4-29-2014

Social Communication and Infants At-Risk for Autism Spectrum Disorder

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As the shift in the epidemiology of autism spectrum disorder (ASD) moves from infancy, to *in utero* development, to prenatal exposure, similarly, the shift to identify subtle behavioral patterns before they are entrenched symptoms of ASD is also moving back in developmental time. Children as young as 14 months can be reliably diagnosed with ASD, however, most are diagnosed between the ages of 4 and 8 years, leaving little room for the efficacy of remarkable early, intensive interventions. Autism spectrum disorder is a general term for a group of complex neurological disorders involving symptoms across multiple domains, most notably in terms of social communication. Rate of recurrence in siblings is approximately 19%, much higher than the general population. As such, infant siblings comprise an important group for study, in prospectively understanding the emerging developmental pathways that may mean the difference between typical development and ASD.

The present study examined 6-month-old infant siblings in a triadic paradigm of infant, caregiver, and toy, during object learning. It was hypothesized that caregiver behavior such as gesturing, vocalizing, or calling infants by name would reflect the subtle cues caregivers may read in their infants' gradual disengagement, resulting in higher or lower frequencies of attempts to engage. Twenty-four infant siblings and 24 infants with no ASD proband participated. Gesture, vocalizations, and calling infant by name, as well as infants' visual attention to toy, caregiver, and other were also compared across groups along four phases of the learning

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paradigm. Results of a two-way analysis of variance were not significant for any dependent variable, indicating that measures of infant behavior must be more refined and nuanced than those in the present study in order to detect reliable differences in infant or caregiver behavior at this age.

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A Dissertation

Submitted in Partial Fulfillment of the

Requirements for the Degree of Doctor of Philosophy

at the

University of Connecticut

2014

APPROVAL PAGE

Doctor of Philosophy Dissertation

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CHAPTER ONE

Literature Review

Overview of Autism Spectrum Disorder.

Autism spectrum disorder (ASD) is a general term for a group of complex of complex disorders of brain development, characterized in varying degrees, by difficulties in social interaction, verbal and nonverbal communication and repetitive behaviors (Autismspeaks.org, 2013). Under new guidelines, ASD is an umbrella term for a group of neurological disorders involving symptoms across multiple domains, including: autistic disorder; Rett syndrome; childhood disintegrative disorder; pervasive developmental disorder – not otherwise specified; and Asperger syndrome (American Psychiatric Association, 2013). Autism is characterized by varying degrees of social and communication deficits, as well as repetitive and restrictive patterns of interests and behavior (Autismspeaks.org, 2011). Primary characteristics of ASD as it pertains to autism, may be accompanied by abnormalities in cognitive functioning, learning, attention, and sensory processing, and therefore represent a spectrum of behaviorally defined conditions diagnosed through clinical observation of development, as well as standardized measures.

The complex nature of this behaviorally defined disorder coupled with newly emerging genetic or biological markers for early and consistent identification, and variability of onset patterns make etiologic investigation challenging (Helt et al., 2008). Only 10% of children with ASD have an identifiable genetic, neurologic, or metabolic disorder, with boys reportedly five times more likely than girls to have an ASD (Morbidity and Mortality Weekly Report (MMWR), 2012). Biological evidence reveals the critical role of genetic factors in vulnerability to ASD (Losh, Sullivan, Trembath & Piven, 2008), with heritability estimates from twin studies as high

as 90% (Bailey et al., 1995; Bailey et al., 1994; Le Couteur et al., 1996), as well as genomic variants in genes involved in synaptic cell adhesion and related pathways (Cook & Schrerer, 2008).

While it is understood that heritability plays a role in autism, the specific mechanisms are under active investigation. Basic science is on the brink of understanding the role of genes in combination with environment – specifically the prenatal environment (Shula et al., 2012). The development of autism seems to involve transactional epigenetic processes between biological predisposition and environmental factors (e.g., Bolton et al., 1994; Jensen, Boggild-Andersen, Schmidt, Ankerhus, & Hansen, 1988; Krakowiak et al., 2012; Losh, Sullivan, Trembath, & Piven, 2008). From a biological perspective this would be considered an epigenetic process, in that the environment can differentially alter the expression of genes (or a set of genes), which then places an organism in a new context in which different genes may be selectively activated. In this way ASD may be viewed as resulting from an environmental trigger that has the ability to produce a cascading effect between the selective activation of critical genes and resulting environmental contexts.

Prevalence and Age of Diagnosis. Epidemiological studies have been subject to flux. According to current estimates, autism affects more than 1% of all children (Autism Speaks, 2012). Previous prevalence estimates of 1 in 110 US children having an ASD (Autism and Developmental Disabilities Monitoring Network (ADDM), 2010) have been recently shattered by new prevalence rates of 1 in 88 children in the US (ADDM, 2012; MMWR, 2012). A 78% increase in estimated prevalence between 2002 and 2008 has prompted the CDC to shift the threat of ASD from a public health crisis to a national epidemic (MMWR, 2012). At the same time, recent surveys of ASD prevalence rates in adults estimate that roughly 1 in 100 have an

ASD, suggesting that the factors contributing to ASD are fairly constant (Brugha et al., 2011). Whether the perceived increase reflects broader awareness of ASD, better detection of the disorder at young ages, and/or differing definitions is unknown, and therefore, an actual increase in the recent rate of occurrence cannot be fully ruled out (CDC, 2011). Regardless, these striking new estimates make the earliest possible detection of ASD even more significant in terms of the opportunity for intervention for optimal outcomes.

Efficacy of Early Intervention Based on Behavioral Symptoms. Most children are clinically diagnosed with autism between the ages of 4.5 years and 5.5 years, despite having a documented developmental disorder prior to the age of 3 years (Rice, 2007). While preliminary evidence suggests that the disorder can be reliably diagnosed as early as 14 months (Landa, Holman, & Garrett-Mayer, 2007), and is routinely diagnosed in clinical research settings between 24 and 36 months (e.g., Lord et al., 2006; Ozonoff et al., 2010), this is not the case in community populations that comprise the vast majority of children with ASD. Disparity in age of diagnosis has an enormous impact on the potential for early intervention to produce optimal outcomes (Sutera et al., 2007). In a meta-analysis of behavioral interventions published only since 2010, Dawson and Burner (2011) found strong support for their efficacy in children with ASD, beginning in toddlerhood. Improved developmental outcomes are most likely when interventions for ASD are implemented during the period of high neural plasticity in early development (Altheimer & Altheimer, 2009; Dawson, 2008; Sutera et al.; 2007; Vivanti, Manzi, Benvenuto, Battan, & Curatolo, 2011; Wallace & Rogers, 2010; Warren et al., 2010). However, targeted, intensive interventions can only serve the majority of children, when early identification is reliable. Therefore, in the absence of biological markers, behavioral

manifestations of ASD at the earliest possible age will improve the efficacy of interventions (Zwaigenbaum et al., 2005).

Risk of Recurrence and Prospective Studies. Early efforts to conceptualize the emergence of ASD symptomology were conducted retrospectively. Using parent recall and home videos, often of first birthdays, early social and communicative abnormalities in children who developed ASD tended to become evident around the first year (Baranek, 1999; Osterling & Dawson, 1994; Palomo, Belinchon, & Ozonoff, 2006; Stone et al., 1999; Werner, Dawson, Osterling & Dinno, 2000). In the second year, differences between children with ASD and their age-matched delayed and typically developing peers were characterized by less orienting to name, gaze to faces, joint attention, and affect sharing (Baranek, 1999; Osterling & Dawson, 1994; Stone et al., 1999; Werner et al., 2000). This research methodology was instrumental in beginning to clarify the developmental trajectory of autism's early symptomology, despite inherent methodological complications. However, retrospective parent reports are subject to errors of recall and bias (Gernsbacher, Sauer, Geye, Schweigert, & Goldsmith, 2008), that can be attributed to many factors, including: misconceptions around typical development; lack of appropriate pediatric screening; the subtle pace at which some symptoms emerge in the business of daily life, as well as a parental tendency to normalize or deny a problem in its early stages. In these myriad ways, retrospective studies of ASD emergence have lacked a degree of standardization and accuracy.

It is now understood that infant siblings of children with ASD have a much higher genetic risk of being born with ASD (Ozonoff et al., 2011) or, what is considered a milder, sub-clinical form of autism, broader autism phenotype (BAP) (Le Couteur et al., 1996; Piven, Palmer, Jacobi, Childress, & Arndt, 1997). While there is no agreed upon definition for BAP in infancy (Yirmiya & Ozonoff, 2007), in older children and adults, BAP has been used to refer to

features that are qualitatively similar to ASD, yet milder in degree of disruption, in the realms of social engagement and reciprocity, language and communication, and repetitive behavior (Bailey, Palferman, Heavey & Le Couteur, 1998). Risk of recurrence, or the likelihood of a subsequent sibling being diagnosed with ASD or BAP, was initially estimated to be between 2%-8%, (Bolton et al., 1994; Folstein & Rosen-Sheidley, 2001), approximately two to three times higher than that of the general population. However, recently published large-scale prospective studies suggest that the risk of recurrence for infant siblings is more likely between 14-20% (Constantino, Zhang, Frazier, Abbachhi, & Law, 2010; Ozonoff et al., 2011; Yirmiya & Ozonoff, 2007), or higher (18%-24%), (Schwichtemberg, Young, Sigmn, Hutman, & Ozonoff, 2010), and higher still (about 1 in 3), if there is more than one biological affected sibling (Ozonoff et al., 2011). The marked degree of increased risk made infant siblings of children with ASD an ideal population to study prospectively (relative to infants suspected to be at low risk for ASD), in order to detect the emergence of differing developmental trajectories between those who later meet criteria for ASD and those who do not.

Difference in risk estimates may be attributable to issues of sampling and methodology. Clinical research typically relies upon small samples, due to the fact that it is very difficult to aggregate the desired population. Smaller studies have differed in diagnostic criteria, with a tendency to be more stringent in diagnosis than would be seen in regular practice (Loh, 2007). Some studies are more like snapshots of two small groups at one point in time, without follow-up data to determine any differential outcome. Therefore, in terms of understanding divergent developmental pathways, infant siblings of children with ASD provide the best source of information for predicting outcomes, *because* they are most at risk. The high recurrence rate presents an opportunity for researchers to select the most appropriate participants, but also a

responsibility to use the best designs. Early intervention is critical for all children suspected to be at risk, but early identification is imperative for those who could benefit most – the current infant populations being studied and their siblings yet to come.

Prospective, longitudinal research has identified factors that allow for earlier detection of ASDs in infants at increased genetic risk (e.g., Landa & Garrett-Mayer, 2006; Landa et al., 2007; Zwaigenbaum et al., 2005). Evidence suggests that the development of social communication is disrupted between the ages of 14 and 24 months in most children later diagnosed with ASDs (Landa et al., 2007). Nonverbal communicative disruption is characterized by infrequent initiation of and response to joint attention cues of others (Charman et al., 2005; Chawarska, Klin, Paul, & Volkmar, 2007; Landa et al., 2007), infrequent reciprocal social interaction, and poor integration of eye gaze within such interactions (Chawarska et al., 2007; Landa et al., 2007). The centrality of these findings to major deficits in later life is striking. Even in community samples of children who were not diagnosed with ASD until age *8*, the most common documented developmental concerns were language and social impairments (Rice, 2007).

Disruption in Development of Social Communication. Language, communicative difficulties, and social relatedness are the most common reasons for initial parental concern and clinical referral (Chwarska, 2007; De Giacomo & Fombonne, 1998). Language skills and milestones, especially by age five, are highly predictive of long-term prognosis (Lord & Paul, 1997; Rogers & DiLalla, 1990; Rutter, 1970; Stone & Yoder, 2001; Szatmari, Bryson, Boyle, Streiner, & Duku, 2003). Children with ASD are often extremely delayed in language acquisition, with average onset of first words around 38 months, compared to 8- 14 months for normative development (Howlin, 2003). In a retrospective design to survey parents of children

with autism, developmental delay, or typically developing children, parents were asked to recall their children's development at 12 months (Watson et al., 2007). Interestingly, on this scale meant to discriminate unique characteristics between groups, parents of children with autism and those with developmental delay, differentially endorsed greater impairment in expressive communication compared to typically developing children, but only parents of children with autism endorsed a significant impairment in social affect compared to others. While language delay is common to children with either ASD or developmental delay, reduced social affect is unique to ASD.

Preferential Looking. Although the outcomes have been conflicting, there has been much speculation regarding preferential looking to the human mouth versus the eyes in young children with ASD (Jones, Carr & Klin, 2008). Significant findings were largely attributed to abnormalities in visual attention pertaining to social emotional development (Bryson, 2007). Recently, an alternate hypothesis has been generated in relation to language development. Typically developing children tend to shift their gaze from a speaker's eyes to the mouth for a span of several months when they are learning to talk, and return their preferential gaze to the eye region once they have developed a foundation for speaking. It is postulated that because children with autism have delayed speech, their prolonged period of looking toward the mouth may correlate with, or is an artifact of, language delay, which may in turn lead to further social disruptions. Le Couteur and colleagues (1996) found that in twin pairs discordant for autism, concordance for language impairment and BAP was significantly greater in monozygotic pairs than dizygotic pairs. From any perspective, the impact of language impairments in ASD is large. Preschoolers with ASD produce more non-speech-like, atypical vocalizations than typically

developing peers (Oller at al., 2010; Schoen, Paul, & Chawarska, 2010; Sheinkopf, Mundy, Oller, & Steffens, 2000; Wetherby, Watt, Morgan, & Shumway, 2007; Wetherby et al., 2004).

Despite what is currently known to distinguish children with autism from typically developing peers beyond the first year, little is known about whether similar signs of developmental disruption may be evident earlier in life for infants at risk for autism and related social and communication delays. Findings have been sparse and have often lacked the necessary follow-up to document whether perceived differences are actually significant predictors. While one might suspect the underlying mechanisms of ASD to be in place from birth there is little evidence in support of behavioral differences in infants suspected to be at risk and those who are typically developing prior to the first year of life. Lack of behavioral predictors in 6 month-olds, coupled with the paucity of longitudinal measures, may obscure the potential to identify early behavioral measures that may be related to outcomes in early childhood. Certainly, very early manifestations are more nuanced than one would expect to see if the key symptoms of childhood ASD were extrapolated and worked progressively backwards. It could be that shifts occur in the dyadic relationship between caregiver and infant as caregivers interpret the most subtle cues and their responses shift slightly as well. This would not imply that the dyadic relationship *causes* ASD, but rather that any signposts that exist may be reflected in the reciprocity of interactions, and not solely in the infant.

Trajectory of Dyadic Interaction. Further, it is unclear whether reciprocity in caregiver/infant dyads reveal slightly different organizational patterns, as caregivers consciously or unconsciously take their cues from slightly altered infant behavior. Do parents of infants who will develop ASD work harder in the first year to maintain communicative reciprocity? Do they attempt to elicit their infants' attention more by calling them by name? Do they expend increased

effort in establishing joint attention? Or, is there a lack of synchrony in social referencing, as the infant uses the parental cues to determine the relative safety of exploring the social world? Siller and Sigman (2002) found that caregivers of children with ASD synchronized their joint attention behaviors with their children to the same extent as parents of typically developing or developmentally delayed children. Further, children with ASD whose caregivers were better able to maintain their child's joint attention at age 2 ½ years showed superior communication skills as they matured, compared to children of caregivers who exhibited low synchronization skills initially.

Conversely, if greater asynchrony in parent/infant interaction does exist, is it manifest in fewer attempts to engage these infants in social communication, as a result of altered infant behavior. If early intervention is behavioral, is it possible that the ecological context has been altered as a result of evolving infant behavior? Could the dyadic context be hyper or hypo stimulating simply as a result of implicitly reading an infant's cues? In a study on preschool children with ASD and those with developmental delay, children with ASD responded less to bids for attention than those with delay (Leekam & Ramsden, 2006). Further, joint attention in children with ASD was lower whether a bid was made vocally or in combination with a gesture, such as touch. Instead, sensitivity to dyadic orienting, considered a prerequisite to joint attention, was significantly related to child initiated acts of joint attention. This implies that joint attention between caregivers and children with autism is largely mediated by parental ability to take cues from the child, an idea that is counterintuitive to the notion of intervention that places demands on the child and might be marked by excessive bids for attention on the part of the parent.

Given the imperative to discriminate risk markers for ASD in the first year of life the following study seeks to identify risk markers in the first six months of life, whether this is

evidenced through infant behavior or parent behavior, in the context of a learning paradigm. Identification of risk at six months would allow for the provision of intensive and efficacious interventions before the age of 1 year, resulting in significantly altered outcomes.

Summary of Literature and Rationale for Study

Yirmiya and Ozonoff (2007) eloquently stated that the “signs of autism are certainly present far earlier than the diagnosis is currently made, yet they emerge over time and are not always evident even to the expert clinical eye” (p. 10). To date, Bhat and colleagues (2010) are the only researchers to identify a potential communicative disruption in infants at-risk as young as six months of age. In the context of a ‘social-object learning’ paradigm infants were faced with competing demands, between the novelty of a stimulating toy they could learn to control, or social interaction with their caregivers, who were at times more and less engaged with the infants. This prospective study included two groups of infants: one at higher risk for ASD because of the prior diagnosis of an older sibling; the other at lower-risk because there was no pre-existing ASD in their family.

Infants in both the high- and low-risk groups learned the cause and effect between the joystick movement and the onset of the musical toy. Infant visual attention was assessed by in the context of *spontaneous* and *social* phases within each of four periods comprising the experimental session. No differences were found between groups in look duration to objects or caregivers during the *social* phases, in which caregivers could read from script or freely interact with the infant. However, during the *spontaneous* phases, only the High-Risk group spent more time looking at the joystick or toy rather than their caregivers, suggesting that, at least in this

triadic paradigm (e.g., infant – mother/social – toy/object) in the absence of more structured prompts, they are less likely to self-initiate socially directed gaze.

The present study seeks to add to the findings of Bhat et al., (2010) by comparing precursors of social communication in 6-month-olds, from the perspective of caregiver behavior in a structured situation. Specifically, assuming adequate caregiving skills, if one would expect to find communicative disruptions in infants who develop ASD, perhaps those nuanced and gradual disruptions are best captured in the behaviors of caregivers who are most sensitive to their infants' cues. Infant visual attention will be examined as well, in an attempt to determine whether certain patterns of looking arise in the context of this 'social-object learning' paradigm (Bhat et al., 2010). The prospective design employs a comparison between two infant groups: one at higher and the other at lower risk of developing autism. Social communication of 6-month-olds and their caregivers will be examined in relation to current functioning between groups. It is hypothesized that this pilot study will expose extremely nuanced differences in the dyadic social engagement of infants and caregivers, contributing to the aggregate knowledge base targeting identification of ASD in the first year.

Research Hypotheses

The following hypotheses guided this study:

1. Caregivers of HR infants will differ from LR caregivers in the amount of vocalization used throughout the experimental session.
2. Caregivers of HR infants will differ from LR parents in the amount of pointing and gesturing used to direct infant attention to the toy during the session.

3. Caregivers of HR infants will differ from LR parents in their rate of calling infants by name throughout the experimental session.
4. LR infants will distribute their visual attention more evenly between caregiver and the two elements of the novel toy than HR infants across all periods of the session.

CHAPTER II

Methods and Procedures

Participants and Setting

High Risk Group. Twenty-four infant siblings of children with autism (HR sibs; males = 14, females = 11) were observed at 6 months on a 'social object learning' task. Mean age (and standard deviation) of HR infants was 6.55 (.66) months. Participants were recruited as part of larger, federally funded prospective study of the identification of early markers of ASD, as well as through ASD advocacy groups, conferences, Kennedy Krieger Institute's Center for Autism and related Disorders, and word of mouth. Because infant siblings of children with ASD are at higher risk for ASD than the general population, the term "high risk" (HR) will be used to reference this group. 'Proband' refers to the first affected family member who seeks medical attention for a genetic disorder.

In this case, the probands were older siblings who met the diagnostic criteria for autism on both the Autism Diagnostic Observation Schedule (ADOS) (Lord et al., 1999) and Autism Diagnostic Interview, Revised (ADI-R) (Lord et al., 1994). The ADOS is a method of standardizing direct observations of social behavior, communication, and play in children 5-12 years, suspected of having autism. The ADOS supports diagnostic decisions on the basis of cutoff scores representing qualitative impairment in communication, reciprocal social interaction, and a total for communication and social interaction combined. The ADI-R is a standardized caregiver interview with questions intended to distinguish qualitative developmental deviance from developmental delay, using cutoff scores. Both measures were used in conjunction with clinician judgment as part of the diagnostic assessment for ASD in

older siblings.

Low Risk Group. Participants for the comparison group were recruited by mailing invitations to families identified through public birth announcements and through word of mouth. This group is referred to as "low risk" (LR) because the general population is at significantly lower risk of developing ASD than younger siblings of children with autism (Bailey, Phillips & Rutter, 1996). The 24 typically developing, low risk infants had no family history of ASD and were exposed to the same 'social-object learning' task. There were no significant differences between groups in terms of age or gender (LR infants; males = 8, females = 16; $X^2 = 2.1$, $p > .1$; indicating a non-significant gender difference between groups). Mean age and standard deviation for the LR group was 6.67 (.50) months, respectively.

There was also no difference on raw scores from the Mullen Scales of Early Learning (MSEL) (Mullen, 1995) (HR sibs = 9.28(1.20), LR = 9.83(1.57), $p > .1$), a measure of visually based cognitive development. Exclusion criteria for both groups were: low birth weight (<2500 grams), gestational age (<35 weeks), birth trauma, head injury, prenatal illicit drug or excessive alcohol exposure, known genetic disorder that would confer increased risk of ASDs (e.g., fragile X). Infants were admitted to the study following informed parental consent as approved by the Johns Hopkins Institutional Review Board. Caregivers were the infants' mothers except for three infants, for whom two were infants' fathers, and one was the grandmother.

Infants were assessed in a laboratory setting at the Kennedy Krieger Institute's Center for Autism and Related Disorders.

Outcome Measures

Dependent Variables. The first dependent variable was *Parent Vocalization.* This was defined as any instance in which the caregiver addressed the infant vocally (by laughing or speaking), with less than 5 seconds elapsing between utterances. For example, a parent may speak for 30 seconds with only very brief pauses (less than 5 seconds) between utterances, or speak for 6 seconds, pause for 25 seconds, and then resume speaking for another 9 seconds. The 5-second interval is an arbitrary metric that allows for utterances to be coded discretely. Examples of parent vocalization include directives (e.g., "Pull the stick!"), encouragement (e.g., "You can do it!"), description (e.g., "They're purple and green and blue."), or laughter in response to the infant's vocalizations or actions. Non-examples include speaking to the examiner and not speaking for at least a 5-second interval. Duration of parent vocalizations in proportion to total duration will be coded for each phase of the experiment.

Parent Gesture. Parent gesture occurred each time the parent communicated physically, with or without the use of vocalizations. Gesture was coded in two categories, point and gesture, but these were collapsed as one to reduce the number of variables being manipulated. Pointing was defined as a specific attempt to orient the infant, in which the parent uses his/her index finger to point directly to the musical toy or joystick. Pointing was indicated whether the caregiver's arm is extended so that their finger is in close proximity to the toy, or flexed so that their hand is close to their body. Gesture was indicated when a caregiver used postural cues to try to communicate with or persuade the infant into 'playing the music'. Gestures may indicate how hard the parent is working to engage the infant or how engaged the parent is in the paradigm. Examples of this might include: leaning in toward the infant so their face is in close proximity to the infant; clapping; raising palms in the air to indicate uncertainty; touching the infant or toy; or motioning how the infant should move the joystick to play the music. Non-examples included

leafing through the script or rearranging themselves in their seats. Each instance of gesturing and pointing was coded in terms of percent duration. In the final analysis, these categories were combined and subsumed under the broader term, gesture.

Calls Infant by Name. This was coded each time the parent called the infant by name or used a term of affection, such as “Sweetie”. Calls were tallied by frequency across all phases of the paradigm to account for extent of usage. Because of the literature on response to name in children with ASD, it would be interesting to see whether parents are developing patterns, in response to infant cues, in which they are working harder to gain the infant’s attention or perhaps calling less due to lack of consistent response.

Distribution of Infant Visual Attention. Attention was used to refer to infant visual attention throughout each phase of the experiment. This was measured by observing where the infant looked during the experiment in real time and assigned to one of four broad categories: *Joystick* (J); *Caregiver* (C); *Toy* (T); and *Other* (O). This is coded as a global measure based on general direction of gaze, rather than specific areas within a category. For example, *Caregiver* was coded whether the infant was looking at the caregiver’s face, lap, or her extended pointing. Similarly, *Other* could indicate the camera, a light in the room, the experimenter herself, or something unknown. *Joystick* referred to any aspect of the device, such as the instrument itself or the tether that loosely connected the infants’ wrist to the joystick. Finally, *Toy* could be coded if the infant was looking straight on at it as well as to the tripod on which it rested. Attention was coded from where ever the infant was looking when recording begins. Shifts between the four areas were also calculated but not formally analyzed to minimize variables.

The *Mullen Scales of Early Learning* (MSEL; Mullen, 1997) is a standardized measure for use with infants and preschool children from birth through 68 months. The Mullen assesses gross motor, visual reception, fine motor, receptive language, and expressive language abilities, and also yields a composite score. The MSEL was administered to all participating infants at 6 months.

Procedure

Experimental set-up. Infants were seated in a specialized infant seat for a 10-minute session with a musical toy to their right and their caregiver to the left, each positioned approximately 12 inches beyond the reach of the infant. A mini DV camcorder was placed in front of the infant with an oblique view, used to record the infant's body movements, visual gaze, and part of the toy. For the purpose of a previous study, infants were involved in a 10-minute associative learning task, in which their right hand was gently tethered to the joystick of a novel object (Bhat et al., 2010). The joystick was positioned in front of the infant, at midline. Figure 1 refers to the experimental set-up for the associative learning task.

Figure 1. Experimental Laboratory Set-Up

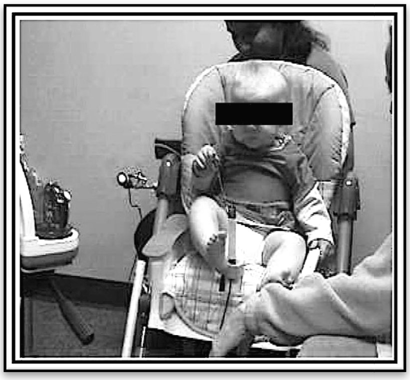

Figure 1. This photo depicts the positioning of all elements of the standardized set-up. Infant is in central focus, with wristband lightly wrapped around the right wrist and tethered to the joystick (directly in front of infant). Caregiver is seated adjacent to the infant on the left, and musical toy is adjacent to the infant's right. Red indicator light is connected to side of infant chair, and experimenter is seated behind infant. Adapted from "Social and Nonsocial Visual Attention Patterns and Associative Learning in Infants At Risk for Autism," by A. Bhat, J. C. Galloway, and R. J. Landa, 2010, *Journal of Child Psychology and Psychiatry, 51,* p. 991. Copyright 2010 by The Authors.

During minutes 0 to 2 (*Baseline*), a red light was activated to indicate the infant's attempts each time the infant moved the joystick. This light was for the benefit of the researcher and was not in the infants' view. During minutes 2 to 8 (*Acquisition 1 and Acquisition 2*), each time the joystick was moved, the toy to the frontal right of the infant was activated for 5 seconds, producing colorful lights and music. *Extinction* occurred during minutes 8 to 10, in which the association between joystick movement and toy activation was broken, but the red light appeared again to indicate joystick movement.

Each social period (baseline, acquisition, extinction) began with caregivers reading loosely from a script. After approximately 30 seconds they were asked to refrain from actively engaging the infant. Therefore, parents were instructed to interact with their infant only if the infant initiated it. For the clarity of this study, engagement within each period will be referred to as active or passive. During active engagement, caregivers are attempting to support their

infants' attempts to "play the music". In the passive phase of each period, caregivers are more or less socially withdrawn, unless engaged by the infant. This study examines only examines behavior that occurs within the social phase referred to in Bhat et al, (2010). This study examines the spontaneous phases referred to in Bhat et al., (2010), using active and passive frames of reference.

During Baseline, caregivers described the animals and colors on the toy. Throughout both acquisition periods, caregivers, using verbal and gestural cues, encouraged their infants to activate the toy by using a script ('*Infant's name,* can you play the music? Where did it go?'), followed by verbal reinforcement ('Yeahh! You played the music!'), each time activation occurred. During extinction, caregivers were instructed to make requests for more, but no reinforcement was provided because the toy was not activated. The suggested parent protocol can be found in Appendix A.

Coding and Intrarater Reliability. Coding was done using custom-made software, Open Shapa, a computer-based observation and video analysis system. Open Shapa allows for frame-by-frame analysis and temporal coding of digital video data. The system enabled timing observational events to the .0001 of a second. For reporting purposes, all times were rounded to the .01 of a second. The author established intrarater reliability by coding 33% of all variables (16 files = 160 minutes), across all phases of the experiment and then recoding those files several weeks later. There were 6 instances in which percentage agreement on particular variables fell below 85%. In these cases, the researcher reviewed and refined operational definitions in order to resolve differences in coding. Ultimately, reliability was computed by one-way random intra-class correlations for each variable, and was above 98% for all.

Data Analysis. The maximum number of cases (n=24) was used for each group whenever possible. Each variable was subjected to an analysis of variance (ANOVA), using QI Macros 2013 in Excel, with groups (HR and LR infants) as the between-subjects factor and learning periods (Baseline, Acquisition 1, Acquisition 2, Extinction) as the within-subjects factor. Preliminary analyses of data did not indicate a need for transformation. Raw data for each variable and relevant analyses are presented in the Appendix. Descriptive statistics and *F*- and *p*-values are reported as well. An alpha level of .05 was used for all statistical tests. The decision to collapse *active* and *passive* phases together was based on the observation that all parents *at least* read the suggested script. However, many went beyond this; talking, instructing, and gesturing long after the 20 to 30 seconds that was expected of them. Combining phases therefore provided a more global rating of parent behavior across structured and unstructured time throughout the infant learning activity.

Chapter III

Results

This chapter examines the results of the present study by analyzing parent and infant behavior in a social-object learning paradigm. Several hypotheses were generated regarding differences in caregiver behavior and infant visual attention, based on group. Specifically, it was hypothesized that percent duration of caregiver vocalizations, gestures, and calling infants by name would differ by group, across the four periods of the experimental paradigm. Direction was not specified.

Hypothesis 1: Caregivers of HR infants will differ from LR caregivers in the amount of vocalization used throughout the experimental session.

The results of a two-way analysis of variance (ANOVA) indicated that there were no main effects for any of the caregiver-related variables. Specifically, for hypothesis 1, group membership did not affect the percent duration of vocalizing ($F(1,180) = 0.00$, $p = .951$). The percent duration of vocalizations did vary across periods ($F(3,180) = 7.63$, $p = 0.000$). However, the pattern was almost identical between groups ($F(3,180) = 0.20$, $p = 0.896$). Therefore, if percent duration of caregiver vocalization increased significantly from Baseline to Acquisition 1 in the high-risk group, this change was almost identical in the low-risk group. Mean percent duration of vocalizing ranged from around 65% during the Baseline period, increasing to around 80% during the Acquisition periods, culminating at 77% for both groups, during Extinction.

The pattern of vocalizations reflects the demands of the periods, and the need caregivers felt to interact with and/or support infants as they engaged in the learning process. During Baseline, caregivers' vocalizations were at their lowest, although still relatively high (LR: mean

= 65%, HR: mean = 66%). Vocalizations peaked during Acquisition 1, when infants were in the process of learning the cause and effect of their actions and the toy's activation (LR: mean = 83%, HR: mean = 84%), declining only slightly during the remaining periods. This would be consistent with providing encouragement during Baseline, followed by sustained vocal engagement during both Acquisition periods into Extinction, when infants are challenged by the broken connection.

Table 1. Mean (SD) of Percent Duration Caregiver Vocalizations between Groups

	Mean (SD) of Caregiver Vocalizations	
Periods	Low-Risk	High-Risk
Baseline	0.65 (.20)	0.66 (.24)
Acquisition 1	0.83 (.20)	0.84 (.20)
Acquisition 2	0.81 (.17)	0.82 (.14)
Extinction	0.80 (.20)	0.77 (.22)
Total	0.77 (.20)	0.77 (.22)

Note. SD = Standard deviation.

Table 2. Two-way ANOVA results of Caregiver Vocalizations across Periods

	SS	*df*	*MS*	*F*	*P-Value*	*F crit*
Sample	0.00	1	0.00	0.00	0.951	3.89
Between	0.91	3	0.30	7.63	0.000	2.65
Interaction	0.02	3	0.01	0.20	0.896	2.65
Within Groups	7.16	180	0.04			
Total	8.09	187				

Note. SS = Sum of squares; df = degrees of freedom; MS = Mean square; *F* = *F* ratio; *F*-crit = critical value for *F*.

Hypothesis 2: Caregivers of HR infants will differ from LR parents in the amount of pointing and gesturing used to direct infant attention to the toy during the session.

Results for hypothesis 2 were similar to those for vocalizations, in that the use of caregiver gesturing did not change by group (*F*(1,178) = 2.54, *p* = 0.617), but did by period (*F*(1,3) = 5.60, *p* = 0.001). Though not as closely aligned in percent duration across periods, group means followed a similar trajectory, with the highest level of gesturing occurring during Baseline (LR: mean = 48%, HR: mean = 55%) and then declining for the remaining periods. Gestures during Baseline included shrugging with palms up in a questioning manner, as well as pointing back and forth between the toy and joystick, and pointing to the colors on the toy, as directed by the script. Gestures during Acquisition 1 and 2 consisted primarily of clapping when the infant made the music play, pointing as a directive, and leaning in toward the infant to signal caregiver engagement, as well as draw the infant's attention to the caregiver's face. Extinction gestures again included questioning motions, as caregivers asked, "Where did it go? Where did the music go?" Some caregivers continued to encourage infants to try to play, by pointing back and forth, and others leaned in as infants responded to the disconnect between toy and joystick.

Table 3. Mean (SD) of percent Caregiver Gestures between Groups

	Mean (SD) of Caregiver Gestures	
Periods	Low-Risk	High-Risk
Baseline	0.48 (.14)	0.55 (.17)
Acquisition 1	0.35 (.24)	0.29 (.28)
Acquisition 2	0.38 (.28)	0.40 (.32)
Extinction	0.44 (.24)	0.32 (.20)
Total	0.41 (.24)	0.39 (.26)

Note. SD = Standard Deviation.

Table 4. Two-way ANOVA results of Caregiver Gestures across Periods

	SS	*df*	*MS*	*F*	*P-Value*	*F crit*
Sample	0.01	1	0.01	2.54	0.617	3.89

	SS	*df*	*MS*	*F*	*P-Value*	*F crit*
Period	0.98	3	0.33	5.60	0.001	2.66
Interaction	0.29	3	0.10	1.64	0.181	2.66
Within	10.40	178	0.06			
Total	11.69	185				

Note. SS = Sum of squares; df = degrees of freedom; MS = Mean square; *F* = *F* ratio; *F*-crit = critical value for *F*.

Hypothesis 3. Caregivers of HR infants will differ from LR parents in their rate of calling infants by name throughout the experimental session.

Again, there was a main effect for period within groups for the rate of calling the infant by name, or using a term of endearment. Caregivers addressed their infants by name an average of 3 to 4 times during Baseline and much more during the first Acquisition period, to an average of 9 calls for the LR group and 11 for the HR group. Calls dropped to approximately 6 or 7 during Acquisition 2, with Extinction means very close to those of Baseline. During Baseline and Extinction, infants' names were used mostly in questions, such as, "Do you see the colors?" or "Where did it go?" in contrast to the Acquisition periods in which they tended to be used as a form of cheerleading (e.g., "Yeah! You did it! Matthew did it!). At other times, names were used to try to draw an infant's attention to a relevant aspect of the learning task.

Table 5. Mean (SD) of percent Calling Infant by Name between Groups

	Mean (SD) of Calling Infant by Name	
Periods	Low-Risk	High-Risk
Baseline	2.92 (2.45)	3.71 (3.26)
Acquisition 1	9.04 (6.57)	11.17 (7.78)
Acquisition 2	6.88 (4.72)	6.46 (7.46)
Extinction	2.71 (4.20)	3.10 (2.70)

Total	5.47 (5.12)	6.20 (6.68)

Note. SD = Standard Deviation.

Table 6. Two-way ANOVA results for Calling Infant by Name across Periods

	SS	*df*	*MS*	*F*	*P-Value*	*F crit*
Group	24.86	1	24.86	0.91	0.342	3.89
Period	1610.00	3	536.67	19.61	0.000	2.66
Interaction	37.60	3	12.53	0.46	0.712	2.66
Within	4870.70	178	27.36			
Total	6543.16	185				

Note. SS = Sum of squares; df = degrees of freedom; MS = Mean square; F = F ratio; F-crit = critical value for F

Hypothesis 4. LR infants will distribute their visual attention more evenly between caregiver and the two elements of the novel toy than HR infants across all periods of the session.

Just as there were no differences between caregivers' attempts to interact with infants in the triadic paradigm, there were no differences in infants' visual attention to the *Toy* ($F(1,180) = .79$, $p = 0.37$). Once again, the demands of the period created different patterns of looking toward the four potential targets: toy, caregiver, joystick, and other, that were remarkably similar for both groups ($F(1,3) = p$ .006). Similar differences across periods were observed for both groups ($F(1,3) = 4.25$, $p = .006$). Infant looking toward the musical toy ranged between 22 and 26 percent (LR: mean = 26.02, HR: mean = 21.76), increasing slightly during both Acquisition periods to around 30%, and then decreasing sharply in Extinction, to a low of approximately16% for both. During this time, the silent toy no longer actively elicited infant attention. Therefore, looks to the toy were more fleeting, and tended to occur after pulling the joystick, apparently in an effort to determine whether the motion had created an effect.

Table 7. Mean (SD) of Infant Visual Attention to Toy between Groups

	Mean (SD) of Infant Attention to Toy	
Periods	Low-Risk	High-Risk
Baseline	26.02 (23.46)	21.76 (21.12)
Acquisition 1	30.24 (20.97)	29.11 (17.39)
Acquisition 2	29.93 (19.49)	26.40 (14.92)
Extinction	16.56 (18.86)	15.70 (13.88)
Total	25.88 (21.19)	23.40 (17.58)

Note. SD = Standard Deviation.

Table 8. Two-way ANOVA results for Infant Visual Attention to Toy

	SS	*df*	*MS*	*F*	*P-Value*	*F crit*
Group	289.79	1	289.79	0.79	0.374	3.89
Period	4656.79	3	1552.10	4.25	0.006	2.65
Interaction	63.76	3	34.15	0.09	0.963	2.65
Within	65767.30	180	365.38	0.06	0.982	2.65
Total	70777.17	187				

Note. SS = Sum of squares; df = degrees of freedom; MS = Mean square; *F* = *F* ratio; *F*-crit = critical value for *F*.

Infant looking to caregiver remained fairly constant across the four periods. There were no main effects for period (*F* (1,3) = *p* .654) and groups were similar in average amount of looking to caregiver throughout (*F* (1,180) = .01, *p* .915). Between Baseline and Extinction, average group looking ranged between 19 and 27 seconds in the LR group, and 21 to 24 seconds in the HR group. Caregivers received attention when infants reciprocated caregiver bids, used caregivers as social references in this unfamiliar situation, or expressed their emotion in regard to this most unusual situation.

Table 9. Mean (SD) Infant Visual Attention to Caregiver between Groups

	Mean (SD) of Infant Attention to Caregiver	
Periods	Low-Risk	High-Risk
Baseline	19.44 (7.52)	21.03 (20.32)
Acquisition 1	19.80 (14.56)	23.85 (19.27)
Acquisition 2	26.86 (21.09)	23.34 (18.05)
Extinction	22.20 (21.47)	21.16 (18.73)
Total	22.07 (18.41)	22.37 (19.40)

Note. SD = Standard Deviation.

Table 10. Two-way ANOVA results for Infant Visual Attention to Caregiver

	SS	*df*	*MS*	*F*	*P-Value*	*F crit*
Group	4.19	1	4.19	0.01	0.915	3.89
Period	607.26	3	202.42	0.56	0.645	2.65
Interaction	383.44	3	127.81	0.35	0.788	2.65
Within	65546.00	180	364.14			
Total	66540.89	187				

Note. SS = Sum of squares; df = degrees of freedom; MS = Mean square; *F* = *F* ratio; *F*-crit = critical value for *F*.

Infant looking to the joystick was relatively high throughout the experiment, although a main effect for period reflects significant changes in look duration between at least two periods in both groups ($F(1,3) = 4.59$, p .004). The highest percentage of looking toward the joystick occurred during Baseline (LR: mean = 42.06 sec., HR: mean = 43.11 sec.), when infants were confronted with the joystick between their legs that moved whenever they waved their tethered arm, or simply manipulated the object. Looking to the joystick decreased slightly during Acquisition 1 and slightly more during Acquisition 2 (LR: s = 25.9 s., HR: s = 35.17 s.). Peak looking for both groups occurred during Extinction (LR: mean = 45.19 sec., HR: mean = 48.78 sec.), when the connection between the toy and the joystick was broken. During Extinction, the

silent toy no longer actively elicited infant attention, although infants checked the toy periodically, in part after moving the joystick, to see whether the joystick had produced the desired effect.

Table 11. Mean (SD) Infant Visual Attention to Joystick between Groups

	Mean (SD) of Infant Attention to Joystick	
Periods	Low-Risk	High-Risk
Baseline	42.06 (25.59)	43.11 (29.95)
Acquisition 1	35.53 (18.45)	38.37 (21.88)
Acquisition 2	25.90 (17.06)	35.17 (19.77)
Extinction	45.19 (25.11)	48.78 (22.45)
Total	37.08 (22.74)	41.28 (24.01)

Note. SD = Standard Deviation.

Table 12. Two-way ANOVA results for Infant Visual Attention to Joystick

	SS	*df*	*MS*	*F*	*P-Value*	*F crit*
Group	723.36	1	723.36	1.37	0.243	3.90
Period	7249.90	3	2416.63	4.59	0.004	2.65
Interaction	481.94	3	160.65	0.31	0.822	2.65
Within	94759.76	180	526.44			
Total	103214.96	187				

Note. SS = Sum of squares; df = degrees of freedom; MS = Mean square; *F* = *F* ratio; *F*-crit = critical value for *F*.

The result of infant attention to ‘other’ was one of the greatest surprises. Not only were there no differences in looking to other between the high- and low-risk groups (F (1,180) = 2.80, p = .096), the LR group actually spent more time looking toward other in every period and across each of them. The difference was most evident during Baseline (LR: mean = 14.63 sec., HR: mean = 7.6 sec.). Although there were no main effects for group or period (F (1,3) = 1.02, p = .387), both groups had the longest average of looking to other during Acquisition 2 and

Extinction. Between Acquisition periods the examiner would sometimes catch the eye of an infant while connecting or disconnecting the cable between joystick and toy. This was one way in which looking to other occurred easily and meaningfully during the experimental paradigm. Looking to other during Extinction sometimes included the camera or the experimenter. This may have occurred as infants grew restless or frustrated with the paradigm. Looking toward something else for a few seconds of distraction may have been a form of self-regulation that would have an adaptive effect.

Table 13. Mean (SD) Infant Visual Attention to Other between Groups

	Mean (SD) of Infant Attention to Other	
Periods	Low-Risk	High-Risk
Baseline	14.63 (13.11)	7.60 (7.26)
Acquisition 1	15.43 (14.49)	13.33 (13.24)
Acquisition 2	17.73 (13.74)	13.91 (12.54)
Extinction	15.18 (13.56)	14.64 (11.29)
Total	15.75 (13.57)	12.32 (11.43)

Note. SD = Standard Deviation

Table 14. Two-way ANOVA results for Infant Visual Attention to Other

	SS	*df*	*MS*	*F*	*P-Value*	*F crit*
Group	553.16	1	553.16	2.80	0.096	3.89
Period	602.98	3	200.99	1.02	0.387	2.65
Interaction	271.25	3	90.42	0.46	0.713	2.65
Within	35613.87	180	197.85			
Total	37041.26	187				

Note. SS = Sum of squares; df = degrees of freedom; MS = Mean square; *F* = F ratio; *F*-crit = critical value for *F*.

Chapter IV

Discussion

Evidence suggests that autism can be reliably diagnosed in children as early as 14 months (Landa et al., 2007), and that at least one aspect of social communication may be observably altered in children at-risk for ASD at 6-months (Bhat et al.). Based on the early identification research regarding behavioral markers, it was hypothesized that there may be other aspects of social communication that display minor disruptions at a very early age. Specifically, patterns of infant visual attention may shift in terms of attention to social and between non-social stimuli. Unlike other prospective studies of delay or disruption of social communication in children who develop autism, this study examined infant behavior as well as their caregivers' behavior within the dyadic (or triadic) interaction, to determine whether subtle differences in infant cues might be reflected in caregivers behavior.

Within the context of a 'social-object learning' paradigm (Bhat et al., 2010), 24 infants considered to be at high-risk for ASD based on the diagnosis of autism in an older sibling were compared to 24 infants considered to be at low-risk, across four periods of an experimental session: Baseline (60 s.); Acquisition 1 (90-120s.); Acquisition 2 (90-120 s.); and, Extinction (60 s.). During the 10-minute session, caregivers were seated to one side of the infants' peripheral vision and a toy that played music and displayed colorful lights was placed to the other side of infants' peripheral view. A wristband attached to a tether was gently wrapped around each infant's right wrist so that a sudden movement would pull the joystick (or the infant could manipulate it directly) that was centered between the infant's legs. Movement of the joystick in turn activated the music and colors of the toy.

During Baseline, infants could pull the joystick but there was no connection to activate the toy. In Acquisition 1, the contingency between infant action and object activation was established. During Acquisition 2, the contingency was briefly broken and then reconnected to capture change in affect and to retest learning. If the infant understands the cause-effect relationship, they should demonstrate positive affect upon the reconnection. During this 4-minute period, all of the infants learned the connection between pulling the joystick and activating the toy (Bhat et al., 2010). In the Extinction period, the joystick and toy were disconnected, so that no matter what was done to the joystick, no lights or sounds were produced. Each period contained *social* and *spontaneous* phases. In spontaneous phases, caregivers were asked to remain silent and only smile in reply to infant-initiated contact. Spontaneous phases always preceded social phases, in which caregivers could freely interact, pointing out parts of the musical toy and encouraging infants to play the music.

Early social and communicative abnormalities in children who developed ASD have been observed around the first year (Baranek, 1999; Osterling & Dawson, 1994; Palomo, Belinchon, & Ozonoff, 2006; Stone et al., 1999; Werner, Dawson, Osterling & Dinno, 2000). Differences between children with ASD and their age-matched delayed and typically developing peers have been characterized by decreased orienting to name, gaze to faces, joint attention, and affect sharing (Baranek, 1999; Osterling & Dawson, 1994; Stone et al., 1999; Werner et al., 2000). Bhat and colleagues (2010) were able to identify a potential marker at 6-months of age: fewer self-initiated social interactions with caregivers when compared to typically developing peers. It seemed reasonable therefore, to attempt to identify other potential markers from such a robust paradigm.

Distribution of visual attention, in the sense of the percentage of time infants attended to stimuli (as opposed to whether their looking was more social or object-oriented), seemed to have the potential to capture slight differences between groups. Also the caregivers themselves seemed a valuable asset. If they are reading their babies' social cues day in and day out, and notice even unconsciously the most subtle shift in their infants' social communication, one might expect to see some parents working harder to maintain typical dyadic engagement or some reducing their overtures in response to less positive feedback. Therefore, the present study examined infant-caregiver dyadic interactions within the context of a triadic paradigm with the hope of highlighting an additional behavioral difference in infants at higher- risk for ASD. The results make abundantly clear, however, that there were no differences between groups on any of the variables of interest, within the context of the experimental session.

Caregiver Behaviors

There were no significant differences for any of the caregiver behaviors. In fact, group means and standard deviations were so similar, they almost mirrored each other. Almost all parents went above and beyond the script, in their vocalizations, gestures, and use of their infants' name. Still, combining the social and non-social phases of the four periods, likely obscured some differences that may have been evident in the non-social phases. The only constant was that differences in behavior occurred across periods, but within groups. It is interesting to note that caregivers called their babies by name at a similar rate between groups across the periods. It is commonly believed that one of the early symptoms in children who develop ASD is a failure to respond to their names, or to orient to the caregiver when their name is called. Although infant response to name was not captured in this coding scheme, it is

hypothesized that the two groups had similar responses. Otherwise, one would expect to see HR caregivers calling their infants' names at a higher rate, in an attempt to gain their attention.

Infant Visual Attention between Groups

Percent duration of Infant Visual Attention was surprising in several ways. First, the groups were uncannily similar during each phase, not just in their split between social and non-social looking (caregiver/objects), but also in the split within non-social looking (e.g., joystick/musical toy), down to *Other*. Given the literature on social looking, one might have expected to see reduced looking to the caregiver in the HR group, across all phases. However, lack of group differences in caregiver calls and vocalizations, coupled with prior findings on self-versus caregiver-initiated interaction (Bhat et al., 2010), suggested the coding scheme in the present study wouldn't have allowed such a difference to emerge. If infants were responding concordantly when their attention was solicited during the social phases, then their responses would be expected to be similar throughout the entire period, in concordance with the bid. Because infant visual attention was only captured as a measure of duration, rather than as a function of reciprocity (e.g., to solicit or respond to a bid), the nature of looking to caregiver is unspecified.

Within looking, it was surprising to find that there were no differences between length of looking toward Other. This is noteworthy because the literature on visual attention of children with ASD posits that children spend more time orienting to non-social stimuli than social stimuli. Further, it is suggested that these children will orient to non-meaningful, non-social stimuli more often than their typical peers. Within this paradigm, not only was looking to Other similar between groups, the LR infants had longer lengths of looking to Other across every period, but

particularly during Extinction. Because the laboratory setting was highly controlled and structured, looking to Other consisted primarily of looking at the experimenter or the camera. There was little to no looking at the ceiling light or staring off into space.

Although the differences were not significant, it is the case that LR infants looked longer toward Other stimuli throughout the experiment, while HR infants looked consistently longer at the joystick. It is possible that throughout the latter periods, most of the 6-month-olds had sufficient time to learn the connection between joystick and musical toy, freeing up their attention to share this experience with their mothers, or to survey the unusual scene in general. Therefore, maintaining the majority of their gaze on the joystick throughout all four periods, particularly in AC2, may represent a point when infants in the HR group cognitively ‘get’ the paradigm, yet they cannot release as much of their visual attention to reallocate it socially or otherwise. In this way, it is possible that the HR group may have mastered the toy, but the mechanism (e.g., joystick) still dominates their visual attention.

Implications

Six-month-old infants at-risk of developing ASD, and those at lower-risk have similar profiles of visual attention in a social-object-learning paradigm. Caregivers of at-risk infants also appear highly similar in the behaviors they engage in while facilitating their infants’ exploration and understanding of novel objects. The hypothesis that on a conscious or unconscious level, parents of infants who will develop ASD are already ‘working’ harder to maintain reciprocity in the dyadic relationship, is not supported by the findings of this research. Given such a premise, one would expect to see this phenomenon reflected in elevated levels of some behavior, whether vocalizations, gestures, or something not captured in this study.

Future Research

It may be the case that differences between groups would appear in the quality rather than the quantity of observations. Infant and caregiver affect were not measured in this study, so it can only be stated anecdotally that infants with flatter affect seemed to have caregivers with exaggerated affect, either in the way they enunciated their child's name, or in the excessively high pitches they invoked when speaking to the infant. Further, all of the infants who were considered (by the researcher) to have flat or fussy affect were later revealed to be in the HR group. AN examination of maternal and infant affect, as well as speech characteristics such as prosody, would be useful in future research.

Examination of the actual patterns of infant looking in the triadic paradigm could yield valuable information about the patterns of social and non-social looking in infants at-risk for ASD. In this study for example, did looking occur in a somewhat fluid and rotational basis (e.g., joystick, toy, caregiver), or was it less seamless, so that there was a weaker sense of coherence? This question could pertain to looking, affect, or vocalizations. Percentages of look duration between HR and LR groups were similar in this study, but this does not necessarily mean that both groups followed the same course of non-social looking and social looking, using the caregiver as a social reference for exploration and responding accordingly to her prompts. Future research that focuses on visual patterns of communication would be useful.

In extensively reviewing these files it became clear that affect and vocalizations are the most likely key to identifying differences between LR and HR infants. Prior studies have cited a lack of affect in children with autism, in comparison to typically or developmentally children (Watson et al., 2007). It feels as if the roots of this phenomenon are evident in only a handful of

the present cases, but the force is almost palpable. While all of the infants did display positive affect at some time during the session, a few were primarily negative or fearful throughout. Others would look more blank or neutral for some time before breaking into a grin and reengaging with the exploration. Therefore, examining proportions of positive, negative, and neutral affect within this triadic paradigm at 6-months would be of value. Coding infant vocalizations would be very useful, in the potential predictive value for speech delay, but also in assessing the synchrony between infant/caregiver interactions. If HR infants are less likely to initiate social interactions in this paradigm, are they also less likely to vocalize, or to initiate an interaction to the toy itself, as so many do in their excitement?

Limitations

While this study was undertaken with much enthusiasm, it has several limitations in generalizing to a larger population. The use of intra-rater reliability for coding was satisfactory, but inter-rater reliability would have improved readers' confidence in the consistency of coding. The small sample size, although considered good for this hard-to-access population, necessitates that any generalizations be made with caution. Finally, this study should be considered part one of a prospective design. Ideally, repeated measures such as the MSEL should be administered at 18-months and compared with 6-month scores as well as select variables such as visual attention. Without a reliable outcome measure, part one has no predictive utility. Finally, in the original study (Bhat et al., 2010), attentional differences were found only in the spontaneous condition and not the social condition. Collapsing the active and passive segments within the social phase may have produced a washout of significant effects in the social condition.

Summary

The structured nature of the task facilitated engagement between infant, object, and caregiver. Perhaps in a naturalistic setting one might see more differences in triadic interaction, especially in terms of vocalizations, for both infant and caregiver. This structured setting played to the strengths of children with ASD, in that it was highly structured, learning-based, and scaffolded by a supportive caregiver. Because of this, some differences may not be as evident between groups as they would be in less structured paradigms. However, as we better understand the factors in infancy that are predictive of ASD, consideration should be given to utilizing aspects of this structured paradigm as a form of intervention for infants identified at-risk.

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Appendix A
Suggested Parent Script

You can make it your own, and say what comes naturally.

PERIOD 1

First time
1. *(Look at baby, and say)* "____________",
2. *(Point to toy and say)* "Looook" *(Emphasize).*
3. "Look at the colors."
4. "There is a purple, green, blue, orange, and yellow. Its such a nice toy"

Second time
1. *(Look at baby, and say)* "____________",
2. (Point to toy and say) "Looook" *(Emphasize)*
3. "Look at the animals."
4. There is an elephant, a rhino, a teddy bear, a lion, and a giraffe. It's such a pretty toy."

OTHER SOCIAL PERIODS

WHEN NO MUSIC
1. *(Look at baby, and say)* "___________",
2. *(Point to the correct switch and say)* "Can you play the music?" *(Emphasize).*
3. "Where did the music go?

WHEN BABY PLAYS MUSIC
1. *(Look at baby, and say) "Yeahh"*, *(Emphasize)*
2. "You played the music"
3. "Good job, ____________," *(Emphasize)*

Appendix B
Raw Data for Percent Duration of Caregiver Vocalizations by Period

Table B1. Percent Duration Data for Vocalizations during Baseline

Low-Risk Group				High-Risk Group			
ID	Vocal	Total	%	ID	Vocal	Total	%
1	47.56	48.92	0.97	1	59.90	59.90	1.00
2	52.48	59.93	0.88	2	36.80	54.30	0.68
3	59.75	59.75	1.00	3	36.41	43.08	0.85
4	31.83	45.98	0.69	4	28.65	59.25	0.48
5	26.58	52.12	0.51	5	32.26	48.86	0.66
6	34.59	46.65	0.74	6	39.72	51.52	0.77
7	25.45	47.81	0.53	7	24.47	46.05	0.53
8	34.26	60.49	0.57	8	41.26	59.58	0.69
9	31.21	53.86	0.58	9	47.82	60.67	0.79
10	34.60	56.40	0.61	10	32.84	41.76	0.79
11	25.07	36.78	0.68	11	37.24	48.98	0.76
12	50.23	59.95	0.84	12	28.67	60.19	0.48
13	42.22	59.87	0.71	13	1.14	43.55	0.03
14	46.47	55.12	0.84	14	59.49	59.49	1.00
15	3.87	57.46	0.07	15	40.33	54.08	0.75
16	57.56	57.56	1.00	16	28.87	50.12	0.58
17	40.02	59.89	0.67	17	37.72	55.59	0.68
18	36.74	53.88	0.68	18	44.39	54.59	0.81
19	39.90	58.52	0.68	19	43.04	43.04	1.00
20	0.00	57.47	0.00	20	45.47	61.04	0.74
21	25.59	57.19	0.45	21	36.60	58.01	0.63
22	26.86	55.86	0.48	22	29.70	48.47	0.61
23	50.97	52.34	0.97	23	1.12	47.52	0.02
24	2.17	56.24	0.04	24	31.73	59.96	0.53

Note. ID = File number identification; Vocal = Caregiver vocalizations made in seconds; Total = Total duration of period; % = Percent duration of caregiver vocalization during period.

Table B2. Percent Duration Data for Vocalizations during Acquisition 1

Low-Risk Group				High-Risk Group			
ID	Vocal	Total	%	ID	Vocal	Total	%
1	47.56	48.92	0.97	1	5.54	100	0.06
2	97.22	100.00	0.97	2	72.1	100	0.72
3	49.03	100.00	0.49	3	100	100	1.00
4	43.90	100.00	0.44	4	173.13	181.95	0.95
5	76.60	100.00	0.77	5	91.43	100	0.91
6	76.60	100.00	0.77	6	159.86	160.86	0.99
7	41.09	100.00	0.41	7	87.44	100	0.87
8	58.91	100.00	58.91	8	119.45	169.01	0.71
9	58.95	100.00	0.59	9	100	100	1.00
10	87.56	100.00	0.88	10	108.17	128.95	0.84
11	56.03	56.03	1.00	11	88.93	100	0.89
12	82.52	100.00	0.83	12	71.82	100	0.72
13	63.10	100.00	0.63	13	98.87	100	0.99
14	55.59	100.00	0.56	14	96.64	100	0.97
15	65.50	100.00	0.66	15	98.76	100	0.99
16	71.69	100.00	0.72	16	92.7	100	0.93
17	68.39	100.00	0.68	17	95.17	100	0.95
18	38.36	100.00	0.38	18	43.69	238.35	0.18
19	86.68	100.00	0.87	19	86.41	100	0.86
20	36.60	58.01	0.63	20	143.53	143.53	1.00
21	31.87	57.34	0.56	21	81.84	99.99	0.82
22	41.60	65.50	0.64	22	92.82	175	0.53
23	42.83	100.00	0.43	23	111.13	160.83	0.69
24	14.35	56.13	0.26	24	71.82	100.00	0.72

Note. ID = File number identification; Vocal = Caregiver vocalizations made in seconds; Total = Total duration of period; % = Percent duration of caregiver vocalization during period

Table B3. Percent Duration Data for Vocalizations during Acquisition 2

Low-Risk Group				High-Risk Group			
ID	Vocal	Total	%	ID	Vocal	Total	%
1	133.09	140.13	0.95	1	87.38	100.00	0.87
2	94.79	100.00	0.95	2	90.48	100.00	0.90
3	79.86	100.00	0.80	3	79.63	100.00	0.80
4	84.13	100.00	0.84	4	140.16	182.08	0.77
5	97.66	100.00	0.98	5	74.75	100.00	0.75
6	97.28	100.00	0.97	6	124.23	124.23	1.00
7	115.18	183.22	0.63	7	90.87	100.00	0.91
8	81.67	100.00	0.82	8	119.45	169.01	0.71
9	68.82	100.00	0.69	9	100.00	100.00	1.00
10	87.15	100.44	0.87	10	81.88	100.00	0.82
11	158.41	180.13	0.88	11	174.69	181.96	0.96
12	98.81	100.00	0.99	12	107.87	146.15	0.74
13	90.22	100.00	0.90	13	68.93	100.00	0.69
14	137.55	175.83	0.78	14	76.08	100.00	0.76
15	48.49	100.00	0.48	15	99.18	100.00	0.99
16	145.33	184.76	0.79	16	94.78	100.00	0.95
17	97.35	100.00	0.97	17	97.93	100.00	0.98
18	168.60	188.60	0.89	18	87.33	100.00	0.87
19	166.13	179.17	0.93	19	64.82	99.99	0.65
20	45.57	99.99	0.46	20	48.04	60.48	0.79
21	91.89	100.00	0.92	21	86.41	100.00	0.86
22	86.02	100.00	0.86	22	96.38	99.59	0.97
23	135.55	228.78	0.59	23	81.84	99.99	0.82
24	50.90	99.99	0.51	24	74.72	186.28	0.40

Note. ID = File number identification; Vocal = Caregiver vocalizations made in seconds; Total = Total duration of period; % = Percent duration of caregiver vocalization during period.

Table B4. Percent Duration Data for Vocalizations during Extinction

Low-Risk Group				High-Risk Group			
ID	Vocal	Total	%	ID	Vocal	Total	%
1	58.28	58.28	1.00	1	79.57	100.00	0.80
2	59.69	59.69	1.00	2	58.90	58.90	1.00
3	54.92	59.92	0.92	3	60.03	60.03	1.00
4	60.08	60.08	1.00	4	40.11	54.15	0.74
5	59.75	59.75	1.00	5	52.58	60.16	0.87
6	41.79	60.25	0.69	6	59.58	59.58	1.00
7	34.61	60.08	0.58	7	46.92	60.84	0.77
8	100.00	100.00	1.00	8	25.41	50.05	0.51
9	55.21	59.99	0.92	9	59.81	59.81	1.00
10	59.97	59.97	1.00	10	58.37	61.22	0.95
11	35.00	58.62	0.60	11	47.03	57.56	0.82
12	49.02	60.09	0.82	12	29.11	59.14	0.49
13	57.05	60.15	0.95	13	41.83	60.11	0.70
14	58.92	58.92	1.00	14	58.94	58.94	1.00
15	34.88	60.48	0.58	15	59.45	100.00	0.59
16	34.15	60.21	0.57	16	34.98	60.28	0.58
17	54.22	59.66	0.91	17	24.81	60.63	0.41
18	21.82	56.06	0.39	18	43.63	58.86	0.74
19	27.01	59.99	0.45	19	57.93	57.93	1.00
20	53.17	60.00	0.89	20	59.85	59.85	1.00
21	25.67	47.96	0.54	21	32.08	59.90	0.54
22	49.26	49.26	1.00	22	47.84	57.24	0.84

Note. ID = File number identification; Vocal = Caregiver vocalizations made in seconds; Total = Total duration of period; % = Percent duration of caregiver vocalization during period.

Appendix C
Raw Data for Caregiver Gesture by Phase

Table C1. Percent Duration of Point/Gesture and Gesture Overall during Baseline

Low-Risk Group						High-Risk Group					
ID	P	G	P&G	Total	%	ID	P	G	P&G	Total	%
1	20.39	9.55	29.94	48.90	0.61	1	12.32	0.00	12.32	28.04	0.44
2	26.65	1.48	28.13	53.03	0.53	2	17.87	0.00	17.87	38.49	0.46
3	35.52	0.76	36.28	52.97	0.68	3	29.80	11.44	41.24	43.08	0.96
4	4.52	8.19	12.71	45.97	0.28	4	26.09	1.21	27.30	65.25	0.42
5	11.28	14.46	25.74	52.11	0.49	5	18.85	0.00	18.85	51.06	0.37
6	30.88	0.00	30.88	46.64	0.66	6	27.64	0.00	27.64	51.51	0.54
7	23.41	2.83	26.24	47.81	0.55	7	14.20	15.60	29.80	45.99	0.65
8	10.76	6.88	17.64	66.67	0.26	8	25.00	0.00	25.00	41.01	0.61
9	28.56	3.63	32.20	55.38	0.58	9	21.71	2.40	24.11	41.75	0.58
10	32.52	0.00	32.52	56.40	0.58	10	16.37	11.88	28.24	48.97	0.58
11	17.16	2.12	19.28	34.14	0.56	11	25.69	10.73	36.41	65.58	0.56
12	19.71	6.52	26.23	55.20	0.48	12	11.78	12.89	24.66	43.47	0.57
13	34.27	0.00	34.27	59.87	0.57	13	25.63	0.00	25.63	56.90	0.45
14	23.54	0.00	23.54	55.11	0.43	14	24.56	16.70	41.26	54.06	0.76
15	32.29	0.00	32.29	57.62	0.56	15	28.52	0.00	28.52	50.12	0.57
16	9.25	6.60	15.85	57.55	0.28	16	18.90	20.03	38.93	55.57	0.70
17	2.92	28.76	31.68	82.40	0.38	17	37.16	0.00	57.19	74.62	0.77
18	30.91	0.00	30.91	53.89	0.57	18	10.72	0.00	10.72	43.03	0.25
19	24.36	3.76	28.11	47.52	0.59	19	27.55	8.56	36.11	61.03	0.59
20	9.66	0.00	9.66	57.13	0.17	20	35.16	8.93	44.08	58.00	0.76
21	21.36	3.36	24.72	57.19	0.43	21	28.62	0.00	28.62	48.47	0.59
22	24.27	0.00	24.27	55.87	0.43	22	24.36	3.76	28.11	47.52	0.59
23	19.22	0.84	20.06	52.32	0.38	23	21.80	0.00	21.80	59.96	0.36
24	23.84	0.00	23.84	56.13	0.42	24	8.07	0.00	8.07	57.66	0.14

Note. ID = File number identification; P=Pointing in seconds; G=Gestures in seconds; P&G=Pointing and Gesture combined; Total = Total duration of period; % = Percent duration of Gestures Overall during period.

Table C2. Percent Duration of Point/Gesture and Gesture Overall during Acquisition 1

Low-Risk Group						High-Risk Group					
ID	P	G	P & G	Total	%	ID	P	G	P & G	Total	%
1	25.1	55.1	80.59	185.50	0.43	1	0.00	0.00	0.00	122.81	0.00
2	26.15	4.88	31.03	149.04	0.21	2	11.91	0.00	11.91	140.65	0.08
3	27.45	17.84	45.29	169.12	0.27	3	19.83	93.85	113.68	139.47	0.82
4	32.06	95.19	127.25	170.54	0.75	4	0.00	32.48	32.48	181.26	0.18
5	0.00	84.77	84.77	178.71	0.47	5	0.64	20.59	21.22	153.50	0.14
6	88.0	0.00	88.0	141.68	0.62	6	1.44	1.60	3.04	160.96	0.02
7	30.97	133.76	164.73	213.50	0.77	7	5.83	116.14	121.97	125.88	0.97
8	5.92	36.2	42.12	189.02	0.20	8	1.91	13.75	15.66	160.83	0.10
9	25.02	61.13	86.15	160.9	0.22	9	1.86	3.48	5.34	155.7	0.03
10	12.60	22.83	35.43	174.7	0.20	10	4.29	0.00	4.29	156.4	0.03
11	12.84	39.02	51.87	182.0	0.28	11	0.00	41.02	41.02	176.2	0.23
12	18.48	43.50	42.48	175.3	0.24	12	0.00	0.00	0.00	129.1	0.00
13	0.00	22.20	22.20	174.3	0.13	13	0.64	0.72	1.36	176.1	0.01
14	9.16	104.13	113.29	175.4	0.65	14	0.00	144.58	144.58	238.8	0.61
15	4.44	154.69	159.13	180.2	0.88	15	35.85	38.80	74.64	181.0	0.41
16	7.81	0.40	8.21	196.5	0.04	16	31.94	81.75	113.69	180.0	0.63
17	0.00	63.16	63.16	227.6	0.28	17	1.24	77.43	78.67	163.6	0.48
18	0.00	112.09	112.09	173.0	0.65	18	4.04	10.70	14.73	109.7	0.13
19	14.02	32.10	46.12	178.4	0.26	19	44.26	1.29	45.55	182.6	0.25
20	1.08	6.29	7.36	177.8	0.04	20	29.95	38.90	68.85	238.4	0.29
21	2.60	27.75	30.35	178.5	0.17	21	11.45	77.05	88.51	185.6	0.48
22	2.80	75.19	77.99	162.0	0.48	22	22.72	4.14	26.87	142.7	0.18
23	19.41	11.94	31.35	179.6	0.17	23	25.05	12.03	37.08	172.0	0.21
24	0.00	0.00	0.00	118.04	0.00	24	7.54	3.75	11.29	182.0	0.6

Note. ID = File number identification; P=Pointing in seconds; G=Gestures in seconds; P&G=Pointing and Gesture combined; Total = Total duration of period; % = Percent duration of Gestures Overall during period.

Table C3. Percent Duration of Point/Gesture and Gesture Overall during Acquisition 2

Low-Risk Group						High-Risk Group					
ID	P	G	P & G	Total	%	ID	P	G	P & G	Total	%
1	14.76	55.49	70.25	140.1	0.50	1	10.67	0.00	10.67	124.8	0.09
2	16.19	5.53	21.72	96.0	0.23	2	3.78	0.00	3.8	102.8	0.04
3	14.07	30.06	44.13	175.7	0.25	3	7.93	97.95	105.9	121.0	0.88
4	3.70	39.47	43.17	182.5	0.24	4	35.70	109.56	145.3	182.0	0.80
5	33.73	100.90	134.62	146.9	0.92	5	2.68	42.60	45.3	125.7	0.36
6	6.78	60.01	66.80	73.6	0.91	6	16.54	27.25	43.8	92.4	0.47
7	0.65	5.85	6.50	183.2	0.04	7	7.66	116.88	124.5	124.5	1.00
8	24.30	42.40	66.70	173.3	0.38	8	0.00	43.39	43.4	141.6	0.31
9	3.48	6.80	10.27	78.0	0.13	9	10.66	4.20	14.9	82.1	0.18
10	8.98	50.99	59.96	177.0	0.34	10	4.22	3.80	4.2	169.4	0.02
11	14.54	128.99	143.53	180.1	0.80	11	3.17	61.72	64.9	139.1	0.47
12	6.28	7.48	13.76	184.6	0.07	12	0.00	0.00	0.0	146.5	0.00
13	11.35	121.77	133.12	185.4	0.72	13	0.00	71.95	71.9	133.9	0.54
14	0.00	106.48	106.48	173.5	0.61	14	0.00	35.76	35.8	52.9	0.68
15	10.67	13.53	24.20	181.5	0.13	15	72.62	52.52	125.1	189.7	0.66
16	0.00	31.69	31.69	184.8	0.17	16	24.95	124.95	149.9	192.2	0.78
17	6.80	99.71	106.50	119.1	0.89	17	0.00	25.05	25.1	66.6	0.17
18	22.18	26.41	48.59	198.6	0.24	18	1.48	20.03	21.5	107.0	0.20
19	0.00	87.92	87.92	179.2	0.49	19	7.33	0.00	7.3	218.1	0.03
20	25.17	26.13	51.30	185.6	0.28	20	3.28	28.97	32.2	68.2	0.47
21	0.00	33.34	33.34	147.0	0.23	21	11.45	77.05	88.5	139.1	0.64
22	0.00	7.44	7.44	138.5	0.05	22	11.45	77.05	88.5	139.1	0.64
23	13.94	0.00	13.94	228.8	0.06	23	2.64	6.67	9.3	219.3	0.04
24	----	----	----	----	----	24	5.52	5.16	10.67	229.6	0.05

Note. ID = File number identification; P=Pointing in seconds; G=Gestures in seconds; P&G=Pointing and Gesture combined; Total = Total duration of period; % = Percent duration of Gestures Overall during period.

Table C4. Percent Duration of Point/Gesture and Gesture Overall during Extinction

Low-Risk Group						High-Risk Group					
ID	P	G	Total	P&G	%	ID	P	G	Total	P& G	%
1	9.79	9.22	51.49	19.01	0.37	1	2.76	0	42.75	2.76	0.06
2	36.11	0.71	47.13	36.82	0.78	2	17.87	0	38.49	17.87	0.46
3	23.85	2.72	59.23	26.57	0.45	3	0	9.3	43.8	9.3	0.21
4	13.32	20.12	54.34	33.44	0.62	4	0	33.3	54.15	33.3	0.61
5	15.55	0	49.2	15.55	0.32	5	0	6.32	43.25	6.32	0.15
6	18.44	18.42	46.99	36.85	0.78	6	6.08	12.9	18.98	59.78	.32
7	0	29.42	62.08	29.42	0.47	7	17.45	21.47	42.24	17.45	0.51
8	1.76	27.99	41.2	29.75	0.72	8	12.56	50.05	50.05	12.56	0.25
9	12.7	0	53.47	12.7	0.24	9	0.0	0.0	64.0	0.0	0.0
10	5.2	9.45	58.23	14.65	0.25	10	2.28	4.74	61.22	7.02	0.11
11	8.61	33.79	64.3	42.4	0.66	11	0.0	0.0	43.53	0.0	0.0
12	1.87	0	49.26	1.87	0.04	12	32.4	0.0	60.2	32.4	0.54
13	10.16	6.44	54.2	16.59	0.31	13	25.64	0	58.9	25.64	0.44
14	0	35.32	42.54	35.32	0.83	14	9.17	14.71	23.88	58.91	0.41
15	9.68	0	55.05	9.68	0.18	15	23.41	7.52	30.92	44.32	0.7
16	14.78	0	65.49	14.78	0.23	16	4.88	5.4	71.24	10.28	0.14
17	26.92	3.93	113.45	30.84	0.27	17	15.56	0	57.07	15.56	0.27
18	0	47.7	54.67	47.7	0.87	18	7.5	9.71	58.85	17.21	0.29
19	2.8	7.91	56.06	10.71	0.19	19	21.73	0	49.18	21.73	0.44
20	0	17.36	49.28	17.36	0.35	20	6.3	7.05	52.52	13.35	0.25
21	16.18	0	43.94	16.18	0.37	21	6.96	3.59	31.55	10.55	0.33
22	10.73	3.87	36.60	14.60	0.3	22	9.98	10.62	56.2	20.6	0.37

Note. ID = File number identification; P=Pointing in seconds; G=Gestures in seconds; P&G=Pointing and Gesture combined; Total = Total duration of period; % = Percent duration of Gestures Overall during period.

Appendix D
Raw Data for Number of Times Caregiver Calls Infant's Name

Table D1. Number of Times Caregiver Calls Infant's Name during Baseline period

Low-Risk Group		High-Risk Group	
ID	Calls	Calls	ID
1	2	3	1
2	1	0	2
3	1	0	3
4	1	5	4
5	1	2	5
6	4	3	6
7	2	2	7
8	2	1	8
9	4	4	9
10	3	12	10
11	2	6	11
12	2	10	12
13	5	1	13
14	7	9	14
15	6	2	15
16	11	1	16
17	1	4	17
18	2	0	18
19	6	4	19
20	0	3	20
21	0	2	21
22	3	2	22
23	1	8	23
24	3	5	24

Note. ID=File Number Identification; Calls=Number of times Caregiver Calls Infant's Name during period.

Table D2. Number of Times Caregiver Calls Infant's Name during Acquisition 1 period

Low-Risk Group		High-Risk Group	
ID	Calls	Calls	ID
1	9	8	1
2	1	8	2
3	5	1	3
4	6	18	4
5	6	2	5
6	2	13	6
7	2	9	7
8	6	16	8
9	6	4	9
10	19	30	10
11	3	2	11
12	20	10	12
13	10	13	13
14	6	20	14
15	22	7	15
16	8	10	16
17	9	12	17
18	21	4	18
19	21	28	19
20	3	9	20
21	11	21	21
22	6	5	22
23	8	13	23
24	7	5	24

Note. ID=File Number Identification; Calls=Number of times Caregiver Calls Infant's Name during period.

Table D3. Number of Times Caregiver Calls Infant's Name during Acquisition 2 period

Low-Risk Group		High-Risk Group	
ID	Calls	Calls	ID
1	3	0	1
2	1	0	2
3	4	1	3
4	8	9	4
5	7	3	5
6	6	2	6
7	1	8	7
8	14	12	8
9	4	0	9
10	5	18	10
11	15	2	11
12	3	3	12
13	8	6	13
14	11	5	14
15	14	6	15
16	0	10	16
17	11	1	17
18	13	0	18
19	5	31	19
20	6	4	20
21	3	21	21
22	3	2	22
23	15	11	23
24	---	---	24

Note. ID=File Number Identification; Calls=Number of times Caregiver Calls Infant's Name during period

Table D4. Number of Times Caregiver Calls Infant's Name during Extinction

Low-Risk		High-Risk	
ID	Calls	Calls	ID
1	5	0	1
2	1	0	2
3	2	1	3
4	2	8	4
5	4	0	5
6	2	4	6
7	2	0	7
8	1	0	8
9	7	1	9
10	1	3	10
11	2	1	11
12	1	3	12
13	6	1	13
14	6	3	14
15	6	7	15
16	3	7	16
17	3	1	17
18	2	7	18
19	4	5	19
20	0	2	20
21	2	6	21
22	0	1	22
23	3	4	23

Note. ID=File Number Identification; Calls=Number of times Caregiver Calls Infant's Name during period.

Appendix E. Raw Data for Infant Visual Attention by Group and Period

Table E1. Percent Duration Infant Looking during Baseline period, **Low-Risk group**

ID	J	M	T	O	% J	% M	% T	% O
1	14.68	19.99	12.61	1.62	30.02	40.88	25.79	3.31
2	24.08	2.72	20.44	6.12	45.14	5.09	38.30	11.47
3	30.91	9.68	8.74	3.64	58.37	18.27	16.50	6.87
4	17.10	1.23	13.22	14.42	37.20	2.67	28.76	31.37
5	17.48	23.11	6.96	4.56	33.54	44.36	13.36	8.75
6	6.44	14.16	23.95	2.08	13.81	30.37	51.37	4.46
7	19.75	4.56	16.60	6.89	41.33	9.53	34.72	14.42
8	14.39	14.04	37.20	0.00	21.93	21.39	56.68	0.00
9	1.28	6.20	44.28	4.64	2.27	10.99	78.52	8.23
10	23.32	5.92	4.74	2.80	63.41	16.09	12.88	7.61
11	11.21	30.87	12.80	0.32	20.31	55.92	23.19	0.58
12	42.34	16.19	1.17	0.16	70.73	27.04	1.96	0.27
13	25.01	6.14	10.23	13.72	45.39	11.14	18.57	24.90
14	45.82	0.00	2.55	8.96	79.94	0.00	4.44	15.62
15	57.56	0.00	0.00	0.00	100.00	0.00	0.00	0.00
16	1.28	24.66	39.55	0.00	1.95	37.66	60.39	0.00
17	8.00	8.10	35.76	2.02	14.84	15.03	66.37	3.76
18	37.72	11.76	8.25	0.65	64.61	20.14	14.14	1.11
19	23.08	9.93	24.12	0.00	40.40	17.38	42.22	0.00
20	27.97	5.01	3.40	13.89	55.64	9.96	6.76	27.64
21	21.49	7.87	22.87	3.63	38.47	14.08	40.95	6.50
22	18.36	25.31	8.65	0.00	35.09	48.37	16.54	0.00
23	45.57	6.96	0.00	3.60	81.20	12.39	0.00	6.41
24	0.13	0.12	0.37	0.00	20.96	19.35	59.67	0.00

Note. J=Joystick, M=Mother, T=Toy; O=Other; % J = Percent Duration of looking at Joystick; % M = Percent Duration of looking at Mother; % T = Percent Duration of looking at Toy; % O = Percent Duration looking at Other.

Table E2. Percent Duration Infant Looking during Baseline period, **High-Risk group**

ID	J	M	T	O	% J	% M	% T	% O
1	11.96	2.52	11.24	2.31	42.66	8.99	40.10	8.25
2	28.17	20.82	2.08	3.21	51.90	8.99	3.83	5.92
3	32.72	0.00	2.16	6.36	79.35	0.00	5.23	15.42
4	8.91	26.65	24.19	5.48	19.38	57.98	52.62	11.91
5	19.80	15.63	15.63	0.00	38.77	30.62	30.61	0.00
6	24.82	1.45	25.25	0.00	48.17	2.81	49.02	0.00
7	18.91	18.19	6.52	2.56	40.95	39.40	14.11	5.54
8	12.97	8.84	17.72	1.51	31.61	21.53	43.18	3.68
9	0.02	0.23	0.03	0.03	0.06	0.74	0.10	0.10
10	44.42	2.40	0.00	2.16	90.70	4.89	0.00	4.41
11	0.37	0.14	0.00	0.03	0.69	0.26	0.00	0.06
12	39.21	1/04	3.24	0.00	90.16	2.39	7.45	0.00
13	22.36	0.00	25.85	8.68	39.31	0.00	45.43	15.26
14	53.17	0.92	0.00	0.00	98.30	1.70	0.00	0.00
15	42.16	0.00	7.96	0.00	84.12	0.00	15.88	0.00
16	28.62	0.00	7.96	0.00	51.51	25.18	21.30	2.01
17	28.62	13.99	11.84	1.12	21.43	27.58	49.24	1.74
18	11.70	15.06	26.88	0.95	25.37	39.43	8.31	26.89
19	10.92	16.96	3.58	11.57	16.89	44.30	3.26	35.56
20	9.16	24.04	1.77	19.30	4.78	14.74	41.74	38.75
21	2.75	8.49	24.04	22.32	23.16	76.84	0.00	0.00
22	11.22	37.24	0.00	0.00	33.65	1.68	64.67	0.00
23	11.54	32.98	13.80	1.63	19.24	55.02	23.02	2.72
24	47.56	5.99	1.76	2.34	82.50	10.40	3.04	4.06

Note. J=Joystick, M=Mother, T=Toy; O=Other; % J = Percent Duration of looking at Joystick; % M = Percent Duration of looking at Mother; % T = Percent Duration of looking at Toy; % O = Percent Duration looking at Other.

Table E3. Percent Duration Infant Looking during Acquisition 1 period, **Low-Risk group**

ID	J	M	T	O	% J	% M	% T	% O
1	59.06	100.39	9.15	16.90	31.84	54.12	4.93	9.11
2	62.01	17.09	53.40	16.55	41.60	11.47	35.83	11.10
3	73.44	31.32	39.94	24.39	43.43	18.52	23.62	14.43
4	47.73	33.47	27.99	54.42	29.17	20.46	17.11	33.26
5	49.63	88.97	39.59	0.52	27.77	49.79	22.15	0.29
6	18.09	52.67	64.32	6.55	12.77	37.19	45.41	4.62
7	37.24	63.76	22.85	89.63	17.45	29.87	10.70	41.98
8	16.85	13.44	97.97	61.08	8.90	7.10	51.75	32.26
9	67.74	2.84	51.77	38.59	42.09	1.77	32.17	23.98
10	32.92	4.71	54.35	82.67	18.85	2.70	31.12	47.33
11	72.18	65.53	9.45	34.83	39.66	36.01	5.19	19.14
12	50.52	52.73	62.05	9.91	28.84	30.09	35.41	5.66
13	117.67	24.66	20.35	11.59	67.52	14.15	11.68	6.65
14	66.65	18.09	17.54	73.07	38.01	10.32	10.00	41.67
15	43.24	4.47	128.19	4.32	23.99	2.48	71.13	2.40
16	76.97	22.94	84.25	12.32	39.18	11.67	42.88	6.27
17	26.55	17.08	139.51	0.00	14.50	9.33	76.18	0.00
18	39.29	29.15	103.38	1.10	22.72	16.86	59.78	0.64
19	35.91	27.87	73.41	41.19	20.13	15.62	41.15	23.09
20	97.97	47.73	26.08	6.00	55.11	26.85	14.67	3.37
21	114.43	10.37	22.66	31.01	77.60	7.03	15.37	21.03
22	51.90	18.30	77.62	11.67	35.11	12.38	52.51	7.89
23	77.43	60.40	19.21	15.74	49.31	38.46	12.23	10.03
24	1	35.59	2.36	41.05	34.79	31.28	2.07	36.08

Note. J=Joystick, M=Mother, T=Toy, O=Other, %J=Percent duration looking at Joystick, %M=Percent duration looking at Mother, %T=Percent duration of looking at Toy, %O=Percent duration of looking at Other.

Table E4. Percent Duration Infant Looking during Acquisition 1 period, **High-Risk group**

ID	J	M	T	O	% J	% M	% T	% O
1	35.59	2.36	41.05	34.79	31.28	2.07	36.08	30.58
2	57.01	98.82	3.81	2.75	35.54	60.36	2.38	1.72
3	50.15	32.58	48.13	8.59	35.96	23.36	34.51	28.48
4	78.54	5.28	51.94	46.59	48.00	3.23	31.75	28.48
5	60.61	29.07	54.08	9.73	39.49	18.94	35.23	6.34
6	68.46	10.95	74.46	7.04	42.55	6.81	46.27	4.37
7	19.70	38.94	60.48	6.71	15.66	30.95	48.06	5.34
8	45.05	19.45	95.06	1.27	28.01	12.09	59.11	0.79
9	110.50	30.02	0.36	14.80	70.98	19.28	0.23	9.51
10	60.45	40.92	39.34	15.62	38.67	26.18	25.17	9.99
11	65.00	48.57	61.79	0.00	37.07	27.70	35.24	0.00
12	73.28	36.74	5.18	13.91	56.75	28.46	4.01	10.77
13	75.61	6.64	42.39	51.43	42.95	3.77	24.07	29.21
14	209.41	11.26	7.44	10.68	87.70	4.72	3.11	4.47
15	96.51	4.11	64.37	16.03	53.32	2.27	35.56	8.85
16	85.61	74.01	19.78	0.00	47.72	41.25	11.02	0.00
17	17.62	89.96	39.63	16.41	10.77	54.98	24.22	10.03
18	8.49	32.74	53.11	15.36	7.74	29.85	48.42	14.00
19	13.31	70.93	62.23	35.15	7.29	38.84	34.62	19.25
20	155.36	4.42	32.18	0.00	65.19	1.86	13.50	19.45
21	18.52	54.30	21.18	46.37	19.70	57.77	22.54	97.46
22	38.69	19.70	95.12	91.60	25.20	12.84	61.96	0.00
23	6.72	92.65	67.27	0.00	4.03	55.60	40.37	3.24
24	121.49	16.30	37.22	5.40	69.42	9.31	21.27	0.00

Note. J=Joystick, M=Mother, T=Toy, O=Other, %J=Percent duration of looking at Joystick, %M=Percent duration of looking at Mother, %T=Percent duration of looking at Toy, %O=Percent duration of looking at Other.

Table E5. Percent Duration Infant Looking during Acquisition 2 period, **Low-Risk group**

ID	J	M	T	O	% J	% M	% T	% O
1	33.35	82.70	7.52	13.29	24.37	60.43	5.49	9.71
2	21.83	15.86	38.41	8.48	25.80	18.75	45.41	10.03
3	57.38	79.66	25.87	11.47	32.91	45.68	14.84	6.58
4	79.14	59.94	22.63	20.72	43.38	32.86	12.40	11.36
5	27.50	57.11	42.43	20.71	18.62	38.65	28.71	14.02
6	3.55	19.70	12.27	38.12	4.82	26.75	16.66	51.76
7	6.22	7.45	130.72	38.85	3.40	4.06	71.34	21.20
8	89.91	0.92	59.93	22.60	51.87	0.53	34.57	13.03
9	4.92	6.88	16.27	49.92	6.31	8.82	20.86	64.02
10	32.36	83.86	23.37	37.43	18.28	47.37	13.20	21.14
11	25.77	61.49	77.60	14.91	14.34	34.20	43.16	8.29
12	152.12	20.33	12.53	49.51	64.87	8.67	5.34	21.12
13	93.01	37.34	14.12	40.95	50.16	20.14	7.61	22.08
14	57.00	6.10	72.11	6.35	40.26	4.31	50.94	4.48
15	10.29	158.69	2.31	10.27	5.67	87.40	1.27	5.66
16	37.13	29.42	106.18	12.08	20.09	15.92	57.45	6.54
17	0.24	0.22	0.29	0.24	8.78	32.73	47.96	10.53
18	17.44	65.00	95.24	20.92	21.75	14.33	39.31	24.61
19	38.96	25.67	70.42	44.09	41.77	16.21	27.66	14.35
20	77.49	30.08	51.32	26.62	22.63	4.20	57.58	15.59
21	33.27	6.17	84.65	22.92	19.73	53.04	9.55	17.68
22	27.32	73.43	13.22	24.47	35.82	10.03	34.73	19.42
23	81.93	22.95	79.44	44.43	26.16	26.60	29.37	17.87
24	11.34	39.26	51.21	17.26	9.52	32.97	43.01	14.50

Note. J=Joystick, M=Mother, T=Toy; O=Other; % J = Percent Duration of looking at Joystick; % M = Percent Duration of looking at Mother; % T = Percent Duration of looking at Toy; % O = Percent Duration looking at Other.

Table E6. Percent Duration Infant Looking during Acquisition 2 period, **High-Risk group**

ID	J	M	T	O	% J	% M	% T	% O
1	73.95	0.00	44.55	0.97	61.90	0.00	37.29	0.81
2	61.22	55.99	13.32	9.28	43.79	40.05	9.53	6.63
3	104.53	19.47	6.64	12.83	72.86	13.57	4.63	8.94
4	49.24	44.66	76.99	11.24	27.04	24.52	42.27	6.17
5	37.02	51.73	35.51	36.72	23.00	32.13	22.06	22.81
6	18.77	80.61	12.68	12.17	15.11	64.89	10.20	9.79
7	26.87	33.94	55.82	7.87	21.58	27.26	44.83	6.32
8	23.69	11.00	106.85	27.48	14.02	6.51	63.22	16.26
9	0.00	45.99	11.41	20.90	0.00	58.73	14.57	26.70
10	75.84	8.20	65.67	7.72	48.17	5.21	41.72	4.90
11	60.94	27.77	75.11	18.14	33.49	15.26	41.28	9.97
12	93.38	18.10	29.08	0.60	67.31	12.39	19.89	0.41
13	97.08	6.52	47.84	32.09	52.90	3.55	26.07	17.48
14	18.80	9.04	24.13	8.66	31.00	14.91	39.80	14.29
15	89.12	16.96	47.90	33.95	47.42	9.03	25.49	18.07
16	91.33	81.78	6.18	3.05	50.09	44.85	3.39	1.67
17	7.41	27.52	15.59	7.16	12.84	47.72	27.04	12.41
18	9.40	31.37	28.11	23.62	10.16	33.91	30.39	25.53
19	65.01	46.38	53.95	20.25	35.03	24.99	29.07	10.91
20	27.46	0.00	7.37	25.64	45.41	0.00	12.19	42.40
21	18.52	54.30	21.18	91.60	9.98	29.25	11.41	49.36
22	35.88	26.20	36.79	0.00	36.29	26.50	37.21	0.00
23	103.83	30.84	41.19	6.72	56.87	16.89	22.56	3.68
24	104.12	15.17	32.37	34.59	35.49	24.01	26.79	13.72

Note. J=Joystick, M=Mother, T=Toy; O=Other; % J = Percent Duration of looking at Joystick; % M = Percent Duration of looking at Mother; % T = Percent Duration of looking at Toy; % O = Percent Duration looking at Other.

Table E7. Percent Duration of Data for Duration of Infant Looking during Extinction period, **Low-Risk group**

ID	J	M	T	O	% J	% M	% T	% O
1	31.82	11.24	3.64	4.80	61.79	21.83	7.06	9.32
2	24.50	7.17	3.20	12.26	51.98	15.22	6.79	26.01
3	40.56	2.60	11.63	4.44	68.48	4.39	19.64	7.49
4	6.68	31.31	13.96	2.40	12.29	57.61	25.69	4.41
5	17.80	10.22	13.56	7.62	36.18	20.77	27.56	15.49
6	10.44	9.75	16.33	10.47	22.22	20.75	34.75	22.29
7	16.00	0.00	30.62	15.47	25.77	0.00	49.32	24.92
8	14.45	0.00	26.76	0.00	35.06	0.00	64.94	0.00
9	8.24	12.36	2.52	30.36	15.41	23.11	4.71	56.77
10	12.72	33.07	1.21	11.24	21.84	56.79	2.08	19.29
11	12.64	26.72	8.26	10.99	21.56	45.59	14.09	18.76
12	40.34	0.12	0.00	8.80	81.89	0.24	0.00	17.86
13	26.46	10.73	3.81	13.20	48.82	19.80	7.03	24.35
14	41.30	1.24	0.00	0.00	97.09	2.91	0.00	0.00
15	12.71	39.92	0.00	2.43	23.09	72.49	0.00	4.42
16	23.47	3.82	31.92	2.40	38.09	6.20	51.81	3.90
17	0.12	0.17	0.00	0.35	35.10	49.59	12.74	2.57
18	31.64	37.36	12.62	27.54	28.98	34.23	11.56	25.23
19	35.64	5.00	12.05	1.97	65.21	9.14	22.05	3.60
20	32.98	3.61	1.45	18.01	58.84	6.45	2.59	32.13
21	45.99	1.74	0.00	1.54	93.34	3.54	0.00	3.12
22	30.82	7.82	0.00	5.29	70.17	17.80	0.00	12.03
23	19.03	5.68	18.10	5.13	39.69	11.84	37.76	10.71
24	19.91	28.13	7.23	1.46	0.35	0.50	0.13	0.03

Note. J=Joystick, M=Mother, T=Toy; O=Other; % J = Percent Duration of looking at Joystick; % M = Percent Duration of looking at Mother; % T = Percent Duration of looking at Toy; % O = Percent Duration looking at Other.

Table E8. Percent Duration of Data for Duration of Infant Looking during Extinction period, **High-Risk group**

ID	J	M	T	O	% J	% M	% T	% O
1	29.65	8.28	2.71	2.11	69.35	19.37	6.34	4.94
2	28.17	20.82	2.08	3.21	51.90	38.35	3.83	5.92
3	31.55	3.04	0.00	9.23	72.00	6.94	0.00	21.06
4	21.32	8.31	6.60	17.92	39.00	15.00	12.00	33.00
5	19.64	0.00	16.50	7.11	45.42	0.00	38.14	16.44
6	17.02	22.83	2.24	3.96	36.96	49.59	4.86	8.60
7	12.90	15.76	7.66	5.93	30.53	37.30	18.13	14.04
8	27.03	0.00	19.77	4.23	52.97	0.00	38.74	8.28
9	9.60	22.56	0.00	13.85	20.87	49.03	0.00	30.10
10	31.42	14.64	6.84	8.33	51.31	23.91	11.17	13.60
11	39.75	0.24	3.53	0.00	91.33	0.56	8.10	0.00
12	21.12	0.00	21.82	17.07	35.19	0.00	36.37	28.44
13	53.04	0.00	4.20	1.67	90.03	0.00	7.13	2.84
14	33.02	5.52	6.77	13.60	56.05	9.37	11.49	23.08
15	0.00	23.20	12.18	8.94	0.00	52.35	27.49	20.16
16	24.60	17.17	5.68	23.78	34.53	24.11	7.97	33.38
17	29.66	22.12	0.75	4.00	52.47	39.13	1.32	7.08
18	19.89	0.00	25.17	12.61	34.48	0.00	43.65	21.87
19	5.84	22.35	8.05	12.94	11.87	45.45	16.37	26.32
20	29.55	4.09	17.29	1.58	56.27	7.79	32.92	3.01
21	34.06	17.05	5.11	0.00	60.58	30.32	9.10	0.00
22	41.69	9.69	5.86	0.00	72.84	16.93	10.24	0.00

Note. J=Joystick, M=Mother, T=Toy; O=Other; % J = Percent Duration of looking at Joystick; % M = Percent Duration of looking at Mother; % T = Percent Duration of looking at Toy; % O = Percent Duration looking at Other.