PREDICTING LANGUAGE AND SOCIAL OUTCOMES AT AGE 5 OF YOUNGER SIBLINGS OF CHILDREN WITH AUTISM SPECTRUM DISORDERS

By

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CHAPTER I

INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by abnormalities and impairments in both social and communicative behavior and development, and by a markedly restricted repertoire of activities and interests (American Psychiatric Association, 2000). The broad diagnostic category of autism spectrum disorder comprises Autistic Disorder, Pervasive Developmental Disorder - Not Otherwise Specified (PDD-NOS), and Asperger's Disorder, along with Rett syndrome and Childhood Disintegrative Disorder. As a spectrum disorder, ASD is characterized by marked heterogeneity, encompassing individuals of varying degrees of intelligence and language ability and spanning vast degrees of severity (Hill & Frith, 2003). Onset and exact manifestation of symptoms also differ by diagnostic category. In terms of prevalence, outcome, distress on family, and cost to society, ASD is considered to be among the more debilitating disorders of childhood (DiCicco-Bloom et al., 2006). Recent epidemiological data released by the CDC's Autism and Developmental Disabilities Monitoring Network estimate that 1 child in 110 is affected by ASD (2009).

At the present state of science, ASDs are diagnosed and characterized in terms of behavior, as biological bases remain largely undefined. While the exact causes and mechanisms for heritability of ASD are not well understood (Hill & Frith, 2003), strong evidence suggests that genetic factors play a significant causal role in its development (see Yang & Gill, 2006, for a review). The genetic underpinnings of ASD result in a manifestation of genetic vulnerability for ASD, or features associated with ASD, in individuals with shared genetic structure (e.g., siblings).

Susceptibility for milder expressions of ASD characteristics has been researched widely in family members of ASD. The majority of research concerning family members has been conducted with parents and siblings of individuals with ASD, with a diverse set of comparison or control groups to examine differences (e.g., typical development, developmental disability, Down syndrome). In particular, those studies focused on social and language ability have demonstrated decreased social aptitude (i.e., social-emotional difficulty, fewer friendships or intimate relationships) of siblings and parents (Bolton et al., 1994; Constantino et al., 2006; Dawson et al., 2005; Pilowsky, Yirmiya, Doppelt, Gross-Tsur, & Shalev, 2004), and lower communication skills in both siblings and parents (Bartak, Rutter, & Cox, 1975; Dawson et al., 2005; Plumet, Goldblum, & Leboyer, 1995), particularly in the realm of pragmatic language use (Landa et al., 1992; Landa, Folstein, & Isaacs, 1991). Furthermore, studies examining family members of individuals with ASD have also identified social-cognitive differences in siblings and parents (Baron-Cohen & Hammer, 1997, Dorris, Espie, Knott, & Salt., 2004, Losh & Piven, 2007), with a higher prevalence of unusual personality characteristics in parents (e.g., aloof, unresponsive, withdrawn, difficult, inflexible, rigid), higher rates of depression in siblings and parents (Bolton, Pickles, Murphy, & Rutter, 1998; Piven et al., 1991; Piven, Gayle, & Chase, 1990; Smalley, McCracken, & Tanguay, 1995), and increased rates of social phobia and obsessive-compulsive disorder in parents (Bolton et al., 1998; Piven & Palmer, 1999; Smalley et al., 1995). However, studies within this realm of research have varied widely in terms of methodology (e.g., different comparison groups, different test instruments to assess functioning, inclusion of broad and heterogeneous age ranges within studies), yielding inconsistent findings.

A new wave of prospective studies has capitalized on the recurrence risk of ASD in younger siblings of children already diagnosed with ASD by examining characteristics of infant siblings of children diagnosed with ASD until an age at which these siblings could themselves be diagnosed. This method poses a unique advantage as it allows for the examination of features of ASD *before* a diagnosis is made, using standardized assessment methods and rigorous experimental measures across the early course of development. Furthermore, younger siblings of children with ASD (Sibs-ASD) have a variety of outcomes that range from typical development, to language delay, to ASD, and thus allow for the opportunity to understand developmental pathways as well as varying forms of expression (Landa & Garrett-Mayer, 2006). Estimated recurrence rates of ASD in younger siblings range from 3% (Gamliel, Yirmiya, & Sigman, 2007) to as high as between 29% and 37% (Landa & Garrett-Mayer, 2006; Zwaigenbaum et al., 2005).

A major objective of studying Sibs-ASD has been to determine whether there are early behavioral differences between the high-risk Sibs-ASD group and other low-risk groups (e.g., siblings of typically developing children), that may reflect genetic vulnerabilities. To date, these studies have focused primarily on children up to the age of three. In particular, when contrasted with siblings of typically developing children (Sibs-TD), Sibs-ASD as a group have been found to exhibit reduced affective expression (Cassel et al., 2007; Yirmiya et al., 2006), less eye-to-eye gaze with mothers (Merin, Young, Ozonoff, & Rogers, 2007), lower attention regulation (Garon et al., 2009), less smiling (Cassel et al., 2007), lower levels of adaptive behavior (Toth, Dawson, Meltzoff, Greenson, & Fein, 2007), lower levels of language (Stone, McMahon, Yoder, & Walden, 2007; Toth et al., 2007; Yirmiya et al. 2006; Yirmiya, Gamliel, Shaked, & Sigman, 2007), and lower levels of requesting and turn-taking (Goldberg et al., 2005). Furthermore, considerable evidence that Sibs-ASD demonstrate differences related to joint attention exists, including lower levels of pointing and showing (Goldberg et al., 2005), less accurate responding to joint attention (Presmanes, Walden, Stone, & Yoder, 2007; Sullivan et al., 2007), less frequent initiating joint attention (Goldberg et al., 2005; Stone et al., 2007), and less frequent use of communicative gestures (Goldberg et al., 2005; Stone et al., 2007; Toth et al., 2007; Yirmiya et al., 2006), as compared to Sibs-TD. Though few of these studies have excluded the Sibs-ASD who later receive an ASD diagnosis (which could arguably skew the results), it has been suggested that differences remain even after this subset of children is removed (Mitchell et al., 2006), and that the lower levels of performance observed are characteristic of a sizable portion of the Sibs-ASD group (Presmanes et al., 2007; Stone et al., 2007).

Another objective in Sibs-ASD research has been to identify the earliest markers, or predictors, of ASD, with the ultimate aim of pinpointing and remediating early deviations that could potentially have adverse effects on subsequent development and functioning (Happé, 1994; Mundy & Crowson, 1997). Studies in this realm have prospectively examined early differences between only those children who later receive a diagnosis of ASD and those children with typical development or those who do not receive a later ASD diagnosis. A number of early markers of ASD have been indicated, including less frequent positive affect (Landa & Garrett-Mayer, 2006), less social smiling (Zwaigenbaum et al., 2005), poorer emotion regulation (Mitchell et al., 2006), as well as lower sensitivity to “social” reward cues (Garon et al., 2009) and lower levels of eye contact, visual tracking, and disengagement to visual attention (Zwaigenbaum et al., 2005). Of particular note are studies by Sullivan et al. (2007) and Yoder, Stone, Walden, & Malesa (2009) which found early differences in joint attention to be significantly related to ASD outcomes.

Impaired joint attention is often considered a key symptom of ASD (Charman, 2003; Travis & Sigman, 1998), and is one of the best-replicated indications for distinguishing young children with ASD from children with intellectual disabilities (Mundy, Sigman, & Kasari, 1990), and typical development (Morgan, Maybery, & Durkin, 2003). By definition, joint attention refers to a triadic exchange in which an individual coordinates attention with a social partner with the use of eye contact, gesture, and/or a vocalization to share interest or positive affect spontaneously about a referent or event (Mundy & Stella, 2000; Seibert, Hogan, & Mundy, 1982). Two main categories of joint attention exist, with functionally different purposes: 1) responding to joint attention (RJA), which refers to the capability to follow an adult's attentional directive (Seibert et al., 1982); and 2) initiating joint attention (IJA), which is defined as the use of eye contact, gesture, vocalization to spontaneously share interest or positive affect about a referent with another individual (Mundy & Stella, 2000; Seibert et al., 1982). In typical development, emergence of RJA occurs by 9 to 12 months, when children appear to comprehend that certain adult behaviors (points, head turns paired with shift in eye gaze direction) signal something about the adult’s intention and attention (Carpenter, Nagell, & Tomasello, 1998). IJA is thought to develop around 12 months of age, when infants begin to point to show objects/events of interest to others (Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004). Communication in infants between 9 and 18 months of age frequently contains these triadic exchanges (Carpenter et al., 1998), which are often prelinguistic in nature. Moreover, the ability to respond to, follow, or direct another's attention and hence participate in the sharing of attention and affect facilitates learning opportunities for the child about his physical and social environment.

Differences in RJA performance have been observed in Sibs-ASD relative to Sibs-TD as early as 15 months (Presmanes et al., 2007) and 18 months (Brian et al., 2008; Cassel et al., 2007). All three of these studies used different methodologies for assessing joint attention: Presmanes et al. (2007) used an observational coding system within an experimental measure, and the latter two used live-coding within semi-structured assessments (Brian et al., 2008, used the Autism Diagnostic Observation Schedule; ADOS, Lord et al., 2000, and Cassel et al., 2007, used the Early Social-Communication Scale; ESCS, Mundy, Hogan, & Doehring, 1996); all three studies used Sibs-TD as controls. Furthermore, Sullivan et al. (2007) examined the stability of RJA in Sibs-ASD who were later diagnosed with ASD and those who were not. This study found significant improvement in RJA between 14 and 24 months in the Sibs-ASD not identified as ASD; a period of rapid growth between these ages would also be expected in typical development (Bakeman & Adamson, 1984). However, RJA improvement over this time period (i.e., 14 to 24 months) was not observed in the Sibs-ASD diagnosed with ASD. This finding indicates that Sibs-ASD who are not diagnosed with ASD, may show promise for growth of RJA skills despite early differences in their abilities.

Lower levels of IJA have also been observed in Sibs-ASD, relative to Sibs-TD, and have been reported at the following mean ages: 15 months (Cassel et al., 2007), 16 months (Stone et al., 2007), 17 months (Goldberg et al., 2007), and 18 months (Brian et al., 2008). Cassel et al. (2007), Stone et al. (2007), and Goldberg et al. (2007) used semi-structured assessments for determination of IJA and all four studies used Sibs-TD as controls. Specifically, Stone et al. used the Screening Tool for Autism in Two-Year-Olds (STAT; Stone, Coonrod, & Ousley, 2000) while Cassel et al. (2007) and Goldberg et al. (2007) used the ESCS. Lastly, Brian et al. (2008) based IJA proficiency on a rating code from a gold-standard ASD diagnostic system (ADOS). Given the consistency of findings across samples and methodologies, it is clear that, as a group, Sibs-ASD exhibit lower levels of IJA and RJA relative to Sibs-TD in their second year of life.

The differences Sibs-ASD exhibit with IJA and RJA are important to consider, as early joint attention abilities have been found to be predictive of important aspects of developmental outcome in children with typical development (Charman et al., 2000; Mundy et al., 2007) as well as in those with ASD or other disorders (Mundy & Crowson, 1997; Rutherford, Young, Hepburn, & Rogers, 2007). For instance, in typical development, the acquisition of joint attention skills early in life is crucial for the later development of social, language, and cognitive abilities (Tomasello, 1995). Furthermore, many of the other hallmark deficits of ASD are theorized to be plausible developmental consequences of early joint attention impairments, such as executive functioning and language development (Bono, Daley, & Sigman, 2004; Dawson et al., 2004; Sigman & McGovern, 2005). Joint attention has been identified as a particularly salient predictor of language and socialization in ASD (e.g., Kasari, Freeman, & Paparella, 2006; Mundy, Sigman, & Kasari, 1994) and typical development (Mundy & Gomez, 1998; Van Hecke et al., 2007) both of which are identified differences in the early development of Sibs-

ASD (Stone et al., 2007; Toth et al., 2007, Yirmiya et al., 2007). Research on the predictive relations between joint attention and social and language outcomes in different populations will be reviewed below.

Language is one of the most widely studied constructs predicted by joint attention. Travis & Sigman (1998) hypothesized that joint attention may be related to later language acquisition. In particular, joint attention may index a child's awareness of the purpose of communication. Furthermore, children who are more capable of joint attention may participate in more social exchanges, inherently allowing for more opportunities for language learning. Empirical evidence suggests that IJA abilities are linked predictively to receptive language in typical development (Bates, Benigni, Bretherton, & Volterra, 1979; Blake, 2000; Desrochers, Morisette, & Ricard, 1995; Ulvand & Smith, 1996) and in ASD (Charman et al., 2003). Furthermore, early IJA is predictively associated with later expressive language in both typical development (Camaioni, Castelli, Longobardi, & Volterra, 1991; Desroches et al., 1995; Mundy & Gomez, 1998; Mundy, Sigman, Kasari, & Yirmiya, 1988; Ulvand & Smith, 1996) and in ASD (Bono, Daley, & Sigman, 2004; McDuffie, Yoder, & Stone, 2005; Mundy et al., 1990; Sigman & Ruskin, 1999; Stone & Yoder, 2001). Predictive relations have also been found for RJA and later receptive language in typical development (Carpenter et al., 1998; Morales et al., 2000; Morales, Mundy, & Rojas, 1998; Mundy & Gomez, 1998; Mundy, Kasari, Sigman, & Ruskin, 1995; Ulvand & Smith, 1986), and between RJA and later expressive language in typical development (Carpenter et al., 1998; Desrochers et al., 1995; Masur & Ritz, 1984; Morales et al., 1998) and ASD (Mundy, Sigman, Ungerer, & Sherman, 1986; Sigman & Ruskin, 1999; Sigman & Ungerer, 1984). One study to date has examined the predictive relation between joint attention and language in a Sibs-ASD sample. Sullivan et al. (2007) found that RJA at 14 months of age predicted later expressive and receptive language at 24 months of age in Sibs-ASD, underscoring the importance of early differences in RJA as potential markers of risk for later language difficulties in this group.

Joint attention skills are also related to indices of social relatedness (Mundy et al., 1994) and are a fundamental component of early social development (e.g., Bruner & Sherwood, 1983; Mundy, Kasari, & Sigman, 1992). Mundy and Sigman (2006) discuss a "social-motivation[al]" component of joint attention, suggesting that use of joint attention may be related to a tendency to express agreeableness and positive emotions, as well as interest in others. Joint attention is also thought to be a precursor for social-cognition, the beginnings of perception and awareness of others' intentions and cognitions (e.g., Tomasello, 1995). Empirical evidence suggests that the development of the tendency to initiate social interactions is predictively related to fewer externalizing problems in cocaine-exposed infants (Sheinkopf, Mundy, Claussen, & Willoughby, 2004), and to better social competence as well as to less externalizing behavior in typical development (Van Hecke et al., 2007). Better performance on RJA has also been predictively associated with social competence and less externalizing behavior in both typical development (Van Hecke et al., 2007) and in cocaine-exposed infants (Sheinkopf et al., 2004). Moreover, Yoder et al. (2009) identified a predictive association between RJA ability at a mean age of 15 months and degree of social aptness at a mean age of 34 months in a sample of Sibs-ASD overlapping with those in the current report. Yoder et al. (2009) also examined the predictive relation between early triadic communication (which subsumes IJA) and later social behavior, and obtained the interesting result that the *growth rate* (but not initial status) of early triadic communication abilities (which were weighted by verbal sophistication) predicted the degree of later social impairment. Thus, empirical evidence supporting the relation between early forms of joint attention and later indices of social difficulties and competence exists.

Thus, some support for the notion of a predictive relation between early joint attention abilities and later social and language outcomes in Sibs-ASD exists. Further, differences in joint attention, socialization, and language domains have been found when comparing Sibs-ASD and Sibs-TD at early ages. However, it remains unknown whether developmental lags in Sibs-ASD will be sustained over time, or if this at-risk group will "catch-up" to the trajectories of their typically developing peers. It is a viable hypothesis that through maturation and experience alone, children may reach a level of functioning similar to their typically developing peers, as has been described for children with early language delays who later "catch up" (Kelly, 1998). Conversely, it is possible that even slight early delays in language and socialization may divert Sibs-ASD onto an atypical developmental pathway that persists into the school years (Gamliel et al., 2007).

To date, very little empirical evidence exists concerning later outcomes (i.e., after age 3) of Sibs-ASD who had been identified as having differences early on (i.e., before the age of 3). The primary advantage of tracking the development of well-characterized Sibs-ASD is the ability to identify the relative importance of early differences, and their potential for adversely affecting later development. Only one published study to date has prospectively followed this population of children past the age of 3. Gamliel et al. (2007) reported on the developmental trajectory of Sibs-ASD from 14 to 54 months, and more recently included results for 7 years of age (Gamliel, Yirmiya, Jaffe, Manor, & Sigman, 2009). It is worthy of note that this group excluded Sibs-ASD with an ASD diagnosis from their analyses. Results revealed that the Sibs-ASD who exhibited differences from Sibs-TD in receptive and/or expressive language differences at either 14 or 24 months of age, continued to exhibit language differences at 54 months (Gamliel et al., 2007), indicating stability of language differences in Sibs-ASD. Further, Gamliel et al. (2009) reported that at 7 years, significantly more Sib-ASD exhibited language deficits (i.e., at least 1.5 standard deviations below average) relative to Sibs-TD. Interestingly, a considerably greater number of children were found to have deficits at 7 years than had previously been identified in their sample (Gamliel et al., 2007; Yirmiya et al. 2006, 2007). Thus, the authors suggest that the time at which children begin school may be a period when language difficulties become more apparent in the face of academic demands. As indicated by Rogers (2009), more data are needed to provide a clearer picture of the developmental course and developmental profile of Sibs-ASD, as the data from Gamliel et al. (2007; 2009) have thus far not been replicated. In particular, longitudinal data are imperative for improving understanding of developmental trajectories of abilities and differences in Sibs-ASD. Furthermore, broader knowledge of the developmental trajectories of Sibs-ASD (e.g., social development) is necessary to characterize the variation in autism symptomatology across development to determine which differences are more enduring (Toth et al., 2007; Yirmiya & Ozonoff, 2007).

Thus, the present study proposes a unique contribution to the literature on Sibs-ASD in three ways: 1) It will examine the developmental trajectory of Sibs-ASD over a longer time span in development and to a later chronological age (i.e., until age five) than has previously been investigated in all but one study (i.e., Gamliel et al., 2009). In particular, this research will provide critical information on the developmental trajectory and outcome of Sibs-ASD who are being identified as exhibiting characteristics related to autism symptomatology at early ages. 2) It will examine predictive relations between early joint attention skills (using both initial status and early growth patterns) and later language and social outcomes, exploring the possibilities of predicting these outcomes in Sibs-ASD. Early social behaviors such as joint attention have been identified as one of the strongest predictors of later language and social outcomes in ASD and typical development, and early differences could potentially have an adverse effect on later development and functioning; thus, the identification of these early markers may lead to promising opportunities for remediation. 3) It will employ a longitudinal approach (growth model) to account for the considerable effect that individual differences have on developmental course and for variations in developmental pathways.

Specific Aims and Hypotheses

The present study examines the social and language outcomes at age 5 for children who were followed longitudinally at several points in time (Yoder et al., 2009). The specific aim is to examine the utility of early joint attention abilities in predicting language and social outcomes in Sibs-ASD, relative to Sibs-TD. Within the domain of social outcome, social skills were considered separately from social difficulties, given recent evidence separating these constructs in children with ASD (Szatmari, 2010).

Specific hypotheses are:

1) Joint attention abilities (i.e., IJA, RJA) measured in the second year of life (i.e., 12-23 months) will be positively related to language and social skills, and negatively related to social difficulties, assessed at five years of age. This relation is predicted to vary by group, such that early joint attention abilities are more indicative of later outcome for Sibs-ASD than for Sibs-TD, due to the probability of lower variance in both the predictor and outcome variables in the Sibs-TD group. In other words, it may be the case that while some variation exists among Sibs-TD in early joint attention abilities, their abilities may all be above a certain threshold, allowing for typical development. In contrast, it may be the case that many of the Sibs-ASD are not reaching this "threshold" of ability and therefore the variation in early joint attention abilities they exhibit could have far reaching implications in terms of the later development of the lower performing Sibs-ASD.

2) Rate of growth (i.e., slope) of joint attention acquisition (i.e., IJA, RJA), determined over three to five time points will be positively related to age 5 language ability and social skill, and negatively related to social difficulty. This relation is predicted to vary by group, such that the growth of joint attention will be more indicative of later outcome for Sibs-ASD than for Sibs-TD, due to the probability of lower variance in both the predictor and outcome variables for the Sibs-TD group.

3) For the Sibs-ASD group, initial level of joint attention (i.e., IJA, RJA) will predict group membership above or below the 10^{th} percentile (i.e., clinically

significant delay) in terms of social and language (i.e., expressive, receptive) standard scores at age 5 outcome.

4) For the Sibs-ASD group, growth of joint attention (i.e., IJA, RJA) will predict group membership above or below the 10^{th} percentile (i.e., clinically significant delay) in terms of social and language (i.e., expressive, receptive) standard scores at age 5 outcome.

CHAPTER II

METHOD

Participants

Children targeted for this follow-up study comprise a subset of children enrolled in a longitudinal study (Yoder et al., 2009) whose developmental trajectories were followed for five time points (i.e., T1-T5), approximately 4 to 6 months apart. Two groups of children were targeted: (1) younger siblings of children with autism spectrum disorders (Sibs-ASD) and (2) a comparison group of younger siblings of children with typical development (Sibs-TD). In the original study, joint attention measures were administered at each research visit (i.e., T1-T5), language assessments were conducted at the first (T1) and last (T5) visit, and diagnostic evaluations were provided at T4 and T5.

The majority of Sibs-ASD (63%) was recruited through a university-based autism-specialized service and outreach program via newsletters, flyers, and websites; other recruitment sources were regional multidisciplinary evaluation and speech-language centers (20%) and community professionals (17%). The majority of Sibs-TD was recruited through a birth-record database in the metropolitan area (56%), with others recruited through a university email announcement (26%) or word-of-mouth (18%).

Eligibility criteria for Sibs-ASD in the original sample were as follows: 1) an older sibling (i.e., proband) with a diagnosis of autism, Asperger's Disorder, or Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS); 2) absence of severe sensory or motor impairments; and 3) no identified metabolic, genetic, or progressive neurological disorders. For Sibs-TD, eligibility criteria were: 1) an older sibling with typical development; 2) no family history of ASD or mental retardation in first-degree relatives; 3) absence of sensory or motor impairments; 4) no identified metabolic, genetic, or progressive neurological disorders. Proband diagnoses for the Sibs-ASD group were confirmed through direct clinical observation, assessment with standardized diagnostic tools (i.e., ADOS and/or Autism Diagnostic Interview – Revised, ADI-R, Lord, Rutter, & Le Couteur, 1994), and via a DSM-IV informed clinical diagnosis from a licensed psychologist. Probands of Sibs-ASD had the following diagnoses: autism (n = 20), PDD-NOS (n = 13), and Asperger's Disorder (n = 3).

For the present study, only children who participated in a minimum of three research visits in the original study were included. Children were invited regardless of their diagnostic outcome. A total of 85 children meeting this criterion were eligible for the follow-up study: 54 Sibs-ASD and 31 Sibs-TD. Of these, 59 (69%) were evaluated at follow-up: 36 (67%) Sibs-ASD (20 male, 16 female) and 23 (75%) Sibs-TD (15 male, 8 female). The remaining 26 (31%) were lost to attrition: 18 (33%) Sibs-ASD and 8 (25%) Sibs-TD. Six could not be located due to changed address and phone number, 8 moved out of state and were unable to return for a visit, 2 were scheduled but failed to show up for their visit and could not be contacted subsequently, and 10 declined to participate in the follow-up (e.g., expressed that their family was too busy to participate). No significant differences were found between families who did and did not participate at follow-up were found for child's gender, $\chi^2 = .02$, p = .89, odds ratio = .93, race, $\chi^2 = 2.48$, $p = .48$, IQ (at any time point measured: T1: $t = 1.08$, $p = .40$, Cohen's $d = -.03$, or

T5: t = .25, p = .80, Cohen's d = -.31), or final diagnosis, χ^2 = 3.26, p = .51. The only group differences between returners and nonreturners were number of visits completed in the original study, χ^2 = 13.70, p = .001, wherein returners had completed a significantly higher proportion of visits in the original study than did nonreturners, and level of maternal education level, χ^2 = 10.29, p = .04, wherein the mothers of returners had achieved significantly higher levels of education than mothers of nonreturners. Differences among returners and nonreturners were also examined separately for Sibs-ASD and Sibs-TD. Among Sibs-ASD, no differences were found between those who returned for follow-up and those that did not for gender, χ^2 = .15, p = .80, odds ratio = .80, race, χ^2 = 2.50, p = .45, IQ (T1: t = -.29, p = .78, Cohen's d = -.08, T5: t = -.37, p = .72, Cohen's d = -.11,), final diagnosis, χ^2 = 3.43, p = .49, or maternal education, χ^2 = 7.69, p = .10. Only number of visit completed differed among Sibs-ASD who returned and who did not, χ^2 = 13.04, p = .001, wherein returners had completed a significantly higher proportion of initial visits than nonreturners. Among Sibs-TD, no differences were found between returners and nonreturners for gender, χ^2 = .26, p = .61, odds ratio = 1.60, race, χ^2 = .10, p = .75, IQ (T1: t = .59, p = .56, Cohen's d = .26, T5: t = 1.22, p = .23, Cohen's d = .49,), visits completed, χ^2 = .002, p = .97, or maternal education, χ^2 = 4.87, p = .18.

Of the returners, 34 (94%) of the Sibs-ASD and 20 (87%) of Sibs-TD were evaluated at all five time-points, and 1 (3%) Sib-ASD and 3 (13%) Sibs-TD were evaluated at four time points; one Sib-ASD (3%) was evaluated at only three time-points.

Participant characteristics and demographic information are included in Table 1. Groups did not differ on CA at any time point (T1 CA, t = -1.78, p = .08, Cohen's d = -

.46, T2 CA, t = -1.73, p = .08, Cohen's d = -.46, T3 CA, t = -1.29, p = .20, Cohen's d = -.35, T4 CA, t = -1.26, p = .21, Cohen's d = -.34, T5 CA, t = -1.19, p = .24, Cohen's d = -.32) or on gender, χ^2 = .543, p = .46, odds ratio = .67; race, χ^2 = 1.49, p = .68, or maternal education level, χ^2 = 4.59, p = .33.

Clinical diagnoses were determined by experienced clinical psychologists on the basis of clinical judgment, ADOS and ADI-R data. Diagnostic outcomes at T5 of the original study were available for 97% (n = 35) Sibs-ASD and 96% (n = 22) Sibs-TD. Outcomes at T5 for Sibs-ASD were as follows: 9% ASD (autism: n = 2; PDD-NOS: n = 1), 1% developmental delay (n = 1), and the remaining 31 (89%) received no formal diagnosis. At follow-up, only two of three children originally diagnosed with ASD were identified as having ASD (autism = 1; PDD-NOS = 1). In particular, one child who had received a diagnosis of PDD-NOS in the original study was deemed to no longer qualify for an ASD diagnosis at follow-up by the clinical psychologist, yet clinical concerns relating to features associated with ASD were noted. The retention rate (i.e., 67%) of ASD diagnoses in this sample is in line with previous research (Turner & Stone, 2007). In addition, one child who was originally diagnosed with autism at T5 was diagnosed with PDD-NOS at follow-up. One child who was considered to have a developmental delay at T5, no longer qualified for this diagnoses at follow-up. None of the Sibs-TD in this sample received a formal diagnosis; all were regarded as having typical development.

Table 1. *Participant Characteristics and Demographics.*

	Sibs-ASD (*n* = 36)	Sibs-TD (*n* = 23)
Chronological Age: Mean (SD); Range		
T1	14.81 (2.77); 12 - 21	16.26 (3.48); 12 - 23
T2	18.86 (2.97); 15 - 25	20.30 (3.31); 16 - 27
T3	23.06 (2.99); 20 - 31	24.18 (3.43); 20 - 32
T4	27.31 (3.13); 24 - 35	28.52 (3.98); 24 - 37
T5	33.57 (3.18); 30 – 41	34.73 (4.09); 29 - 43
T6 Follow-up	63.56 (8.60); 50 - 88	65.65 (5.25); 60 – 77
Gender		
Male (%)	20 (56%)	15 (65%)
Female (%)	16 (44%)	8 (35%)
Race		
Caucasian (%)	32 (89%)	21 (91%)
African American (%)	1 (3%)	0 (0%)
Hispanic	1 (3%)	0 (0%)
Multi-racial (%)	2 (6%)	2 (9%)
Maternal Education		
High School or less (%)	2 (6%)	0 (0%)
Partial College	5 (14%)	1 (4%)
College Degree	22 (61%)	13 (57%)
Graduate Degree	7 (19%)	9 (39%)

Procedure

Approval from the Vanderbilt University Institutional Review Board was sought for the follow-up visit (T6). An initial letter was mailed to the families to inform them of the additional visit. Families were subsequently contacted via telephone, to schedule a lab visit during the period in which the child was between 4 and 6 years of age. Due to some scheduling difficulties, two children were not evaluated until they were 7 years of age. A packet of parent questionnaires, as well as consent forms, were mailed to those families who agreed to participate. Teacher address information was obtained from the parents during either their scheduling call or research visit, and a packet of questionnaires, along with a postage-paid envelope for return mailing and consent forms, were mailed directly to the teachers. Parents were asked to bring their completed packets to the lab on the day the child's follow-up visit was scheduled. Parents also participated in a diagnostic interview during their visit, while their children were being assessed. Child assessments were conducted by a licensed psychologist or trained examiner (under the supervision of a licensed psychologist) in a room adjacent to their parents that contained a double sided mirror so that parents could observe the assessment, if so desired. Evaluations were performed in a way that was compatible with the individual child's attention span, activity level, and need for access to his/her parent(s). Breaks were given as often as needed.

Measures

Predictor variables

Data for the predictor variables were collected through the original study.

Joint attention measures. The Screening Tool for Autism in Two-Year-Olds (STAT) was used to measure IJA and a responding to joint attention task that was designed specifically for the original study was used to measure RJA.

Screening Tool for Autism in Two-Year-Olds (STAT; Stone et al., 2000; Stone, Coonrod, Turner, & Pozdol, 2004; Stone, McMahon, & Henderson, 2008). The STAT is an empirically derived, interactive screening instrument for ASD. It consists of 12 items in the following domains: play (2 items), initiating joint attention (4 items), requesting (2 items), and imitation (4 items). Items are presented in a non-fixed order and within a play-like interaction. Activities and verbal instructions are standard for all children. Items are administered either at a child-sized table or on the floor, depending on child preference. The child's parent is present if necessary; however, parents are encouraged not to interact with the child. Administration takes approximately 20 minutes, and items are scored live on a pass/fail basis by trained examiners according to specific criteria in the administration manual. Training criteria include demonstrating administration fidelity and scoring agreement of a minimum of 83% on three STAT administrations with a certified examiner.

Past research supports reliable and stable *in vivo* scoring of the STAT (Stone et al., 2004). Composite scores are derived for each of the four domains; however, only the initiating joint attention (IJA) domain composite score was used in the current study. The four items that comprise the IJA domain are: Balloon, Puppet, Bag of Toys, and Noisemaker (see the Appendix for a detailed description). In all of these items, it was observed whether the child indicated his awareness of the object or event to the examiner using behaviors such as pointing at an object and looking at the examiner, commenting about an event, or holding up and showing an object. A score of '1' was given for each of the IJA items passed and a '0' was given for item that was failed, thus yielding a range of scores from 0 to 4.

Descriptions in greater detail, including materials used and verbal instructions, are available in the STAT manual (Stone & Ousley, 2008). STAT sessions were videotaped, and reliability coding for the IJA items was conducted through these videotaped recordings. Independent codings were conducted for randomly selected tapes that comprise approximately 20% of the sample at each time period. Inter-observer reliability was estimated using the conservative absolute-agreement intra-class correlation coefficient (ICC), and was based on independent codings of an average of 21.52% (SD = .01) randomly selected sessions from each time period. Adequate reliability was obtained for both groups at all time points (see Appendix). The average ICC was .90 (SD = .13).

Responding to Joint Attention Task (Deak, Walden, Kaiser, & Lewis, 2008; Presmanes et al., 2007). This experimental measure was approximately 20-30 minutes in duration and included 20 opportunities to elicit RJA from the child. The child and experimenter sat at a table facing a wall of eight novel target objects on individual plexiglass shelves in a 3 x 3 matrix across one wall, with a camera placed in the middle of the bottom row. The experimenter produced attention-eliciting and directing cues in a predetermined order while the child was visually engaged with age-appropriate toys. For each trial, the child's attention was directed to one of the eight objects. Ten different types of attention-eliciting prompts were used; each was presented to the child twice, once with the experimenter on the child's left and once on the right, resulting in a total of 20 RJA trials. Cues ranged in difficulty level and consisted of different combinations of physical and verbal prompts (i.e., head and gaze shifts, pointing gestures, and eliciting and directing verbalizations). Cue presentation order was randomized and counterbalanced across participants and was 10-seconds in duration, during which time the experimenter held her physical position and facial expression constant.

Children's gaze toward the stimuli was recorded by 3 cameras (one in front, and one each at the child's far left and far right), positioned to capture the child's head and upper body movements. The accuracy with which children located the actual target location was evaluated and scored for each of the 20 trials, and coded by trained observers. If the code matched the true target location, a score of 1 was given for that trial. If the code was vertically adjacent to the target location, a score of 0.5 was given. Scores of 0 were given for all other responses. Scores from the 20 trials were summed (i.e., RJA total score) and reflect the accuracy of looking responses; this score was used in appropriate analyses. The possible range for the RJA total score spans from 0 to 20. The average absolute-agreement interobserver reliability (ICC) was estimated, and was based on independent codings of an average of 20.64% (SD = 4.72) randomly selected sessions from each time period. Adequate reliability was obtained for both groups at all time points (see Appendix). The average ICC was .94 (SD = .06).

Outcome variables

Social and language outcome variables were collected at the follow-up (T6) visit. According to classical measurement theory, the validity of a construct can be increased by combining non-redundant but valid measures of that construct (Allen & Yen, 1979; Baggaley, 1988). In particular, the creation of aggregates of multiple measures reduces measurement error, and allows for a more a more valid and reliable assessment of the constructs being studied (Rushton, Brainerd, & Pressley, 1983). Furthermore, the use multiple measures may be more useful at capturing variability at both the severe and mild ends of a continuum (Martin, Schwartz, & Kohen, 2006). Thus, a multi-measurement approach was used for data collection for the follow-up portion of the project.

Language measures. Language ability data were obtained through a standardized clinical assessment as well as through a parental report.

Clinical Evaluation of Language Fundamentals- Preschool (CELF-P; Wiig, Secord, & Semel, 2004); *Clinical Evaluation of Language Fundamentals- Fourth Edition* (CELF-4; Semel, Wiig, Secord, 2003). The CELF is an individually administered test that is standardized and takes 30 to 45 minutes to administer. The CELF-P is for children between the ages of 3 and 6 years, and the CELF-4 is designed for children ages 5 to 21. The CELF-P was administered to children who were between 4 and 6 years old (n = 57), and the CELF-4 was administered to those children who were 7 (n = 2). The CELF is intended to assess performance in aspects of language that are fundamental to the development of effective communication skills. These fundamentals of language are defined as receptive and expressive language abilities in the areas of semantics, morphology, syntax, and auditory memory. Norm-referenced, standard scores (Mean 100, SD = 15) provided by the CELF are available for the following composites: Receptive Language Index (RLI), Expressive Language Index (ELI), Language Context

Index (LCI), Language Structure Index (LSI), and the Core Language Score (CLS). The CLS, a measure of general language ability (i.e., overall language performance), the RLI, and the ELI were used in appropriate analyses. The CELF-P and CELF-4 have acceptable internal consistency, test-retest reliability, and interrater reliability (ranging from r = .30 to r = .97). Further, both the CELF-P and CELF-4 demonstrate evidence of internal consistency reliability in clinical samples that include children with ASD (Semel et al., 2003 Wiig et al., 2004).

Children's Communication Checklist-2 for Parents (CCC-2; US Edition, Bishop, 2006). The CCC-2 is a 70-item, norm-referenced, parent-completed questionnaire assessing language competence in a variety of domains. The version utilized in this study is standardized for children 4 to 7 years of age and takes approximately 10-15 minutes to complete. Each item on the CCC-2 is rated 0–2 (0 = doesn't apply, 1 = applies somewhat, and 2 = definitely applies). Standard scores and percentiles are provided for each of the following 10 subscales: a) Speech, b) Syntax, c) Semantics, d) Initiation, e) Scripted Language, f) Context, g) Nonverbal Communication, h) Social Relations, and i) Interests. A General Communication Composite (GCC) score (Mean = 100, SD = 15), which is a norm-referenced standard score based on the composite of subscales a) – h), is derived to represent overall language performance, and was used in relevant analyses. The CCC-2 was developed in response to the dearth of clinical instruments available for assessing pragmatic language deficits as well as other communication strengths and weaknesses specific to ASD, as these aspects of communication are difficult to elicit in the context of standardized language assessment. The CCC-2 has demonstrated moderate internal consistency (α = .69 - .85) and high test-retest reliability (r = .86 - .96). Content validity and construct validity have been demonstrated. This measure has also been validated on sample of children with ASD (Bishop, 2006). Given that this measure is intended for children who speak in sentences, this questionnaire was deemed inappropriate for the one child in the Sib-ASD group who was nonverbal; although the measure was administered, the data were excluded from analysis.

Social measures. Two constructs related to social outcome were of interest: social skill and social difficulty. Social outcome data were obtained via questionnaire from both parents and teachers. Teacher questionnaires were used in tandem with parent questionnaires to measure social outcome, to circumvent any concerns regarding parental ability to accurately evaluate their child's social abilities, as a result of the frequently noted co-occurrence of social difficulties in family members of children with ASD. Furthermore, information from teachers was used to provide observations from adults who regularly observe children in a social setting, and who have extensive experience and understanding of normative behavior in this setting. For social outcome, direct observation is subject to a considerable amount of error and requires extensive observations within a natural setting. No matter how internally stable and elaborate the observational system, data obtained may be unreliable and of questionable utility (Merrell, 2001). Thus, scores from parent and teacher questionnaires were combined for a multi-measurement approach for (a) social skills and (b) social difficulty.

Social Skill

Social Skills Rating System (SSRS; Gresham & Elliott, 1990). The SSRS is a widely used, norm-referenced scale for parent and teacher ratings of a child's overall social skills and takes approximately 20 minutes to complete. The SSRS Preschool level form is standardized on children from 3 years 0 months to 4 years and 11 months, and the Elementary level form is standardized for children in kindergarten through fifth grade. The preschool form was used for children under five and the elementary level form was for children five and older. Teachers and parents each respond to 40 questions using a 3-point response format based on how often the child displays a given behavior (0 = never, 1 = sometimes, 2 = very often). The SSRS has empirically derived subscales for social skills (Cooperation, Assertion, Responsibility, Empathy, and Self-Control), which together comprise a Total Social Skills Scale standard score (Mean = 100, SD = 15). Subscales assessing problem behavior (Internalizing Problems, Externalizing Problems, and Hyperactivity) create the Problem Behaviors Scale standard score. An aggregate of the parent and teacher Total Social Skills Scale composites was used in applicable analyses. The SSRS has been used in several studies with children with high-functioning autism (e.g., Bauminger, 2002; Ozonoff & Miller, 1995). A review by Demaray et al. (1995) concluded that the SSRS was the most comprehensive instrument for assessing social skills because of its multi-source approach and the strong overall evidence for reliability and validity of resulting scores. Moderate to high levels of internal consistency (α = .82 - .94) and test-retest reliability (r = .85 -.87) have also been reported. The SSRS also demonstrates construct, content, and concurrent validity (Gresham & Elliott, 1990).

Social Difficulty

Social Responsiveness Scale (SRS; Constantino & Gruber, 2005). The SRS a 65-item standardized rating scale that was completed by each child's teacher and parent(s). It is suitable for children 4-18 years of age and takes approximately 15-20 minutes to complete. The SRS measures impairment on a 4-point quantitative scale (0 = never true to 3 = almost always true) across a wide range of severity, allowing for increased sensitivity of detection of milder degrees of ASD presentation. It assesses social impairments across a number of domains including social awareness, social information processing, capacity for social communication, social anxiety/avoidance, and stereotypic/repetitive behaviors/preoccupations. The SRS generates an SRS Total Score which is a T-score (Mean = 50; SD = 10) that serves as an index of severity of social deficits related to ASD; higher scores indicate greater severity of social impairment. The SRS is widely used in ASD research and has been used specifically in sibling studies (e.g., Constantino et al., 2006). This measure has demonstrated high internal consistency ($\alpha = .76$), moderate test-retest reliability ($r = .51 - .91$), and moderate inter-rater reliability ($r = .51 - .67$).

Diagnostic Outcomes. Diagnostic outcomes at age 5 were obtained on the basis of gold-standard autism diagnostic measures (ADOS and ADI-R) in combination with DSM-IV informed clinical diagnosis; these were administered to all children.

Autism Diagnostic Observation Schedule (*ADOS* ; Lord et al., 2000). The ADOS is a semi-structured observational assessment of play, social interaction, and communicative skills, designed as a diagnostic tool for identifying the presence of ASD. Administration time ranges from approximately 30 to 45 minutes. Four modules of the measure exist, distinguished by their appropriateness for use with individuals functioning at different developmental levels, ranging from nonverbal children to highly fluent adults. Each module provides a set of behavioral ratings and an algorithm that can be used for the diagnosis of ASD. The majority of the current sample was given the Module 3 (n = 58); however one nonverbal child was given the Module 1. The algorithm provides a Communication, Social Interaction, and Communication + Social Interaction Total score, each with specific autism and autism spectrum cut-offs. The Communication + Social Interaction Total score were used for the purpose of making ASD diagnostic formulations. Across all modules, inter-observer agreement for research-reliable examiners is .92, and the test-retest correlation is .82 (Lord et al., 2000). Agreement about diagnostic classification (autism vs. PDD-NOS vs. nonspectrum) ranges from 81% - 93% (Lord et al., 2000).

Autism Diagnostic Interview – Revised (*ADI-R*; Lord et al., 1994). The ADI-R is a standardized semi-structured, investigator-based interview for parents/caregivers that was developed for the purpose of making diagnostic classifications. The ADI-R provides explicit scoring criteria and a DSM-IV-based diagnostic algorithm that yields cut-off scores in the following three domains: Reciprocal Social Interaction, Communication, and Restricted, Repetitive, and Stereotyped Patterns of Behavior. Administration time for algorithm items ranges from approximately 30 to 90 minutes. Typically, a classification of autism is given when scores in all three domains meet or exceed the specified cut-offs, and onset of the disorder is evident by 36 months of age. This measure possesses strong psychometric properties in terms of inter-observer agreement, internal consistency, and test-retest reliability, and has been found to discriminate autism from non-autism in individuals with mental ages of at least 18 months (Lord et al., 1997).

CHAPTER III

RESULTS

Statistical Analysis Plan

To address the research questions, Hierarchical Linear Modeling (HLM, Raudenbush & Bryk, 2002) was used to describe the developmental course of IJA and RJA, approximating intercepts and linear growth curve parameters of the measures in question. HLM software allows for unbalanced and missing data, offering an "optimal analytic strategy for the study of change" (Francis, Schatschneider, & Carlson, 2000). In particular, HLM has been described as a rich and flexible alternative to the more traditional repeated measures approach (Bryk & Raudenbush, 1992). To assess variation over time, two-level growth models were used: level 1 data estimated the parameters of individual growth (i.e., within-person), and level 2 data estimated the parameters of mean growth (i.e., between-person) of the sample overall (i.e., with Sibs-ASD and Sibs-TD combined). A series of models was tested for IJA and RJA, to determine the growth models that best fit the data. Age in months was used as an indicator of time, and was tested in linear, quadratic, and cubic terms within the growth model. The fit of the base model was compared to other nested models using likelihood ratio tests ($\Delta\chi 2$-Δdf). Guided by the difference in the deviance statistic for the nestled model as well as the principle of parsimony, the best fitting models were determined for IJA and RJA separately. A slope was estimated for each child (if appropriate), derived from the best fitting model. Finally, a series of multiple regression analyses were performed to assess the degree of relatedness between HLM fitted predictors (i.e., IJA and RJA estimated intercept) and outcome variables (i.e., social and language aggregates).

Descriptive Statistics for Predictor Variables

The means and SDs for the predictor variable (i.e., IJA and RJA) raw scores for Sibs-ASD and Sibs-TD at T1 - T5 are presented in Table 2. In general, the means for IJA and RJA demonstrate growth over time in both groups.

Table 2. *Means and SDs for Predictor Variable Raw Scores for Sibs-ASD and Sibs-TD at T1 – T5.*

	Sibs-ASD				Sibs-TD			
Variable	*Mean*	*SD*	*Range*	*n*	*Mean*	*SD*	*Range*	*n*
IJA								
T1*	.89	.95	0 – 3	36	1.57	.99	0 - 3	23
T2	1.56	1.21	0 - 4	36	2.09	1.13	0 - 4	23
T3	2.06	1.37	0 - 4	34	1.91	1.38	0 - 4	22
T4	2.06	1.33	0 - 4	35	2.52	1.33	0 - 4	21
T5	2.50	1.23	0 - 4	36	2.73	1.08	0 - 4	22
RJA								
T1*	3.82	2.82	0 – 12	36	5.88	2.97	1 – 11	23
T2	5.05	3.20	0 – 13	36	6.35	3.47	0.5 – 12.5	23
T3*	5.65	3.38	0 – 12	34	7.61	2.93	2 – 12.5	22
T4*	5.44	3.03	0.5 – 12.5	33	7.63	2.90	3.5 – 15	21
T5	6.83	3.30	0 – 13	32	8.30	2.25	5 – 14	22

* indicates group differences, $p < .05$; Cohen's *ds* = .70, .71, .62, .74, respectively

Descriptive Statistics and Data Preparation for Outcome Variables

The means and SDs for the outcome variables for Sibs-ASD and Sibs-TD at T6 are in Tables 3 and 4. Table 5 represents outcome above and below the 10^{th} percentile on language (receptive and expressive) and social measures for Sibs-ASD and Sibs-TD, separately. The number of measures collected varied by participant. Some data were not collected due to protocol error. Teacher data were not available for several participants as forms were not returned. Furthermore, the CCC-2 was not included for one participant given that the child was non-verbal and the measure was not applicable.

Table 3. *Means and SDs for Language Outcome Measures for Sibs-ASD and Sibs-TD.*

	Sibs-ASD				Sibs-TD					
Measure	*Mean*	*SD*	*Range*	*n*	*Mean*	*SD*	*Range*	*n*	*t*	*p*
CELF CLS[a]	101.78	17.19	45- 135	36	108.57	12.14	90 - 133	23	1.57	.12
CELF RLI[a]	101.61	18.84	45 – 127	36	108.61	12.68	81 - 127	23	1.45	.15
CELF ELI[a]	99.56	18.22	45 – 134	36	105.78	12.08	87- 132	23	1.65	.11
CCC-2[a]	109.68	13.96	85 – 133	34	115.30	14.91	82 - 138	23	1.45	.15

[a] Norm-referenced standard scores, higher scores indicate more proficiency

Table 4. *Means and SDs for Social Outcomes Measures for Sibs-ASD and Sibs-TD.*

	Sibs-ASD				Sibs-TD					
Measure	*Mean*	*SD*	*Range*	*n*	*Mean*	*SD*	*Range*	*n*	*t*	*p*
Social Skill										
SSRS- Parent[a]	100.75	15.28	60 – 130	36	101.85	13.81	68 - 123	20	2.30	.79
SSRS- Teacher[a]	108.60	13.23	88 – 130	20	110.79	13.74	84 - 128	14	.87	.64
Social Difficulty										
SRS- Parent[b]	47.18	7.70	37 - 62	33	42.73	5.88	34 – 57	22	2.67	.03[c]
SRS- Teacher[b]	45.14	6.59	38 - 58	22	43.24	6.92	37 – 65	17	.47	.39

[a] Norm-referenced standard scores, higher scores indicate more proficiency

[b] T-scores, higher scores indicate greater difficulties

[c] Cohen’s d = .65

Table 5. *Membership Above and Below the 10th Percentile for Language and Social Outcomes.*

Measure	Sibs-ASD n below 10th %ile	Sibs-ASD n above 10th %ile	Sibs-TD n below 10th %ile	Sibs-TD n above 10th %ile	X^2	*p*
CELF-P RLI	5	31	1	22	1.40	.24
CELF-P ELI	6	30	0	23	4.27	.04[a]
Social Skills aggregate[b]	4	32	1	19	.59	.44

[a] Odds ratio = 1.77

[b] See page 37

To increase validity of language and social outcomes (i.e., social skill, social difficulty), several different aggregate (i.e., average) measures were created, contingent upon minimum correlation coefficient of 0.5 among component measures. Composites were created regardless of missing data (e.g., if only two of three measures were available for a certain participant, those two measures would be combined rather than eliminating that participant), but were represented with multiple scores whenever possible to better represent the constructs they assess.

The language ability construct is represented by CELF-P Core Language Structure (CLS) composite and the CCC-2. While the correlation between the CELF-P CLS and CCC-2 was significant, $r = .31$, $p = .02$, it did not meet the minimum correlation standard of .50, thus these measures were considered separately in subsequent analyses.

The social skills construct was represented by SSRS Parent and Teacher questionnaires. The SSRS Parent and Teacher questionnaires met the minimum correlation requirement, $r = .60$, $p < .001$; thus an aggregate was created. Scores were restandardized after the aggregate was created, to have a mean of 100 and a standard deviation of 15.

The social difficulties construct was represented by the SRS Parent and Teacher questionnaires. Though the SRS Parent and SRS Teacher were significantly correlated, $r = .44$, $p = .006$, they did not meet the minimum correlation standard of .50; thus these measures were considered separately in subsequent analyses.

Hierarchical Linear Model fitting for IJA and RJA

HLM 6.08 software was used to estimate growth in joint attention (i.e., IJA and RJA) over five points in time (T1-T5). Age was centered at the average age at the first evaluation (i.e., 15.37 months). The practical implication of centering at 15.37 months is that the intercept term in the model reflects estimated level of IJA or RJA at the average age at T1, rather than at age 0 (i.e., birth).

Linear models were fit for both IJA and RJA. Hypothesis testing of fixed effects indicated large and highly significant *t* statistics for the estimated intercept and slope values of IJA and RJA, suggesting that both intercept and slope parameters were needed for capturing mean growth trajectories (results presented in Table 6). Additionally, deviance statistics for respective models indicated that random intercept, random slope models exhibited a significantly better fit than less complex models, IJA: $X^2\,(3) = 58.81$; $p < .001$; RJA: $X^2\,(3) = 41.07$; $p < .001$. For RJA, the homogeneity of growth parameters (chi-square statistics) indicated that significant variation existed within individual growth trajectories for both intercept and slope. For IJA, homogeneity of growth parameters suggested significant variance in the intercept but *not* slope. Nevertheless, the random intercept, random slopes model was chosen for IJA, given that the goal was to select a model that would provide the most accurate estimates of individual growth, without making the assumption that every child has the same growth pattern. In other words, the random slopes model permits variation in slopes across children, allowing each child to be different, and was chosen despite the fact that the variance was not significant. Quadratic and cubic growth models were also considered for both IJA and RJA. Though hypothesis testing suggested that the quadratic models exhibited a significantly better fit than the linear models, the addition of more complex parameters decreased the reliabilities for intercept and slope considerably, and reliability estimates for the quadratic and cubic parameters were trivial. In addition to reductions in reliability, there was no significant variance in the quadratic or cubic terms. These factors, coupled with the principle of parsimony, supported the selection of linear functions for final (i.e., unconditional) models.

The intercept coefficients in both models (i.e., IJA and RJA) represent the mean value of intercept of the fitted HLM model at the first time point (T1). For example, in the fitted model for RJA the estimated mean value was 4.90, which represents mean number of instances of RJA elicited during the observation (i.e., during the experimental task). The observed mean value for RJA at the first time point was 4.60. The slope estimates the average amount of growth in the variable in question over time (i.e., months). In the case of RJA, children on average became capable of responding to .14

more instances of joint attention per month. Estimated slope values for IJA and RJA were positive, indicating positive change over time.

A series of tests assessing whether the growth models met HLM assumptions (i.e., normality of residuals, no multicollinearity, homoscedasticity of residuals, correct functional form) were performed. These assumptions were tested on the final IJA and RJA random intercept, random slope models. Tests of assumptions were focused at level-1, given that individual change trajectories were of interest and that no level-2 time-invariant predictors had been added at level-2. Inspection of normal probability plots suggested some deviance from normality at the tail ends for both IJA and RJA. Further insight into the normality of the data was sought through examination of standardized residual plots. These plots revealed that the data appeared to conform to normal theory assumptions. Acceptable multicollinearity was determined using Tabachnick & Fidell's (1989) convention of an $r = .90$ covariation or less among intercept and slope. This assumption was met for both models with *rs* of -.58 for IJA and -.42 for RJA, indicating that there was acceptable mulitcollinearity. Apart from determining that the correlations of intercept and slope do not violate assumptions of multicollinearity, it is notable that the correlations between intercepts and slopes are substantial, indicating that their combination may be important to consider within their respective models. Assumptions of correct functional form were investigated through examination of growth plots, which appeared largely linear over time for both IJA and RJA. Finally, homoscedasticity of residuals was examined for both models, revealing that this assumption was met. Given that both models were found to be tenable, ordinary least square (OLS) estimates for intercept and slope were extracted and used in subsequent applicable analyses for both IJA and RJA.

Table 6. Linear Growth Models for IJA and RJA.

	Fixed Effects			*Random Effects*		
Variable	*Coefficient*	*SE*	*t*	*Variance*	X^2	*Reliability*
IJA						
Intercept	1.34	.12	11.02**	.33	97.85*	.38
Slope	.07	.01	7.69**	.001	68.23	.11
RJA						
Intercept	4.90	.36	13.74**	5.05	169.19**	.64
Slope	.14	.02	5.97**	.006	78.63*	.21

* $p < .05$; ** $p < .001$.

Testing of Hypotheses

Hypothesis 1: Initial joint attention abilities will be positively related to language and social outcomes; but will vary by group.

Regression analyses were performed to examine relations between initial joint attention and later language and social outcomes, where IJA and RJA intercepts from the fitted HLM models were used. For the purposes of examining the possibility of a difference in the strength of relations between groups, product terms were created for respective interactions. Before each product term was created, predictor variables (i.e., IJA intercept, RJA intercept) were grand-mean centered in order to minimize multicollinearity (Aiken & West, 1991).

Regression analyses revealed that initial IJA was significantly and positively correlated with the CELF-P CLS standard score at outcome, $\beta = .37$, $p = .004$, $R^2 = .14$. The strength of this relation in the Sibs-ASD versus Sibs-TD was also of interest. Therefore a regression with initial IJA, and the group X initial IJA interaction was performed. Results revealed that the interaction term was not significant, $p > .05$ and was trivial in size, indicating that the relation between initial IJA and later language ability was not different for Sibs-ASD and Sibs-TD. The positive predictive relation between early IJA and later language was further supported with a significant relation between the IJA intercept and CCC-2 at outcome, $\beta = .36$, $p = .007$, $R^2 = .13$. Again, the interaction term was added, but was non-significant and trivial in size. Regression analyses also indicated significant and positive relations between initial RJA and later language ability, both in terms of the CELF-P CLS outcome, $\beta = .29$, $p = .026$, $R^2 = .08$, and CCC-2, $\beta = .27$, $p = .04$, $R^2 = .07$. However, the addition of the group interaction term in either model did not reveal any differences between groups, $p > .05$, indicating no difference in the relation between initial RJA and later language for Sibs-ASD versus Sibs-TD.

The relation between early joint attention and social outcomes (i.e., social skills and social difficulty) were also assessed. The relation between early IJA and later social difficulties as reported via parent questionnaire was found to be significant. In particular, a significant and negative relation was revealed between the IJA intercept and Parent SRS Total Score at outcome, $\beta = -.32$, $p = .02$, $R^2 = .10$, with greater proficiency with early IJA being indicative of fewer later social difficulties related to ASD. Given that the

SRS is not norm-referenced, this relation was reassessed with age at T6 entered in as a covariate to ensure that age did not account for the relation found. The relation between initial IJA and the Parent SRS remained significant after controlling for age, $\beta = -.30$, $p = .03$, $R^2 = .13$. The group X IJA intercept interaction term was subsequently added to the model and was not found to be significant, $p > .05$. A significant and positive relation was also found between early RJA and the Parent SRS, $\beta = -.31$, $p = .02$, $R^2 = .10$. However, when age at T6 was added as a covariate, the relation only approached significance, $\beta = -.28$, $p = .057$, $R^2 = .10$. All other analyses examining the relation between early joint attention (i.e., IJA and RJA) and social outcomes (i.e., SRS Teacher Total Score, SSRS aggregate score) yielded non-significant findings, *ps* > .05.

A series of assumptions was tested to assess the tenability of the regressions performed (i.e., correct specification of form, correct model specification, independence of residuals, and homoscedasticity). In performing regression diagnostics, a violation of the assumption of homoscedasticity was suspected for analyses involving the Teacher SRS**.** Thus, robust regressions, which are not constrained to the limitations of traditional regression, were performed to reexamine these relations. Robust regressions also indicated that the relations between IJA intercept and Teacher SRS, and RJA intercept and Teacher SRS were non-significant, *ps* > .05.

Hypothesis 2: Growth of joint attention abilities will be positively related to language and social outcomes; and will vary by group.

Estimates for IJA and RJA slope were extracted from the fitted HLM models. Given that differences in the strength of relations across groups (i.e., Sibs-ASD and Sibs-

TD) were again of interest, predictor variables (i.e., IJA slope, RJA slope) were grand-mean centered and product terms for respective interactions were created.

Relations between growth in joint attention and language and social outcomes were examined. In contrast to what was expected, regression analyses revealed a negative and significant relation between growth in IJA and language ability as assessed by the CCC-2, $\beta = -.35$, $p = .01$, $R^2 = .12$, suggesting that greater growth in IJA is indicative of lower language ability at outcome. Given that where children start in terms of the joint attention may confound their growth (e.g., children with high skills at the start point have little room for growth), intercept was added into the model as a covariate. Indeed, when controlling for intercept, slope of IJA was no longer a significant predictor of language outcome (i.e., CCC-2), $p > .05$. No relation was found between RJA and the CCC-2, or between either joint attention variable and the CELF-P CLS, *ps* > .05.

With regard to social outcome, a positive relation was initially found between IJA growth and the Parent SRS (i.e., representing social difficulties) was found, $\beta = .28$, $p = .04$, $R^2 = .08$, suggesting that greater growth in IJA is predictive of increased social difficulties at outcome. This model remained significant after age at T6 was added as a covariate, $\beta = .28$, $p = .04$, $R^2 = .11$. However, when status at T1 (i.e., IJA intercept) was controlled for, IJA slope was no longer found to be a significant predictor of social difficulties, $p > .05$. Finally, a positive relation between RJA growth and social skills outcome (i.e., aggregate of Parent and Teacher SSRS) was found, $\beta = .31$, $p = .02$, $R^2 = .10$. This relation remained significant after controlling for intercept, $\beta = .45$, $p = .002$, $R^2 = .20$. However, when the interaction term was then added to the model, it was not found to be significant, $p > .05$. Remaining analyses examining the relation between the growth of joint attention and Teacher SRS yielded non-significant findings, *ps* > .05.

Assumptions of multiple regression were tested to determine the tenability of the results yielded. As suspected previously, a violation of the assumption of homoscedasticity was again suspected for analyses involving the Teacher SRS**.** Thus, robust regressions were performed to reexamine these relations. The relations between IJA slope and Teacher SRS, and RJA slope and Teacher SRS, remained non-significant in robust regressions, *ps* > .05.

Hypothesis 3: For the Sibs-ASD group, initial joint attention will predict group membership above or below the 10th percentile in terms of social and language standard scores at T6.

To address this and the subsequent question (i.e., Hypothesis 4), the standardized norm-referenced language (CELF-P: Receptive Language Index; Expressive Language Index) and social (Social skills aggregate: SSRS Parent and Teacher) measures were dichotomized, and replaced the continuous language/social variables in analyses above. Receptive and Expressive language scores were used instead of the overall language score (i.e., CELP-P CLS) for the purposes of increasing clinical utility, given that language delays are classified in terms of delays in expressive and receptive language separately. Variables were dichotomized at the 10th percentile, a cut-off that was based on eligibility criteria often used by language intervention service agencies to determine eligibility (McCauley & Swisher, 1984) and by the Specific Language Impairment literature to represent clinically significant delays.

Binary log-linear regression analysis was used to test predictions given the dichotomous outcomes in question. Neither initial IJA nor initial RJA was found to significantly predict Receptive Language or Expressive Language status outcome above or below the 10th percentile for Sibs-ASD, *ps* > .10. Initial IJA and RJA were also used to test dichotomous social outcomes, above and below the 10th percentile on the aggregate social skills measure (i.e., SSRS Parent and Teacher). No relation significant relations were found, *p* > . 05.

Hypothesis 4: For the Sibs-ASD group, growth of joint attention will predict group membership above or below the 10th percentile in terms of social and language standard scores at T6.

Binary log-linear regression analyses did not indicate any significant relations between growth of RJA and later Receptive or Expressive language status, *p* > .10. However, a significant and positive relation was revealed between growth of RJA and group membership above and below the 10th percentile for social skill outcome, β = 9.66, Wald statistic (1) = 4.59, *p* = .03, sensitivity = .25, specificity = .97, PPV = .50, NPV = .92, indicating that slow growth in early RJA was predictive of social impairment. This relation remained only marginal after controlling for RJA intercept, β = 15.97, Wald statistic (1) = 3.54, *p* = .06, sensitivity = .50, specificity = .97, PPV = .67, NPV = .94. No relation was found between growth of IJA and social outcome, *p* > .05.

CHAPTER IV

DISCUSSION

Early joint attention abilities are fundamentally important in a child's early development, as they have significant implications for subsequent developmental sequelae. Language and social abilities are particularly salient developmental outcomes of joint attention (e.g., Tomasello, 1995). Individual differences in joint attention have been associated with later language and social development, both theoretically and empirically, in children with typical development (e.g., Mundy & Gomez, 1998), as well as with ASD (e.g., Mundy, Sigman, & Kasari, 1994). Limited evidence also suggests their importance in younger siblings of children with ASD, in terms of being predictive of later language and social outcomes (Sullivan et al., 2007, Yoder et al., 2009). Younger siblings of children with ASD (Sibs-ASD) have been shown to exhibit early difficulties with joint attention (Goldberg et al., 2005; Presmanes et al., 2007; Stone et al., 2007; Sullivan et al., 2007), and are also thought to be at heightened risk for other features associated with ASD (e.g., Toth et al., 2007; Stone et al., 2007; Yirmiya et al. 2006), in addition to being at increased risk for the disorder itself (e.g., Landa & Garrett-Mayer, 2006; Zwaigenbaum et al., 2005). Little is known, however, regarding developmental profiles of Sibs-ASD after the age of 3, or about the predictive utility of early differences as indices of later outcome. Thus, the current study examined the longitudinal development of Sibs-ASD across a longer developmental time span than previously reported in all but one study (Gamliel et al., 2009), looking specifically at joint attention as a potential early marker of later social and language outcomes.

The heightened genetic susceptibility that characterizes Sibs-ASD makes this group exceptionally heterogeneous, with developmental outcomes ranging from typical development, to language delay, to ASD. Despite the increased risk for a broad range of atypical outcomes, the results of this study suggest that Sibs-ASD, as a group, exhibited outcomes similar to the younger siblings of children with typical development (Sibs-TD, whose genetic vulnerability is considerably lower). Specifically, findings regarding *Hypothesis 1* supported the relations between early (i.e., at a mean age of 15.37 months) joint attention abilities and language and social outcomes in this sample (i.e., at a mean age of 5.36 years), with no indication of a difference in the relation for Sibs-ASD versus Sibs-TD. In other words, the estimated intercepts for IJA and RJA allowed for the reliable prediction of later social and language outcomes, with no evidence for differences in the characteristics of this relation between groups. Overall and across groups, the findings of this study support associations between early joint attention and later language and social outcomes. In particular, the most consistently supported relations observed were those between early joint attention and later language outcomes, with IJA and RJA intercepts significantly related to both the standardized clinical assessment of language (i.e., CELF-P CLS) and the parental report measure of language (CCC-2). In terms of social outcomes, both IJA and RJA intercepts significantly predicted social difficulty, as reported via parent questionnaire (SRS Parent). Given that the SRS was not norm-referenced for age, age at outcome was covaried, which left the relation between IJA and social skills significant and caused the relation between RJA and social difficulty to become marginal (p = .06). Neither IJA nor RJA intercept had significant predictive utility for either teacher-reported social difficulty (SRS Teacher) or social skills outcome aggregate (SSRS Parent and Teacher aggregate).

The sample of children represented in this study is unique in that the social and communication skills of included children were evaluated from a young age (i.e., at an average of 15 months) and subsequently followed up at 5 years. Early reports with this sample revealed developmental differences between Sibs-ASD and Sibs-TD, with Sibs-ASD demonstrating lower levels of IJA, RJA, nonverbal problem-solving, motor imitation, understanding words and phrases, gesture use, and social-communicative interactions with parents, as well as increased autism symptomatology at 15-16 months of age (Presmanes et al., 2007; Stone et al., 2007). Therefore, though ancillary to the central research questions presented here, it was of interest to examine whether group differences in social and communication skills remained in this sample at follow-up. Examination of group differences at follow-up (i.e., at age 5 years) indicated that Sibs-ASD generally did not demonstrate language or social differences relative to Sibs-TD. The only difference that was detected between Sibs-ASD and Sibs-TD was in social difficulty as reported by parents (i.e., Parent SRS), in that parents of Sibs-ASD reported that their children exhibited greater social difficulties related to autism than did parents of Sibs-TD. It is important to note that though elevated as compared to Sibs-TD, the mean score for Sibs-ASD was in 'normal' range (i.e., mean T-score = 47.18; T-scores of 59 or less are in the 'normal range'). Thus, this finding is consistent with literature that suggests that relatives of individuals with ASD exhibit some mild difficulties related to ASD (i.e., the broad autism phenotype), though generally do not experience differences that are clinically impairing (e.g., Losh & Piven, 2007).

The difference between Sibs-ASD and Sibs-TD on the SRS was not, however, found for the parallel Teacher report form (i.e., Teacher SRS). It may be that parents of children with ASD may be particularly attuned to -- and perhaps even hypervigilant regarding -- atypical social behaviors relating to ASD, and may in turn endorse these behaviors to a greater degree as compared to teachers. Alternatively, it may be that teachers are not noticing some of the subtle social difficulties that Sibs-ASD are experiencing, perhaps because of a lack of expertise in autistic symptomatology. Overall, our findings relating to group differences suggest that despite some early differences in development, the subset of children presented in this study generally seems to have caught up to the typically developing comparison sample. In particular, language and social skill differences were not observed between groups, despite the fact that two children in the Sibs-ASD sample had a diagnosis of ASD.

The second major research question in this study (*Hypothesis 2*) assessed whether early growth in joint attention was an important predictor of later social and communication outcome. It should be noted that growth curve modeling indicated that simple linear models (i.e., straight line) best fit the growth of both IJA and RJA. Two of the findings related to this hypothesis initially seemed counterintuitive in suggesting that faster growth in IJA predicted lower language abilities (on the CCC-2) and greater social difficulties (on the SSRS aggregate). However, when initial IJA skills were added to the models, these relations disappeared. It may be the case that a subset of children who had a high level of initial joint attention skills (i.e. at 15 months), were left with little room for growth during the developmental time frame of our original study. Thus, it is suggested that the timing of the initial study may not have captured the earliest phases of IJA development in enrolling infants at 12-24 months. Indeed, Mundy et al. (2007) examined the developmental trajectories of joint attention in typical infants from ages 9 to 18 months and found that infants experienced the majority of growth in IJA skills *prior to* 15 months, after which age their skills appear to level off. The implication for the present study is that early IJA development may not have been captured during its steepest growth for many children. In interpreting results of the present study, it is important to consider the "initial" level of IJA (e.g., controlling for level of skill at our starting point) when interpreting the rate of growth occurring between ages 15 and 34 months, and the potential implications of this growth rate on later outcomes.

In contrast to IJA, which appears to develop largely before 15 months of age, findings presented by Mundy et al. (2007) are suggestive of continued growth of RJA between the ages of 15 and 18 months. In the present study, a positive relation was found between growth in RJA and later social skills. Given that little is known regarding developmental trajectories of RJA beyond 18 months of age, "initial" RJA abilities were also considered as they may have influenced the magnitude of growth of RJA. When initial RJA was controlled for within the model relating RJA growth to the SSRS aggregate measure, the importance of growth remained significant. This finding underscores the importance of early growth of RJA for later social outcomes, and extends the findings of Yoder et al. (2009). In particular, this finding reinforces the notion that establishing joint attention in response to others' referents of interest and becoming increasingly proficient in this skill may be an early indicator of a child's motivation and interest in responding to others in social interaction, as well as a predictor of later social skills.

The third and fourth hypotheses of this study surround the question of whether it is possible to predict language or social outcome above or below the 10^{th} percentile among Sibs-ASD using early joint attention abilities. This question is of interest given that literature concerning siblings of children with ASD suggests that a significant proportion of this group exhibits clinically significant impairments in communication and social abilities (e.g., Bolton et al., 1994). As described previously, the 10^{th} percentile was chosen as a cut-off point since it is often used by service agencies to determine clinically significant delays and eligibility for language intervention (McCauley & Swisher, 1984). Interestingly, the only significant finding in this regard is the relation between growth of RJA and social outcome (i.e., the SSRS aggregate) below or above the 10^{th} percentile, which became marginal ($p = .06$) after controlling for initial status of RJA. Though the relatively low sensitivity (.50) and positive predictive value (.67) associated with this relation indicate that RJA growth has limited clinical utility for predicting social outcome (i.e., measuring growth of RJA would not be a cost effective screening strategy for identifying children who will exhibit later social impairments), it remains an valuable early indicator of later social aptness.

One possible explanation for the poor predictive utility of joint attention as a marker for later delay (Hypotheses 3 and 4) may be the presence of other skills or factors that interact conditionally with early joint attention abilities in predicting which children will or will not exhibit a clinically significant social delay later in life. In particular, we suggest a multiplicative model such that if child is at X level of marker A (e.g., has low initial levels of joint attention), the variance on marker B (e.g., patterns of gaze fixation) is related to outcome, but not if child is at Y level of marker A (e.g., has high initial levels of joint attention). This model would suggest that certain difficulties (e.g., poor early joint attention) may only result in later problems in certain circumstances or under certain conditions. Future research could help clarify which markers may of greatest importance within the proposed multiplicative model, and which may operate as protective or risk factors for later impairment.

Central to the proposed conditional model are gene by environment interactions, which may contribute a further source of variability within the behavioral presentation of Sibs-ASD. As Yirmiya et al. (2001) discuss, the environment may have a role in exacerbating or lessening manifestations of behavior in relatives. In particular, it has been suggested that individuals may be differentially vulnerable to environmental influences, depending on their specific form of risk, both "for better and for worse" (Belsky et al., 2007). For instance, increased social support could operate as a protective factor. One possible support mechanism that may operate specifically within the social environments of Sibs-ASD is the indirect effect of intervention the older child with ASD received on the development of younger siblings. Parents may consciously or subconsciously implement strategies they acquired through being involved in intervention services with their diagnosed child when interacting with their younger child, which could in turn have some positive developmental effects on the younger child. In particular, research has suggested that parent-child interaction styles have an important role in mitigating the sequelae of early autism risk (Baker, Messinger, Lyons, & Grantz, 2010) and that the strongest predictor of gain of IJA (shown in this study to be a strong predictor of later social and language outcome if relatively well-developed by 15 months of age) can be attributed to the degree to which caregiver initiations of IJA are synchronized with their child's focus of attention (Siller & Sigman, 2002). Another possible explanation for the mitigation of between-group differences over time is that some of the children in the Sibs-ASD group who had early developmental difficulties may have been recipients of direct intervention themselves, which could have had beneficial developmental consequences. Finally, it is also quite plausible that the findings can be explained by sampling error, thus replication will be important.

One could also envision environmental risk factors that may be present for Sibs-ASD in particular. For example, living with an individual with ASD may significantly alter interactions among siblings. For example, siblings with low genetic vulnerability may be affected by the atypical responses they receive to their social overtures from their sibling with ASD. Having a sibling with ASD may also have significant implications for family well-being; for example, parents of children with ASD experience a higher level of stress than parents of children with other disorders (e.g., Schieve, Blumberg, Rice, Visser, & Boyle, 2007). Elevated parental stress has been shown to be related to deficits and delays in children's social relatedness in children with ASD (Davis & Carter, 2008). Together, these findings suggest that there may be a number of other factors that moderate the relation between early skills such as joint attention and later social and communication outcomes. As such, future research should be conducted in this arena to further explore the possibility that changes within the environment may serve to help Sibs-ASD overcome the adverse impact of genetic vulnerability as well as to explore other early factors that may serve as markers of risk for later difficulties.

Overall, findings of minimal group differences between Sibs-ASD and Sibs-TD in social and language domains at age five years and indications of an analogous predictive association between early joint attention and later social and language outcomes across groups are quite positive indicators for children in the Sibs-ASD group. Given our findings that Sibs-ASD may have similar outcomes to Sibs-TD, despite evidence of early differences relative to Sibs-TD, early lags observed in Sibs-ASD may not be a cause for alarm. Instead, findings suggest that early developmental differences in a child who is a sibling of child with ASD may have implications similar to those identified in a child without any specific genetic vulnerabilities (e.g., Sibs-TD). For both groups, early differences may warrant continued monitoring and possibly intervention when skills are sufficiently low, but not necessarily elevated concern for more subtle delays or differences. Then again, as mentioned, it is also possible that many of the Sibs-ASD with early developmental difficulties received benefits from intervention (whether direct or indirect), which allowed this group to exhibit similar language and social developmental profiles to Sibs-TD, both over time and at age five skills. More research is needed to determine the mechanisms by which Sibs-ASD appear to have "caught-up" with Sibs-TD. It is also important to keep in mind that the lack of group differences and group interactions (i.e., null findings) must be interpreted very cautiously. Several other factors may explain these findings (*see* Limitations and Methodological Considerations), which precludes our ability to conclude that Sibs-ASD are truly developmentally equivalent to Sibs-TD by age five years.

To date, only Yirmiya and colleagues have longitudinally followed the development of Sibs-ASD to school age, thus our basis for comparing our findings to others' is extremely limited. Yirmiya's group (i.e., Gamliel et al., 2009) reported that significantly more Sibs-ASD exhibited 'BAP related difficulties' (i.e., language, cognitive and/or academic delays – i.e., 1.5 sd below the average) as compared to Sibs-TD. These results are not directly comparable to ours given that we did not create a specific category representing children who exhibited any language *or* cognitive *or* academic delays (nor did we measure the latter two in this study); nevertheless, in line with Gamliel et al.'s (2009) findings, our study showed that significantly more Sibs-ASD experienced clinical delays in expressive language (i.e., below the 10^{th} percentile) at school age as compared to Sibs-TD. Replication in larger samples and across other sites will be important.

Limitations

The current study possesses many strengths, including a prospective-longitudinal design wherein individual trajectories were estimated for each child via growth modeling; a carefully chosen comparison group (i.e., younger siblings of typically developing children) that was also followed over time; and the use of gold standard ASD diagnostic procedures. At the same time, this study also has several limitations, all of which can be improved on in future studies.

The first of these limitations involve the IJA assessment. In particular, as mentioned previously, it is likely that assessing IJA earlier on (e.g., starting at 9 months or earlier) would have captured a more developmentally-appropriate time window for observing growth in IJA (see Mundy et al., 2007). Furthermore, it is possible that the IJA measure used in this study may not have been sensitive enough to capture the construct of interest. In particular, the procedure from which the IJA variable was extracted used only four items and thus may not have had sufficient trials to capture variability in IJA skills across children. Additional items in future measures of IJA used for predictive purposes would provide a more continuous measure of IJA with greater range and sensitivity to individual differences in IJA skills. Such measures tend to enhance our ability to find associations with later outcomes (Aiken & West, 1991). Nevertheless, findings of a predictive relation between initial level of IJA and later language and social outcomes, assessed with a measure having a limited range of possible scores, suggest that the effect size of this association may be even greater when initial level of IJA is assessed using a more sensitive measure. The RJA measure, on the other hand, had a total of 20 trials that varied systematically along a continuum of saliency, perhaps allowing for more subtle estimation of variability of skill among children, thus allowing for greater predictive utility of later clinically significant deficits in social and language skills. It is quite possible that the greater number of items (i.e., greater variability in) the RJA variable may, for example, explain why growth in RJA was able to predict later social outcome while growth in IJA could not.

Another previously mentioned limitation relates to sample size. It is likely that limited power affected some of the findings (particularly marginal findings); thus, replication with a larger sample size is critical. A related limitation involves the possibility of sampling error. One indication of possible sampling error is the relatively homogeneous nature of our sample, i.e., largely limited to Caucasian families who had higher education levels, from the greater Nashville area. The second relates differences in the recurrence rate of ASD in our sample (i.e., 15% at the conclusion of our original study; Yoder et al., 2009) relative to other sites examining younger siblings of children with ASD. Given that recurrence rates in other studies have ranged from 3% (Yirmiya et al., 2006) to 36% (Baker et al., 2010) it is clear that variability across samples may play a role in different characterizations observed across studies; thus results should be interpreted with caution. As such, our findings suggesting that Sibs-ASD *in general* develop similarly to Sibs-TD could be unique to our sample. It is also of note that three of the six (50%) Sibs-ASD who had received a diagnosis of ASD through the original study were lost to attrition and are not included in the subsample presented here. However, the proportion of children who were diagnosed with ASD within the original sample as compared to the follow-up sample was not significantly different ($Z = 1.27$, $p = .20$). Therefore, while the reduction in the number of Sibs-ASD with an ASD diagnosis included in the follow-up study should be considered, it is not thought to be of methodological concern.

Methodological Considerations

In addition to the aforementioned limitations, several methodological considerations also exist. The first concerns correlated measurement error, in addressing whether observers coding the predictor variables were blind to group status or ASD diagnostic status (designated at T5). It is possible that some of the ‘live’ coders of IJA variables were aware of group status, as some of the children may have been accompanied by their older affected siblings, or parents could have mentioned the older siblings’ diagnostic status to the examiner, in which case they might be able to infer in the child’s group. The majority of the T1 through T4 RJA coding was conducted by individuals who were unaware of group or ASD diagnostic status, which was not assigned until T5. However, for a small minority of the T5 RJA tapes that were coded after a diagnosis was assigned, coders may have been aware of diagnostic status. Unlike for RJA, prior awareness of diagnostic status would have been highly improbable for coders of T5 IJA, given that diagnoses were procedurally not assigned until well *after* the STAT was administered and scored *in vivo*. Thus, while it is possible that correlated measurement error may have influenced the effect size of the reported relations for a small minority of participants, it is rather implausible that this error could have explained the findings.

Another methodological consideration relates to the fact that one of the outcome measures (i.e., SRS) used was not norm-referenced by age. Given that the age range of children at outcome varied considerably (i.e., 50 to 88 months), it is possible that one explanation for variance in SRS scores could be age, rather than true differences in social difficulty across children. To account for this possibility, age at outcome was controlled (i.e., covaried), which is not an ideal way to address this issue. A more meaningful way to interpret social difficulties would be to use a measure that has been norm-referenced for exact age (i.e., a measure that considered age when creating norms); however, to the best of our knowledge, the field has yet to develop such a measure (i.e., that focuses specifically on social difficulties relating to ASD and is age-referenced). Alternatively, future research could focus on children within a narrower age range. Another concern relating to the SRS is that though this measure purports to be a measure of "severity of autistic social impairment," it contains items assessing repetitive and stereotypic behaviors in addition to those focused on social domains. Thus, the degree to which the

SRS truly measures social difficulty (i.e., as opposed to deficits in broader aspects of autism symptomatology including repetitive/stereotyped behaviors) is not clear.

Finally, as with any study that uses correlational analyses to make predictions, we must be mindful of the logical fallacy that assumes that correlation implies causation. Specifically, our data do not allow us to conclude causal links between joint attention and later language and social outcomes. As suggested previously, there is always the possibility that unmeasured factors may be responsible for these relations. While this inherent weakness in correlational designs must be acknowledged, theoretical support encourages further study into the potential causal influence of joint attention on later language and social outcomes in Sibs-ASD.

Future Directions and Conclusions

The results of this study provoke a number of additional questions for future investigation. As mentioned, it may be important to account for other environmental factors as potential moderators of developmental outcome (e.g., sex, IQ, temperament, early intervention, environmental stress, maternal sensitivity). Additionally, it may be important to consider the long term implications that joint attention may have on other important developmental outcomes, such as cognitive abilities (Tomasello, 1995), theory of mind (Charman et al., 2000) and executive dysfunction (McEvoy, Rogers, & Pennington, 1993). Studies should also consider other *predictors* of later outcome, with a focus on recently identified neurobiological differences in Sibs-ASD, such as atypicalities in eye gaze (Ibanez, Messinger, Newell, Lambert, & Sheskin, 2008) and face processing (Elsabbagh et al., 2009). Neurobiological differences may precede or underlie behavioral differences such as joint attention, and thus could shed light on the differential development of various behavioral features. Further, given that neurobiological markers may be identifiable earlier on, pinpointing specific differences could potentially allow for earlier intervention.

Future studies should also seek to develop better measures for identifying subtle characteristics associated with ASD. It may be that the measures used in the current study were not sensitive enough to pick up on some of the subtle difficulties that Sibs-ASD may be experiencing. For instance, future studies could use a systematic observational approach for assessing social interactions, examining the quality of reciprocal social behavior (e.g., response to social cues or convention) in a controlled measurement context (i.e., controlling for irrelevant influences on behavior). Facets of language such as pragmatics should also be examined more closely in Sibs-ASD, as difficulties in this area have been consistently identified in relatives of individuals with ASD (e.g., Hurley, Losh, Purlier, Reznick, & Piven, 2007; Landa et al., 1992). This aspect of language could be assessed via an intricate interviewer-based measure (e.g., Pragmatic Rating Scale, PRS) or language sample, rather than relying on a parent questionnaire (i.e., CCC-2) as used in the current study. Furthermore, it will be important to follow this group of children to a later point in development to assess whether any of the early developmental differences identified have longer-term consequences than could be observed in the current study at age five years. Studies focusing on Sibs-ASD at older ages (e.g., in adolescence), could examine quality and number of confiding friendships (e.g., having an intimate and reciprocal relationship), the presence of social isolation and comorbid depression and anxiety that could arise from social rejection, or pragmatics. Finally, replication of the current findings is needed.

The present study represents a unique contribution to the literature in that it extends our knowledge of the development of social and communication skills in younger siblings of children with ASD. While our sample of younger siblings of children with ASD, initially enrolled at a mean age of 15 months, exhibited a number of ASD-related differences, outcome at age 5 for this sample overall was comparable to that of children without an older sibling with ASD. In particular, surprisingly few group differences were seen between Sibs-ASD and Sibs-TD on language and social measures, and the relation of these skills to early joint attention abilities was similar in both groups. As in typically developing children, early joint attention remains an important marker for development of later language and social abilities in this high-risk group, and similar developmental patterns indicate that intact early skills are a positive indicator for later outcome. While future research should clarify other factors that predict later difficulties, the present findings represent an important contribution to our understanding of younger siblings of children with ASD, their developmental trajectory, and how early concerns translate into later outcomes.

APPENDIX

A. STAT IJA Item Description

Table A1

Detailed description and examples of initiating joint attention (IJA) items in the STAT.

Item	**Description**	**Example of a "pass"**
Balloon	The examiner inflates a balloon and then lets it go so that it flies across the room. The examiner maintains neutral affect and waits to see the child's reaction.	Looking back and forth between the examiner and the balloon and laugh, or pointing to the balloon and say, "Look".
Puppet	The examiner puts on an animal hand puppet outside of the child's view and pretends to write some notes. If the child does not react that examiner yawns and scratches his/her head with the hand wearing the puppet. Should the child continue not to respond the examiner will place the puppet on the table in front of the child. The examiner remains neutral until the child responds.	Saying "Puppy" while looking at the examiner or by pointing to the puppet and smiling at the examiner.
Bag of Toys	The examiner gives the child an opaque bag of toys. If needed the examiner will partially reveal the toys inside of the bag. The examiner maintains neutral affect until the child responds.	Holding up and showing toys to the examiner or looking at the examiner while labeling a toy (e.g., "Snake").
Noisemaker	The examiner activates an electronic noisemaker out of the child's view.	Looking at him/her and saying, "Uh-oh" or by pointing toward the sound with a surprised facial expression.

B. Intra-class correlation coefficients

Table A2

Absolute-agreement intra-class correlation coefficients based on independent codings of IJA and RJA, randomly selected from the entire data set at each time period

		Group	
	Time Period	*Sib-ASD*	*Sib-TD*
IJA			
	T1	.875	1.00
	T2	.961	.750
	T3	.972	.862
	T4	1.00	.667
	T5	.955	1.00
RJA			
	T1	.976	.978
	T2	.940	.990
	T3	.962	.846
	T4	.939	.809
	T5	.982	.996

REFERENCES

Aiken, L. S., & West, S. G. (1991). *Multiple Regression: Testing and Interpreting Interactions.* Newbury Park, CA: Sage.

Allen, M. & Yen, W. (1979). Strong true-score theories and latent trait models, in *Introduction to Measurement Theory* (pp. 239-272). Monterey, CA: Brooks/Cole.

American Psychiatric Association, (2000). *Diagnostic and Statistical Manual of Mental Disorders-IV-Text Revision (4th ed., rev.).* Washington DC: Author.

Baggaley, A. (1988). The relative usefulness of multiple measures for differentiating among groups of people. *Educational and Psychological Measurement, 48,* 89-92.

Baker, B. K., Messinger, D. S., Lyons, K. K., & Grantz, C. J. (2010). A pilot study of maternal sensitivity in the context of emergent autism. *Journal of Autism and Developmental Disorders,* doi: 10.1007/s10803-010-0948-4.

Bakeman, R., & Adamson, L. B. (1984). Coordinating attention to people and objects in mother-infant and peer-infant interaction. *Infant Behavior & Development, 55,* 467–478.

Baron-Cohen, S., & Hammer, J. (1997). Parents of children with Asperger syndrome: What is the cognitive phenotype? *Journal of Cognitive Neuroscience, 9,* 548-554.

Bartak, L., Rutter, M., & Cox, A. (1975). A comparative study of infantile autism and specific developmental receptive language disorder: I. The children. *British Journal of Psychiatry, 126,* 127-145.

Bates, E., Benigni, L., Bretherton, I., & Volterra, V. (1979). *The emergence of symbols: Cognition and communication in infancy.* New York: Academic Press.

Belsky, J., Bakermans-Kranenburg, M. J., and van IJzendoorn, M. H. (2007). For better and for worse: Differential susceptibility to environmental influences. *Current Directions in Psychological Science, 16,* 300-304.

Bauminger, N. (2002). The facilitation of social-emotional understanding and social intervention in high-functioning children with autism: Intervention outcomes. *Journal of Autism and Developmental Disorders, 32,* 283-298.

Bishop, D. V. M. (2006). *The Children's Communication Checklist-2, United States Edition.* San Antonio,TX: Harcourt Assessment, Inc.

Blake, J. (2000). *Routes to child language: Evolutionary and developmental precursors.* New York: Cambridge University Press.

Bolton, P., Macdonald, H., Pickles, A., Rios, P., Goode, S., Crowson, M. et al. (1994). A case-control family history study of autism. *Journal of Child Psychology and Psychiatry, 35*, 877-900.

Bolton, P., Pickles, A., Murpy, M., & Rutter, M. (1998). Autism, affective and other psychiatric disorders: Patterns of familial aggregation. *Psychological Medicine, 28,* 385-395.

Bono, M., Daley, T., & Sigman, M. (2004). Relations Among Joint Attention, Amount of Intervention and Language Gain in Autism. *Journal of Autism and Developmental Disorders, 34,* 495-505.

Brian, J., Bryson, S. E., Garon, N., Roberts, W., Smith, I. M., Szatmari, P., et al. (2008). Clinical assessment of autism in high-risk 18-month-olds. *Autism. Special Issue: Early detection, 12,* 433-456.

Bruner, J. & Sherwood, V. (1983). Thought, language, and interaction in infancy. In J. Call, E. Galenson, R. Tyson, (Eds.). *Frontiers of infant psychiatry* (pp. 38-55). New York: Basic Books.

Bryk, A. S., & Raudenbush, S. W. (1992). *Hierarchical linear models for social and behavioural research: Applications and data analysis methods*. Newbury Park, CA: Sage Publications.

Camaioni, L., Castelli, M., Longobardi, E., & Volterra, V. (1991). A parent report instrument of early language assessment. *First Language, 11,* 345-359.

Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development, 63* (4, No. 255).

Cassel, T. D., Messinger, D. S., Ibanez, L. V., Haltigan, J. D., Acosta, S. I., & Buchman, A. C. (2007). Early social and emotional communication in the infant siblings of children with autism spectrum disorders: An examination of the broad phenotype. Journal *of Autism and Developmental Disorders*, *37,* 122-132.

Centers for Disease Control and Prevention. (2009). Prevalence of Autism Spectrum Disorders --- Autism and Developmental Disabilities Monitoring Network, United States, 2006. *Morbidity and Mortality Weekly Report, 58,* 1–20.

Charman, T. (2003). Why is joint attention a pivotal skill in autism? *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences, 358*, 315-324.

Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Cox, A. & Drew, A. (2000). Testing joint attention, imitation, and play as infancy precursors to language and theory of mind. *Cognitive Development, 15,* 481-498.

Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Drew, A., & Cox, A. (2003). Predicting language outcomes in infants with autism and pervasive developmental disorder. *International Journal of Language and Communication Disorders, 38,* 265-285.

Constantino, J. N. & Gruber, C. P. (2005). *The Social Responsiveness Scale Manual.* Los Angeles: Western Psychological Services.

Constantino, J. N., Lajonchere, C., Lutz, M., Gray, T., Abbacchi, A., McKenna, K., et al. (2006). Autistic social impairment in the siblings of children with pervasive developmental disorders. *American Journal of Psychiatry, 163,* 294-296.

Davis, N. O., & Carter, A. S. (2008). Parenting stress in mothers and fathers of toddlers with autism spectrum disorders: Associations with child characteristics. *Journal of Autism and Developmental Disorders, 38,* 1278-1291.

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., et al. (2004). Early social attention impairments in autism: Social orienting, joint attention, and attention to distress. *Developmental Psychology, 40,* 271-283.

Dawson, G., Webb, S. J., Wijsman, E., Schellenberg, G., Estes, A., Munson, J., et al. (2005). Neurocognitive and electrophysiological evidence of altered face processing in parents of children with autism: Implications for a model of abnormal development of social brain circuitry in autism. *Development and Psychopathology, 17,* 679-697.

Deak, G. O., Walden, T., Kaiser, M. G., & Lewis, A. (2008). Driven from distraction: How infants respond to parents' attempts to elicit and re-direct their attention. *Infant Behavior and Development, 31*, 34–50.

Demaray, M. K., Ruffalo, S. L., Carlson, J., Busse, R. T. Olson, A. E., McManus, S. M. et al. (1995). Social skills assessment: A comparative evaluation of six published rating scales. *School Psychology Review*, *24,* 648-671.

Desrochers, S., Morisette, P., & Ricard, M. (1995). Two perspectives on pointing in infancy. In C. Moore & P. Dunham (Eds.). *Joint attention: It's origins and role in development* (pp. 85-102). Hillsdale, NJ: Erlbaum.

DiCicco-Bloom, E., Lord, C., Zwaigenbaum, L., Courchesne, E., Dager, S. R., Schmitz, C. et al. (2006). The developmental neurobiology of autism spectrum disorder. *Journal of Neuroscience. 26,* 6897-6906.

Dorris, L., Espie, C. A., Knott, F., & Salt, J. (2004). Mind-reading difficulties in the siblings of people with Asperger's syndrome: evidence for a genetic influence in the abnormal. Journal of *Child Psychology and Psychiatry, 45,* 412-418.

Elsabbagh, M. & Johnson, M.H. (2010). Getting answers from babies about autism. *Trends in Cognitive Science, 14*, 81-87.

Elsabbagh, M., Volein, A., Csibra, G., Holmboe, K., Garwood, H., Tucker, L., et al. (2009). Neural correlates of eye gaze processing in the infant broader autism phenotype. *Biological Psychiatry, 65,* 31-38.

Francis, D. J., Schatschneider, C., & Carlson, C. D. (2000). Introduction to individual growth curve analysis. In D. Dotter (Eds.). *Handbook of research in pediatric and clinical child psychology: Practical strategies and methods. Issues in clinical child psychology*. (pp. 51-73). Dordrecht, Netherlands: Kluwer Academic Publishers.

Gamliel, I., Yirmiya, N., Jaffe, D. H., Manor, O., & Sigman, M. (2009). Developmental trajectories in siblings of children with autism: cognition and language from 4 months to 7 years. *Journal of Autism and Developmental Disorders, 39,* 1131-1144.

Gamliel, I. Yirmiya, N. & Sigman, M. (2007). The development of young siblings of children with autism from 4 to 54 months. *Journal of Autism and Developmental Disorders, 37,* 171-183.

Garon, N., Bryson, S. E., Zwaigenbaum, L., Smith, I. M., Brian, J., Roberts, W., et al. (2009). Temperament and its relationship to autistic symptoms in a high-risk infant sib cohort. *Journal of Abnormal Child Psychology, 37,* 59-78.

Goldberg, W. A., Jarvis, K. L., Osann, K., Laulhere, T. M., Straub, C., Thomas, E., et al. (2005). Brief report: Early social communication behaviors in the younger siblings of children with autism. *Journal of Autism and Developmental Disorders, 35,* 657-664.

Gresham, F. M., & Elliott, S. N. (1990). *The Social Skills Rating System.* Circle Pines, MN: American Guidance Service.

Happé, F. (1994). *Autism: An introduction to psychological theory*. Cambridge, MA: Harvard University Press.

Hill, E., & Frith, U. (2003). Understanding autism: Insights from mind and brain. *Philosophical Transactions of the Royal Society, 358*, 281–289.

Hollander, E. & Anagnostou, E. (2007). *Clinical manual for the treatment of autism.* Arlington, VA: American Psychiatric Publishing, Inc.

Hurley, R. S., Losh, M., Purlier, M., Reznick, J. S., & Piven, J. (2007). The broad autism phenotype questionnaire. *Journal of Autism and Developmental Disorders, 37,* 1679-1690.

Ibanez, L., Messinger, D. S., Newell, L., Lambert, B., & Sheskin, M. (2008). Visual disengagement in the infant siblings of children with an autism spectrum disorder. *Autism, 12,* 473-485.

Kasari, C., Freeman, S., & Paparella, T. (2006). Joint attention and symbolic play in young children with autism: A randomized controlled intervention study. *Journal of Child Psychology and Psychiatry, 47,* 611-620.

Kelly, D. J. (1998). A clinical synthesis of the "late talker" literature: Implications for service delivery. *American Speech, and Hearing Services in Schools, 29,* 76-84.

Kraemer, H. C., Kiernan, M., Essex, M., & Kupfer, D. J. (2008). How and why criteria defining moderators and mediators differ between the Baron & Kenny and MacArthur approaches. *Health Psychology, 27,* S101-8.

Landa, R., Folstein, S. E., & Isaacs, C. (1991). Spontaneous narrative-discourse performance of parents of autistic individuals. *Journal of Speech and Hearing Research, 34,* 1339-1345.

Landa, R. & Garrett-Mayer, E. (2006). Development in infants with autism spectrum disorders: A prospective study. *Journal of Child Psychology and Psychiatry, 47,* 629-638.

Landa, R., Piven, J., Wzorek, M., Gayle, J., Chase, G., & Folstein, S. (1992). Social language use in parents of autistic individuals. *Psychological Medicine, 22,* 245-254.

Liszkowski. U., Carpenter, M., Henning, A., Striano, T., & Tomasello, M. (2004). Twelve-month-olds point to share attention and interest. *Developmental Science, 7,* 297-307.

Littell, R. C., Milliken, G. A., Stroup, W. W., Wolfinger, R. D., & Schabenberger, O. (2007). SAS for Mixed Models (2^{nd} ed.). *Journal of Biopharmaceutical Statistics, 17,* 363-365.

Lord, C., Pickles, A., McLennan, J., Rutter, M., Bregman, J., Folstein, S. et al. (2007). Diagnosing autism: Analyses of data from the Autism Diagnostic Interview. *Journal of Autism and Developmental Disorders*, *27*, 501-517.

Lord, C., Risi, S., Lambrecht, L., Cook, E., Leventhal, B., DiLavore, P., Pickles, A. et al. (2000). The Autism Diagnostic Observation Schedule-Generic: A standard measure of social and communication deficits associated with spectrum of autism. *Journal of Autism & Developmental Disorders, 18,* 505-524.

Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism Diagnostic Interview--Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24,* 659-685.

Lord, C., Pickles, A., McLennan, J., Rutter, M., Bregman, J., Folstein, S., Fombonne, E., Leboyer, M., & Minshew, N. (1997). Diagnosing autism: Analyses of data from the autism diagnostic interview. *Journal of Autism and Developmental Disorders*, *27,* 501-517.

Losh, M., & Piven, J. (2007). Social-cognition and the broad autism phenotype: identifying genetically meaningful phenotypes. *Journal of Child Psychology and Psychiatry*, *48*, 105-112.

Martin, N., Schwartz, M. F. & Kohen, F. P. (2006). Assessment of the ability to process semantic and phonological aspects of words in aphasia: A multi-measurement approach. *Aphasiology, 20,* 154-166.

Masur, E. F., & Ritz, E. G. (1984). Patterns of gestural, vocal, and verbal imitation performance in infancy. *Merrill-Palmer Quarterly, 30,* 369-392.

McCauley, R., & Swisher, L. (1984). Use and misuse of norm-referenced tests in clinical assessment: A hypothetical case. *Journal of Speech and Hearing Disorders*, *49,* 338-348.

McDuffie, A., Yoder, P., & Stone, W. (2005). Prelinguistic predictors of vocabulary in young children with Autism spectrum disorders. *Journal of Speech, Language, and Hearing Research, 48,* 1080-1097.

McEvoy, R. E., Rogers, S. J., & Pennington, B. F. (1993). Executive function and social communication deficits in young autistic children. *Journal of Child Psychology and Psychiatry, 34,* 563-578.

Merin, N., Young, G. S., Ozonoff, S., & Rogers, S. J. (2007). Visual fixation patterns during reciprocal social interaction distinguish a subgroup of 6-month-old infants at-risk for autism from comparison infants. *Journal of Autism and Developmental Disorders, 37,* 108–121.

Merrell, K. (2001). Assessment of children's social skills: Recent developments, best practices, and new directions. *Exceptionality, 9,* 3-18.

Mitchell, S., Brian, J., Zwaigenbaum, L. Roberts, W., Szatmari, P., Smith, I., et al. (2006). Early language and communication development of infants later diagnosed with autism spectrum disorder. *Journal of Developmental & Behavioral Pediatrics, 27,* 69-78.

Morales, M., Mundy, P., Delgado, C. E., Yale, M., Messinger, D., Neal, R., & Schwartz, H. K. (2000). Responding to joint attention across the 6- through 24-month age period and early language acquisition. *Journal of Applied Developmental Psychology, 21,* 283-298.

Morales, M., Mundy, P., & Rojas, J. (1998). Following the direction of gaze and language development in 6-month-olds. *Infant Behavior and Development, 21,* 373-377.

Morgan, B., Maybery, M., & Durkin, K. (2003). Weak central coherence, poor joint attention, and low verbal ability: independent deficits in early autism. *Developmental Psychology, 39,* 646–656.

Mundy, P., Block, J., Van Hecke, A., Delgado, C. E. F., Parlade, M., & Parmares, Y. (2007). Individual differences and the development of joint attention in infancy. *Child Development, 78,* 705 - 722.

Mundy, P. & Crowson, M. (1997). Joint attention and early communication: Implications for intervention with autism. *Journal of Autism and Developmental Disorders, 6,* 653-676.

Mundy, P. & Gomez, A. (1998). Individual differences in joint attention skills in the second year. *Infant Behavior and Development, 21,* 469-482.

Mundy, P., Hogan, A., & Doehring, P. (1996). *A preliminary manual for the abridged early social communication scales.* Coral Gables, FL: University of Miami.

Mundy, P., Kasari, C., & Sigman, M. (1992). Joint attention, affective sharing, and intersubjectivity. *Infant Behavior and Development, 15,* 377-381.

Mundy, P., Kasari, C., Sigman, M., & Ruskin, E. (1995). Nonverbal communication and early language acquisition in children with Down syndrome and in normally developing children. *Journal of Speech and Hearing Research, 38,* 157-167.

Mundy, P. & Sigman, M. (2006). Joint attention, social competence, and developmental psychopathology. In D. Cicchetti & D. J. Cohen, Donald J. (Eds). *Developmental psychopathology, Vol 1: Theory and method* (2nd ed.) (pp. 293-332). Hoboken, NJ: John Wiley & Sons Inc.

Mundy, P., Sigman, M., & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal of Autism and Developmental Disorders, 20,* 115-128.

Mundy, P., Sigman, M., & Kasari, C. (1994). Joint attention, developmental level, and symptom presentation in autism. *Development and Psychopathology, 6,* 389-401.

Mundy, P., Sigman, M., Kasari, C., & Yirmiya, N. (1988). Nonverbal communication skills in Down syndrome children. *Child Development, 59,* 235-249.

Mundy, P. & Sigman, M., Ungerer, J., & Sherman, T. (1986). Defining the social deficits of autism: The contribution of nonverbal communication measures. *Journal of Child Psychology and Psychiatry, 27*, 657-669.

Mundy, P. & Stella, J. (2000). Joint attention, social orienting, and noverbal communication in autism. In A. Wetherby & B. Prizant (Eds.). *Communication and Language Intervention Series, Vol. 9: Autism spectrum disorders: A transactional developmental perspective* (pp. 55-77). Baltimore, MD: Brookes.

Ozonoff, S. & Miller, J. N. (1995). Teaching theory of mind: A new approach to social skills training for individuals with autism. *Journal of Autism and Developmental Disorders, 25,* 415-433.

Pilowsky, T., Yirmiya, N., Doppelt, O., Gross-Tsur, V., & Shalev, R. (2004). Social and emotional adjustment of siblings of children with autism. *Journal of Child Psychology and Psychiatry, 45,* 855-865.

Piven, J., Chase, G. A., Landa, R., Wzorek, M., Gayle, J., Cloud, D., et al (1991). Psychiatric disorders in the parents of autistic individuals. *Journal of the American Academy of Child and Adolescent Psychiatry, 30*, 471-478.

Piven, J., Gayle, J., & Chase, G. A. (1990). A family history study of neuropsychiatric disorders in the adult siblings of autistic individual. *Journal of the American Academy of Child and Adolescent Psychiatry, 29,* 177-183.

Piven, J. & Palmer, P. (1999). Psychiatric disorder and the broad autism phenotype: Evidence from a family study of multiple-incidence autism families. *American Journal of Psychiatry, 156*, 557-563.

Plumet, M. H., Goldblum, M. C., & Leboyer, M. (1995). Verbal abilities of autistic females. *Cortex, 31*, 723-733.

Presmanes, A. G., Walden, T. A., Stone, W. L., & Yoder, P. J. (2007). Effects of different attentional cues on responding to joint attention in younger siblings of children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 37,* 133-144.

Raudenbush, S. W., & Bryk, A. S., (2002). *Hierarchical linear models: Applications and data analysis methods, second edition.* London: Sage.

Rogers, S. (2009). What are infant siblings teaching us about autism in infancy? *Autism Research, 1,* 1–13.

Rutherford, M. D., Young, G., Hepburn, S., & Rogers, S. (2007). A longitudinal study of pretend play in autism. Journal of Autism and Developmental Disorders, 37, 1024-1039.

Rushton, J. P., Brainerd, C. J., & Pressley, M. (1983). Behavioral development and construct validity: The principle of aggregation. *Psychological Bulletin, 94,* 18-38.

Schieve, L. A., Blumberg, S. J., Rice, C., Visser, S. N., & Boyle C. (2007). The relationship between autism and parenting stress. *Pediatrics, 119,* 114-121.

Seibert, J. M., Hogan, A. E., & Mundy, P. (1982). Assessing interactional competencies: The Early Social-Communication Scales. *Infant Mental Health Journal, 3,* 244-259.

Semel, E., Wiig, E. H., & Secord, W. (2003). *Clinical evaluation of language fundamentals-Fourth Edition.* San Antonio, TX: Psychological Corporation.

Sheinkopf, S. J., Mundy, P., Claussen, A. H., & Willoughby, J. (2004). Infant joint attention skill and preschool behavioral outcomes in at-risk children. *Development and Psychopathology, 16,* 273-291.

Sigman, M. & McGovern, C. W. (2005). Improvement in Cognitive and Language Skills from Preschool to Adolescence in Autism. *Journal of Autism and Developmental Disorders, 35,* 15-23.

Sigman, M. & Ruskin, E. (1999). Continuity and change in the social competence of children with autism, Down syndrome, and developmental delays. *Monographs of the Society for Research in Child Development, 64* (1, Serial Number 256).

Sigman, M. & Ungerer, J. A. (1984). Attachment behaviors in autistic children. *Journal of Autism and Developmental Disorders, 14,* 231-244.

Siller, M. & Sigman, M. (2002). The behaviors of parents of children with autism predict the subsequent development of their children's communication. *Journal of Autism and Developmental Disorders, 32,* 77-89.

Singer, J. D., & Willett, J. B. (2003). *Applied Longitudinal Data Analysis: Modeling change and event occurrence.* New York: Oxford University Press.

Smalley, S., McCracken, J., & Tanguay, P. (1995). Autism, affective disorders, and social phobia. *American Journal of Medical Genetics (Neuropsychiatric Genetics), 60*, 19-28.

Stone, W. & Yoder, P. (2001). Predicting spoken language level in children with autism spectrum disorders. Autism. *The International Journal of Research and Practice, 5,* 341-361.

Stone, W. L., Coonrod, E. E., Turner, L. M., & Pozdol, S. L. (2004). Psychometric properties of the STAT for early autism screening. *Journal of Autism and Developmental Disorders, 34,* 691-701.

Stone, W. L., McMahon, C. R., & Henderson, L. M. (2008). Use of the screening tool for autism in two-year-olds (STAT) for children under 24 months: An exploratory study. *Autism. Special Issue: Early detection, 12,* 557-573.

Stone, W. L., McMahon, C., Yoder, P. J., & Walden, T. A. (2007). Early social-communicative and cognitive development of younger siblings of children with autism spectrum disorders. *Archives of Pediatric and Adolescent Medicine, 161,* 384 – 390.

Stone, W., Coonrod, E. & Ousley, O. (2000). Brief report: Screening tool for autism in two year olds (STAT): Development and preliminary data. *Journal of Autism and Developmental Disorders, 30,* 607-611.

Stone, W.L. & Ousley, O. (2008). *STAT Manual: Screening Tool for Autism in Two-year-olds.* Nashville, TN: Vanderbilt Kennedy Center.

Sullivan, M., Finelli, J., Marvin, A., Garrett-Mayer, E., Bauman, M., & Landa, R. (2007). Response to joint attention in toddlers at risk for autism spectrum disorder: A prospective study. *Journal of Autism and Developmental Disorders, 37,* 37-48.

Szatmari, P. (May, 2010). *Developmental trajectories in young children with ASD* [Powerpoint Presentation]. To be presented at the International Meeting for Autism Research.

Tomasello, M. (1995). The culture and origins of human cogntion. In C. Moore & P. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp.103-130). Hillsdale, NJ: Erlbaum.

Toth, K., Dawson, G., Meltzoff, A. N., Greenson, J., & Fein, D. (2007). Early social, imitation, play, and language abilities of young non-autistic siblings of children with autism. *Journal of Autism and Developmental Disorders, 37,* 145-157.

Travis, L. L. & Sigman, M. (1998). Social deficits and interpersonal relationships in autism. *Mental Retardation and Developmental Disabilities, 4,* 65-72.

Turner, L. M. & Stone, W. L. (2007). Variability in outcome for children with an ASD diagnosis at age 2. *Journal of Child Psychology and Psychiatry, 48,* 793-802.

Ulvand, S., & Smith, L. (1996). The predictive validity of nonverbal communicative skills in infants with perinatal hazards. *Infant Behavior and Development, 4,* 1-12.

Van Hecke, A., Mundy, P., Acra, C. F., Block, J., Delgado, C. E., Parlade, M., et al. (2007). Infant joint attention, temperament, and social competence in preschool children. *Child Development, 78,* 53–69.

Wiig, E. H., Secord, W., & Semel, E. (2004). *Clinical evaluation of language fundamentals-Preschool.* San Antonio, TX: Psychological Corporation.

Yang, M. S., & Gill, M. (2006). A review of gene linkage, association and expression studies in autism and an assessment of convergent evidence. *International Journal of Developmental Neuroscience, 25,* 69-85.

Yirmiya, N., Gamliel, I., Pilowsky, T., Baron-Cohen, S., Felman, R., & Sigman, M. (2006). The development of siblings of children with autism at 4 and 14 months: Social engagement, communication, and cognition. *Journal of Child Psychology and Psychiatry, 47,* 511-523.

Yirmiya, N., Gamliel, I., Shaked, M., & Sigman, M. (2007). Cognitive and verbal abilities of 24- to 36-month-old siblings of children with autism. *Journal of Autism and Developmental Disorders, 37,* 218-229.

Yirmiya, N. & Ozonoff, S. (2007). The very early autism phenotype. *Journal of Autism and Developmental Disorders, 37,* 1-11.

Yirmiya, N., Shaked, M., Erel, O. (2001). Comparison of siblings of individuals with autism and siblings of individuals with other diagnoses. In E. Schloper, N. Yirmiya, C. Schulman, & L. Marcus (Eds.), *The Research Basis for Autism Intervention* (pp. 59-70). New York, NY: Kluwer Academic/Plenum Publishers.

Yoder, P. J., Stone, W. L., Walden, T. A., & Malesa, E. (2009). Predicting social impairment and ASD diagnosis in younger siblings of children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 39,* 1381-1391.

Zwaigenbaum, L., Bryson, S., Rogers, T., Roberts, W., Brian, J., & Szatmari. (2005). Behavioral manifestations of autism in the first year of life. *International Journal of Developmental Neuroscience, 23,* 143-152.