gaze variables at six months of age during the FFSF and joint attention at eight months of age in the ESCS. See Table 3 for the mean and standard deviations of the joint attention variables.

For all infants, Frequency of Gaze Shifts At Parent was positively correlated with Lower Level IJA, $r = .41$, $ps < .04$, and Total IJA, $r = .46$, $ps < .02$ (see Figure 3). There were no other significant correlations between gaze and joint attention variables (see Table 4). Also, there were no significant correlations between IJA variables and RJA (see Table 4). Correlations were not conducted by group due to the critical decrease in *n* that would occur in the analyses.

Chapter 4: Discussion

Over 60% of parents report, retrospectively, that their children with autism, “looked through or past people” in the first year of life (Gomez & Baird, 2005, pg. 113). The current study is one of several attempting to prospectively identify potential early deficits associated with the broader autism phenotype in the infant siblings of children with ASDs (Landa & Garrett Mayer, 2006; Yirmiya et al., 2006; Zwaigenbaum et al., 2005). I found that, during the FFSF, ASD-sibs shifted their gaze less frequently and had longer mean durations of gaze away from their parents’ faces than COMP-sibs. Furthermore, infants’ shifts in gaze to and from their parents’ faces were positively correlated to later initiating joint attention behaviors.

Landry and Bryson (2004) found that older children with Autism/PDD took significantly longer to disengage from experimental stimuli than both TD children and children with Down Syndrome. Using a visual-orienting paradigm, Zwaigenbaum et al. (2005) found that ASD-sibs, who became slower at disengaging from standard stimuli between six and twelve months of age, went on to receive an ASD classification on the ADOS at 24 months of age. There may be a neurological basis for these disengagement deficits given that delayed attentional orienting has been associated with severity of cerebellar hypoplasia in children with autism between two and six years of age (Harris et al., 1999). ASD-sibs had a lower frequency of gaze shifts to and from their parents’ faces and longer mean duration of gazes away from their parents’ faces than COMP-sibs, which may represent developing deficits in the capacity to disengage; they may characterize the hallmark “sticky” attention of children with ASDs.

Merin et al. (2007) used the FFSF procedure to assess infant-parent visual and emotional engagement during a dyadic interaction and perturbations of that interaction. They did not find differences in the proportion of time six-month-old ASD-sibs and COMP-sibs gazed at versus away from their parents' faces. Yirmiya et al. (2006) also found no differences between six-month-old ASD-sibs and COMP-sibs in the proportion of time they gazed at their parents' faces throughout the FFSF. I replicated these null effects for proportion of time gazing at the parent. Relatedly, I found no differences between the groups in Mean Durations of Gaze At Parent.

Compared to COMP-sibs, ASD-sibs had longer mean durations of gazing away from their parents' faces. This suggests that while ASD-sibs are more interested in non-social stimuli than COMP-sibs, both sibling groups are equally interested and engaged by the parent's face, a salient social stimulus. These findings may be relevant to children with ASDs. These children are delayed in their ability to shift attention and engage with social stimuli (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Dawson et al., 2004), but, once engaged with social stimuli like their parents' faces, may do so for a typical amount of time. Sigman, Mundy, Sherman, and Ungerer (1986), for example, found that older children with an ASD spent a similar amount of time gazing at their caregivers when compared to TD and mentally retarded children.

There were interaction trends indicating that female ASD-sibs showed lower frequency of gaze shifts to and from their parents' faces and longer mean duration of gazes away from their parents' faces than female COMP-sibs, and male ASD-sibs and COMP-sibs. This finding was unexpected given that male rather than female children are at greater risk for developing ASD symptomatology (Fombonne, 1999). I am hesitant to interpret this trend further until it is replicated. This study expands our understanding of the broad phenotype and deficits that may be associated with developing ASDs. I did not, however, contrast participants based on later ASD classification because 15 out of the 34 participants have not reached 30 months of age.

Furthermore, infants' frequency of gaze shifts was positively related to their IJA behaviors at eight months of age. While I did not specifically examine for group differences in the correlational patterns between gaze and joint attention variables, it is important to consider how deficits in shifting gaze may also relate to deficits in joint attention. The ability to shift visual attention may be a rudimentary, but necessary mechanism for the emergence of the joint attention. Consequently, impairments in IJA and its possible precursor, disengagement, may be critical early markers of identification, as deficits in IJA have helped differentiate the majority of children with an ASD from children with other developmental delays (Lewy & Dawson, 1992; Mundy, Sigman, Ungerer, & Sherman, 1986).

While the ability to disengage seems to be a basic mechanism in RJA, we did not find a significant relationship between frequency of gaze shifts and RJA. This may be due to the age of the participants. At eight months of age, RJA abilities are just beginning to emerge and will almost triple by 18 months of age (Mundy, Hogan, & Doehring, 1996). In the future, frequency of gaze shifts relationship with IJA and RJA should be further investigated by comparing groups on their correlations, and examining joint attention at later ages.

Atypical patterns of disengagement may also be adversely related to later emotional regulation and other abilities directly associated with socio-emotional functioning. The ability to disengage visual attention is important in the regulation of emotional states (Rothbart, Ziaie, & O'Boyle, 1992). Children at risk for autism may exhibit a tendency to fussiness (Yirmiya et al., 2006) due to their inability to easily disengage from a disconcerting interaction (Bryson et al., 2004).

Some of the current limitations involve both parent and infant factors not examined in the study. While parents' touching, tickling, and positive affect were controlled for, their vocalizations were not examined. This would be another important factor to consider, as it may affect infants' gazing at and away from their parents' faces. Another factor to consider is infants' posture and mobility. Those infants, who are, for example, sitting up more in the car seat, may spend less time attending to their parents' faces. It seems that these factors, as well as other factors that may share a relationship with disengagement, like infant emotional expressivity (Bryson et al., 2004), should be considered in the future.

Overall, ASD-sibs' decreased ability to shift their attention to social presses may be due to their heightened interest in less social, non-face stimuli in their environment. The developmental importance of disengagement abilities may be seen in that frequency of shifts in gaze to and from the parents' was positively correlated to IJA behaviors. These findings extend our knowledge of visual attention differences at the broader phenotypic level in at-risk siblings within the first year of life. The differences may be representative of early deficits and could have adverse implications for developmentally critical domains such as joint attention. The identification of such deficits is crucial as it may facilitate early diagnosis and implementation of interventions, which can improve outcomes later in life (Kazdin & Weisz, 2003).

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Footnotes

[1] This section appears in the method sections of Cassel et al., 2007.

Tables

Table 1

Participant Demographics

Demographics	*ASD-sibs*	*COMP-sibs*
Gender [% / (n)]		
Male	58.8 / (10)	47.1 / (8)
Female	41.2 / (7)	52.9 / (9)
Older Sibling Gender[% / (n)]		
Male	76.5 / (13)	29.4 / (5)
Female	23.5 / (4)	70.6 / (12)
Ethnicity [% / (n)]		
White/Non-Hispanic	29.4 / (5)	35.3 / (6)
White/Hispanic	70.6 / (12)	41.2 / (7)
African-American/Biracial	0 / (0)	11.7 / (2)
Biracial	0/ (0)	5.9 / (1)
Asian	0/ (0)	5.9 / (1)
Parent Education [% / (n)]		
Some College	11.6 / (2)	29.4 / (5)
4-year College	23.5 / (4)	29.4 / (5)
Advanced Professional Degree	64.7 / (11)	41.2/ (7)
Gestational Age (Weeks) [M / (SD)]	39.06 / 1.20	38.47 / 1.46

Note: ASD-sibs had significantly more male older siblings than COMP-sibs, $\chi^2 = 7.56$, *ps* < .01. There were no other significant differences between ASD-sibs and COMP-sibs on these demographics variables.

Table 2

Joint Attention Participants

Gender	*ASD-sibs*	*COMP-sibs*
Male	8	5
Female	5	9
Total	13	14

Table 3

Gaze and Joint Attention Means and Standard Deviations

Variables	*ASD-sibs*	*COMP-sibs*
Gaze [M / (SD)]		
Frequency of Gaze Shifts (rpm)	13.19 / (5.55)	18.16/ (8.36)
Mean Duration of Gaze At Parent (seconds)	4.16 / (3.33)	3.47 / (2.35)
Mean Duration of Gaze Away (seconds)	8.44 / (16.15)	4.72 / (4.00)
Joint Attention [M / (SD)]		
IJA Lower (rpm)	.68 / (.33)	1.22 / (.57)
IJA Higher (rpm)	.01 / (.01)	.04 / (.12)
IJA Total (rpm)	.69 / (.34)	1.26 / (.57)
RJA (correct responses)	1.69 / (1.44)	2.57 / (1.40)

Table 4

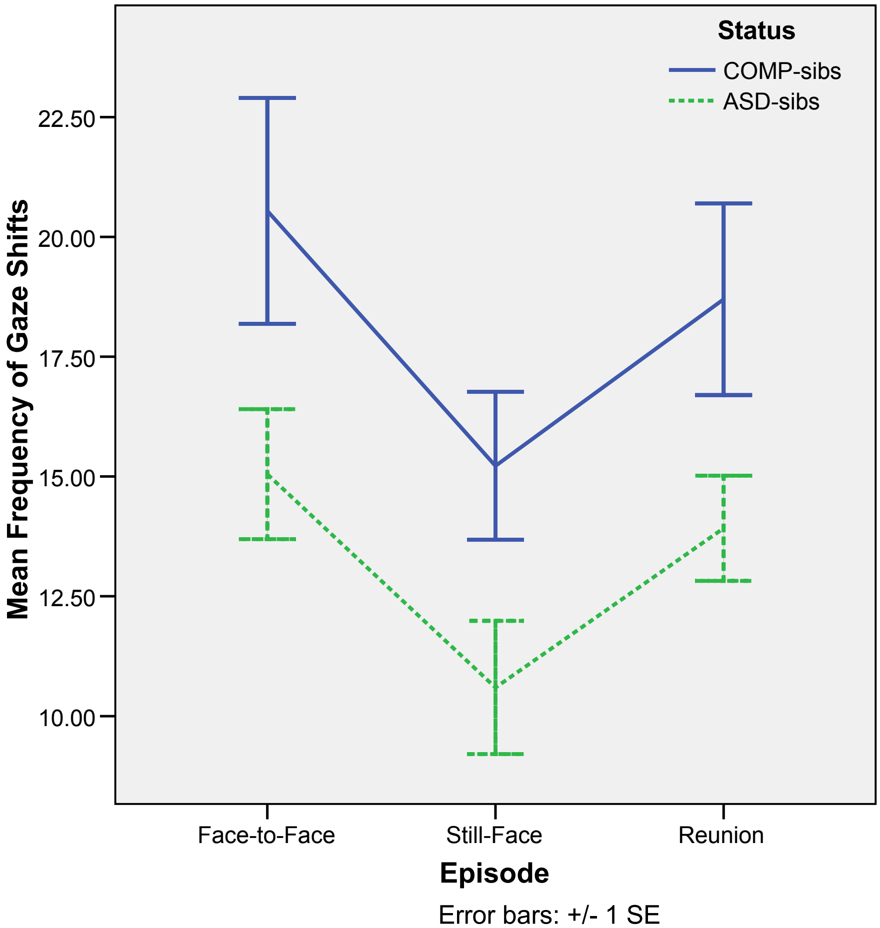
Correlations between Gaze and Joint Attention

	Frequency of Gaze Shifts	*Mean Duration Gaze At Parent*	*Mean Duration Away*	*IJA Lower Level*	*IJA Higher Level*	*IJA Total*	*RJA*
Frequency of Gaze Shifts	_	-.54*	-.68*	.41*	-.10	.46*	-.10
Mean Duration Gaze At Parent	_	_	-.21	-.27	-.13	-.28	.10
Mean Duration Away	_	_	_	-.26	.16	-.30	-.01
IJA Lower Level	_	_	_	_	-.04	.99*	.07
IJA Higher Level	_	_	_	_	_	-.08	-.11
IJA Total	_	_	_	_	_	_	.08
RJA							

*p≤.05

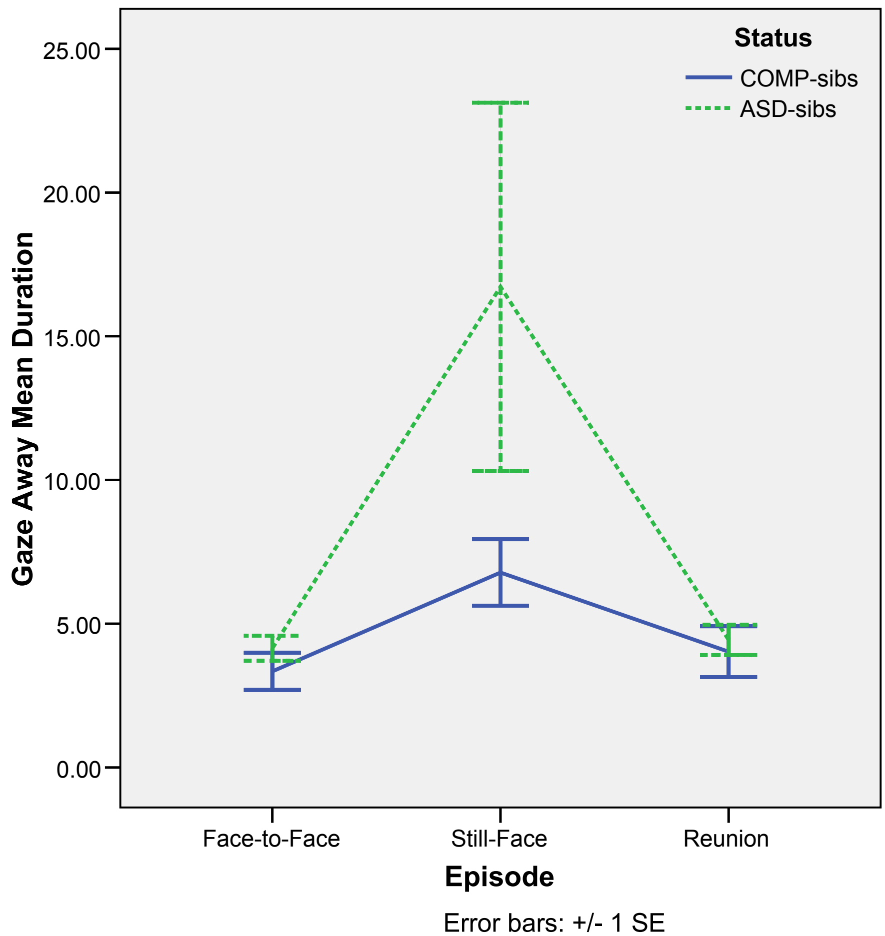
Figures

Figure 1. **Overall Gaze Shifts in the FFSF**



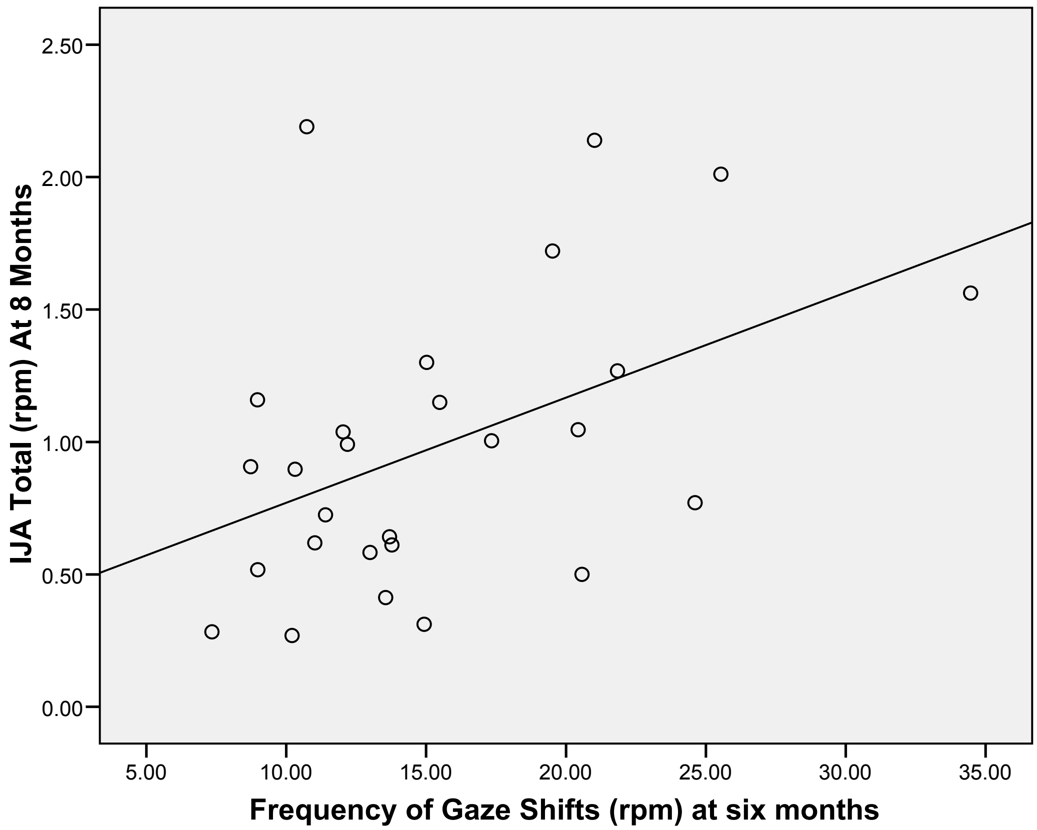
Note: ASD-sibs has significantly lower Frequency of Gaze Shifts than COMP-sibs across the FFSF protocol, $F(1, 27) = 4.98$, $p = .03$, $\eta 2 = .16$.

Figure 2. **Gaze away from parent's face (mean duration) during the FFSF**



Note: ASD-sibs had significantly longer Mean Duration of Gaze Away than COMP-sibs across the FFSF protocol, $F(1, 27) = 5.31$, $p = .03$, $\eta 2 = .16$. There was no interaction between episode and group, $F(2, 27) = .56$, $p = .58$.

Figure 3. **Frequency of Gaze Shifts and Joint Attention**



Note: Frequency of Gaze Shifts was positively correlated with Total IJA, $r = .46$, $ps < .02$.