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UNIVERSITY OF MIAMI

DEVELOPMENTAL TRAJECTORIES OF ATTENTION AND THEIR IMPACT ON LANGUAGE AND SEVERITY IN THE INFANT SIBLINGS OF CHILDREN WITH AN AUTISM SPECTRUM DISORDER

By

Lisa V. Ibanez

A DISSERTATION

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Doctor of Philosophy

Coral Gables, Florida

May 2010

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Developmental Trajectories of Attention and Their Impact on Language and Severity in the Infant Siblings of Children with an Autism Spectrum Disorder (May 2010)

Abstract of a dissertation at the University of Miami.

Dissertation supervised by Associate Professor Daniel S. Messinger.
No. of pages in text. (60)

Children with Autism Spectrum Disorders (ASD), and their infant siblings (ASD-siblings), exhibit deficits in their ability to shift visual attention, and to initiate and respond to joint attention. The current study examined early associations between visual attention and joint attention, and between these types of attention and later language ability and ASD severity in ASD-siblings (n = 31). This study investigated the possibility that ASD-siblings, who are at-risk for atypical development, differed from infants who have an older sibling(s) with no evidence of an ASD (Comparison-siblings; n = 23) on the following: 1) means of visual and joint attention, 2) the associations between these constructs, and 3) developmental trajectories of joint attention. Early visual attention was measured using infants' gazes at and away their parents' faces during the Face-to-Face Still-Face Protocol at 6 months. Initiating joint attention (IJA) and responding to joint attention (RJA) were measured during the Early Social Communication Scales at 8, 10, 12, 15, and 18 months. Language ability was measured with the Mullen Scales of Early

Learning language at 24 and 36 months. ASD severity was measured on the Autism Diagnostic Observation Schedule at 30 months.

Results indicated that ASD-siblings and Comparison-siblings were comparable in their gaze shifting and mean durations of gazes away from their parents' faces. These two components of visual attention were associated with parent behaviors, and the type of chair infants sat in. There were group differences in IJA at 10 months and RJA at 8, 15, 18 months, with ASD-siblings performing fewer behaviors than Comparison-siblings. There were developmental associations between visual and joint attention, and joint attention and later language and ASD severity. ASD-siblings differed from Comparison-siblings in their RJA development. ASD-siblings also had lower language ability and greater ASD severity than Comparison-siblings. The current study's limitations included low statistical power, and a difficulty inherent to prospective studies, which are at a disadvantage because a high proportion ASD-siblings may not develop an ASD. Nevertheless, the findings have clinical implications for the development of interventions targeting RJA behaviors within the first year of life.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Children with Autism Spectrum Disorders (ASDs) are impaired in their ability to shift their visual attention. They have also shown deficits in their ability to initiate and respond to joint attention (IJA; RJA), which are related to later language development in typically developing children. The infant siblings of children with an ASD (ASD-siblings) have also demonstrated possible impairments in the ability to shift their visual attention and engage in joint attention (Cassel et al., 2007; Yirmiya et al., 2006; Zwaigenbaum et al., 2005). Although these studies with ASD-siblings have provided insight into how early deficits in gaze shifting and joint attention may manifest in ASDs, no study has examined how these deficits are longitudinally associated.

Children with ASDs experience core deficits in both social and communicative functioning, and exhibit restricted interests and repetitive behaviors (APA, 2000). ASD-siblings are at a heightened risk, 9-30%, of developing an ASD (Gamliel, Yirmiya, & Sigman, 2007; Landa & Garrett Mayer, 2006; Zwaigenbaum et al., 2005). In addition, as many as 40% of ASD-siblings exhibit sub-clinical deficits in social and communicative functioning, such as atypical eye contact and difficulty relating to others, which are indicative of the broader phenotype (Constantino et al., 2006, Dawson et al., 2002; Landa & Garrett Mayer, 2006; Losh, Sullivan, Trembath, & Piven, 2008; Zwaigenbaum et al., 2005).

The parents of children with an ASD have reported impairments in their child's social-communicative development within the first year of life, this despite ASDs not being diagnosed until after age 2 (Werner, Dawson, Osterling, & Dinno, 2000; Zwaigenbaum et al., 2005). The parents of ASD children have retrospectively reported witnessing atypical characteristics in visual attention, including difficulties disengaging attention within the first year of life (Gomez & Baird, 2005).

Disengaging attention involves shifting visual contact from one object to another. At 6 months of age, gaze shifting to and away from surrounding stimuli is thought to index attentional flexibility and signal readiness for engagement with a partner. In the next 12 months, gaze shifts are integrated into a communicative system of joint attention. This development signals a transition from dyadic to triadic attention in which infants gaze between an object and a partner to refer to the object. Although a topic of theoretical interest and a cross-sectional report (Mundy, Sullivan, & Mastergeorge, 2009; Striano & Stahl, 2005), little is known about the longitudinal association between early gaze shifting and later joint attention.

Joint attention is comprised of initiating joint attention (IJA) and responding to joint attention (RJA). IJA is the ability to share attention by coordinating gaze and gestures between an object, or event, with a social partner (Jones & Carr, 2004; Messinger & Fogel, 1998). RJA is the ability to shift attention to follow a social partner's joint attention initiation, or line of regard. The ability to shift gaze from an object or event appears to be a basic component of both IJA and RJA .

The current study examined the early developmental associations between gaze shifting, and joint attention in ASD-siblings, and explored the possibility that ASD-siblings had different associations than Comparison-siblings. This study also examined how deficits in early gaze shifting and joint attention are related to later outcomes, such as language ability and severity of ASD symptomatology. Furthermore, ASD-siblings and Comparison-siblings were compared on their developmental trajectories of joint attention. Overall, this study investigated whether early deficits in visual attention led to disruptions in social communication development (i.e. joint attention and language) and later ASD symptomatology.

Visual and Joint Attention in ASDs

Children with an ASD exhibit "sticky" visual attention, which is characterized by disengaging visual attention slowly or not at all. Using a visual disengagement paradigm, these children were slower than children with Down syndrome, and typically developing children, to shift their gaze to peripheral and concurrent stimuli (Landry and Bryson, 2004, Newell et al., 2007). Furthermore, parents have retrospectively reported that their children with an ASD displayed delayed gaze shifting within the first year of life (Gomez & Baird, 2005).

Prospective studies have also identified possible early deficits in disengaging visual attention when comparing ASD-siblings and Comparison-siblings. Zwaigenbaum et al. (2005) found that ASD-siblings, who went on to receive an ASD classification on the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2005) at 24 months of age, exhibited slower disengagement at 12 months of age when compared to Comparison-siblings. Furthermore, ASD-siblings exhibited fewer gaze shifts to and away from their parent's faces, and longer mean durations away from their parents' faces, than Comparison-siblings at 6 months of age (Ibanez, Messinger, Newell, Lambert, & Sheskin, 2008).

Depressed joint attention is also a hallmark characteristic of children with ASDs. Children with ASDs have fewer instances of IJA (Baranek, 1999; Jones & Carr, 2004), and these deficits have helped differentiate them from children with other developmental disorders (Dawson et al., 2004). Some have suggested that these children *covertly* engage in joint attention through atypical parallel perception and resistance to distraction (Gernsbacher, Stevenson, Khandakar, & Goldsmith, 2008). Overall, joint attention deficits appear to be integrally related to profound impairment in social cognition (Mundy et al., 2009; Mundy & Newell, 2007). Although such deficits have not been as apparent in RJA as in IJA, ASD-siblings have demonstrated lower levels of RJA than Comparison-siblings (Cassel et al., 2007; Goldberg et al., 2005).

While examining average group differences has shed some light on early deficits, it is also important to examine the developmental trajectories of IJA and RJA. Mundy, Block, Delgado, Pomares, Van Hecke et al. (2007a) documented the trajectories of both IJA and RJA at multiple ages. Infants demonstrated an increase in production, or growth of IJA between 9 and 12 months, but experienced a decrease, or disruption, between 12 and 15 months, before once again demonstrating growth to 18 months. Infants showed consistent growth in RJA from 9 to 18 months of age. Yoder, Stone, Walden, & Malesa (2009) used hierarchical linear modeling (HLM), to examine the individual developmental trajectories of weighted triadic attention, which is composed of IJA and verbal communication, and RJA in ASD-siblings. They found that between 15 and 30 months the growth in weighted triadic attention and the start point of RJA predicted later ASD symptomatology. The current study is one of the first to use HLM to model IJA and RJA in ASD-siblings as well as Comparison-siblings between the critical ages of 8-18 months.

Overall, it appears that the ability to shift visual attention may be a rudimentary, but necessary mechanism for the emergence of joint attention. If so, impairments in IJA and its possible precursor, gaze shifting, may be critical early markers for identifying ASDs and differentiating them from other developmental delays (Lewy & Dawson, 1992; Mundy, Sigman, Ungerer, & Sherman, 1986). The current study specifically examined group differences in the relationship between visual and joint attention over time.

Joint Attention and Later Language Development

The current study also examined the relationships between gaze shifting and joint attention and later language development. Numerous studies have indicated that higher levels of IJA and RJA within the first 18 months of life are associated with higher language ability between 24 and 36 months of age (Delgado et al., 2002; Markus, Mundy, Morales, Delgado, & Yale, 2000; Morales et al., 2000; Mundy, Fox, & Card, 2003; Mundy, Block, Delgado, Pomares, Van Hecke et al., 2007b). Likewise, Sullivan et al. (2007) found that joint attention behaviors at 14 months were predictive of later ASD classification and language ability. A similar relationship to later language ability may also be present for gaze shifting (Young, Merin, Rogers, & Ozonoff, 2009). However, there is some evidence indicating that play and imitation, and not initiating joint attention, are predictive of language ability at ages 4 and 5 in children with an ASD (Toth, Munson, Meltzoff, & Dawson, 2006).

Early Group Differences and Later ASD Symptomatology

While ASD-siblings have demonstrated differences in visual attention patterns when compared to Comparison-siblings, these differences have not necessarily been associated with the later development of an ASD. Merin, Young, Ozonoff, & Rogers (2007) identified a sub-group of 6-month-old ASD-siblings who gazed longer at their parents' mouths relative to their eyes during a truncated version of the Face-to-Face Still-

Face. However, none of those ASD-siblings went on to receive a later ASD classification (Young et al., 2009). This indicated that group differences at 6 months of age were not necessarily of consequence to the later development of ASDs (Rogers, 2009)

Zwaigenbaum et al. (2005) demonstrated an association between early visual attention and later ASD classification. ASD-siblings classified as having an ASD at 24 months, previously experienced a decrement in the ability to shift their gaze between 6 and 12 months of age By comparison, the current study examined whether later *severity* of ASD symptomatology could be predicted from slowed visual and joint attention before the first year of life.

Specific Aims and Hypotheses

This study investigated whether early deficits in gaze shifting were associated with later social communication development (i.e. joint attention and language) and ASD severity. Specifically, the aims of this study were to: 1) investigate differences in visual attention between ASD-siblings and Comparison-siblings, 2) examine early developmental associations between gaze shifting and joint attention and potential group differences in these associations, 3) examine the associations between these types of attention and later language ability and ASD severity, and potential group differences in these associations, 4) examine the possibility that joint attention would mediate the relationship between gaze shifting and later outcomes and group status would moderate this mediation, and 5) examine the developmental trajectories of IJA and RJA, including potential group differences.

The following hypotheses were tested: 1) ASD-siblings would have lower levels of gaze shifting and longer mean durations of gazes at and away from their parents' faces than Comparison-siblings, 2) gaze shifting would predict later joint attention differently for ASD-siblings and Comparison-siblings, 3) both types of attention would predict later language ability and ASD severity differently for ASD-siblings and Comparison-siblings, 4) IJA would mediate the relationships between gaze shifting and ASD severity and language ability, and these relationships would be moderated by group status, and 5) ASD-siblings would have different developmental trajectories for IJA and RJA than Comparison-siblings.

CHAPTER 2: METHOD

Participants

Participants were enrolled in a longitudinal study at the University of Miami investigating the early social and emotional development of ASD-siblings. ASD-siblings (*n* = 31) had at least one older sibling with Autism, Asperger's Syndrome, or Pervasive Developmental Disorder – Not Otherwise Specified, with the diagnosis confirmed through the ADOS, Social Communication Questionnaire (SCQ; Berument, Rutter, Lord, Pickles, & Bailey, 1999), and a licensed psychologist's clinical impression. Comparison-siblings (*n* = 23) had no older sibling(s) diagnosed with, and evidencing symptoms of, an ASD-related disorder (i.e., did not exceed cut off score of nine on the SCQ). Exclusionary criteria for both groups included gestational ages below 37 weeks or above 41 weeks, and major medical complications or illness. There were no differences between ASD-siblings and Comparison-siblings on ethnicity, gender, parental education and gestational age (Table 1). See Table 2 for the gender information of each group by age and protocol.

Procedure

As part of a larger longitudinal study, participants came in for visits at 6, 8, 10, 12, 15, 18, 24, 30, and 36 months of age. To assess visual attention, participants were observed interacting with their parents during the Face-to-Face Still-Face (FFSF) Protocol (Adamson & Frick, 2003; Tronick et al., 1978) at 6 months of age. To assess joint attention, participants were administered the Early Social Communication Scales (ESCS; Mundy et al., 2003) at eight, 10, 12, 15, and 18 months. To assess language ability, participants were administered the Mullen Scales of Early Development at 24 and

36 months of age. To assess ASD severity, participants were administered the ADOS at 30 months. See Table 2 for the *n* for each procedure at each age.

Visual Attention

The FFSF 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; see Ibanez et al., 2008). Infants sat in a car seat (n = 23; ASD-siblings, n = 8) or a high chair (n = 31; ASD-siblings, n = 23) facing their parents and were videotaped at an angle that captured the infant's face and a one-quarter view of the parents' faces. A chi-square indicated that there were more ASD-siblings in the high chair and more Comparison-siblings in the car seat, $\chi^2 = 8.39$, $p < .01$. The type of chair infants sat in was controlled for in all of the analyses below.

Gaze[1]

After the two-second tone signaled the start of the FFSF**,** infants were coded as either gazing directly at the parent's face or not gazing at the parent's face. Twenty-five percent of FFSFs were coded by a second coder with high agreement (% agreement = .93, *kappa* = .90) and reliability (absolute intra-class correlation = .92).

Gaze patterns were examined using the frequency of gaze shifts and mean durations of gaze. The frequency of gaze shifts was calculated as the sum of the frequency of gaze shifts to and away from the parent's face per minute; gaze shifts at the parents face and away from the parents face were not examined separately because these values were, by definition, close to identical. The mean duration of gaze away was calculated as the mean duration of individual gazes away from the parent's face. The mean duration of gaze at parent was calculated as the mean duration of individual gazes at the parent's face.

Parent Behaviors[2]

Due to the interactive aspects of the FFSF, parent behaviors that could potentially influence infants' gaze, such as smiling, tickling, and touching were coded. Parent's smiling at the 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. Touch was coded when the parent makes physical contact that does not involve tickling the infant. Ten percent of the video clips were coded for reliability by two coders with a mean interclass correlation of .70. Coders were blind to participant status. Independent *t*-tests indicated that there were no group differences on the three parent behaviors, $p > .30$. The three types of parent behaviors were included as covariates in all repeated-measures ANOVAs as proportions of time.

Joint Attention[3]

All infants were administered the ESCS at 8-18 months of age. This assessment elicits joint attention and behavioral requesting, and the sharing of positive affect with an examiner. The ESCS take approximately 15-25 minutes to administer, during which only the experimenter, and not the parent, interacts 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 eye contact after a mechanical toy became inactive, IJA behaviors 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 elicit the infant's attention were not coded.

IJA was comprised of lower and higher level behaviors. Lower level IJA behaviors included gaze 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 a distal object of interest or clearly holding up a toy and showing it to the examiner.

Total IJA, which combined both lower and higher level IJA, was examined. IJA, at all time points, was indicated as a rate per minute (rpm) with respect to the total duration of the ESCS. Total IJA at each age was used in HLM analyses. A mean composite of IJA across the five ages was used in all correlations, moderated mediations, and moderation analyses. Twenty percent of ESCSs were coded for reliability on IJA with a mean absolute intra-class correlation of .80.

Responding to joint attention (RJA) referred 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). Total RJA at each age was used in HLM analyses. A mean composite of RJA across the five ages was used in all correlations, moderated mediations, and moderation analyses. Twenty percent of ESCSs were coded for reliability on RJA with a mean absolute intra-class correlation of .80.

Language Ability

Participants were administered the Mullen Scales of Early Learning (Mullen, 1995) at 24 and 36 months of age by a trained administrator. The Mullen measures developmentally critical abilities. It contains four domain scores that produce an overall composite T-score: Visual Reception, Expressive Language, Receptive Language, and Fine Motor. The Mullen domains of Expressive Language and Receptive Language were examined in the current study. While the current study only focuses on the domains relating to language ability, the descriptive information for all four domains is in Table 3. The Expressive Language domain assesses the children's word production as an examiner asks them to label objects, answer basic knowledge question, and repeat sentences. The Receptive Language domain assesses children's ability to understand language as an examiner asks them to identify a particular object and follow simple verbal commands. These scales inter-scorer reliabilities range from .94 to .98, and test-retest reliabilities range from .71 to .77 (Mullen, 1995). Language ability was measured as total combined language, which was the mean of the sums of expressive and receptive language T-scores at each age.

Severity of ASD Symptomatology

Participants were administered the ADOS at 30 months of age by a trained clinician. The ADOS creates a "social world" between the examiner and child through a series of presses. This social situation facilitates the more naturalistic observation of the child's abilities in the areas of social interaction, communication, and play. Items presented differ based on the language level of the child. Module 1 was administered to children who had little to no language. Module 2 was used when language was present. For the scales of Social Interaction, Communication, Communication-Social Interaction Total, and Stereotyped Behaviors and Restricted Interests, the inter-rater reliabilities range from .82 to .93, and the test-retest reliabilities range from .59 to .82 (Lord et al., 2000).

The ASD calibrated severity score at 30 months of age was used as an outcome to measure ASD symptomatology. This score is the sum of the Communication-Social Interaction Total and Stereotyped Behaviors and Restricted Interests scales adjusted for age, module, and verbal ability (Gotham, Risi, Pickles, & Lord, 2007). Nine out of 20 ASD-siblings had a calibrated ASD severity score that was consistent with an ASD at 30 months. None of the Comparison-siblings had a score that classified them as having an ASD.

Statistical Analyses

Data were screened for normality. The only adjustment procedures deemed necessary were a square root transformation of frequency of gaze shifts and an inverse transformation of mean duration away and at parent (Tabachnick & Fidell, 2007) due to high values for skewness and kurtosis. The transformed variables were used in the analyses and the raw variables are presented in the tables and figures. Analyses of Variance (ANOVAs), moderated mediations, Pearson's *r* correlations, and Hierarchical Linear Models (HLMs), and follow-up independent samples *t*-tests, were conducted to investigate mean group differences, developmental associations, and trajectories of IJA and RJA.

CHAPTER 3: RESULTS

In order to test the proposed hypotheses: 1) ANOVAs were used to examine mean group differences in visual attention, 2) Pearson's correlations and hierarchical linear regressions testing for moderation were used to examine developmental associations between gaze shifting and joint attention, 3) Pearson's correlations were used to examine developmental associations between both gaze shifting and joint attention and later outcomes, 4) hierarchical linear regressions were used to examine the moderated mediation of gaze shifting on later outcomes, and 5) Hierarchical Linear Models (HLMs) were used to examine the developmental trajectories of IJA and RJA. See Tables 3 and 4 for descriptive information on all of the variables examined in the analyses.

Hypothesis 1: Examining Mean Differences in Visual Attention

For Hypothesis 1, repeated-measures ANOVAs were used to examine whether ASD-siblings (n = 31) had a lower frequency of gaze shifts (rate per minute), and longer mean durations of gaze away and gaze at their parents' faces (seconds) than Comparison-siblings (n = 23) during the FFSF protocol. These analyses controlled for gender, type of chair, and parent behaviors (tickling, touch, and smiling).

Contrary to Hypothesis 1, a 2 (group) x 3 (episode) x 2 (gender) repeated-measures ANOVA indicated that ASD-siblings and Comparison-sibling did not differ in their frequency of gaze shifts, $F(1, 44) = .29$, $p = .60$, $\eta^2 = .01$, observed power = .08 (see Table 4 and Figure 1). It should be noted that power was low for detecting the expected group differences. There was a main effect for type of chair, with children in the car seat shifting their gaze more frequently than those in the high chair, $F(1, 44) = 5.35$, $p = .03$, $\eta^2 = .11$, observed power = .62 (see Figure 2). There was a main effect for parent tickling on frequency of gaze shifts, $F(1, 43) = 15.86$, $p < .01$, $\eta^2 = .27$, observed power = .97; more tickling was related to higher frequency of gaze shifts. There was a main effect for parent touching on frequency of gaze shifts, $F(1, 44) = 9.26$, $p < .01$, $\eta^2 = .17$, observed power = .85; more touching was related to a lower frequency of gaze shifts. Within-subjects contrasts indicated a tendency for infants, regardless of group, to shift their gaze at their parents' faces less frequently during the SF compared to the FF and RE, $F(1, 44) = 3.29$, $p = .08$, $\eta^2 = .07$, observed power = .43. There were no main effects for mean parent smiling, gender, or interaction effects.

Contrary to Hypothesis 1, a 2 (group) x 3 (episode) x 2 (gender) repeated-measures ANOVA indicated that ASD-siblings and Comparison-siblings did not differ in mean duration of gaze away from their parent's faces, $F(1, 44) = .23$, $p = .63$, $\eta^2 = .01$, observed power = .08 (see Table 4). It should be noted that power was low for detecting the expected group differences. There was a main effect for mean parent tickling on mean duration away, $F(1, 44) = 18.59$, $p < .01$, $\eta^2 = .30$, observed power = .99; more tickling related to greater mean durations away from the parent's faces. There was a main effect for mean parent touching on mean duration away, $F(1, 44) = 7.78$, $p < .01$, $\eta^2 = .15$, observed power = .78, such that more touching was related to shorter mean durations away. There were no main effects for episode, gender, chair, parent smiling, or interaction effects.

Contrary to Hypothesis 1, 2 (group) x 3 (episode) x 2 (gender) indicated that ASD-siblings and Comparison-sibling did not differ in mean duration at their parent's faces, $F(1, 44) = .19$, $p = .67$, $\eta^2 < .01$, observed power = .07 (see Table 4). It should be noted that power was low for detecting the expected group differences. There were no significant main effects for parent behaviors, chair, episode, gender, or interaction effects.

A mean composite score of frequency of gaze shifts, combining the gaze shifts of each episode, and controlling for type of chair, was used to predict all later outcomes. Type of chair was controlled for because it had a main effect on frequency of gaze shifts and was confounded with group status; more ASD-siblings sat in the high chair while more Comparison-siblings sat in the car seat. This variable is referred to in the following analyses simply as gaze shifts.

Hypothesis 2: Developmental Associations between Gaze Shifting and Joint Attention

For Hypothesis 2, Pearson's correlations and hierarchical linear regressions testing for moderation were used to examine whether ASD-siblings exhibited stronger developmental associations between gaze shifting and joint attention than Comparison-siblings. Supporting Hypothesis 2, among ASD-Siblings, gaze shifts at six months were correlated with mean IJA (over all months), $r(29) = .53$, $p < .05$ (see Figure 3). In contrast, there were no significant correlations between gaze shifts and IJA among Comparison-Siblings, $r(21) = .08$. Contrary to Hypothesis 2, there were no significant correlations between gaze shifting and RJA.

To further examine Hypothesis 2, two hierarchical linear regressions were conducted to investigate whether group status moderated, or altered, the relationship between gaze shifts and later RJA and IJA using the full sample ($n = 54$). Contrary to Hypothesis 2, gaze shifts, group status, and their interaction did not predict RJA, $R^2 = .12$, $F(3, 50) = 2.19$, $p = .10$, observed power = .71, and there was no moderation of gaze shifts by group status (see Figure 4). Group status did significantly predict RJA, with ASD-siblings scoring lower than Comparison-Siblings. Partially supporting Hypothesis 2, gaze shifts, status, and their interaction predicted IJA, $R^2 = .14$, $F(3, 50) = 2.78$, $p = .05$, observed power = .67, but there was no moderation of gaze shifts by group status (see Figure 5). Both of the regressions performed had low power for detecting the moderation of gaze shifting on later joint attention by group status.

Hypothesis 3: Developmental Associations with Later Outcomes

For Hypothesis 3, several Pearson's correlations were used to investigate whether ASD-siblings exhibited stronger developmental associations between both gaze shifting and joint attention and the later outcomes of ASD severity and language ability. Partially supporting Hypothesis 3, Pearson's correlations indicated that IJA predicted ASD severity and language ability, but there were no significant correlations by group status. There was an overall significant relationship between mean IJA and ASD severity, $r(30) = -.46$, $p < .01$ (see Figure 6), and later total combined language, $r(34) = .40$, $p < .05$ (see Figure 7). There were no significant correlations between gaze shifting and later ASD severity or language ability.

Hypothesis 4: Moderated Mediation of Gaze Shifting on Outcomes

For Hypothesis 4, two moderated mediation models were conducted to examine whether mean IJA mediated the effect of gaze shifts on the later outcomes of ASD calibrated severity and total combined language, and whether those possible mediations were moderated by group status. The technique for examining moderated mediation indicated by Preacher, Rucker, and Hayes (2007) was used via their SPSS® Macro syntax. First, this incorporated Baron and Kenny (1986) steps for mediation guidelines (see Figure 8a) which examined the relationship (path *a*) between gaze shifts and IJA (mediator), gaze shifts and outcome (path *c'*), IJA and outcome (path *b*), and the indirect of effect of gaze shifts on the outcome as transmitted through IJA. If there were complete mediation, path *c'*, which indicates the direct relationship between gaze shifts and outcome, would be equal to zero. Furthermore, the current analyses examined the possibility that this mediation (see Figure 8b) was moderated by group status. This measured whether group status altered the relationships between gaze shifts and IJA (path *a*) and IJA and outcome (path *b*). It also produced a *conditional* indirect effect, which is the indirect effect of gaze shifts on the outcome at each level of the moderator (each group). Bootstrapping techniques recommended by Preacher et al. to improve power were also examined, but were not reported because they did not change the pattern of results.

Contrary to Hypothesis 4, there was no evidence of moderated mediation between gaze shifts and ASD calibrated severity (see Figure 9). The mediator model, $R^2 = .20$, $F(3, 28) = 2.27$, $p = .10$, observed power = .72, indicated that gaze shifts, status, and their interaction were not significant predictors of IJA. The dependent model, $R^2 = .37$, $F(5, 26) = 3.10$, $p < .03$, observed power = .76, indicated the overall model significantly predicted ASD severity, but gaze shifts, mean IJA, and their interactions with group status were not significant predictors of ASD calibrated severity. Group status did significantly predict ASD calibrated severity such that ASD-siblings had higher scores than Comparison-Siblings. The conditional indirect effects of overall gaze shifts on ASD calibrated severity were not significant for ASD-siblings ($B = -.03$, $p = .23$) or Comparison-siblings ($B = -.002$, $p = .81$). An independent samples *t*-test confirmed that

ASD-siblings had higher ASD calibrated severity scores than Comparison-siblings, $t(30) = -3.90$, $p < .01$ (see Table 4). Both the mediator and dependent model had low power for detecting the moderation mediation of gaze shifting on ASD severity.

Contrary to Hypothesis 4, analyses provided no evidence of moderated mediation between gaze shifts and total combined language (see Figure 10). The mediator model, $R^2 = .19$, $F(3, 32) = 2.43$, $p = .09$, observed power = .73, indicated that gaze shifts, and status, and the interaction between the two were not significant predictors of mean IJA. The dependent model, $R^2 = .25$, $F(5, 30) = 2.02$, $p = .11$, observed power = .11, indicated that gaze shifts, mean IJA, and their interactions were not significant predictors of total combined language. Group status did significantly predict total combined language such that ASD-siblings had lower scores than Comparison-Siblings. The conditional indirect effects of gaze shifts on total combined language were not significant for ASD-siblings ($B = .12$, $p = .31$) or Comparison-siblings ($B = .01$, $p = .93$). An independent samples *t*-test confirmed that ASD-siblings had lower total combined language scores than Comparison-siblings, $t(32) = 2.56$, $p = .02$ (see Table 4). Both the mediator and dependent model had low power for detecting the moderated mediation of gaze shifting on language ability.

Hypothesis 5: Developmental Trajectories of IJA and RJA

For Hypothesis 5, HLMs were used to examine the developmental trajectories of both IJA and RJA and the possible presence of group differences. HLM has advantages over repeated-measures ANOVAs because it models the growth of joint attention across time both at the individual and group levels, and does not discard the data of participants who are missing data at different ages. In all of the models below: 1) Full Maximum

Likelihood was used in the estimation of the parameters, 2) time parameters were centered so that eight months was the intercept (initial or start point), 3) level-1 predictors, which varied within the individual (i.e. time-varying), were allowed to vary at level-2 only when there was significant variance between individuals (if not they were fixed) and 4) level-2 predictors varied between subjects (i.e. group status). The final level-1 and level-2 models were built using theory and deviance statistics, which indicated which level-1 and level-2 predictors improved the fit of the model when entered.

IJA was modeled using linear, quadratic, and cubic terms to model rates of change in IJA across time (see Figure 11 and Table 5). The unconditional means model which only contained IJA (outcome) had an inter-class correlation (*ICC*) = .58, indicating that 58% of the variability in IJA was attributable to inter-individual differences. The final level-1 growth model contained an intercept allowed to vary at level-2 and fixed linear, quadratic, and cubic rates of change, which were all significantly different from zero (see Table 7); This model had a Proportion of Variance Accounted For (*PVAF*) =.07, indicating that the linear, quadratic, and cubic rates of change accounted for only 7% of the intra-individual variance in IJA from 8-18 months of age.

In the final model, group status, gaze shifts, and the interaction between the two were added as level 2 predictors of the IJA intercept; gender was not retained in this model as it decreased model fit. This model had a *PVAF* = .21, indicating that group status shifts, and the interaction between the two, which were not significant predictors of the intercept (see Table 5), explained 21% of the inter-individual variance in IJA at eight months of age. Overall, this final model did not support Hypothesis 5. ASD-siblings did not differ from Comparison-siblings on the intercept, and that the trajectory of IJA was the same for all individuals with significant linear, quadratic, and cubic rates of change. The combined equation for the final model is below:

$$Y_{ti} = \beta_{00} + \beta_{01}*Status_i + \beta_{02}*GazeShifts_i + \beta_{03}*GazeShiftsXStatus_i +$$

$$\beta_{10}*LinearTime_{ti} + \beta_{20}*QuadraticTime_{ti} + \beta_{30}*CubicTime_{ti} + r_{0i} + e_{ti}$$

RJA was modeled using linear and quadratic rates of change (see Figure 12 and Table 6). The unconditional means model which only contained RJA (outcome) had an *ICC* = .27, indicating that 27% of the variability in RJA was attributable to inter-individual differences. The final level-1 growth model contained an intercept, and linear and quadratic rates of change, which were allowed to vary at level-2. This model had a *PVAF* =.55, indicating that the linear and quadratic rates of change accounted for 55% of the intra-individual variance in RJA from eight-18 months of age.

In the final model, group status was added as a level-2 predictor of the intercept, as well as the linear and quadratic rates of change; gender was not retained in this model as it decreased model fit. This model had a *PVAF* = .18 for the intercept, indicating that group status, which was a significant predictor (see Table 6), explained 18% of the inter-individual variance in IJA at eight months of age. The *PVAF*s for linear and quadratic rates of change were not calculated as group status was not a significant predictor of either. Overall, this model supported Hypothesis 5 as ASD-siblings began lower, and remained lower, than Comparison-siblings in their developmental trajectory of RJA. The combined equation for the final model is below:

$Y_{ti} = \beta_{00} + \beta_{01}*Status_i + \beta_{10}*LinearTime_{ti} + \beta_{11}*Status_i*LinearTime_{ti} +$

$\beta_{20}*QuadraticTime_{ti} + \beta_{21}*Status_i*QuadraticTime_{ti} + r_{0i} + r_{1i}*LinearTime +$

$r_{2i}*QuadraticTime + e_{ti}$

Several follow-up independent sample *t*-tests were conducted on IJA and RJA at all ages (see Table 4). Differences between ASD-siblings and Comparison-siblings were observed on IJA at 10 months, on RJA at 8, 15, and 18 months.

CHAPTER 4: DISCUSSION

This study investigated the developmental associations between early visual attention, joint attention, and later social and communicative abilities in ASD-siblings. It was also one of the first to examine and identify differences between ASD-siblings and Comparison-siblings on early developmental trajectories of joint attention. Contrary to Hypothesis 1, ASD-siblings did not differ from Comparison-siblings in their frequency of gaze shifts and the mean durations of their gazes away from their parents' faces at six-months of age. These two components of visual attention were instead impacted by external factors, such as parental behaviors and playroom equipment. Hypotheses 2 and 3 were partially supported as there were developmental associations between visual attention and joint attention, and between joint attention and later language and ASD severity. Contrary to Hypothesis 4, joint attention did not mediate the relationship between early visual attention and ASD severity and language ability. Hypothesis 5 was partially supported because there were group differences in the developmental trajectory of RJA and in mean IJA and RJA at different ages. Differences between the two groups were also present in later language ability and ASD-severity. Overall, the results of the study suggested that ASD-siblings may begin to experience difficulties in joint attention over the first 18 months of life.

Hypothesis 1: The Absence of Early Markers at Six Months

Hypothesis 1 indicated that ASD-siblings would have lower levels of gaze shifting and longer mean durations of gaze at and away from their parents' faces than Comparison-siblings. Contrary to Hypothesis 1, gaze shifting at six months did not appear to be an early marker of ASDs. Compared to Comparison-siblings, ASD-siblings did not demonstrate the "sticky attention" and focus on non-social stimuli previously documented in a smaller sample of the current study (Ibanez et al., 2008). Visual attention has been a prominent area of focus in these prospective studies because "sticky attention" has been a hallmark characteristic of older children with ASDs (Bryson, Landry, & Wainwright, 1997). Furthermore, while all infants exhibit "sticky" or obligatory attention, typically developing infants begin to outgrow it by 6 months of age (McConnell & Bryson, 2005) in part because of complex advances in neural circuitry (Posner, 1995).

Taken with the null findings of the current study, this suggests that children developing ASDs might outgrow fixed attention by 6 months of age only to have rigid visual attention come online later in development. The current literature supports this assertion. While ASD-siblings have been shown to shift their gaze between the eyes and mouth of their parent differently than Comparison-siblings at 6 months of age (Merin et al., 2007), a follow-up study indicated that this group difference did not relate to later ASD classification (Young et al., 2009). Recently, Rogers (2009), questioned whether early markers of ASDs are behaviorally observable, or even exist, at 6 months of age. Rogers (2010) has also suggested that the developmental trajectories of ASD deficits may be more predictive of eventual diagnosis. Zwaigenbaum and colleagues (2005) found that a *decrement* in the development of gaze shifting between 6 and 12 months of age predicted an ASD classification at 24 months of age. Overall, this suggests that visual attention will need to be examined later in the first year, as well as second year of life, as deficits may not be present until after 6 months of age.

Infants' visual attention was associated with their parent's tickling and touching during the interactive FFSF protocol. Infants, regardless of group, shifted their gaze more frequently and had longer mean durations away when their parents spent a greater proportion of time tickling them. Infants shifted their gaze less frequently and had shorter mean durations away from their parents' faces when their parents' spent a greater proportion of time touching them. These results are consistent with what previous investigators have found when manipulating tickling and touching conditions in the FFSF (Peláez-Nogueras et al., 1997).

Furthermore, the type of chair infants sat in emerged as another important factor in early visual attention. Results indicated that infants who sat in the car seat shifted their gaze more frequently than those who sat in a high chair. These differences may be in part related to differences in the postural orientation of each chair. Infants in the high chair sat more upright than those in the car seat, who were more reclined. Posture has been demonstrated to affect visual activity in infants (Fogel, Dedo, & McEwen, 1992; Fredrickson & Brown, 1975; Lefèvre, 2002). While the repeated-measures ANOVAs did not indicate an interaction between group status and type of chair, Figure 2 appears to indicate that type of chair may have impacted group differences. In the car seat, Comparison-siblings seem to shift their gaze more frequently than ASD-siblings. This advantage is no longer present when Comparison-siblings and ASD-siblings are both seated in the high chair. The high chair may have affected both groups because it provided more compelling things to look at than the car seat, because the infants sat more upright and saw more of their surroundings.

Hypothesis 2: Associations between Gaze Shifting and Joint Attention

The current study also examined longitudinal associations between gaze shifting and joint attention abilities. Hypothesis 2 indicated that gaze shifting would predict joint attention differently for ASD-siblings and Comparison-siblings. Partially supporting Hypothesis 2, gaze shifting appeared to have a predictive relationship to IJA. However, the hypothesis was not fully supported because there was no moderation of the relationship between gaze shifting and IJA. The absence of moderation indicates that the noticeably different correlations exhibited by ASD-siblings and Comparison-siblings (Figure 3) were not, in fact, *significantly* different from each other. ASD-siblings' frequency of gaze shifts at six months was related to mean IJA at 8-18 months as indicated by Pearson's correlations. It has been theorized that gaze shifting is an earlier key component of IJA (Mundy et al. 2009). The variability in IJA, as measured by the ESCS, has been primarily driven by gaze shifting behaviors (Mundy et al., 2007). IJA gaze shifting behaviors at age two are also related to later social cognition and ASD symptomatology (Charman et al., 2000). Although shifting attention would appear to be a basic behavioral mechanism of RJA, there was no significant relationship between gaze shifting and later RJA. It may be that gaze shifting is proto-referential at 6 months, suggesting infants are essentially initiating, rather than responding to attention in the FFSF.

Hypothesis 3: Associations with ASD Severity and Language Ability

Hypothesis 3 indicated that both types of attention would predict later ASD severity and language ability differently for ASD-siblings and Comparison-siblings. Partially supporting Hypothesis 3, IJA ability was associated with later ASD severity, but

ASD-siblings and Comparison-siblings exhibited comparable associations; gaze shifting did not show any relationship to ASD severity. Higher levels of IJA were associated with lower ASD severity. The centrality of IJA deficits in ASDs has long been established. IJA helps distinguish children with an ASD from those children with other developmental disorders (Dawson et al., 2004) and is predictive of later ASD symptomatology (Charman, 2000). IJA appears to be an important component of a rich social feedback loop that offers social inputs and allows children to act on them; it may be a keystone of overall social cognition (Charman et al., 2004; Mundy et al., 2009; Tomasello, Carpenter, Call, Behne, & Moll, 2005).

Partially supporting Hypothesis 3, higher levels of IJA were related to higher language ability, but ASD-siblings and Comparison-siblings exhibited comparable associations between IJA and language ability; gaze shifting did not show any relationship to language ability. The relationship between joint attention and language ability has been identified numerous times with both IJA and RJA (Morales et al., 2000; Mundy, Block, Delgado, Pomares, Van Hecke et al., 2007b; Shumway & Wetherby, 2009; Van Hecke et al., 2007). IJA ability may facilitate language acquisition because it helps children attend to the labeling and naming of objects and events in their surroundings (Baldwin, 1995).

Unlike IJA, RJA was not related to the later outcomes. RJA has been previously shown to relate to later language ability in typically developing children (Morales et al., 2000). Contrary to the current findings, RJA has also been found to relate to later language ability and ASD classification in ASD-siblings (Sullivan et al., 2007). While the current study used the ESCS to measure RJA, Sullivan et al. used a different task, which offered children varying levels of cues to prompt an RJA behavior. This task may have been better at identifying individual differences in RJA ability than the ESCS. Some children responded when the prompt was just a subtle gaze shift, and others when it was a gaze shift and a point; yet others only responded when the prompt was a gaze shift, point, and calling of their name. The ESCS only gives that latter prompt and codes whether or not the child responds.

Hypothesis 4: Moderated Mediation of Gaze Shifting by Joint Attention

Hypothesis 4 indicated that IJA would mediate the relationships between gaze shifting and ASD severity and language ability and these relationships would be moderated by group status. Contrary to Hypothesis 4, IJA did not mediate the relationship between gaze shifting and the outcomes of ASD severity and language ability for ASD-siblings or Comparison-siblings. However, the dependant model used to examine moderated mediation in ASD severity provides an intriguing account of how these domains relate to later ASDs. Gaze shifting, IJA, and their interactions with group status, explained 37% of the observed variability in ASD severity. This indicates that may be the shared variance between these variables that is of relevance to children with ASDs. In other words, the path to an ASD is complex and may be best explained by the additive combination of several factors and not a one-to-one correspondence between a single early marker and the outcome.

ASD-siblings also differed from Comparison-siblings on ASD severity and language ability, which are more proximally related than gaze shifting and IJA to the age and basis of an ASD diagnosis (APA, 2000). ASD-siblings demonstrated lower language ability and higher ASD severity than Comparison-siblings at 24-36 months. Previous studies have also found impaired language ability in ASD-siblings by age three (Toth et al., 2007), although impairments did not persist through age 5 (Gamliel et al., 2007).

Hypothesis 5: Developmental Trajectories of Joint Attention

In addition to examining the longitudinal associations of initiating and responding to joint attention, their developmental trajectories were also investigated. Hypothesis 5 indicated that ASD-siblings and Comparison-siblings would differ in their developmental trajectories of IJA and RJA. Contrary to Hypothesis 5, there were no differences between ASD-siblings and Comparison-siblings on the intercept and on the rates of change. The developmental trajectory of IJA was linear, quadratic, and cubic in nature. IJA increased between eight and 10 months, declined at 12 months and then began to increase again between 15 and 18 months of age (see Figure 11). A similar trajectory has been documented in typically developing children between the ages of 9-18 months and has been thought to be influenced by motor and language development (Mundy et al., 2007). The model indicated that all infants, regardless of group status, followed a similar growth trajectory on IJA. Also, independent samples *t*-tests identified that ASD-siblings had lower rates of IJA than Comparison-siblings only at 10 months of age. While no later group differences were identified on IJA, the rate of change in later IJA development has been predictive of ASD symptomatology (Yoder et al., 2009). Future studies might consider predicting symptomatology from IJA trajectories.

Supporting Hypothesis 5, the model examining RJA indicated that ASD-siblings were initially lower on RJA than Comparison-siblings, however the two groups did not differ on the linear and quadratic rates of change (see Figure 12). Overall this model suggested that ASD-siblings may have a persistent deficit in RJA. ASD-siblings were lower than Comparison-siblings on RJA at 8 months, and remained lower until18 months of age. A similar interpretation was also derived from the independent samples *t*-tests, which indicated that ASD-siblings demonstrated difficulties in joint attention as early as eight months of age. ASD-siblings had lower rates of RJA at 8, 15, and 18 months than Comparison-siblings. RJA differences have not been as commonly reported (Sullivan et al., 2007) and have been considered difficult to identify using the ESCS, which offers infants several simultaneous cues including calling their name (Presmanes, Walden, Stone, & Yoder, 2007). This is the first prospective study to identify lower RJA in ASD-siblings at eight months of age. These results are supported by retrospective studies which found that children with an ASD responded and oriented to their name half as often as typically developing children at 8 and 10 months of age (Werner et al., 2000).

Beyond the differences between ASD-siblings and Comparison-siblings, it is important to note that IJA and RJA had different developmental associations and developmental trajectories. This may be partially explained by the disassociation evident between these types of joint attention across typical development (Meltzoff & Brooks, 2008; Mundy et al., 2007). Furthermore, while IJA develops in the anterior portion of the brain, including the frontal cortex and eye fields, and relates to more willful attention, RJA develops in the posterior portion and relates more to involuntary attention (Dawson et al., 2004; Henderson, Yoder, Yale, & McDuffie, 2002; Mundy & Newell, 2007). With regard to developmental trajectories, IJA had a cubic component, and indicated fewer differences between individuals than RJA. Differences in the trajectories have been documented with regard to ASDs, as impairments in IJA clearly persist past the preschool years, while RJA impairments decline (Mundy, Sigman, & Kasari, 1994).

Limitations and Future Directions

The current study had limitations related to data analyses as well as its basic nature as a prospective study. Several of the analyses, such as moderated mediation analyses, had lower power than the desired .85 (Cohen, 1988). In these analyses, the low power was due to both a small sample size and the ratio of predictors to participants. In addition, most infants were missing data at different time points, which may have biased the mean joint attention and language ability scores and estimated coefficients in HLM.

In the current study, Pearson's correlations and hierarchical linear regressions that were conducted to test different hypotheses, at times, overlapped in the associations they examined. The association between gaze shifting and IJA, and the associations between IJA and later outcomes, appeared to be inconsistent across different types of analyses. Unlike the association demonstrated by Pearson's correlation, gaze shifting was not positively related to IJA in the hierarchical linear regressions used to examine moderated mediation. This difference may have occurred because the hierarchical linear regression analyses only used infants with outcome data and, consequently, had a smaller *n* than the Pearson's correlation. Additionally, an association between IJA and language ability may have not emerged in the hierarchical linear regression because IJA was combined with predictor of group status, which proved to be a significant, more robust, predictor of language ability.

Prospective studies may experience difficulty in identifying group differences between ASD-siblings and Comparison-siblings because a high proportion (up to 61%; see Gamliel et al., 2007; Landa & Garrett Mayer, 2006; Losh et al., 2007; Zwaigenbaum et al., 2005) of ASD-siblings will not develop an ASD, or sub-clinical deficits associated with the broad autism phenotype. In the current study, 55% (*n* = 11 out of 20) of ASD-siblings did not have an ASD severity score on the ADOS suggesting the presence of an ASD. These unaffected ASD-siblings may obscure the deficits demonstrated by the ASD-siblings who do go on to develop an ASD by elevating the mean scores of the group. When deficits are not identified via more conventional statistical analyses, a case study approach can be used to extract information about the early development of the few ASD-siblings who developed an ASD. Young and colleagues (2009) implemented this approach to characterize the early deficits seen in the three ASD-siblings who developed an ASD in their study.

Future investigations should continue this study to focus on longitudinal associations and trajectories. The trajectory of gaze shifting within the first year of life, in particular, remains a fruitful area of examination. Changes that occur within the first year of life in gaze shifting are related to later ASD outcome in ASD-siblings (Zwaigenbaum et al., 2005). Yet, no study has examined dyadic attention at more than two time points and used more sophisticated analyses like HLM. While the current study examined the trajectories of IJA and RJA at five different time points, it is important to examine these trajectories beyond 18 months of age. A recent study indicated that linear change between 15 and 30 months in weighted triadic communication, which includes IJA, predicted ASD classification at 34 months for ASD-siblings (Yoder et al., 2009).

Furthermore, the use of neurophysiological measures should be utilized in conjunction with behavioral measures to thoroughly assess whether or not early markers of ASDs are present at 6 months. Electroencephalogram (EEG), for example, can be used to measure infants' neural activity, including event related potentials (ERPs), which are positive or negative deflections in activity that are linked in time to a specific event or stimulus. ASD-siblings and Comparison-siblings could be compared on their levels of neurological activity in certain brain regions, as well as on the amplitudes of ERPs previously documented to correspond to visual and joint attention early in life. When compared to Comparison-siblings, ASD-siblings might be expected to show lower levels of left frontal cortical activity and a smaller amplitude on the N300-700 ERP component, which are established neurological correlates of joint attention in typically developing infants (Henderson et al., 2002; Mundy, Card, Fox, 2000; Striano, Reid, & Hoehl, 2006).

The current study also has implications for joint attention interventions. ASD-siblings appeared to have persistent difficulties in their development of RJA when compared to Comparison-siblings. Martins and Harris (2006) focused on training examiners to offer specific joint attention initiations to improve and scaffold the RJA abilities of children with an ASD. In the early stages of intervention, examiners gave children highly redundant and synchronous cues, which consisted of shifting their gaze while calling the child's name and pointing, in an attempt to orient them to a target object. Throughout the intervention, examiners gradually decreased the number of cues they gave the children and only offered a subtle shift in gaze in the final stage of the intervention. In the beginning stages of a similar study, parents provided proximal joint attention initiations, like placing their child's hand on a toy, and then in the later stages only offered a shift in their gaze (Rocha, Schreibman, & Stahmer, 2006). While these studies on joint attention interventions have successfully improved the RJA abilities of preschool age children, the proposed interventions could easily be implemented within the first year of life. Interventions may need to target RJA behaviors before 8 months of age and focus on providing infants multiple redundant cues to give them extra cues that may facilitate their ability to respond. It is important to note, however, that the current study did not establish that RJA difficulties in ASD-siblings were linked to later ASD severity.

Conclusions

In conclusion, clear early markers of ASDs were not present at 6 months of age, but there were differences between ASD-siblings and Comparison-siblings on RJA development, and later language ability, and ASD severity. There were also relationships between IJA and ASD severity and language ability. This study, like many other prospective studies, did not find differences at 6 months of age. This inability to find differences could have a considerable impact on the future use of behavioral measures as tools to identify early markers (Rogers, 2009). The continued investigation of longitudinal associations and developmental trajectories, as already suggested by some (see Rogers, 2010), appears critical to detecting the emergence of differences between ASD-siblings and Comparison-siblings. This may have implications for how early intervention should be tailored to meet the needs of children developing an ASD within the first year of life.

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Footnotes

[1] This parts of this section appears in the method section of Ibanez et al., 2008.

[2] This parts of this section appears in the method section of Ibanez et al., 2008.

[3] This parts of this section appears in the method section of Cassel et al., 2007.

TABLES

Table 1

Participant Demographics

Demographics	*ASD-siblings*	*Comparison-siblings*
Gender [% / (n)]		
Male	61.3 / (19)	47.8/ (11)
Female	38.7 / (12)	52.2 / (12)
Ethnicity [% / (n)]		
White/Non-Hispanic	45.2 / (14)	43.4 / (10)
White/Hispanic	43.3 / (13)	39.1 / (9)
African-American/Biracial	6.5 / (2)	13.0 / (3)
Asian	6.5/ (2)	4.3 / (1)
Parent Education [% / (n)]		
Some College	28.6 / (8)	19.0 / (4)
4-year College	21.4 / (6)	33.3 / (7)
Advanced Professional Degree	50.0 / (14)	47.6/ (10)
Gestational Age (Weeks) [M / (SD)]	38.96 / (1.24)	38.83 / (1.56)

Table 2

Participants by Protocol and Age

Assessment	ASD-siblings *[n (males)]*	Comparison-siblings *[n (males)]*
Face to Face Protocol		
6 months	31 (19)	23 (11)
Early Social Communication Scales		
8 months	27 (17)	20 (8)
10 months	22 (14)	19 (8)
12 months	25 (16)	14 (6)
15 months	18 (12)	15 (7)
18 months	23 (13)	14 (6)
Mullen		
24 months	21 (14)	6 (2)
36 months	14 (8)	13 (7)
Total Combined	22 (14)	14 (7)
ADOS		
30 months	20 (13)	12 (6)

Table 3

Mean and standard deviations for Mullen and ADOS variables

Assessment	ASD-siblings *[M (SD)]*	Comparison-siblings *[M (SD)]*
Mullen		
Visual Reception	45.82 (10.95)*	57.39 (12.67)
Fine Motor	41.75 (12.29)*	51.79 (10.32)
Expressive Language	46.50 (11.49)*	55.25 (10.09)
Receptive Language	43.91(11.90)*	53.00 (6.97)
Total Language	45.20 (11.33)*	54.13 (8.03)
ADOS		
Calibrated Severity	3.33 (1.92)*	1.42 (.79)

Note. ASD-siblings were significantly lower on all of the domains of the Mullen and higher on Calibrated Severity on the ADOS than Comparison-siblings. $*p < .05$.

Table 4

Mean and Standard Deviations for FFSF and ESCS Variables

Assessment	ASD-siblings *[M (SD)]*	Comparison-siblings *[M (SD)]*
Face to Face Protocol		
FF Frequency of Gaze Shifts (rpm)	15.19 (5.54)	18.46 (9.59)
SF Frequency of Gaze Shifts (rpm)	10.57 (5.20)	13.71 (6.14)
RE Frequency of Gaze Shifts (rpm)	14.44 (5.84)	16.88 (8.02)
Overall Gaze Shifts (rpm)	14.45 (4.02)	15.69 (6.35)
FF Mean Duration Away	5.52 (7.42)	5.16 (5.76)
SF Mean Duration Away	11.16 (6.70)	7.76 (4.55)
RE Mean Duration Away	4.82 (3.07)	5.13 (4.47)
FF Mean Duration At	4.32 (3.44)	3.40 (2.63)
SF Mean Duration At	2.63 (2.10)	2.73 (1.83)
RE Mean Duration At	4.77 (3.19)	3.81 (1.96)
Early Social Communication Scales		
8 month		
IJA Total (rpm)	1.05 (.72)	1.54 (1.01)
RJA Total	.80 (1.30)*	1.75 (1.29)
10 month		
IJA Total (rpm)	1.14(.75)*	1.83 (.77)
RJA Total	.98 (1.83)	1.84(2.01)
12 month		
IJA Total (rpm)	1.38 (.69)	1.13 (.47)
RJA Total	1.70 (1.76)	2.93 (2.56)
15 month		
IJA Total (rpm)	.97 (.73)	.97 (.43)
RJA Total	2.53 (1.99)*	4.6 (2.56)
18 month		
IJA Total (rpm)	1.12 (.65)	1.24 (.82)
RJA Total	3.07 (1.71)*	4.64 (2.34)
Mean Across All Ages		
IJA Total (rpm)	1.24 (.63)	1.45 (.87)
RJA Total	1.94 (1.55)	2.75 (1.60)

Note. *$p < .05$

Table 5

HLM Continuous Models for IJA

	Estimated parameters	Unconditional Means Model	Final Level 1 Model	Final Level 2 Model
IJA Model				
Fixed Effects				
Initial Status, π_{0i}	Intercept, β_{00} (*s.e.*)	1.31 (.09)*	1.25 (.11)*	1.38 (.14)*
	Status, β_{01} (*s.e.*)	-	-	-.18 (.17)
	Gaze Shifts, β_{02} (*s.e.*)	-	-	.003 (.007)
	Status X Gaze, β_{02}(*s.e.*)	-	-	.02 (.01)
Rate of Change, π_{1i}				
	Time (linear), β_{10} (*s.e.*)	-	0.37 (.12)*	.23 (.08)*
	Time (quad), β_{20} (*s.e.*)	-	.23 (.08)*	-.06 (.02)*
	Time (cubic), β_{30} (*s.e.*)	-	-.06 (.02)*	.004 (.001)*
Variance Components				
	Level-1, σ^2 (*s.e.*)	.28 (.03)	.26 (.03)	.26 (.03)
	Level-2, τ_{00} (*s.e.*)	.38 (.09)	.38 (.09)	.30 (.07)
	Level-2, τ_{11} (*s.e.*)	-	-	-
Model Fit				
	Deviance	397.10	386.39	377.50
	# parameters	3	6	9

Note. The numbers reflected in the table are the unstandardized beta coefficients and standard errors. *p <.05.

Table 6

HLM Models for RJA

	Estimated parameters	Unconditional Means Model	Final Level 1 Model	Final Level 2 Model
RJA Model				
Fixed Effects				
Initial Status, π_{0i}	Intercept, β_{00} (*s.e.*)	2.26 (.21)*	1.04 (.19)*	1.51 (.27)*
	Status, β_{01} (*s.e.*)	-	-	-.83 (.37)*
Rate of Change, π_{1i}				
	Time (linear), β_{10} (*s.e.*)	-	0.37 (.12)*	0.38 (.19)*
	Status, β_{11} (*s.e.*)	-	-	-.04 (.24)
	Time (quad), β_{20} (*s.e.*)	-	.01 (.01)	-.01 (.02)
	Status, β_{21} (*s.e.*)	-	-.06 (.02)*	-.01 (.02)
Variance Components				
	Level-1, σ^2 (*s.e.*)	1.30 (1.14)	.38 (.62)	1.58 (1.26)
	Level-2, τ_{00} (*s.e.*)	3.60 (1.90)	.25 (.50)	.31(.43)
	Level-2, τ_{11} (*s.e.*)	-	01 (.05)	.26(.51)
Model Fit				
	Deviance	853.58	768.34	757.64
	# parameters	3	10	13

Note. The numbers reflected in the table are the unstandardized beta coefficients and standard errors. *p <.05.

FIGURES

Figure 1. Mean frequency of gaze shifts in the FFSF protocol

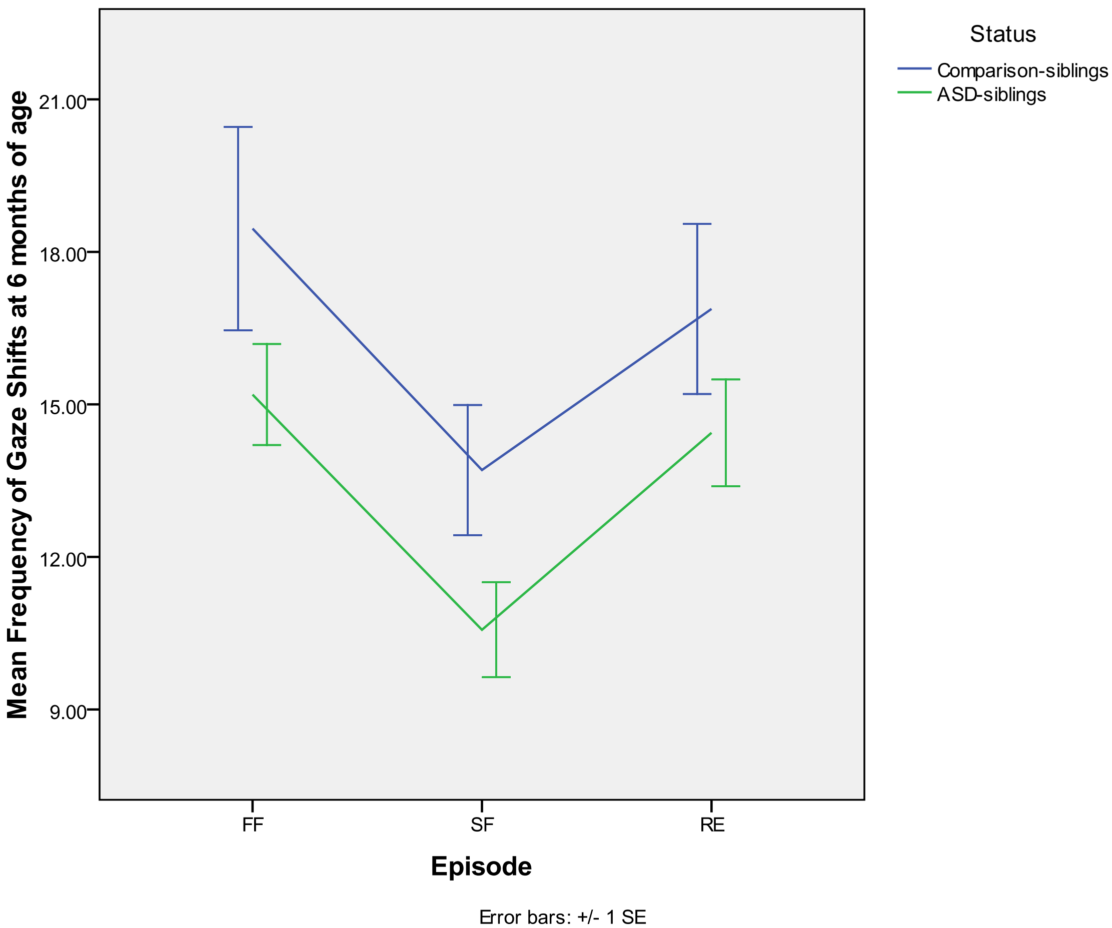


Figure 2. Mean frequency of gaze shifts by group status and type of chair

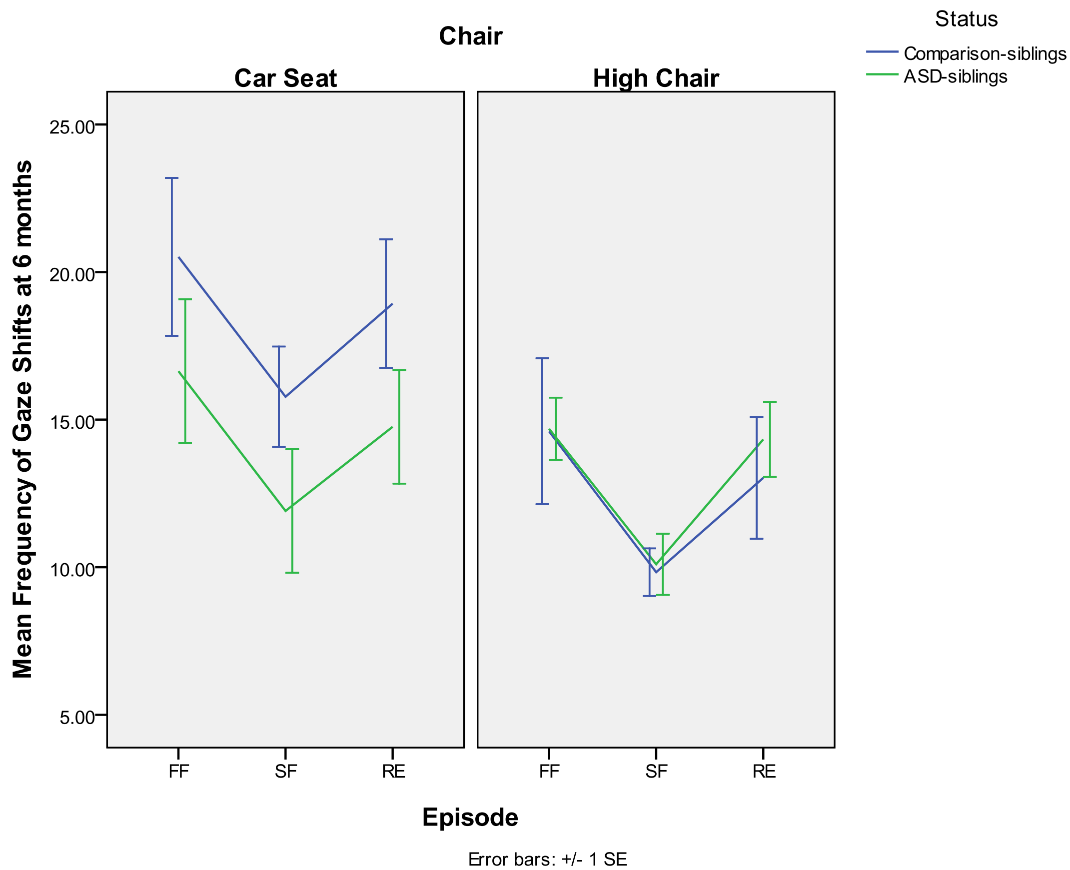
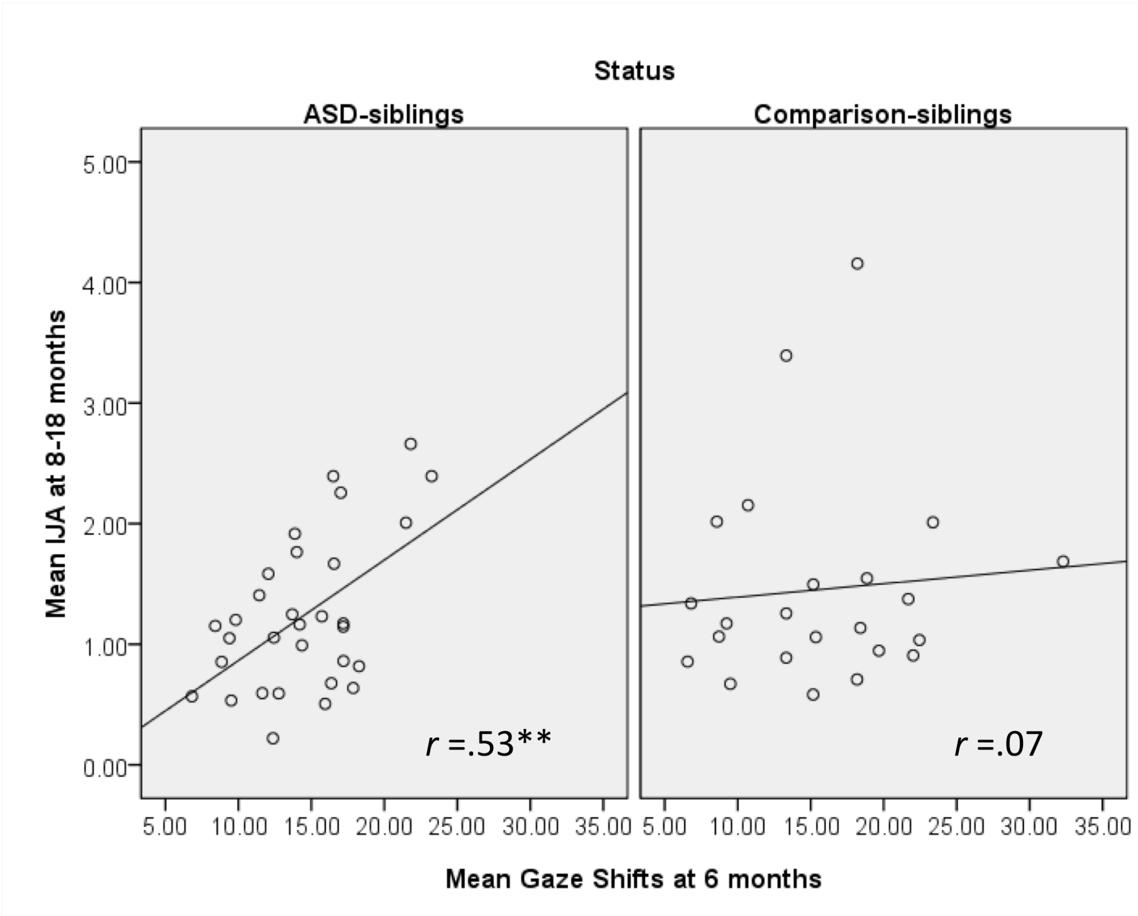
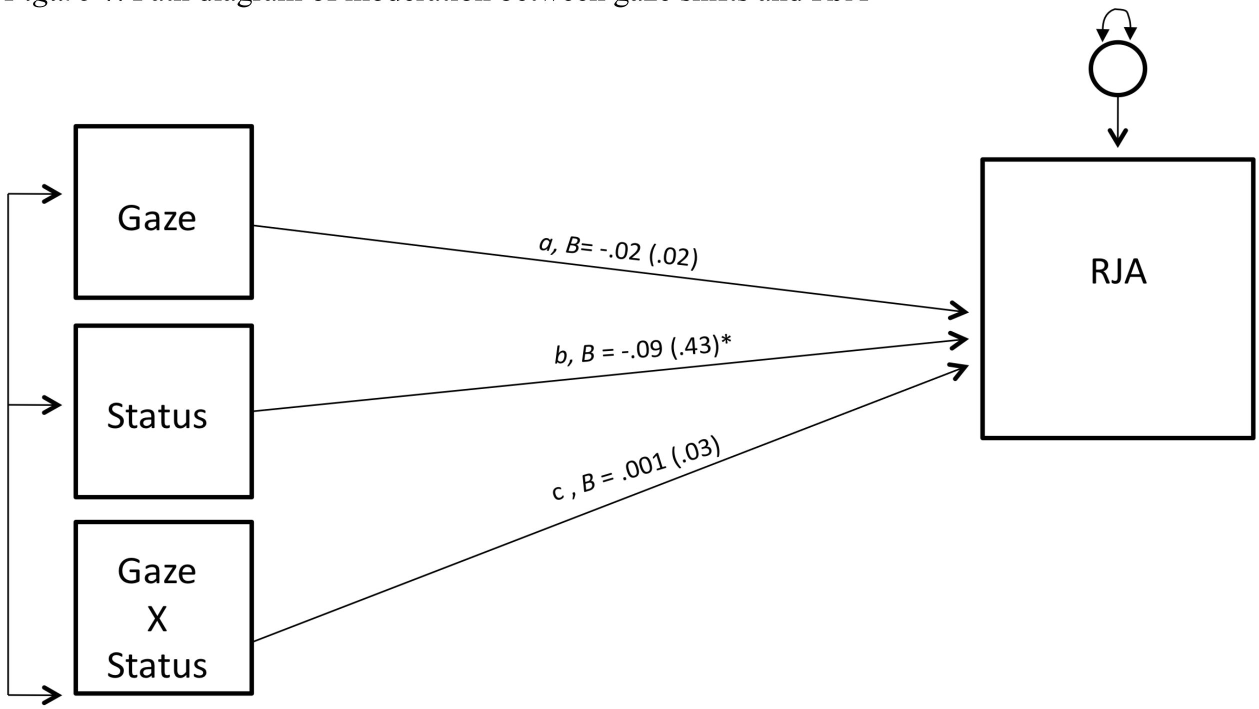


Figure 3. Gaze shifts and later mean initiating joint attention



Note. ***p* < .01.

Figure 4. Path diagram of moderation between gaze shifts and RJA



Note. **p* <. 05.

Figure 5. Path diagram of moderation between gaze shifts and IJA

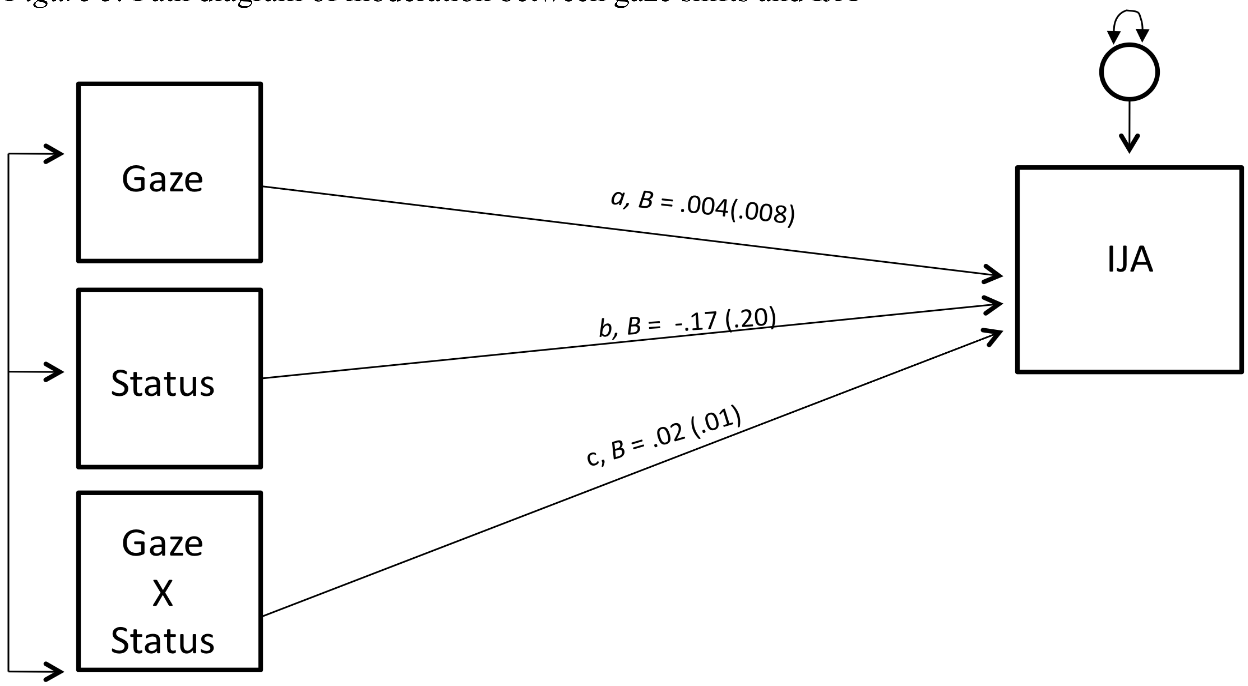
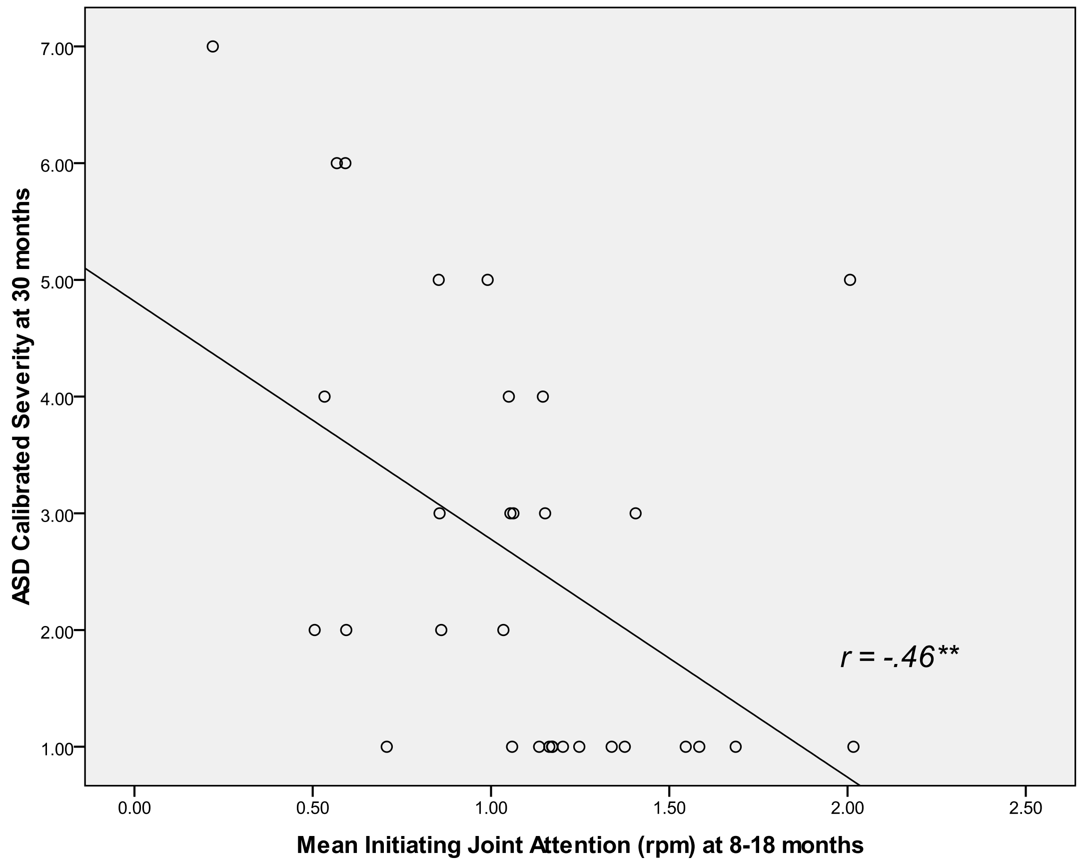
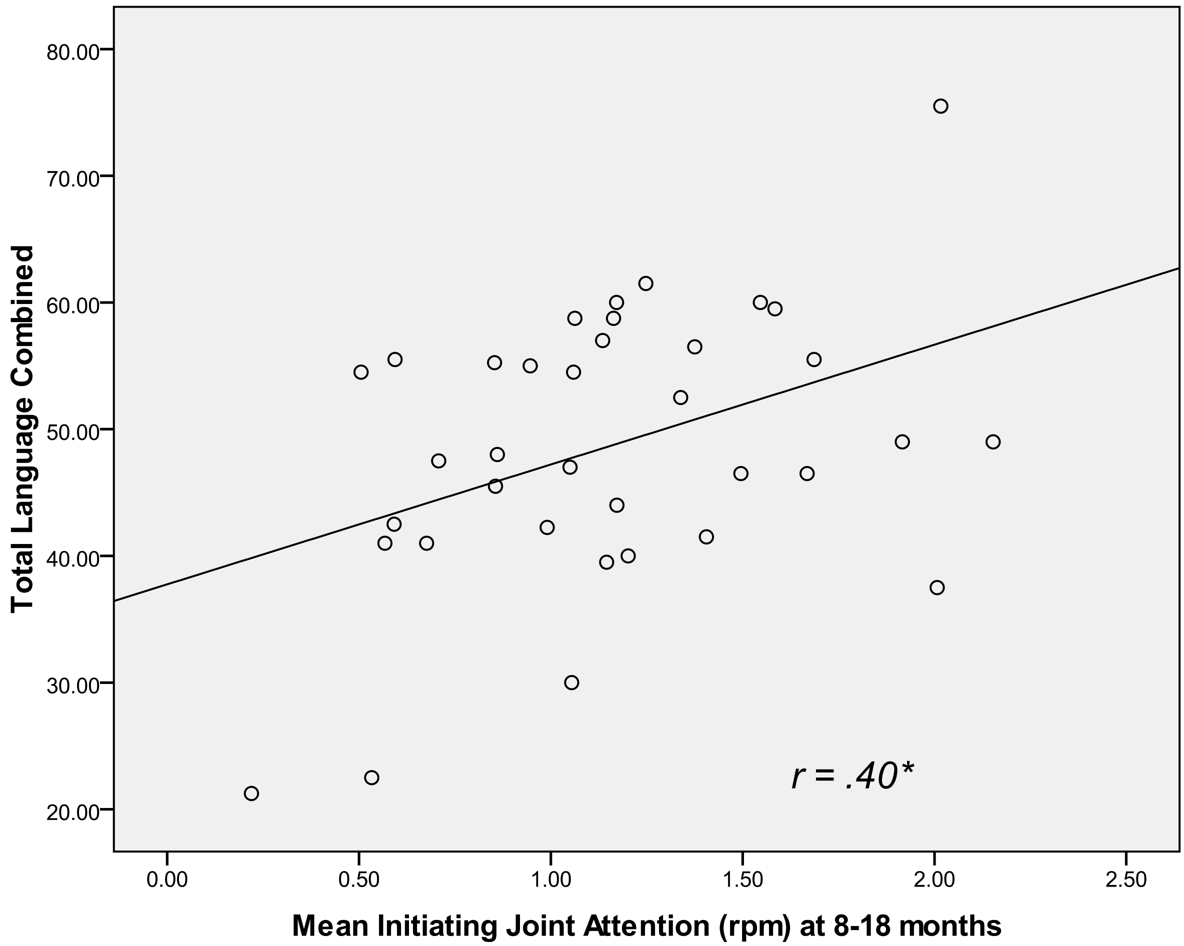


Figure 6. Mean initiating joint attention and later ASD calibrated severity



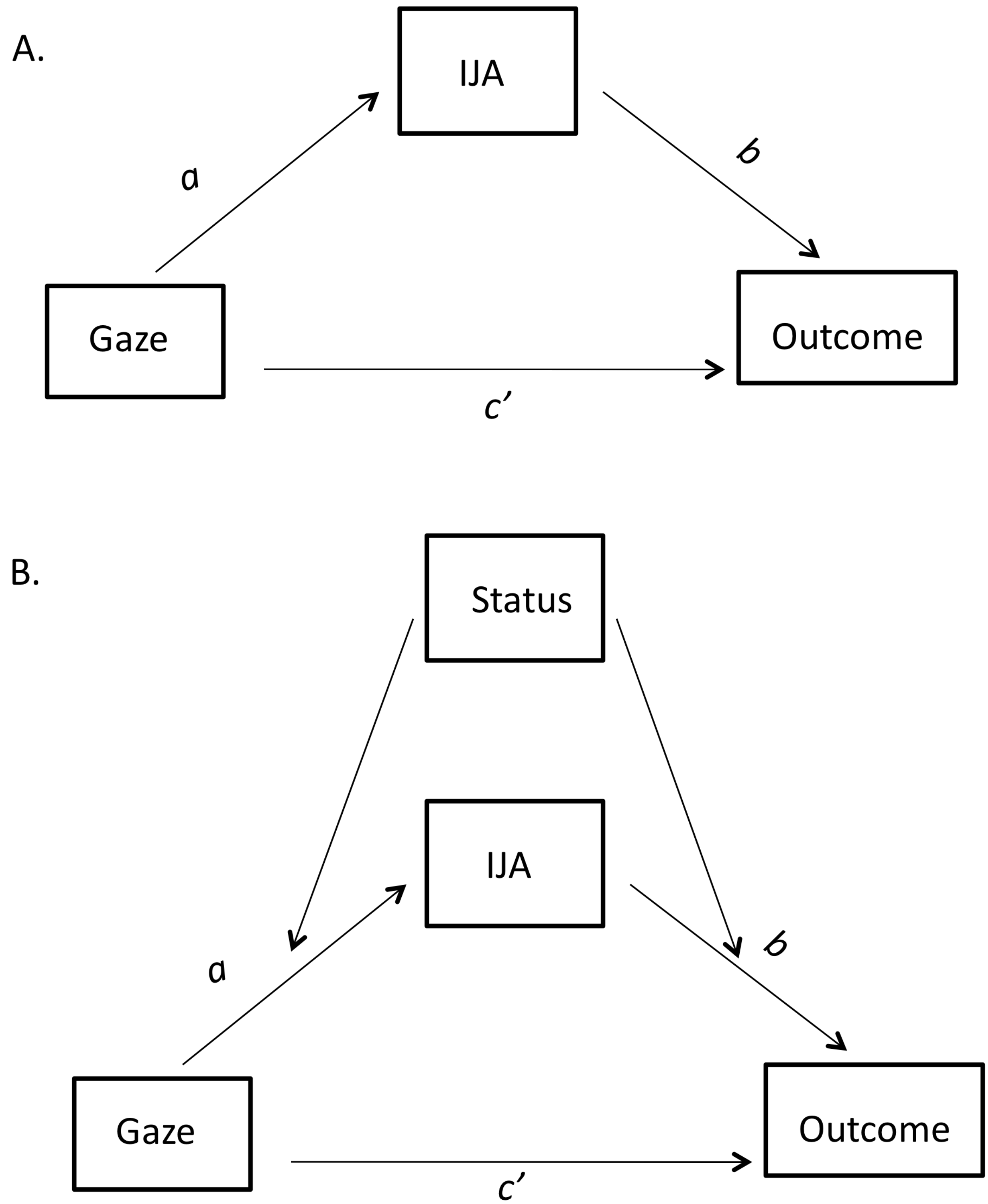
Note. **$p < .01$.

Figure 7. Mean initiating joint attention and later total combined language



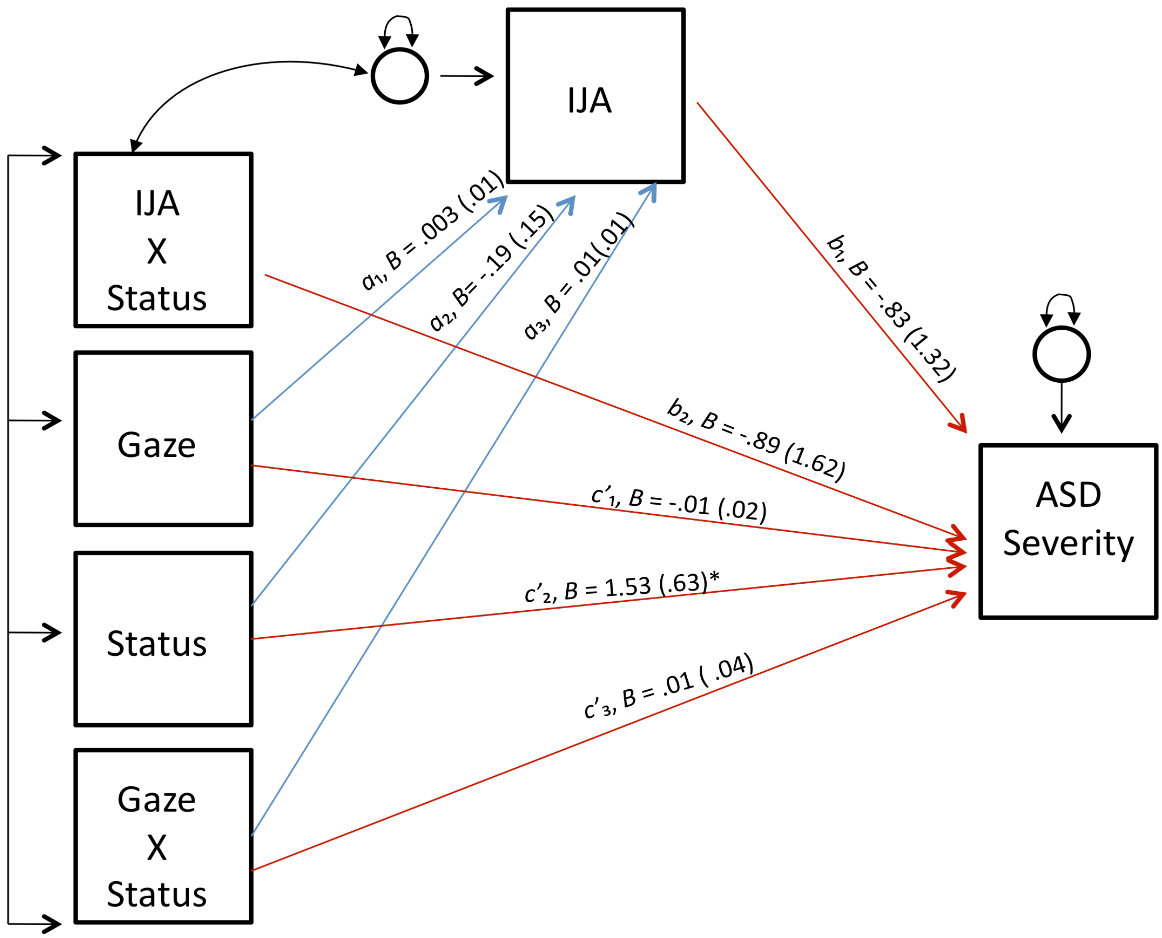
Note. *$p < .05$.

Figure 8. Conceptualization of moderated mediation



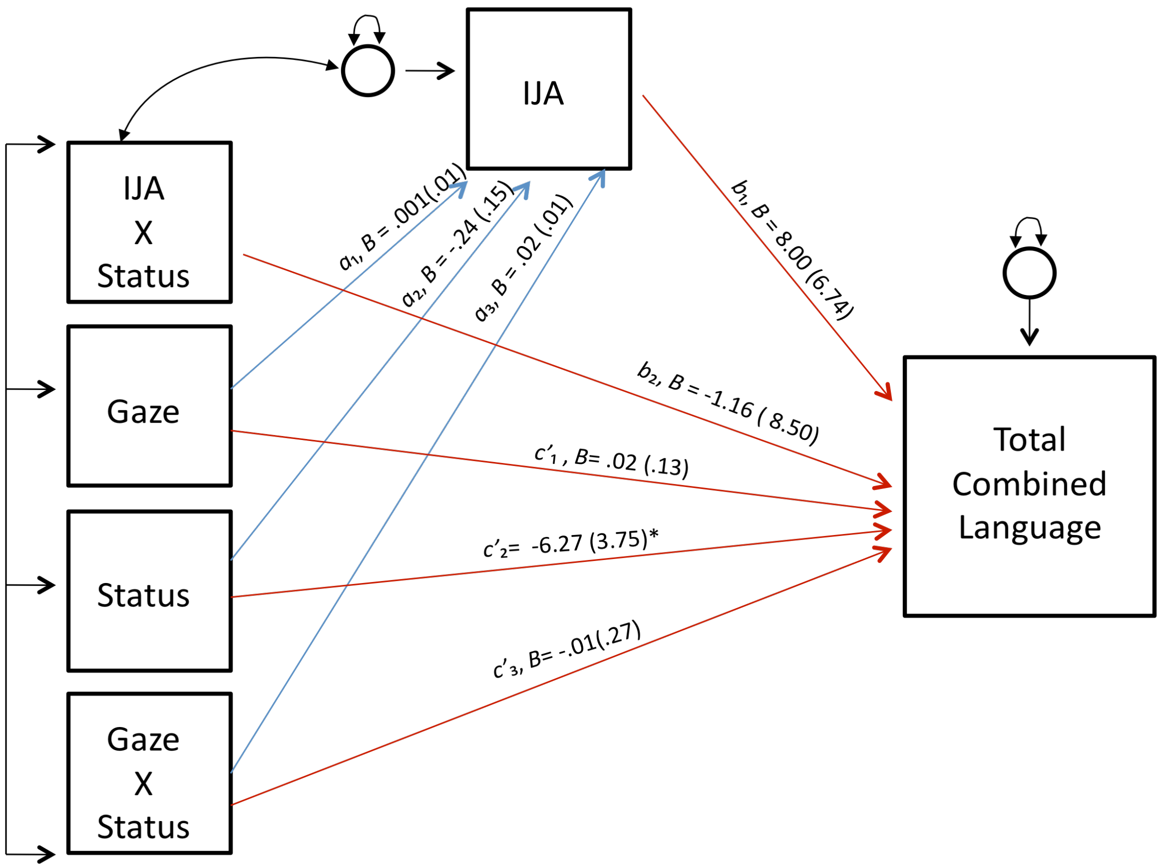
Note. Moderated mediation examined whether mean IJA mediated the effect of gaze shifts on the later outcomes of ASD calibrated severity and total combined language (A.), and if those possible mediations were moderated by group status (B.).

Figure 9. Path diagram for moderated mediation of ASD severity



Note. The blue lines indicate the mediator model and the red lines indicate the dependent model. The numbers used in this path diagram reflect the unstandardized beta coefficients and the standard errors. **p* <.05.

Figure 10. Path diagram for moderated mediation of total combined language



Note. The blue lines indicate the mediator model and the red lines indicate the dependent model. The numbers used in this path diagram reflect the unstandardized beta coefficients and standard errors. *p <.05.

Figure 11. The trajectory of IJA from eight to 18 months of age

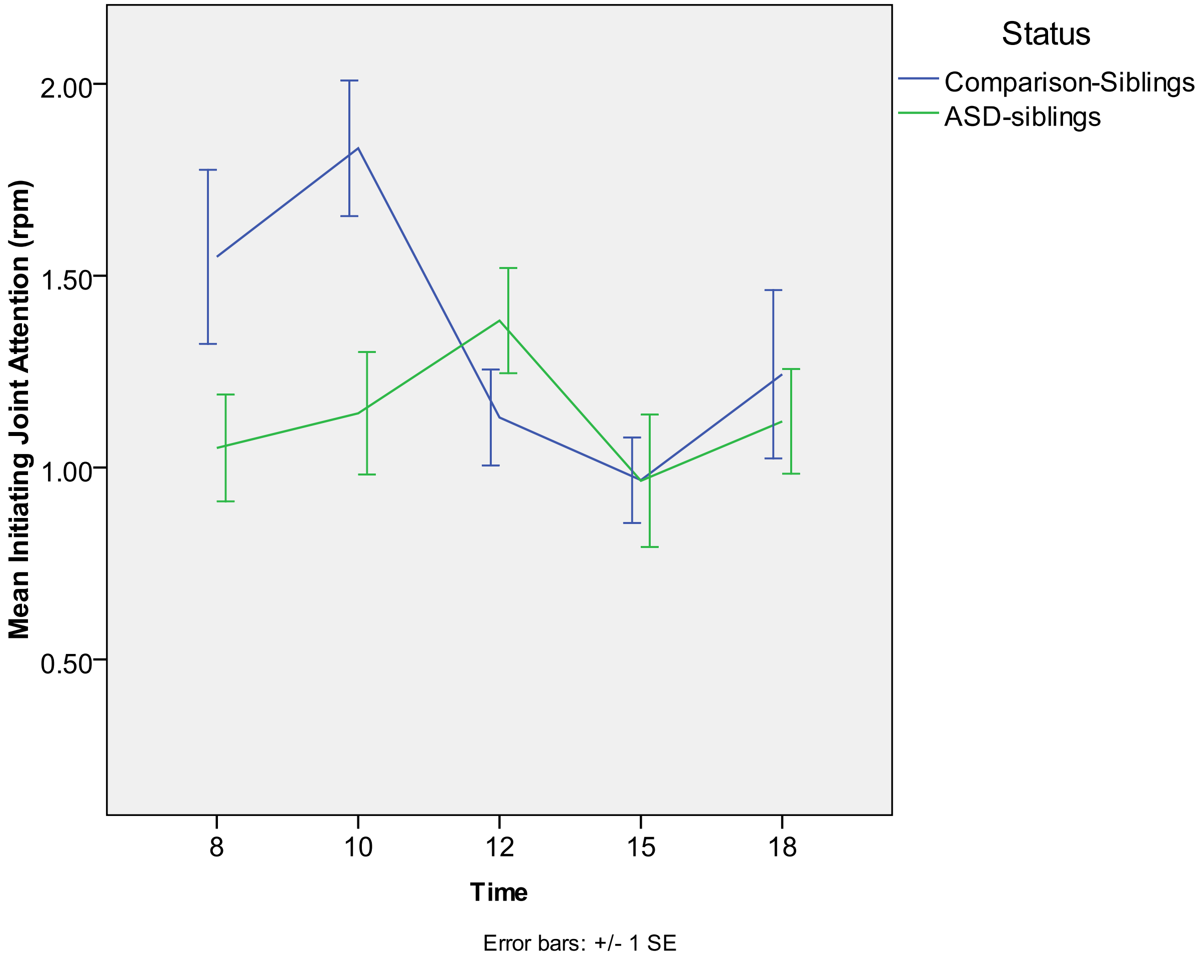


Figure 12. The trajectory of RJA from eight to 18 months of age