# THE SMILING BEHAVIOR OF INFANTS AT HIGH- AND LOW-RISK FOR AUTISM, THEIR MOTHERS, AND AN UNFAMILIAR ADULT: THE EFFECTS OF INTERACTION TASK, INFANT RISK-STATUS, AND INFANT AGE

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The infant siblings of individuals with autism spectrum disorders (ASD) are at risk for atypical development of affective reciprocity. Early affective atypicality may become most apparent through the comprehensive study of these high-risk infants' emotional expressions, the affective expressions of interacting adults, and changes in this expressivity as a result of development and interactive context. The current study examined the interactive smiling behavior of 6- and 11-month-old infants with (high-risk) and without (low-risk) a sibling with ASD, their mothers and an unfamiliar adult blind to risk status. Smiling was measured across two adult-infant interaction contexts, a non-specific (NS) interaction and peek-a-boo (PAB). During interaction with their mothers 6- and 11-month-old low-risk (LR) infants demonstrated significantly more smiling during PAB than a NS interaction. In contrast, high-risk (HR) infants showed delayed development of affective reciprocity, not showing an increase in smiling during PAB until 11 months of age. During interaction with an unfamiliar adult HR and LR infants performed similarly at 6 and 11 months of age. An investigation of mothers' smiling demonstrated that mothers of HR 6- and 11-month-old infants smile significantly less than mothers of LR infants, while also smiling significantly more high intensity smiles than mothers of LR infants. The smiling behavior of the unfamiliar adult was not significantly affected by infant risk-status or age, but by interaction type alone; with more smiling and more high intensity smiles occurring during PAB than a NS interaction.

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# PREFACE

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# 1.0 INTRODUCTION

Autism spectrum disorders (ASDs) are characterized by a triad of symptomatology: impaired reciprocal social interaction skills, impaired communication abilities, and the presence of stereotyped behavior, interests, and activities (American Psychiatric Association, 2000). Patterns of behavior that characterize children with an autism spectrum disorder are clearly deviant relative to their mental age, are evident in the first years of life, and greatly impair functioning throughout the life course. While level of communicative impairment and presence of restricted/repetitive behavior and interests are variable features of the ASD diagnosis, impairment in social functioning is core and consistent across diagnoses that fall within the autism spectrum (Carter, 2005).

For an individual to receive a diagnosis of an autism spectrum disorder they must have observable, qualitative impairments in reciprocal social interaction abilities that manifest in the following ways: marked impairments in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body posture, and gestures to regulate social interaction; failure to develop peer relationships appropriate to developmental level; lack of social or emotional reciprocity; a lack of spontaneous seeking to share enjoyment, interests, or achievement with other people (e.g. by a lacking of showing, bringing, or pointing out objects of interest; DSM-IV-TR, 2000). Individuals with different diagnoses along the autism spectrum (i.e., autism, pervasive developmental disorder – not otherwise specified, and Asperger syndrome) look very different in terms of age of symptom onset, severity of cognitive impairment, age of onset and degree of communication difficulties, and presence of stereotypic behavior or circumscribed interests (DSM-IV-TR, 2000; Klin, McPartland, & Volkmar, 2005), however, all individuals with autism spectrum disorders display these common and core deficits in the social domain (Carter et al., 2005).

## 1.1 LIFE-LONG SOCIAL IMPAIRMENT IN ASD AND ITS IMPLICATIONS

Because the social impairment characteristics of autism are life-long (Carter, 2005), those interested in the early development and identification of children with autism spectrum disorders have studied some of the earliest emerging social behaviors (Chawarska et al., 2008). Young children with autism spectrum disorders can be differentiated from their typically developing and developmentally delayed peers in these areas of general social development. Research has demonstrated that typically developing infants show preferential attention to the human face (Haith, Bergman, & Moore, 1979; Olson & Sherman, 1983; Spitz, 1965; Johnson et al., 1991), spend a lot of time in mutual gaze with their caregivers (Trevarthen, 2005; Trevarthen, 1977; Trevarthen, 1979), and have a preference for the human voice (Alegria & Noiroy, 1978; DeCasper & Fifer, 1980). In contrast, retrospective studies utilizing parent report suggest children with autism have less interest in the human face (Volkmar, 1987b) and do not share eye-gaze in this typical manner (Volkmar & Mayes, 1990; Volkmar et al., 1986). Additionally, toddlers with autism do not seem to show a preference for speech like sounds (Klin, 1991; Osterling & Dawson, 1994). In late infancy and early toddlerhood typically developing children begin to share attention with another person about objects or events (joint attention; Bruner, 1983; Hannan, 1987; Hannan & Fogel, 1987; Tomasello & Carpenter, 2007), reliably imitate the actions of another (Werner & Kaplan, 1963), and develop play skills (e.g. spatial exploration of objects, functional and symbolic play; Singer, 1996; Piaget, 1951). Retrospective studies, which reviewed early home videos of those later diagnosed with an autism spectrum disorder, concluded that these infants and toddlers engaged in fewer joint attention behaviors (e.g. pointing, showing objects, looking at others) than their developmentally delayed and typically developing peers (Osterling & Dawson, 1994; Osterling et al., 2002). At this young age children with ASD also show deficits in spontaneously and elicited imitation (Dawson & Adams, 1984, Meltzoff & Gopnik, 1993; Charman et al., 1994; Stone et al., 1990) and have observable deficits in functional and symbolic play (Sigman & Ungerer, 1984b; Stone et al., 1990).

The social development of individuals with autism spectrum disorders becomes derailed in the early years of life and this has implications for later reciprocal social interaction abilities. School-age children, adolescents, and adults have continued trouble with social interaction including decreased eye-contact and nonverbal social communication, a lack of age-appropriate play skills, and impaired ability to take part in social interchange (Carter, 2005). Trouble with basic social skills becomes more significant and apparent as children with ASD begin interacting with peers, peers who are often less forgiving of social irregularity than adults (Little, 2002). As children grow older the social and prosocial skills needed to successfully develop relationships, specifically peer relationships, become more complex (Gifford-Smith & Brownell, 2002; Saarni et al., 2006). Foundational social interaction skills (e.g. eye-contact, nonverbal communication skills) which help typically developing children, adolescents, and adults navigate social situations successfully

(Spence, 2002) are impaired in older individuals with ASD (Harris, 1998). As a result, children and adolescents with these disorders move into ever more complicated social scenarios with few skills to fall back on.

Evidence of the compounding effects of these early social deficits is that children, adolescence, and adults with ASD have a very difficult time utilizing appropriate social overtures and conventions (Carter, 2005; Chawarska, Klin, & Volkmar, 2008). These difficulties, along with less overall interest in peers (Koning & Magill-Evans, 2001; Le Couteur et al., 1989; Orsmond et al., 2004), make the development of peer relationships especially challenging for individuals with autism. It has been shown that older children with ASD fail to engage in social exchanges with peers, lack cooperative play, and approach peers far more infrequently than their typically developing peers (Koning & Magill-Evans, 2001; Le Couteur et al., 1989). Trouble making friends and understanding the central features of friendship (Lord et al, 1994) often causes older individuals with ASD to report greater feelings of loneliness than their typically developing peers (Bauminger, Shulman, & Agam, 2003; Bauminger & Kasari, 2001). Clearly, the social impairments of individuals with autism spectrum disorders are far-reaching, debilitating, and pervade many areas and stages of social development.

## 1.2 A SPECIFIC FOCUS ON AFFECTIVE DEVELOPMENT IN ASD

Although there are a range of social deficits in ASD, deficits in emotional development have received a great deal of attention in the autism literature for decades. There are two main reasons why autism researchers have focused on the development of emotion in ASD. First, researchers investigating the *typical* development of affect recognize that social development and affective development are inextricably linked (Hobson, 2005; Saarni, 2006). The appropriate understanding, perception, and expression of emotional cues are essential to fluid social interactions. Acknowledging the intertwined nature of these two areas of development it is not surprising that, along with general social impairments in autism spectrum disorders, researchers and clinicians have observed specific impairments in affective expression and understanding. A second reason researchers studying ASD have focused on emotional development is that aberrant affect was documented in the earliest description of autism. In Kanner's original writings (1943) he identified affective development as being an area of social development that was strikingly deviant in children with autism. Kanner stated that social dysfunction is the predominant area of impairment for those with autism, but more specifically he documented marked "disturbances of affective contact" (p. 242). Kanner was struck by the difficulties these children had in making appropriate affective initiations and responses in social-emotional interactions. He believed that " . . . further study . . . may help to furnish concrete criteria regarding the still diffuse notions about the constitutional components of emotional reactivity [in these children]." (p. 250). Since Kanner published his observations, clinicians and researchers have continued to observe, explore, and more specifically define the affective atypicalities in individuals with autism spectrum disorders.

### 1.2.1 Typical Affective Development

Our understanding of the typical developmental course of emotion has assisted in our understanding of the atypical development of emotion in ASD. As our knowledge of the typical course of affective development has expanded (Campos, Barrett, Lamb, Goldsmith, & Sternberg, 1983; Saarni, Campos, Camras, & Witherington, 2006) researchers have been able to make specific hypotheses as to how and when affective development may go awry in children with ASD. It is clear that many of the foundational aspects of affect typically develop during infancy. Early developing abilities to perceive and recognize the emotional cues of others and to express one's own emotional states begin in infancy (Leppanen & Nelson, 2009). These abilities serve as a foundation for the later development of more complex affective, social abilities (Saarni, 2006).

Researchers have documented several early "milestones" characteristic of the typical development of affect, milestones now assumed to be important to later understanding and appropriate expression of emotion. Initial experience with affective states has been hypothesized to occur as a part of infant-caregiver interaction. Infants younger than three months engage in synchronous interchange with their caregiver. More specifically, contingencies have been observed in the timing of emotion responses between infant and caregiver during bouts of face-to-face interaction. The infant's emotional state spurs a caregiver emotional response and visa versa (Cohn & Tronick, 1988; Feldman, Greenbaum, & Yirmiya, 1999; Field, Healy, Goldstein, & Guthertz, 1990; Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001; Moore & Calkins, 2004). Some researchers have concluded from these observations that infants have an initial ability to perceive the caregiver's affective state, perceive when the caregiver's emotional response is directed toward them, and to align their affective state with what is observed in their caregiver (i.e. affective "matching"; Feldman et al., 1999; Tronick & Cohn, 1989; Weinberg, Tronick, Cohn, & Olson, 1999). Many researchers believe that this synchronous interaction is evidence of direct, unmediated, and rapid communication of affective state between the infant and their interactive partner. This behavior is thought to demonstrate communication of affective state between mother and infant before the infant is able to verbally communicate his or her feelings (Haviland & Lelwica, 1987; Stern, 1985; Trevarthen & Hubley, 1978). Researchers have also suggested that this interactional synchrony may contribute to development of emotion regulation (Feldman, 1999; Moore, Cohn, & Campbell, 2001).

There is further evidence, beyond what can be inferred from the evidence of infant-caregiver interactional synchrony, that typically developing infants are able to perceive differences in emotional states. By four months infants have a preference for certain emotional expressions over others. Infants at this age visually fixate on smiling faces more than non-smiling faces (La Barera, Izard, Vietze, & Parisi, 1976; Young-Browne, Rosenfeld, & Horowitz, 1977). Similarly, D'Entremont and Muir (1999) found that five-month-old-infants smile more at happy facial expressions than sad facial expressions. Experimental data also suggests that from infancy typically developing children perceive differences in emotional valence in more than one modality. In addition to responding to affective visual stimuli, six-month-old infants respond differentially to the emotional valence of vocal stimuli (Fernald, 1993) and infants show a preference for concordant, not disconcordant, facial and auditory expressions of emotion (Soken & Pick, 1999). By seven months infants viewing static images of facial expressions discriminate happy expressions from expressions of sadness, anger, surprise, and fear and can differentiate angry, fearful, and sad facial expressions (Kestenbaum & Nelson, 1990, Ludemann & Nelson, 1988; Oster & Ewy, 1980; Schwartz, Izard, & Ansel, 1985). Seven-month-old infants not only distinguish between facial expressions displaying different basic emotions, they have been shown to discriminate variations of emotion within the same emotional tone – positive and negative. Soken and Pick (1999) found infants at this age demonstrated differentiation among specific, dynamic positive (e.g. happy, interested) facial expressions and negative (e.g. sad, angry) facial expressions of emotion.

Using the Face-to-Face Still-Face (FFSF) interaction paradigm, researchers have further demonstrated the infant's ability to perceive different and multimodal emotional expression. During the still-face paradigm caregivers are instructed to begin an interactional sequence with their infant as they normally would during face-to-face interaction (e.g. by smiling and speaking warmly). After a short period caregivers are instructed to stop this typical dyadic interaction pattern and remain silent, directing a neutral, still facial expression toward the infant (Tronick et al., 1978). Typically developing infants, as young as two months of age, find this disruption of the typical, contingent, affective infant-caregiver exchange to be extremely distressing (Striano &

Bertin, 2004). It has been found that if a caregiver exudes a smiling facial expression during the still-face period of the procedure, as opposed to a neutral or sad facial expression, two-month-old infants do not become as distressed (Rochat, Striano, & Blatt, 2002). This finding is taken as evidence that typically developing infants are able to perceive differences in facial expressions of emotion and that the infant's affinity for happy facial expressions can help them overcome the negative emotional impact of the contingency disruption that takes place during the FFSF paradigm (Rochat, Striano, Blatt, 2002). It appears that the positive emotional expression of another help to regulate the infant's emotional reaction in a stressful circumstance.

The typical development of emotion and emotion regulation becomes more refined as infants begin to combine their developing affective and attentional abilities by way of affective sharing and referential communication of emotion. By seven months, infants deliberately target their emotional expressions. Sternberg and Campos (1990) found that infants, whose hands had been restrained, directed their negative expressions and reactions toward their mother. This directed affective expression can be considered evidence of early, intentional communication of mood state. At nine months, infants continue to share and communicate emotion, but do so more effectively as a result of developments in attentional abilities. For example, infants begin to engage in referential communication with their caregiver, that is, they begin to follow the directed attention of the caregiver toward an object in the environment (Bakeman & Adamson, 1984; Campos et al., 2000). This shared attention allows for the development of more complex and efficient means of affective communication and sharing. At this early stage, the emotional expression that a caregiver directs toward an object in the environment can augment an infant's behavioral response. Mumme and colleagues (1996) found that an infant's response to a toy was altered by the affective facial expression that an adult directed toward the toy. Similarly, Boccia and Campos (1989) found that an infant's behavioral response to a stranger was affected by the emotional expression with which the mother greeted the stranger (e.g., pleasant, cheery facial expression versus a stern facial expression).

As infants get older, the precision with which they communicate affective information continues to increase. At around one year children begin to understand the exact referent of a caregiver's emotional expression (Herenstein & Campos, 2004; Moses et al., 2001; Mumme & Fernald, 2003; Phillips et al., 2002; Rapacholi et al., 1998), in other words they develop referential specificity. A task that has been used repeatedly to demonstrate these developing abilities is the "visual cliff" task (Campos, Bertenthal, Kermoian, 1992; Campos, Hiatt, Ramsay, Henderson, & Svejda, 1978). In this task infants are placed on one end of a surface and caregivers are asked to stand on the other. The mothers encourage their infants to crawl in their direction, however, before the infants reach their mother the surface the infants are crawling on appears to drop off. In actuality, the infants are crawling on a clear plastic surface and the drop is a visual illusion. Twelve-month-old infants augment their behavior, either passing over the cliff or not, depending on their mother's emotional expression (e.g., happiness, interest, fear, sadness, or anger). In these experiments the mother communicates affectively about a specific object in the environment, the visual cliff (Sorce, Emde, Campos, & Klinnert, 1985). The twelve month olds' behavioral response, contingent on the mother's emotional expression, provides evidence that the infant understands what the mother is making affective reference to and how to augment their behavior based on their mother's expression.

### 1.2.2 Affective Development in ASD

Although there is much evidence that affective development typically begins in infancy *and* that impairment in socio-emotional reciprocity characteristic of ASD begins in the first years of life, most studies of affective development in ASD have been conducted with older children and adults. Studies of older individuals with ASD have helped clarify the behavioral phenotype of affective impairment, explored underlying abnormalities in processing or perception of emotional cues, and helped delineate abnormalities in brain areas associated with the processing of emotional stimuli. Data from these areas of research converge, supporting the hypothesis that school-age children, adolescents, and adults with ASD experience atypical emotional development.

The observable affective atypicalities of older individuals with autism are reasonably well established (Kanner, 1943; Rutter, 1978; Wing, 1985; Wing, 1979; American Psychiatric Association, 1980; American Psychiatric Association, 1987; American Psychiatric Association, 1994; American Psychiatric Association, 2000). Kanner described these affective atypicalities in his book, *Autistic Disturbances of Affective Contact*. Wing's *Autistic Disorders Checklist in Children*, included items capturing the social inappropriateness of these children's affective exchanges. Examples of such items include: "shows distress but no seeking comfort", "ignores others' existence, feelings", and "indifferent to or laughs at distress" (Wing, 1985). More recent diagnostic systems continue to include characteristics relating to disturbances of affect, such as "lack of . . . emotional reciprocity" and "impairments in the use of . . . facial expressions . . . to regulate social interaction" as defining criteria for ASD (American Psychiatric Association, 2000). Characteristics such as these delineate the behavioral phenotype of affective impairment in older individuals with ASD.

Along with the precise definition of observable affective impairments researchers have utilized behavioral and neuroimaging studies to document how older individuals with autism atypically attend to, perceive, and process emotional cues. Research has shown that older individuals with ASD are more likely than typically developing and mentally retarded peers to group photographs of faces based on non-emotional features (e.g., presence of hats) than emotional features (e.g., emotional facial expression; Jennings, 1973). There is also a large amount of empirical evidence that individuals with ASD have difficulty recognizing body postures that may be emotional or non-emotional (Moore, Hobson, & Lee, 1997; Blake, Turner, Smoski, Pozdol, Stone, 2003; Hubert, Wicker, Moore, Manfardini, Duverger, Fonseca, & Deruelle, 2007) and display impairment in the coordinated processing of different modes of emotional expression (e.g., determining the facial expression, gestural/full body expression, vocal expression, and situation that are indicative of a particular emotion; Hobson, 1986a, 1986b). Individuals with ASD also have difficulty discriminating (Weeks & Hobson, 1987) and identifying (Capps, Yirimiya, & Sigman, 1992; Celani, Battachi, & Arcidiacono, 1999; de Gelder, Vroomen, & van der Heide, 1991; Loveland et al., 1997; Ozonoff et al., 1990) different facial expressions, and process facial expression of emotion in an atypical manner (e.g., using "non-emotional" face cues to process facial expressions of emotion; Hobson et al., 1989). Utilizing recent technological advances, such as infrared eye-tracking technology, researchers have shown that adolescent and adults with ASD visually scan faces and facial expressions differently than their peers (Klin, Jones, Schultz, Volkmar, Cohen, 2002; Pelphrey, Sasson, Reznick, Paul, Goldman, & Piven, 2002). Utilizing neuroimaging techniques, such as functional magnetic resonance imaging (fMRI), researchers have demonstrated that older individuals with ASD show different patterns and levels of activation in brain regions used by typically developing individuals to process socio-emotional stimuli (e.g. facial expressions; Pelphrey et al., 2007; Critchley et al., 2000; Schultz et al., 2000; Pierce et al., 2001; Hubl et al., 2003; Pierce et al., 2004; Piggot et al., 2004; Wang et al., 2004; Dalton et al., 2005; Castelli et al., 2002; Baron-Cohen et al., 1999; Ogai et al., 2003).

### 1.2.3 Studies of Early Affective Development in ASD

There is ample research evidence documenting atypical affective development in older individuals with ASD, however, there is far less research describing potential affective deficits of ASD in the first years of life. Researchers are still at the early stages of defining the characteristic features of ASD in infancy. Attempting to document the very early social, and specifically affective, difficulties of infants who later receive a diagnosis of ASD researchers have used retrospective analysis of home videotapes (Osterling & Dawson, 1994; Baranek, 1999; Adrien et al, 1992, 1993; Joseph et al., 1997; Werner et al., 2000) and prospective methods (Zwaigenbaum et al., 2005; Yirmiya et al., 2006; Merin et al., 2007; Cassel et al., 2007; Rogers, 2009; Young et al., 2009). Unfortunately, studies published to date, both retrospective and prospective, provide an inconsistent picture of the early affective development of infants who later develop an autism spectrum disorder.

While retrospective studies of children with ASD have helped specify important future directions for research, questionable methodology and conflicting findings make their validity and utility doubtful. Researchers utilizing this methodology analyzed early home videotapes of children who were later diagnosed with ASD. Analysis of videotaped infant behavior was completed across non-standard contexts making each infant participant's behavior hard to compare. Also, the quality of the videotapes and their ability to capture emotional expression could not be controlled as the videos were not recorded with specific research questions in mind. It is not surprising, therefore, that studies based on this methodology report conflicting findings. Some studies documented that infants later diagnosed with ASD exhibited deviant emotional reciprocity (Adrien et al., 1992, 1993; Joseph et al., 1997; Werner et al., 2000), whereas others did not (Osterling & Dawson, 1994; Baranek, 1999). Conflicting findings and questionable methodology have left researchers questioning the true state of early emotional development in ASD.

Recently, with the advent of the prospective infant-sibling methodology, researchers have been able to correct the flaws of retrospective studies and have the opportunity to clarify the presence of affective atypicality in infants later diagnosed with ASD. The prospective study of the infant siblings of children diagnosed with an ASD (high-risk infants), takes advantage of our current knowledge of the heritability of ASD (recurrence risk in siblings estimated to be as high as 25 percent; Landa & Garrett-Mayer, 2006) and promises to provide the field with a wealth of information about the early impairments of those later diagnosed with an autism spectrum disorder. Researchers are also interested in using this methodology to define the broader autism phenotype (Piven et al, 1997b), the subclinical features of autism that are prevalent in the first-degree relatives of those with ASD (Piven, 1999; Bailey, Phillips, & Rutter, 1996; Landa et al, 1992; Narayan, Moyes, & Wolff, 1990), and other general developmental delays that have been shown to be more prevalent in the relatives of those with ASD (Piven, 1994; Bolton et al., 1994; Iverson & Wozniak, 2007). Using this method researchers have begun to compare infants at high-risk (HR) for developing an autism spectrum disorder to infants with no family history of ASD, and thus at low-risk (LR) for developing ASD. Published research using this methodology to study affect in HR and LR siblings is sparse. To date only a few studies have documented the early emotional development of these infants.

Currently there are only four published studies that have compared the affective expressivity of high-risk and low-risk infants (Yirmiya et al., 2006; Cassel et al., 2007; Merin et al., 2007, Young et al., 2009). All of these studies used a similar methodology; all studies compared high and low risk infants' facial expressions of emotion during face-to-face interaction with their primary caregiver. Each study coded infant's facial expressions of emotion globally, assessing the proportion of the total face-to-face interaction episode that the infant spent in positive emotional expression (i.e. smiling), negative emotional expression (i.e. crying and fussing), and neutral facial expressions (i.e. not smiling or crying). In addition to this similar coding system, all of these studies measured the infant facial expressions that occurred during to the same, standardized face-to-face interaction sequence – the Face-to-Face Still Face paradigm (FFSF; Tronick, Als, & Brazelton, 1978). Despite these similarities in methodology, the authors report conflicting findings.

Yirmiya and colleagues (2006) and Cassel and colleagues (2007) report a difference in the affective responsivity of HR and LR infants, whereas Merin and colleagues (2007) and Young and colleagues (2009) do not. Yirmiya et al. (2006) conducted the FFSF paradigm with four-month-old high- and low-risk infants. The authors found two significant differences between HR and LR infants: HR infants displayed significantly less negative affect during the still face phase of the paradigm and showed more neutral affect during the entire FFSF procedure. Therefore, compared to LR infants, HR infants displayed less variation in expressed emotion and seemed to demonstrate a flattened, muted affective profile. Cassel and colleagues (2007) also conducted the FFSF procedure and found that compared to six-month-old LR infants, six-month-old HR infants displayed less smiling behavior during the initial face-to-face phase and reunion phase of the paradigm. Again, these results suggest that in comparison to LR infants, HR infants display more blunted, neutral affect during social interaction. In contrast to studies by Yirmiya et al. (2006) and Cassel et al. (2007), Merin and colleagues (2007) and Young and colleagues (2009) report no difference in the positive, negative, and neutral facial expressions displayed by six-month-old high and low risk infant siblings during the FFSF paradigm. This null finding could be the result of study methodology (i.e. using an unnatural, closed circuit TV system to conduct the FFSF paradigm) or could truly reflect lack of observable socio-emotional impairment in this group of HR infants (only 25 percent of all HR infant siblings are expected to display autistic symptomatology).

The above studies provide clues as to how affective development may be impaired in infants at risk for ASD, while also providing a basis for future, more fine-grained research. Thus far, researchers have documented HR and LR infant's emotional responsivity during face-to-face interaction in a global way, coding the valence of emotional expression (e.g. positive, negative, or neutral expressions). While using such a method is a logical first step in determining differences between high and low risk infant's affective expressivity, it is now clear that a more detailed and comprehensive measure of HR and LR infants' facial expressions may be necessary to produce more robust and reliable findings. Coding only total amount of affect (positive, negative, and neutral) does not appear to be enough to distinguish these infant groups, but significant difference may become more evident when the quality, or intensity, of infant's expressed affect is examined. Results of studies by Yirmiya et al. (2006) and Cassel et al. (2007) tentatively suggests that HR infants display more neutral, less extreme positive and negative emotional expressions during face-to-face interaction, and therefore provide support for a more comprehensive analysis of this kind.

Support for conducting a fine-grained analysis of the intensity of these infants' expressed affect also comes from literature describing the affective expressivity of typical infants. There is evidence that typically developing infants not only communicate through valence of expressed emotion, but also through varying the *intensity* of the affect expressed (Messinger & Fogel, 2007). Researchers have recently begun to assert that typically developing infants' social smiles represent varying degrees of infant expressions of joy which are qualitatively different and reflect different intensities of emotion (Messinger et al., 2005; Messinger & Fogel, 2007). During face-to-face interaction typical infant smiles include smiles with and without eye constriction, smiles with jaw dropping, and smiles with eye constriction and jaw dropping (duplay smiles). These different smiles are thought to represent increasingly intense positive emotion (Messinger & Fogel, 2007). Researchers have suggested that more intense smiles indicate more intense emotion and engagement (Hsu, 2001) and smiles of low intensity (particularly smiles without eye-constriction or jaw dropping) express non-emotional social signals (Ekman et al., 1990; Dawson et al., 1997). In a recent study, Fogel et al. (2006) found that face-to-face interaction games, such as peek-a-boo and tickling games, elicit high intensity smiles in 6 and 12-month-old typically developing infants.

### 1.2.4 The Current Study

Considering evidence that intensity of positive emotional expression is an important part of typical infant's affective communication repertoire (Messinger et al., 2005; Messinger et al., 2007), that typical infants display the most high intensity smiles during social games like peek-a-boo (Messinger et al., 2001; Fogel et al., 2000; Dickinson et al., 1997; Fogel et al., 2006), and that some researchers have reported HR infants display more muted affect (Yirmiya et al., 2006; Cassel et al., 2007), it seems appropriate to compare HR and LR infants' smiling behavior during non-specific face-to-face interaction *and* during social games that typically elicit high intensity smiles (i.e. peek-a-boo). The first aim of the current study is not only to globally assess these infant's smiling behavior, but to also assess intensity of smiling. It is hypothesized that this comprehensive method of assessment may exaggerate differences between HR and LR infants.

Second, there is no published research that systematically examines the affective behavior of individuals interacting with at-risk infants, although researchers have suggested that investigating the interaction partner's behavior may provide relevant diagnostic information (Baranek et al., 1999; Hobson, 1991). Hobson (1991) posited that typically developing adults augment their behavior as they interact with individuals with ASD and that this change in behavior may provide information about the socio-emotional impairments of individuals with ASD. In a retrospective study of infants later diagnosed with ASD, Baranek (1999) made the observation that parents, not yet cognizant of their infant's deficits, were scaffolding their infant's behavior to "bring about the desired [social] response". Baranek (1999) suggested examining caregiver responses during socio-emotional interaction and that "parent's compensatory behaviors may provide a reflection of autistic symptoms during infancy". Even though researchers have made these recommendations, no studies to date have systematically explored the behavior of the "interactive partner". A second aim of the current study is to begin to fill this gap in the literature by providing information about the affective responsivity of adults interacting with infants at HR versus LR for ASD.

Finally, studies of high- and low-risk infants' affective expressivity have not yet investigated how emotional expression in an interactive context may change with infant age. It is possible that HR and LR infants follow a slightly different developmental trajectory when it comes to smiling behavior exhibited during common, face-to-face social games. Likewise, it is possible that adult interaction partners exhibit differences in smiling as a function of infants' risk-status and age. Therefore, a third aim of this study is to determine the effect of infant age (i.e., 6- or 11-months) on the smiling expressed by infants and interaction partners across both infant risk groups and interaction tasks.

The overall goal of the current proposal is to contribute to the definition of affect-specific early markers of ASD. Again, the three specific aims of this study are to: 1) investigate the intensity, or quality, of positive expressions of emotion in HR and LR infants, 2) explore how smiling behavior displayed by familiar (i.e. mother) and unfamiliar (i.e. experimenter) adults may differ when interacting with HR versus LR infants, and 3) determine the effects of infant's age on both infant and adult interaction partner smiling behavior. An investigation of HR and LR infants' affective behavior, as it varies by interaction type and infants' age, may assist in defining differences between HR and LR infants. Likewise, the effect of interaction type and infant age will carefully delineate contextual and developmental factors that affect infant and adult-interaction partner's affective displays. Overall, this study has the potential to identify early markers of autism and lead to more targeted early intervention.

# 2.0 METHOD

## 2.1 PARTICIPANTS

Two sets of infant-mother dyads were recruited to participate in this study: a group of 6-month-olds and their mothers as well as a group of 11-month-old infants and their mothers (see Table 1 for infant demographics). Within the 6-month-old group, there were 9 HR infants and 17 LR infants. Within the 11-month-old group, there were 10 HR infants and 10 LR infants. Some mother-infant dyads participating at 6 months of age also participated at 11 months of age, however, some mother-infant dyads only participated in the 6- or 11-month-age point (see Table 2). Mothers and infants were participants in a larger, NIH-funded infant-sibling project at the University of Pittsburgh investigating HR and LR infants cognitive abilities at 6, 11, and 16 months of age. Infant-mother dyads were recruited through research registries at local hospitals, local obstetrician offices, local day-cares, autism-specific parent organizations, autism awareness events, day schools for children with autism and related disabilities, and by word of mouth.

Table 1: Demographic characteristics of HR and LR 6- and 11-month-old infants

| | **6-month Time Point** | | | | **11-month Time Point** | | | |
|---|---|---|---|---|---|---|---|---|
| | *HR Infants* | | *LR Infants* | | *HR Infants* | | *LR Infants* | |
| | Day 1 (*N* = 9) | Day 2 (*N* = 7) | Day 1 (*N* = 17) | Day 2 (*N* = 15) | Day 1 (*N* = 10) | Day 2 (*N* = 10) | Day 1 (*N*=10) | Day 2 (*N*=10) |
| | M(SD) | M(SD) | M(SD) | M(SD) | M(SD) | M(SD) | M(SD) | M(SD) |
| **Age (months)** | 6.6(0.4) | 6.8(0.4) | 6.6(0.6) | 6.7(0.5) | 11.8(0.5) | 12.8(0.5) | 11.6(0.3) | 11.8(0.4) |
| **Gender (M:F)** | (3:6) | (3:4) | (9:8) | (8:7) | (4:6) | (4:6) | (4:6) | (4:6) |

Before HR and LR infants participated in the research project, study eligibility was determined. To determine HR infants eligibility, the diagnosis of the proband (i.e. older sibling) was confirmed by clinicians affiliated with the research project using the Autism Diagnostic Observation Schedule-Generic (ADOS-G; Lord et al., 2000) and the Autism Diagnostic Interview-Revised (ADI-R; Lord et al., 1994). For HR infants to participate in the current study an older sibling was required to meet the cut-off for an autism spectrum disorder diagnosis on these two diagnostic instruments. To ensure infants who were reported to have typically developing siblings (i.e., LR infants) did not have an older sibling displaying ASD symptoms, a brief phone screen was be completed with the parents before mother and infant were asked to participate in the study. Screening interviews were also used to gather data regarding study exclusion criteria. High-risk infants were excluded from the study if they had history of low birth weight (<2500 grams), problems during pregnancy, labor, or delivery, traumatic brain injury, or severe birth defects. Low-risk infants were excluded if they had first or second degree relatives with ASD, a history of low birth weight (<2500 grams), problems with pregnancy labor or delivery, traumatic brain injury, or severe birth defects.

Table 2: The number of high- and low-risk mother-infant dyads participating at each time point

| **Only 6-month Time Point** | | **Only 11-month Time Point** | | **Both Time Points** | |
|---|---|---|---|---|---|
| HR | LR | HR | LR | HR | LR |
| 3 | 9 | 4 | 2 | 6 | 8 |

## 2.2 GENERAL PROCEDURE

Following the study eligibility screening process, those HR and LR infants who met inclusion/exclusion criteria and their mothers were scheduled to come to the university for a two day visit. Depending on the age of the infant at the time the parent indicated their interest, infants either began the study at 6 or 11 months of age. On the first day of the visit study staff discussed the details of study participation and scheduled the second day of the two day visit. Mothers indicated agreement to their own participation and their infant's participation by signing informed consent documents approved by the University of Pittsburgh's Institutional Review Board.

Following informed consent, paperwork and eye-tracking studies related to the larger infant-sibling study, infants and mothers were escorted to the face-to-face interaction room to complete the study procedure. On the first testing day, infants and their mothers engaged in face-to-face interactions for a period of time. During the second day of testing infants interacted in the same way with an unfamiliar, female research assistant who was blind to the specific aims of the study and the risk status of the infant. Following the two days of participation mothers were thanked for their participation, debriefed, and compensated for their time.

### 2.2.1 Procedure

*Face-to-Face Interaction Room Apparatus*: The face-to-face social interaction sequence on day one and two occurred in a room with a two-way mirror on one wall. Two cameras, placed on tripods, were positioned in order to capture the mother/infant and experimenter/infant interactions, specifically the facial expressions that occur during these interaction bouts. Cameras were controlled from the room on the other side of the two-way mirror. From this control room an experimenter, not visible to the mother/infant or experimenter/infant dyad, was able to move the cameras to keep the participants in view. The experimenter in the camera control room was responsible for recording a close up image of each interacting partner's face using split-screen technology. The interaction bouts were viewed by this experimenter on a TV and recorded onto a DVD-R using a DVD-recorder, audio/video mixer, and microphone (see Figure 1 for diagram).

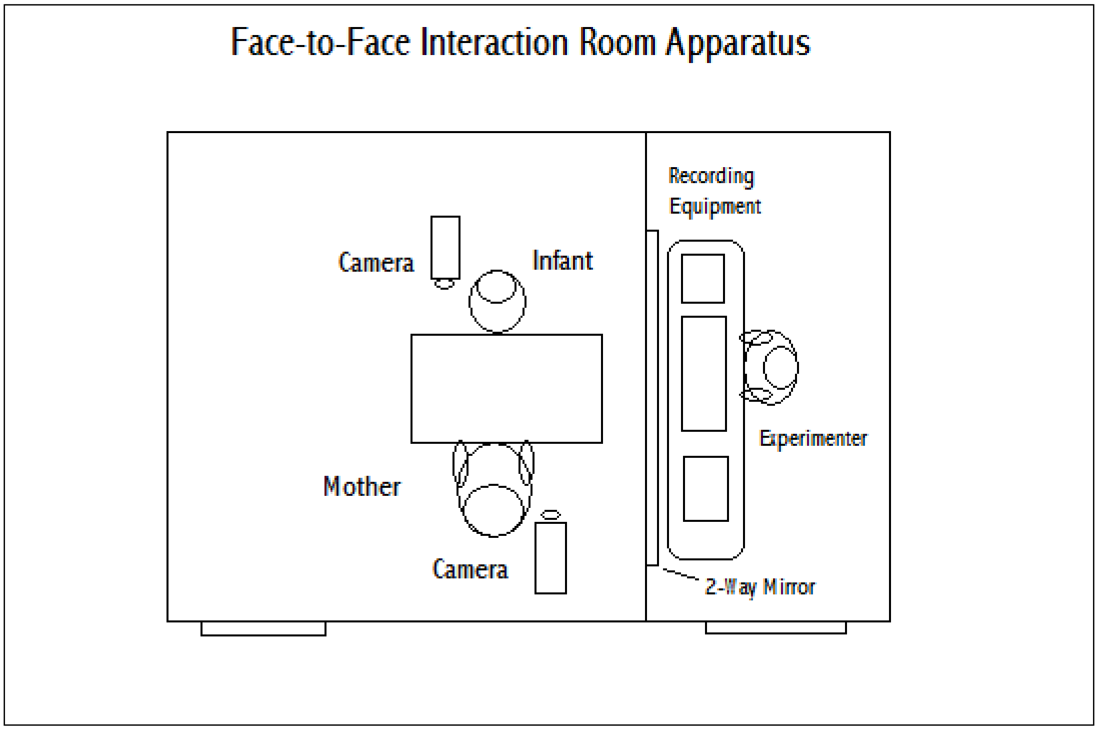


Figure 1: The set up of the Face-to-Face Interaction Room.

*Detailed Procedure:* On day one, after being escorted to the face-to-face interaction room, mothers were given detailed instructions about the interaction sequence they agreed to take part in with their infant. Mothers were asked to first "interact with their infant as they normally would for a couple of minutes". Then mothers were told they would hear a "knock" on the one-way mirror separating the interaction and recording rooms. This "knock" indicated to the mother it was time to move to the next type of interaction. Mothers were asked to "play peek-a-boo" with their infant after hearing this knock. To ensure the peek-a-boo sequence was played in a standard across mothers each mother was be asked to play peek-a-boo in a standard way. The research assistant modeled the peek-a-boo sequence for the mother. Mothers were asked to "first say 'Where's [infant's name]?" with both your hands covering your face. Then slowly and in a teasing voice say 'There you are!' or 'There's [infant's name].'" Mothers were asked to act naturally, but to try to use these phrases during the interaction bout. Mothers were also directed to cue cards hanging on a bulletin board and told the cue cards would help them remember what to do during the interaction sequence. The cue cards read: "engage with your infant as you normally do", "knock", "play peek-a-boo". Finally, mothers were told that a research assistant would come back into the room when the sequence was complete.

Before starting the interaction mothers were given a few more detailed instructions and asked a few questions. First, mothers were instructed not to touch their infant during the sequence. Also, mothers were asked if and how they have played peek-a-boo in the past with their child. All answers were recorded by a research assistant in the recording room. Mothers were instructed to remain in their chair during the interaction sequence so that they would not move out of the camera's capture area. Finally, the research assistant instructed the mother to begin the interaction sequence once the research assistant left the room. After all instructions were given and any questions answered, the infant was placed in an infant high chair and the mother was directed to sit across from her infant, in a stationary chair at eye level with the infant. The research assistant giving instructions then left the interaction room and moved to the recording room where another research assistant began to record the interaction. The interaction sequence lasted a total of three minutes: 2 minutes of a non-specific (NS) interaction and 1 minute of peek-a-boo (PAB). Following the interaction sequence on day one mothers were thanked for their participation and asked if the interaction seemed typical of most interactions between the mother-infant dyad. Answers were recorded by a research assistant.

On day two the same face-to-face interaction sequence was conducted with the infant and an unfamiliar experimenter. The experimenter was always a female, undergraduate member of the lab staff who was blind to the aims of the study and the infant's risk status. Each undergraduate research assistant was trained in the experimental paradigm, specifically, they were be instructed to interact "as they would with any infant" for two minutes and then to interact in a peek-a-boo sequence for the next minute. The peek-a-boo instructions these undergraduate assistants received were the same instructions as the mother received on day one. Like the mothers on day one, the undergraduate interaction partner used cue cards and heard knocks to indicate what type of interaction to engage in and when to start and stop. The interaction was recorded by another research assistant in the recording room adjacent to the interaction room. For the day two interaction mothers are asked to remain in the room with the infant and to sit directly behind the infant so they are out of their infant's view. Again, on day two mothers were thanked for their participation and asked if the interaction they watched between a stranger and their infant was typical of other interactions between their infant and an unfamiliar adult. Answers were recorded by a research assistant.

2.2.2 Coding System

The Facial Action Coding System (FACS; Ekman, Friesen, & Hagar, 2002) was used to code the valence and intensity level of the infant's, mother's, and stranger's facial expressions. FACS is a manualized system of coding temporary facial muscle movements that has frequently been used to code adult emotional facial expressions and have been adapted to code infant facial expressions (Oster, 1995, 2005).

One research assistant, trained and certified in the FACS, coded all recorded interactions. The coder was blind to the infants' risk status and the aims of the current study. Twenty percent of the interaction recordings were coded for reliability purposes. The main FACS coder was reliable with the FACS certified graduate student running this study at 0.88 percent agreement. This level of coder agreement was considered acceptable as a similar level of agreement (0.70) is required for FACS certification. All behavioral coding was completed using Noldus Observer 5.0 software.

Coding of infant behaviors will be done in passes. As a first pass, infant's facial expressions were coded. Smiling intensity codes were based on FACS codes adapted from Fogel et al. (2006). Fogel et al. (2006) coded the facial expressions and intensity of facial expressions displayed by typical infants during social games, like peek-a-boo. Infant smiles were coded as simple smiles (AU 12, lip corner retraction only), open-mouth simple smiles (AU 12 + 25), Duchenne smiles (AU 6 + 12, simple smile plus cheek raising), open-mouth Duchenne smiles (AU 6 + 12 + 25), play smiles (AU 12 + 26/27, simple smile plus jaw drop), and duplay smiles (AU 6 + 12 + 26/27, Duchenne smile plus jaw drop). Again, the specific action units coded were: AU 12 (lip corner raise or zygomatic major contraction), AU 6 (cheek raise or orbicularis oculi contraction), AU 25 (lips parted), and AU 26/27 (jaw drop). To determine the amount of time spent in positive expressions of affect, the total time spent in display of these "smile" action unit combinations was calculated.

The second wave of coding focused on the adult interaction partner's (i.e., mother and stranger) positive facial expressions. Adults' smiling behavior was also coded using FACS. The same action units used to code infant smiling behavior were used to code adult smiling behavior. As for infants, total time spent in positive affect was determined by summing the total time adults spent in "smiling" action units of different intensities.

# 3.0 RESULTS

Analysis of overall smiling behavior and intensity of smiling behavior during of mother-infant interaction at infant's 6- and 11-months time points will be presented. Subsequently, analyses of overall smiling behavior and intensity of smiling during 6 and 11 month stranger-infant interaction will be discussed. Although some mother-infant dyads participated in both the 6- and 11-month age points, other mother-infant dyads were unique to each age group. For this reason, in all analyses age is treated as a cross-sectional, not longitudinal, factor and was analyzed as a between-group factor. All omnibus tests, Analyses of Variance (ANOVAs), were run using arcsine transformations of proportion values, however, all reported follow-up t-tests were run using original proportion data. Also, means (M) and standard deviation (SD) data reported below are based on proportion data, not transformed values.

## 3.1 PRELIMINARY ANALYSES

A preliminary analysis of gender differences in smiling behavior was completed for mother-infant dyads at the 6-month time point. Due to limited sample size this analysis of gender differences was only completed for the 6-month-old infant group and for mother-infant interaction only. To compare male versus female infants' mean proportion total smiling and mean proportion of high-intensity smiles a series of independent sample t-test analyses were conducted. Similarly, to compare mothers' mean proportion total smiling and mean proportion of high-intensity smiling with male versus female infants a series of independent sample t-test analyses were conducted. There were no significant effects of infants' gender on infants' or mothers' smiling behavior.

## 3.2 ANALYSIS OF MOTHER-INFANT INTERACTION

### 3.2.1 Infants' Overall Smiling Behavior during Mother-Infant Interaction

To investigate the effects of risk-status (i.e., HR or LR), type of interaction task (i.e., non-specific interaction task versus peek-a-boo), and age (i.e., 6- and 11-month time points) on the proportion of total interaction time infants spent smiling (i.e., in AU 12, AU 12 + 6, AU 12 + 25, AU 12 + 25 + 6, AU 12 + 26/27, and AU 6 + 12 + 26/27) a repeated measures Analysis of Variance (ANOVA) was conducted with the risk-status and infant age as between factors and interaction task as a within factor. Proportion scores were used to control for differences in the duration of interaction task for each infant. Also, to correct for skewedness of proportion scores and violation of the ANOVA homogeneity of variance assumption, an arcsine transformation was performed prior to all ANOVA analyses. The initial 2 X 2 X 2 repeated measures ANOVA revealed a significant effect of task, $F(1, 42) = 34.799$, $p = 0.000$, $\eta_p^2 = 0.453$ indicating that, on average, infants smiled more during the peek-a-boo (PAB) task (M = 0.581, SD = 0.254) then the non-specific (NS) interaction task (M = 0.382, SD = 0.231). Additionally, there was a significant interaction between task and age, $F(1, 42) = 4.490$, $p = 0.040$, $\eta_p^2 = 0.097$. This two way interaction is superseded by a significant three-way interaction among risk-status of the infant, interaction task, and age, $F(1, 42) = 4.981$, $p = 0.031$, $\eta_p^2 = .106$. In order to understand this three-way interaction separate, follow-up 2 (task) X 2 (risk-status) ANOVA analyses were run for 6- and 11-month old infants and are described below. The values indicating the mean proportion of interaction time high- and low-risk 6- and 11-month-old infants spent in overall smiling behavior during mother-infant interaction are represented in Table 3.

Table 3: Proportion of interaction time infants spent in overall smiling to mothers

| | Low-Risk Infants | | High-Risk Infants | |
|---|---|---|---|---|
| | **Non-specific** **M**(SD) | **Peek-a-boo** **M**(SD) | **Non-specific** **M**(SD) | **Peek-a-boo** **M**(SD) |
| ***6-month Time Point*** | **0.34**(0.22) | **0.58**(0.27) | **0.53**(0.24) | **0.55**(0.28) |
| ***11-month Time Point*** | **0.32**(0.19) | **0.54**(0.24) | **0.37**(0.25) | **0.65**(0.25) |

*6-month-old Infants' Overall Smiling Behavior during Mother-Infant Interaction*: A 2 (risk-status) X 2 (interaction task) repeated measures ANOVA demonstrated a significant main effect of task with both high- and low-risk infants smiling more during PAB than NS interaction, $F(1, 24) = 8.051$, $p$ = 0.009, $\eta_p^2$ 0.251. There was also a significant interaction between task and infant risk-status $F(1, 24) = 5.895$, $p = 0.023$, $\eta_p^2 = 0.644$ (see Figure 2). This significant interaction of task and risk-status demonstrated that, during interaction with their mothers, low-risk infants smiled more during the PAB task (M = 0.58, SD = 0.27) than during the NS task (M = 0.34, SD = 0.22) ($t(16) = -4.52$, p = 0.000)). In contrast, high-risk infants did not demonstrate any differences in their smiling rates between the PAB (M = 0.55, SD = 0.28) and NS tasks (M = 0.53, SD = 0.24) ($t(8)= -0.390$, p = 0.706). Thus, the results indicate that during infant-mother interaction low-risk infants modify their smiling across the two interaction tasks, whereas high-risk infants do not.

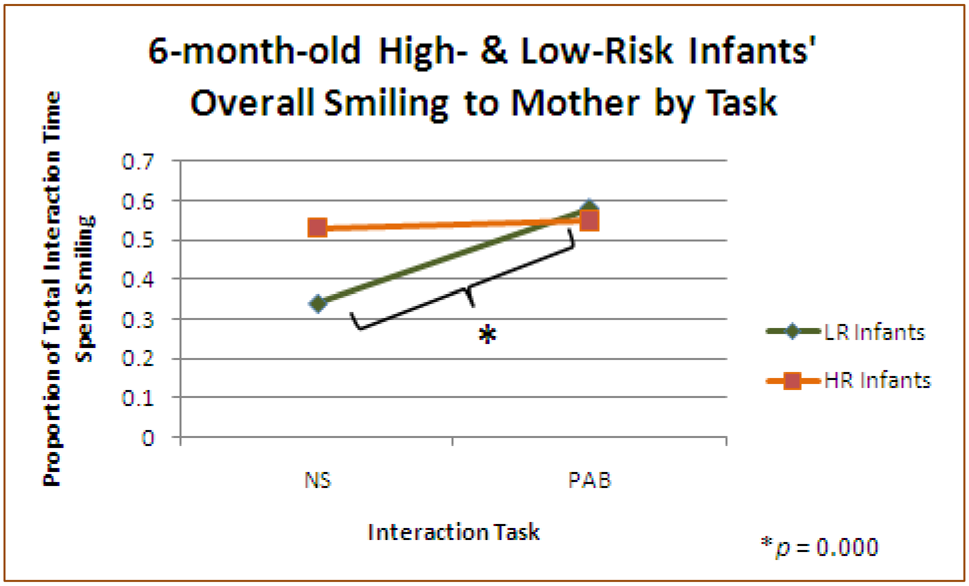


Figure 2: Mean proportion of total NS and PAB interaction time HR and LR infants spent smiling during mother-infant interaction.

*11-month-old Infants' Overall Smiling Behavior during Mother-Infant Interaction*: A 2 (risk-status) X 2 (interaction task) repeated measures ANOVA was conducted and demonstrated a significant effect of task $F(1, 18) = 28.437$, $p = 0.000$, $\eta_p^2 = 0.612$ , but no interaction between risk-status and task. Thus, at 11 months, both the low- and high-risk infants smiled more during more during the PAB task (M = 0.60, SD = 0.24) than during the NS interaction task (M = 0.35, SD = 0.22). Thus, in comparison to findings at the 6 month time point, by 11 months of age high-risk infants begin to show a normative increase in smiling behavior from a non-specific interactive context to a structured, familiar peek-a-boo interaction.

### 3.2.2 Smiling Intensity Displayed by Infants during Mother-Infant Interaction

These analyses looked at the proportion of total interaction time infants spent in high intensity smiles (i.e., in AU 12 + 26/27 and AU 6 + 12 + 26/27) over the total time spent in high and low intensity smiles (i.e., in AU 12, AU 12 + 6, AU 12 + 25, AU 12 + 26/27, and AU 6 + 12 + 26/27). Again, proportion scores were arcsine transformed. A repeated measures ANOVA analysis of infants' smiling intensity during mother-infant interaction was conducted, with infant age and risk-status being between factors and interaction task being a within factor. This analysis revealed only a significant effect of task, $F(1, 42) = 13.545$, $p = 0.001$, $\eta_p^2 = 0.244$. When interacting with their mothers, infants of both risk-status groups and of both age groups displayed more high intensity smiling during PAB (M = 0.523, SD = 0.303) than NS interaction (M = 0.362, SD = 0.278).

### 3.2.3 Mothers' Overall Smiling Behavior during Mother-Infant Interaction

To investigate the combined effects of risk-status (i.e., HR or LR), interaction task (i.e., NS versus PAB), and age (i.e., 6- and 11-month time points) on the proportion of total interaction time mothers spent smiling (i.e., in AU 12, AU 12 + 6, AU 12 + 25, AU 12 + 25 + 6, AU 12 + 26/27, AU 6 + 12 + 26/27), a three-way repeated measures ANOVA was conducted. Between factors included risk-status and age, while interaction task was treated as a within factor. Again, for mother's smiling behavior proportion scores were used to correct for differences in the duration of the interaction task for each mother-infant dyad and arcsine transformations were run to correct for violation of the ANOVA homogeneity of variance assumption. This initial 2 X 2 X 2 repeated measures ANOVA indicated a significant main effect of task, $F(1, 42) = 18.351$, $p = 0.000$, $\eta_p^2 = 0.304$ indicating that all mothers smiled more during PAB (M = 0.841, SD = 0.175) than a NS interaction (M = 0.759, SD = 0.187). Additionally, the interaction of task, risk-status, and age indicated a near significant three-way interaction, $F(1, 42) = 3.551$, $p = 0.066$, $\eta_p^2 = 0.078$. In order to understand this three-way interaction, separate 2 (task) X 2 (risk-status) ANOVA analyses were run for mothers of 6- versus 11-month old infants. The values indicating the mean proportion of interaction time mothers of high- and low-risk 6- and 11-month-old infants spent in overall smiling behavior during mother-infant interaction are represented in Table 4.

Table 4: Proportion of interaction mothers spent in overall smiling to infants

| | Low-Risk Infants | | High-Risk Infants | |
|---|---|---|---|---|
| | **Non-specific** **M**(SD) | **Peek-a-boo** **M**(SD) | **Non-specific** **M**(SD) | **Peek-a-boo** **M**(SD) |
| ***6-month Time Point*** | **0.84**(0.12) | **0.92**(0.09) | **0.74**(0.19) | **0.81**(0.15) |
| ***11-month Time Point*** | **0.77**(0.21) | **0.80**(0.21) | **0.63**(0.20) | **0.77**(0.24) |

*Mothers' Overall Smiling Behavior during Mother-Infant Interaction with 6-month-old Infants*: A 2 (task) X 2 (risk-status) repeated measures ANOVA demonstrated a significant main effect of task and risk status, but no interaction between the two. The main effect of task demonstrates that mothers of both high- and low-risk infants smiled more during peek-a-boo (M = 0.884, SD = 0.126) than a non-specific interaction (M = 0.806, SD = 0.153), $F(1, 24) = 7.006$, $p = 0.014$, $\eta_p^2 = 0.226$. There was also a significant main effect of risk-status on mother's smiling behavior, $F(1, 24) = 4.778$, $p = 0.039$, $\eta_p^2 = 0.166$ indicating that mothers of high-risk infants smiled significantly less (M = 0.777, SD = 0.173) across the two tasks than did mothers of low-risk infants (M = 0.881, SD = 0.113).

*Mothers' Overall Smiling Behavior during Mother-Infant Interaction with 11-month-old Infants*: A 2 (task) X 2 (risk-status) repeated measures ANOVA indicated a significant main effect of task on mother's smiling behavior and a significant interaction of task and 11-month-old infant's risk-status on mother's smiling behavior. The main effect of task demonstrated that mothers of high- and low-risk 11-month-old infants smiled significantly more during PAB (M = 0.787, SD = 0.216) than a NS interaction (M = 0.697, SD = 0.212), $F(1, 18) = 17.527$, $p = 0.001$, $\eta_p^2 = 0.493$. The significant interaction of task and infant risk-status on mother's smiling behavior revealed that mothers of high- and low-risk infants smiled to a significantly different degree as a function of task, $F(1, 18) = 5.582$, $p = 0.030$, $\eta_p^2 = 0.237$. Follow-up analyses demonstrate that by the time low-risk infants are 11 months of age their mothers no longer exhibit a significant increase in smiling from a non-specific interaction (M = 0.767, SD = 0.207) to peek-a-boo (M = 0.801, SD = 0.205) ($t(9) = -1.392$, $p = 0.197$), as did mothers of the 6-month-old, low-risk infants. In contrast, mothers of high-risk infants continue to demonstrate the significant increase in smiling from a non-specific interaction (M = 0.628, SD = 0.203) to peek-a-boo (M = 0.773, SD = 0.236) with their 11-month-old infants ($t(9) = -4.731$, $p = 0.001$) (see Figure 3).

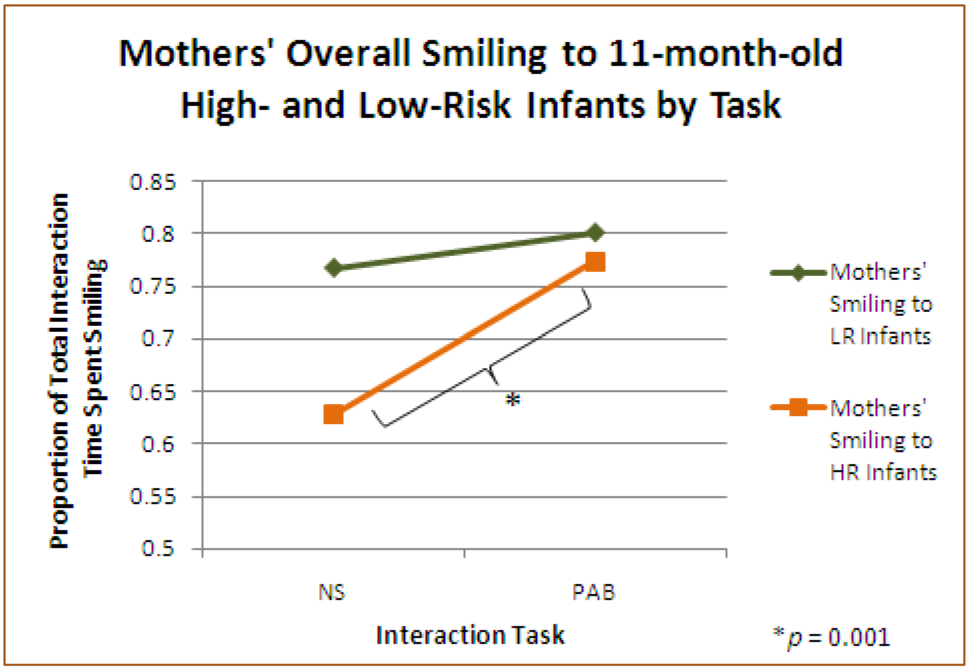


Figure 3: Mean proportion of total NS and PAB interaction time mothers spent smiling with their 11-month-old HR or LR infants.

3.2.4 <u>Smiling Intensity Displayed by Mothers during Mother-Infant Interaction</u>

An omnibus ANOVA analysis examined the effect of risk-status (i.e., HR versus LR), task (i.e., NS interaction versus PAB), and age (i.e., 6- versus 11-month-olds) on mothers' smiling intensity. The dependent variable was the arsine transformed proportion of total interaction time mothers spent in high intensity smiles (i.e., in AU 12 + 26/27 and AU 6 + 12 + 26/27) over the total time mothers spent in high and low intensity smiles (i.e., in AU 12, AU 12 + 6, AU 12 + 25, AU 12 + 26/27, and AU 6 + 12 + 26/27). The analysis revealed a main effect of risk-status, $F(1, 42) = 4.845$, $p = 0.033$, $\eta_p^2 = 0.103$. Mothers of high-risk 6- and 11-month-old infants smiled more high intensity smiles across both tasks (M = 0.416, SD = 0.12) than mothers of low-risk 6- and 11-month-old infants (M = 0.318, SD = 0.172).

## 3.3 ANALYSIS OF STRANGER-INFANT INTERACTION

### 3.3.1 Infants' Overall Smiling Behavior during Stranger-Infant Interaction

A three-way repeated measures Analysis of Variance (ANOVA) was conducted to investigate the effects of risk-status (i.e., HR or LR), interaction task (i.e., NS interaction task and PAB), and age (i.e., 6- and 11-month time points) on the proportion of total interaction time the infant spent smiling during interaction with an unfamiliar, female interaction partner. Between factors included infant risk-status and age, while interaction task was treated as a within factor. As with all previous analyses, the arcsine transformation of the proportion of total interaction time infants spent smiling was used as the dependent variable. The initial 2 X 2 X 2 repeated measures ANOVA indicated a significant effect of task on infant smiling to a stranger, $F(1, 38) = 17.977$, $p = 0.000$, $\eta_p^2 = 0.321$, demonstrating that infants smiled more during the PAB task (M = 0.455, SD = 0.289) than during the NS task (M = 0.319, SD = 0.249) regardless of the infants risk-status. Additionally, this analysis revealed a significant interaction effect of task and age, $F(1, 38) = 8.756$, $p = 0.005$, $\eta_p^2 = 0.187$. In face-to-face interaction with a stranger, 11-month-old HR and LR infants demonstrated a significantly greater amount of smiling during PAB (M = 0.499, SD = 0.318) than NS interaction (M = 0.265, SD = 0.260) ($t(19) = -5.399$, $p = 0.000$). On the other hand, 6-month-old HR and LR infants smiled to a similar degree during NS (M = 0.369, SD = 0.234) and PAB interactions (M = 0.416, SD = 0.261) when interacting with a stranger ($t(21) = -1.022$, $p = 0.318$).

### 3.3.2 Smiling Intensity Displayed by Infants during Stranger-Infant Interaction

A 2 (risk-status) X 2 (interaction task) X 2 (age) repeated measures ANOVA analysis was conducted to investigate these variables' effects on infant smiling intensity during stranger-infant interaction. The dependent variable was the arcsine transformed proportion of total interaction time infants spent in high intensity smiles (i.e., in AU 12 + 26/27 and AU 6 + 12 + 26/27) over the total time infants spent in high and low intensity smiles (i.e., in AU 12, AU 12 + 6, AU 12 + 25, AU 12 + 26/27, and AU 6 + 12 + 26/27). This analysis revealed no main or interaction effects.

3.3.3 Strangers' Overall Smiling Behavior during Stranger-Infant Interaction

To investigate the combined effects of risk-status (i.e., HR or LR), interaction task (i.e., NS interaction task and PAB), and age (i.e., 6- and 11-month time points) on the proportion of total interaction time strangers spent smiling a three-way repeated measures Analysis of Variance (ANOVA) was conducted. Between factors included infant risk-status and age, while interaction task was treated as a within-subjects factor. The dependent variable for these analyses was the arcsine transformation of the proportion total interaction time the stranger spent smiling. This omnibus test indicated a significant main effect of task on stranger's smiling behavior during stranger-infant interactions, $F(1, 38) = 39.826$, $p = 0.000$, $\eta_p^2 = 0.512$ indicating that unfamiliar adults smiled more during PAB (M = 0.892, SD = 0.090) than NS interaction (M = 0.794, SD = 0.125) no matter the risk-status of the infant. The three-way interaction of task, risk-status, and age of the infant on the stranger's smiling behavior approached significance, $F(1, 38) = 2.801$, $p = 0.102$, $\eta_p^2 = 0.069$. To understand the interaction between task, risk-status, and age separate, follow-up 2 (task) X 2 (risk-status) ANOVA analyses were run for stranger's smiling behavior during interaction with 6- versus the 11-month old infants. The values indicating the mean proportion of interaction time strangers spent in overall smiling during interaction with high- and low-risk 6- and 11-month-olds are represented in Table 5.

Table 5: Proportion of interaction time strangers spent in overall smiling to infants

| | **Low-Risk Infants** | | **High-Risk Infants** | |
|---|---|---|---|---|
| | **Non-specific** **M**(SD) | **Peek-a-boo** **M**(SD) | **Non-specific** **M**(SD) | **Peek-a-boo** **M**(SD) |
| ***6-month Time Point*** | **0.83**(1.0) | **0.87**(0.08) | **0.80**(0.14) | **0.91**(0.11) |
| ***11-month Time Point*** | **0.76**(0.13) | **0.91**(0.08) | **0.78**(0.16) | **0.89**(0.11) |

*Strangers' Overall Smiling Behavior during Stranger-Infant Interaction with 6-month-old Infants*: A 2 (task) X 2 (risk-status) repeated measures ANOVA revealed a significant main effect of task on stranger's smiling behavior, $F(1, 20) = 12.489$, $p = 0.002$, $\eta_p^2 = 0.384$. On average, stranger's smiled more during peek-a-boo (M = 0.884, SD = 0.090) than a non-specific interaction (M = 0.817, SD = 0.109) with both high- and low-risk 6-month-old infants. The analysis also demonstrated a task by risk-status interaction effect that approached significance, $F(1, 20) = 2.893$, $p = 0.104$, $\eta_p^2 = 0.126$. Follow-up analyses reveal that strangers tend to smile more during peek-a-boo (M = 0.871, SD = 0.080) than non-specific interaction (M = 0.825, SD = 0.095) when interacting with LR 6-month-old infants ($t(14) = -2.02$, $p = 0.063$), but not HR 6-month-old infants ($t(6) = -1.64$, $p = 0.151$).

*Strangers' Overall Smiling Behavior during Stranger-Infant Interaction with 11-month-old Infants*: A 2 (task) X 2 (risk-status) repeated measures ANOVA was completed and demonstrated a significant main effect of task on stranger's smiling behavior to 11-month-old infants, $F(1, 18) = 29.539$, $p = 0.000$, $\eta_p^2 = 0.621$. Stranger's smiled significantly more during peek-a-boo (M = 0.901, SD = 0.092) than a non-specific interaction (M = 0.768, SD = 0.139) with both high- and low-risk infants. There was not a significant main effect of risk status, $F(1, 18) = 0.125$, $p = 0.728$, $\eta_p^2 = 0.007$, or interaction effect of task and risk-status, $F(1, 18) = 0.416$, $p = 0.527$, $\eta_p^2 = 0.023$. Strangers smiled similarly to high- and low-risk infants across both task types.

### 3.3.4 <u>Smiling Intensity Displayed by Strangers during Stranger-Infant Interaction</u>

A 2 (risk-status) X 2 (interaction task) X 2 (age) repeated measures ANOVA was conducted to determine the effect of these variables on strangers' smiling intensity displayed during stranger-infant interaction. Again, infant risk-status and age were treated as between factors, while interaction task was treated as a within-subjects factor. As in previous analyses, the dependent variable was the arcsine transformed proportion of total interaction time infants spent in high intensity smiles (i.e., in AU 12 + 26/27 and AU 6 + 12 + 26/27) over the total time infants spent in high and low intensity smiles (i.e., in AU 12, AU 12 + 6, AU 12 + 25, AU 12 + 26/27, and AU 6 + 12 + 26/27). The analysis revealed a significant main effect of task, $F(1, 42) = 35.317$, $p = 0.000$, $\eta_p^2 = 0.482$, indicating that across risk-status and age groups strangers smiled more high intensity smiles during PAB (M = 0.505, SD = 0.243) than NS interaction (M = 0.293, SD = 0.180).

# 4.0 DISCUSSION

The results of this study help to elucidate the differences between the positive affect expressed by high- and low-risk infants, their mothers and, and an unfamiliar adult when engaged in infant-adult face-to-face interaction. The data support a clear effect of risk-status on infant smiling behavior expressed during face-to-face interaction, and therefore meld well with past work that has found difference in the affective behavior of high- and low-risk infants as early as 4- to 6-months of age (Yirmiya et al., 2007; Cassel et al., 2007). Additionally, this study adds to the infant sibling literature by: 1) demonstrating differential effects of infant risk-status on the smiling behavior of adult interaction partners (i.e., mothers and an unfamiliar adult) and 2) highlighting how infant age and interactive context (i.e., non-specific interaction versus peek-a-boo) alter the effects of infant risk-status on infant and adult interaction partners' affective behavior.

As shown in previous studies (Yirmiya et al., 2007; Cassel et al., 2007), high- and low-risk infants can be distinguished by their affective expressivity. Unlike other studies, however, the current study found that high- and low-risk smiling behavior differed as a function of the infants' age and the interactive context (i.e., task and interaction partner). High- and low-risk 6-month-old infants were distinguished from one another during interaction with their mothers. When interacting with their mothers, 6-month-old high-risk infants did not show an increase in smiling from a non-directed interaction to a structure, familiar social game (i.e., peek-a-boo). On the other hand, low-risk infants did show an increase in smiling from non-specific interaction to peek-a-boo when interacting with their mother. Therefore, while high-risk infants did not show a shift in smiling based on interactive context, low-risk infants interacting with their mothers did. Past research with 6 to 12-month-old typically developing infants has shown that a greater amount of smiling behavior occurs during social games, like peek-a-boo, than non-directed infant-mother interaction (Messinger et al., 2001; Fogel et al., 2000; Dickinson et al., 1997). Therefore, a lack of shift in smiling based on this contextual change suggests that high-risk infants may be less attuned to changes in social context than their low-risk counterparts.

Unlike at the 6-month time point, both high- and low-risk 11-month-old infants demonstrate a significant increase in smiling from non-directed interaction to peek-a-boo when engaged with their mothers. Thus, while low-risk infants demonstrated increased positive affect in response to a contingent social game by 6 months of age, high-risk infants do not show typical increased smiling in response to peek-a-boo until 11 months of age. Hence, it appears high-risk infants are capable of displaying a typical reaction to task-specific changes in interactive context, but this contextual attunement develops at a delayed pace.

Infant smiling behavior in response to interactions with an unfamiliar, female adult was quite different from affect expressed by infants during mother-infant interaction. At 6 months, both low- and high-risk infants showed no increase in smiling from a nonspecific interaction to peek-a-boo when interacting with a stranger. The finding that low-risk, 6-month-old infants' smiling was not augmented by task during infant-stranger interaction may be attributed to the unfamiliarity of the adult interaction partner. During the first year of life, typical infants are generally more subdued and wary during interaction with a stranger, which leads to decreases expression of positive affect (Waters, Matas, & Sroufe, 1975). Therefore, it appears reasonable that differences between low-risk infants' smiling during mother-infant and stranger-infant interaction is a result of "stranger anxiety". While low-risk 6-month-olds pattern of smiling behavior is affected by type of interaction partner, high-risk infants' pattern of smiling across the two interactive tasks is not. In both mother-infant and stranger-infant interaction, 6-month-old high-risk infants show the same pattern of smiling across interactive context. Change in interaction partner does not appear to have the equivalent effects on low- and high-risk infants suggesting again that 6-month-old high-risk infants are less attuned to aspects of social context that augment low-risk infants behavior.

Mothers' smiling behavior during mother-infant interactions depended on the risk-status of the infant, as well as infant age and type of interaction task. At the 6-month infant age point, mothers of both high- and low-risk infants demonstrated an increase in smiling from a non-specific interaction to a more structure, peek-a-boo game. Although mothers of both high- and low-risk infants showed the same pattern of smiling across interaction tasks, on average high-risk mothers smiled significant less than low-risk mothers when interacting with their 6-month-old infants. These data can be interpreted in a number of ways, but clearly demonstrate that high- and low-risk mothers interact with their 6-month-olds differently. This difference may be due to high-risk mother's concern regarding their infant's development, increased stress experienced by parents of children with ASD, or increased depressed mood in mothers of high-risk infants. Past work has demonstrated that parents of high-risk infants report more parental stress than parents of low-risk infants (Johnson et al, 2009). This increased stress could affect parent behavior during social interactive contexts. Although work has not been published linking parental concern or depression to parenting behaviors exhibited by the parents of infants at-risk for autism, it may be the case that these factors influence how parents interact with high-risk infants.

When infants reach 11 months of age maternal smiling behavior appears to change as a function of infants' risk-status. Mothers interacting with low-risk, 11-month-old infants no longer exhibit an increase in smiling from a non-directed interaction to peek-a-boo. In contrast, mothers of 11-month-old high risk infants continue to display a distinct increase in smiling from non-specific interaction to peek-a-boo. Thus, it appears that mothers of 11-month low-risk infants taper their smiling behavior as their infant ages and social games, like peek-a-boo, become less salient. Mothers of high-risk infants continue to interact with their infants in a way characteristic of mothers of younger infants, indicating mothers of high-risk infants may be scaffolding their 11-month-olds behavior.

This study provides the first evidence that parents of high-risk infants scaffold their infants' behavior in a way that low-risk infants' parents do not. At both 6- and 11-month time points mothers of high-risk infants perform higher intensity, more exaggerated smiles across both non-specific interaction and peek-a-boo tasks. Also, mothers of low-risk infants tapered the smiling behavior they exuded during social games as their child got older (i.e., at 6 versus 11 months of age), while mothers of high-risk infants did not. Therefore, it appears, as Baranek (1999) suggested, parents scaffold their infant's behavior to "bring about the desired [social] response" or are engaging in "compensatory behaviors". In 1999, Baranek suggested these behaviors may occur in parents not yet cognizant of their infant's later ASD diagnosis, however, this study demonstrates the importance of examining the responses of caregivers who are aware only of their infant's high-risk status. The broader phenotype analysis performed in this study demonstrates that parents' knowledge of their infants' high risk for developing ASD, in the absence of an ASD diagnosis, is enough to induce parental scaffolding of their infants' socio-emotional behavior.

The smiling behavior of an unfamiliar adult (i.e., stranger) exhibited during stranger-infant interaction was impacted by interactive task. Clearly significant findings indicate that when interacting with both risk groups at each infant age point, strangers did increase their smiling from a non-specific interaction to peek-a-boo. While this result was clear at the 11-month age point, with strangers' smiling significantly more during peek-a-boo than a non-directed interaction with both risk groups, strangers' smiling behavior at 6-months was less straightforward. It appears that strangers blind to infant risk-status may smile differently to low- and high-risk 6-month-old infants. Since these findings represent only a non-significant trend in the data, further research will need to be completed to determine the veracity of such a claim. In contrast to mothers, it appears that strangers' smiling behavior is influenced more by interaction task than by any other factor. At both ages, and with high- and low-risk infants, strangers tend to smile more during peek-a-boo than a non-specific interaction.

The investigation of strangers' smiling intensity also demonstrates differences between strangers' and mothers' smiling behavior during adult-infant interaction. At both age points and for both infant risk groups, strangers demonstrate more intense, or exaggerated, smiles during peek-a-boo than non-directed interaction. In contrast, the main influence on mothers' smiling intensity was not task, but infants' risk status. As reported earlier, mothers' of high-risk infants exhibiting more exaggerated smiles across both interaction tasks and at both infant age-points than mothers' of low-risk infants. Therefore, while the intensity of strangers' smiling is driven by the properties of the interaction task, the intensity of mothers' smiling behavior appears to be driven by whether or not their infant is at high-or low-risk for autism.

In summary, the current study found significant differences in the smiling behavior of high- and low-risk infants, their mothers, and an unfamiliar adult. Importantly, high- and low-risk infants are distinguished from one another at 6 months of age. At this age high-risk infants are not as attuned as low-risk infants to changes in interactive context (e.g., interaction task and partner). Also, high-risk infants appear to be delayed in their development of typical smiling responses during mother-infant face-to-face interaction. While low-risk infants show an increase in smiling behavior during peek-a-boo at 6-months and a tapering of smiling by 11-months, high-risk infants do not show an increase in smiling to this social game until 11 months of age. Mothers of high- and low-risk infants also display different patterns of smiling behavior. Mothers of high-risk infants appear to scaffold their infants' behavior during socio-emotional interaction. These mothers exhibit more exaggerated smiles across all interactive contexts and at both infant age points. While mothers of low-risk infants taper their smiling to social games (e.g., peek-a-boo) by 11-months, mothers of high-risk infants continue a pattern of increased smiling to peek-a-boo over non-specific interaction at 11-months. In contrast to mothers, strangers' smiling behavior appears to reflect the changes in task characteristics only.

These results help delineate the early broader autism phenotype and have implications for early identification and treatment of ASD. Decreased attention, or reaction, to changes in interaction context may have cascading effects on high-risk infants' affective and socio-communicative development. Future investigations will follow these infants to the age of 3, when an autism spectrum disorder diagnosis can be reliably made. At that time, it will be important to investigate patterns of smiling behavior at 6 and 11 months of age that predict later ASD diagnosis.

The fact that high-risk infants' mothers are scaffolding their infants' affective behavior from an early age has implications for these infants later development and for treatment. Once autism diagnostic status is assessed at 3 years, it may be beneficial to look back at the behavior of mothers of high-risk infants who did or did not receive an ASD diagnosis. Perhaps mother's behavior will inform clinicians regarding early intervention strategies.

A number of important differences exist between this study and past infant sibling studies of infant affective behavior. First, the design of this study allowed for the examination of the differential impact of interaction partner, mothers versus a stranger, on the smiling behavior expressed by infants during social interaction. Past infant-sibling studies of infant affective expression have only examined these behaviors in response to mothers' affective cues. Nelson and colleagues (2009) recently presented preliminary evidence from electrophysiological studies that low-risk infants differentiate their mother's versus a stranger's face in a way that high-risk infants do not. This finding and the findings of the current study suggest that low-risk infants respond differentially to their mothers, at the neural and behavioral level, while infants at high-risk for autism do not show this same understanding. It appears that further investigation of infant response to mothers versus unfamiliar adults may provide a more complete picture of the differences between high- and low-risk infants during the first year of life.

The current study also used different interaction tasks than past research describing the interactive smiling behavior of infant-siblings at risk for autism. Prior research describing the affective expression of at-risk infants in the first year of life (Cassel et al, 2007; Merin et al, 2007; Yirmiya et al, 2007; Young et al, 2009) has utilized the classic Face-to-Face Still Face paradigm (FFSF; Tronick et al, 1978). Use of this paradigm has not provided a platform for clear understanding of these infant's affective behavior. Using the FFSF paradigm, some researchers find significant differences between high-and low-risk infants smiling behavior and some do not. Researchers who have found differences between high- and low-risk infants' affect, find these difference exist only during portions of the paradigm that represent more "typical" mother-infant interactions (the face-to-face and reunion phases of the interaction). These findings and data from the current study provide evidence that differences between high- and low-risk infants may be heightened during interactions that typically induce shared *positive* affect.

The unique design of this study allows for conclusions to be drawn about the development of infant-sibling affective expression, or socio-emotional development, that could not be drawn on the basis of previously published work. The current study sought to determine the affective expression of not only the high- or low-risk *infant* groups engaged in face-to-face interaction, but also the affective expression of their *adult* interaction partner. This study also couched this behavioral expression in an interactive (i.e., task) and developmental (i.e., infant age) context. All contextual variables investigated (interaction partner, task, and age) had a significant impact on how high- and low-risk infants express positive affect. This study therefore calls attention to the bidirectional, transactional nature of affective development in an infant-sibling sample. Even in the pursuit of early markers of a highly heritable, genetically-based disorder like autism it appears important that studies look beyond the characteristics of the infant. The results of the current study demonstrate that to understand the individual characteristics of the high- or low-risk infant, a more complex analysis of the developmental context is necessary. As Sameroff and colleagues (2003) note, "child effects [do] not provide a complete picture unless they [are] spelled out over time in a model of reciprocal influences." The current project represents only an initial investigation of this type, therefore, future infant-sibling investigations must continue to bring to light the impact of context and development on behaviors of study.

There are several limitations of the current study that need to be considered. One important limitation is sample size. Like many studies of infants at-risk for autism, the current study reports on the behavior of a relatively small number of high- and low-risk infants. While current effects were strong enough to allow for statistical significance, the addition of more participants will allow current findings to be accepted with greater confidence. An additional limitation of this study is that, at this point in time, it is not clear what underlies important differences found in infants', mothers', and strangers' observable behavior during face-to-face interaction. As is often the case in research, the current findings lead to more questions. For instance, to what extent are group differences between high- and low-risk infants and mothers driven by mothers' behavior, infants' behavior, or an interaction of the two? A number of variables may drive these group differences, and so, future directions of study include an investigation of: 1) the synchronicity of the infant's behavior with mothers and strangers, 2) the role of mother's child-rearing experience and attitudes, 3) the role of mother's mood (i.e., depression), 4) the impact of infant temperament, 5) the impact of infants' perception and cognitive processing of adult facial expressions, 6) the impact of the older siblings' ASD severity and level of functioning on high-risk mother's behavior, and 7) the impact of the older siblings' intervention and mothers' experiences as a result of this treatment. With the infants and mothers represented in the current study, our lab is collecting infant temperament measures, measure of infants' perception of adult facial expressions, measures of adult interaction partner's mood, and older siblings' intervention history and ASD severity. The relation between these factors and the group differences found in this study will be addressed in future work. Therefore, the current investigation offers clear rationale for future study and a glimpse into the complex dynamics of high- and low-risk infants' socio-emotional development. Future investigation will help determine specifics of this transactional process, particularly the precursors to and outcomes of existing differences between high- and low-risk infants', mothers' and strangers' affective displays and interaction.

In conclusion, it appears that differences between high-risk and low-risk infants affective behavior is apparent early in the first year of life and changes across development. Interactive context, both interaction type and partner, have significant effects on the ability to detect differences between these infant groups. Also, the finding that mothers' affective behavior differs by infant risk-status demonstrates the importance of thoroughly documenting both infant *and* adult interaction partner behavior when investigating the development of socio-emotional behavior in high-risk infants. Further infant-sibling studies should continue to addresses the effect of high-risk status on parental behavior, developmental change in high-risk infants' behavior, and the effect of these factors on the diagnostic outcomes of high- and low-risk infants.

## Bibliography


Adrien, J. L., Lenoir, P., Martineau, J., Perrot, A., Hameury, L., Larmande, C., Sauvage, D. (1993). Blind ratings of early symptoms of autism based upon family home movies. *Journal of the American Academy of Child and Adolescent Psychology, 32*, 617-626.

Adrien, J. L., Perrot, A., Sauvage, D., Leddet, I., Larmande, C., Hameury, L. (1992). Early symptoms in autism from family home movies. Evaluation and comparison between 1st and 2nd year of life using I.B.S.E. scale. *Acta Paedopsychiatria, 55*, 71-75.

Alegria, J., & Noirot, E. (1978). Neonate orientation behavior towards human voice. *International Journal of Behavioral Development, 1*, 291-312.

American Psychiatric Association. (1980). *Diagnostic and statistical manual of mental disorders* (3rd ed.). Washington DC: Author.

American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders* (3rd, rev. ed.). Washington D.C.: Author.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.).

American Psychiatric Association. (2000) *Diagnostic and statistical manual of mental disorders* ($4^{th}$, rev. ed.)

Bailey, A., Philips, W., & Rutter, M. (1996). Autism: Toward an integration of clinical, genetic, neuropsychological, and neurobiological perspectives. *Journal of Child Psychology and Psychiatry, 37*, 89-126.

Bakeman, R., & Adamson, L. (1984). Coordinating attention to people and objects in mother-infant and peer-infant interaction. *Child Development, 55*(4), 1278-1298.

Baranek, G. (1999). Autism during infancy: a retrospective video analysis of sensory-motor and social behaviors at 9-12 months of age. *Journal of Autism and Developmental Disorders, 29*(3), 213-224.

Baron-Cohen, S., Ring, H.A., Wheelwright, S., et al (1999). Social intelligence in the normal and autistic brain: an fMRI study. *European Journal of Neuroscience, 11*, 1891-1898.

Bauminger, N. K., C. (2001). The experience of loneliness and friendship in autism: theoretical and practical issues. In N. Y. B. Schopler, C. Shulman, & L. Marcus (Ed.), *The Research Basis for Autism Intervention*. New York: Kluwer/Plenum.

Bauminger, N., Shulman, C., & Agam, G. (2003). Peer interaction and loneliness in high-functioning children with autism. *Journal of Autism and Developmental Disorders, 33*(5), 489-507.

Blake, R., Turner, L.M., Smoski, M.J., Pozdol, S.L., & Stone, W.L. (2003). Visual recognition of biological motion is impaired in children with autism. *Psychological Science, 14*, 151-157.

Boccia, M., & Campos, J.J. (1989). Maternal emotional signals, social referencing, and infants' reactions to strangers. In N. Eisenberg (Ed.), *New directions of child development* (Vol. 44, pp. 25-49). San Francisco: Jossey-Bass.

Bolton, R., MacDonald, H., Pickles, A. et al. (1994). A case-control family history of autism. *Journal of Child Psychology and Psychiatry, 35*, 877-900.

Bruner, J. (1983). *Child talk: Learning to use language*. New York: Norton.
Campos, J. J., Barrett, K.C., Lamb, M.E., Goldsmith, H.H., & Stenberg, C. (1983). Socioemotional development. In M. M. Haith, & Campos, J.J. (Ed.), *Handbook of child psychology* (4th ed., Vol. 2, pp. 783-915). New York: Wiley.
Campos, J., Bertenthal, B., & Kermoian, R. (1992). Early experience and emotional development: The emergence of wariness of heights. *Psychological Science, 3*, 61-64.
Campos, J., Hiatt, S., Ramsay, D., Henderson, C., & Svejda, M. (1978). The emergence of fear on the visual cliff. In M. Lewis, & Rosenblum, L. (Ed.), *The development of affect* (pp. 149-182). New York: Plenum.
Campos, J. J., Anderson, D.I., Barbu-Roth, M.A., Hubbard, E.M., Hertenstein, M.J., Witherington, D. (2000). Travel broadens the mind. *Infancy, 1*(2), 149-219.
Capps, L., Yirmiya, N., Sigman, M. (1992). Understanding of simple and complex emotions in non-retarded children with autism. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 33*, 1169-1182.
Carter, A. S., Davis, N.O., Klin, A., Volkmar, F. (2005). Social Development in Autism. In F. R. Volkmar, Paul, R., Klin, A., Cohen, D. (Ed.), *Handbook of Autism and Developmental Disorders* (3 ed., Vol. 1, pp. 312-334). New Jersey: John Wiley & Sons, Inc.
Cassel, T., Messinger, D.S., Ibanez, L., Haltigan, J., Acosta, S., Buchman, A. (2007). Early social and emotional communication in the infant siblings of children with autism spectrum disorders: an examination of the broad phenotype. *Journal of Autism and Developmental Disorders, 37*, 122-132.
Castelli, F., Frith, C., Happe, F, Frith, U. (2002). Autism, Apserger syndrome and brain mechanisms for the attribution of mental states to animated shapes. *Brain, 125*, 1839-1849.
Celani, G., Battacchi, M.W., Arcidiacono, L. (1999). The understanding of the emotional meaning of facial expressionin people with autism. *Journal of Autism and Developmental Disorders, 29*(57-66).
Charman, T., & Baron-Cohen, S. (1994). Another look at imitation in autism. *Development and Psychopathology, 6*, 403-413.
Chawarska, K., Klin, A., & Volkmar, F.R. (Ed.). (2008). *Autism Spectrum Disorders in Infants and Toddlers: Diagnosis, Assessment, and Treatment*. New York: The Guilford Press.
Cohn, J. F., & Tronick, E.Z. (1988). Mother-infant face-to-face interaction: Influence is bidirectional and unrelated to periodic cycles in either partner's behavior. *Developmental Psychology, 24*(3), 386-392.
Critchley, H. D., Daly, E.M., Bullmore, E.T. (2000). The functional neuroanatomy of social behaviour: changes in cerebral blood flow when people with autistic disorder process facial expressions. *Brain, 123*(11), 2203-2212.
D'Entremont, B., & Muir, D. (1999). Infant responses to adult happy and sad vocal and facial expressions during face-to-face interactions. *Infant Behavior & Development, 22*(4), 527-539.
Dalton, K. M., Nacewicz, B.M., Johnstone, T., et al. (2005). Gaze fixation and the neural circuitry of face processing in autism. *Nature Neuroscience, 8*, 519-526.
Dawson, G., & Adams, A. (1984). Imitation and social responsiveness in autistic children. *Journal of Abnormal Child Psychology, 12*, 209-226.
Dawson, G., Hill, D., Spencer, A., Galpert, L., Watson, L. (1990). Affective exchanges between young autistic children and their mothers. *Journal of Abnormal Child Psychology, 18*(3), 335-345.
Dawson, G., Panagiontides, H., Klinger, L.G., Spieker, S. (1997). Infants of depressed and nondepressed mothers exhibit differences in frontal brain electrical activity during the expression of negative emotions. *Developmental Psychology, 33*, 650-656.
DeCasper, W. F., W. (1980). Of human bonding: Newborns prefer their mother's voices. *Science, 208*, 1174-1176.

de Gelder, B., Vroomen, J., Van der Heide, L. (1991). Face recognition and lip-reading in autism. *European Journal of Cognitive Psychology, 3*(1), 69-86.
Dickinson, K.L., Walker, H., & Fogel, A. (1997). The relationship between smile-type and play-type during parent-infant play. *Developmental Psychology*, *33*, 925-933.
Ekman, P., Davidson, R.J., Freisen, W. (1990). The Duchenne smile: Emotional expression and brain physiology II. *Journal of Personality and Social Psychology, 58*, 342-353.
Ekman, P., Friesen, W., Hagar, J. (2002). *Facial action coding system: the manual*. Salt Lake City: Research Nexus.
Feldman, R., Greenbaum, C.W., & Yirmiya, N. . (1999). Mother-infant affect synchrony as an antecedent of the emergence of self-control. *Developmenal Psychology, 35*, 223-231.
Fernald, A. & Morikawa, H. (1993). Common themes and cultural variations in Japanese and American mothers' speech to infants. *Child Development*, *64*(3), 637-656.
Field, T., Healy, B.T., Goldstein, S., & Guthertz, M. (1990). Behavior-state matching and synchrony in mother-infant interactions of non-depressed versus depressed dyads. *Developmenal Psychology, 26*, 7-14.
Fogel, A. Nelson-Goens, C.G., Hsu, H., & Shapiro, A.F. (2000). Do different infant smiles reflect different positive emotions? *Social Development, 9,* 497–520.
Fogel, A., Hsu, H., Shapiro, A.F., Nelson-Goens, G.C., & Secrist, C. (2006). Effects of normal and perturbed social play on the duration and amplitude of different types of infant smiles. *Developmental Psychology, 42*(3), 459-473.
Gifford-Smith, M. B., C. (2003). Childhood peer relationships: social acceptance, friendships, and peer networks. *Journal of School Psychology, 41*(4), 235-284.
Haith, M. M., Bergman, T., & Moore, M.J. (1979). Eye contact and face scanning in early infancy. *Science, 198*, 853-855.
Hannan, T. E. (1987). A cross-sequential assessment of the occurrences of pointing in 3- to 12-month-old human infants. *Infant Behavior & Development, 10*(1), 11-22.
Hannan, T. E., Fogel, A. (1987). A case-study assessment of "pointing" during the first three months of life. *Perceptual and Motor Skills, 65*(1), 187-194.
Harris, S. L. (1998). Behavioural and educational approaches to the pervasive developmental disorders. In F. R. Volkmar (Ed.), *Autism and pervasive developmental disorders. Cambridge monographs in child and adolescent psychiatry* (pp. 195-208). New York: Cambridge University Press.
Haviland, J., & Lelwica, M. (1987). The induced affect response: Ten-week-old infants' response to three emotional expressions. *Developmental Psychology, 23*(97-104), 97.
Herenstein, M. J., & Campos, J.J. (2004). The retention effect of an adult's emotional displays on infant behavior. *Child Development, 75*(2), 595-613.
Hobson, P. (2005). Autism and Emotion. In F. R. Volkmar, Paul, R., Klin, A., Cohen, D. (Ed.), *Handbook of Autism and Pervasive Developmental Disorders* (Vol. 1, pp. 406-421). New Jersey: John Wiley & Sons, Inc.
Hobson, R. P. (1986a). The autistic child's appraisal of expressions of emotion. *Journal of Child Psychology and Psychiatry, 27*(3), 321-342.
Hobson, R. P. (1986b). The autistic child's appraisal of expressions of emotion: a further study. *Journal of Child Psychology and Psychiatry, 27*(5), 671-690.
Hobson, R. P. (1989). Beyond cognition: A theory of autism. In G. Dawson (Ed.), *Autism: Nature*, *diagnosis*, *and treatment,* (pp. 22-48). New York: Guilford Press.
Hobson, R. P. (1991). Methodological issues for experiments on autistic individuals' perception and understanding of emotion. *Journal of Child Psychology and Psychiatry, 32*(7), 1135-1158.
Hsu, H. C., Fogel, A., Messinger, D.S. (2001). Infant non-distress vocalizations during mother-infant face-to-face interaction: Factors associated with quantitative and qualitative differences. *Infant Behavior & Development, 24*, 107-128.

Hubert, B., Wicker, B., Moore, D.G., Monfardini, E., Duverger, H., DaFonseca, D., Deruelle, C. (2007). Brief report: recognition of emotional and non-emotional biological motion in individuals with autistic spectrum disorders. *Journal of Autism and Developmental Disorders, 37*, 1386-1392.

Hubl, D., Bolte, S., Feineis-Matthews, S., et al. (2003). Functional imbalance of visual pathways indicates alternative face processing strategies in autism. *Neurology, 61*, 1232-1237.

Iverson, J. M., & Wozniak, R.H. (2007). Variation in vocal-motor development in infant siblings of children with autism. *Journal of Autism and Developmental Disorders, 37*, 158-170.

Jaffe, J., Beebe, B., Feldstein, S., Crown, C.L., & Jasnow, M.D. (2001). Rhythms of dialogue in infancy: Coordinated timing in development. *Monographs of the Society for Research in Child Development, 66*.

Jennings, W. B. (1973). A study of the preference for affective cues in autistic children. Unpublished Ph.D. thesis. Memphis State University.

Johnson, J. L., Koterba, E. A., Parlade, M. V., & Iverson, J. I. (2009, May). *The Effects of Parental Stress on the Emergence and Development of Joint Attention Behaviors in Infant Siblings of Children with Autism.* Presented at International Meeting for Autism Research (IMFAR), Chicago, IL.

Johnson, M. H., Dziurawiec, S., Ellis, H., & Morton, J. (1991). Newborn's preferential tracking of face-like stimuli and its subsequent decline. *Cognition, 40*(1/2), 1-19.

Jospeh, R. M., Tager-Flusberg, H. (1997). An investigation of attention and affect in children with autism and down syndrome. *Journal of Autism and Developmental Disorders, 27*(4), 385-396.

Kanner, L. (1943). Autistic disturbances of affective contact. In *Nervous Child.* Vol. 2, pp. 217-250.

Kestenbaum, R. & Nelson, C.A. (1990). The recognition and categorization of upright and inverted emotional expressions by 7-month-old infants. Infant Behavior & Development, 13(4), 497-511.

Klin, A. (1991). Young autistic children's listening preferences in regard to speech: A possible characterization of the symptom of social withdrawal. *Journal of Autism and Developmental Disorders, 21*, 217-250.

Klin, A., Jones, W., Schultz, R., Volkmar, F., Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry, 59*(9), 809-816.

Klin, A., McPartland, J., Volkmar, F.R. (2005). Asperger's Syndrome. In F. R. Volkmar, Klin, & Cohen, D. (Ed.), *Handbook of Autism and Pervasive Developmental Disorders* (3rd ed., pp. 88-125). Hoboken: Wiley.

Koning, C. Magill-Evans, J. (2001). Social and language skills in adolescent boys with Asperger syndrome. *Autism, 5*(1), 23-36.

LaBarbera, J. D., Izard, C.E., Vietze, P., Parisi, S.A. (1976). Four- and six-month-old infants' visual responses to joy, anger, and neutral expressions. *Child Development, 47*(2), 535-538.

Landa, R. & Garrett-Mayer, E. (2006). Development in infants with autism spectrum disorders: a prospective study. Journal of Child Psychology and Psychiatry, 47(6), 629-638.

Landa, R., Piven, J., Wzorek, M.M., Gayle, J.O. et al. (1992). Social language use in parents of autistic individuals. *Psychological Medicine, 22*, 245-254.

Le Couteur, A., Rutter, M., Lord, C., Rios, P., Robertson, S., Holdgrafer, M., & McLennan, J. (1989). Autism diagnostic interview: a standardized investigator-based instrument. *Journal of Autism and Developmental Disorders, 19*(3), 363-387.

Leppänen, J.M. & Nelson, C.A. (2009). Tuning the developing brain to social signals of emotions. *Nature Reviews Neuroscience*, *10*, 37-47.

Little, L. (2002). Peer victimization of children with Asperger syndrome disorders. *Journal of American Academy of Child and Adolescent Psychiatry, 40*(9), 995-996.

Lord, C., Risi, S., Lambrecht, L., Cook, E.H., Leventhal, B.L., DiLavore, P.C., Pickles, A., & Rutter, M. (2000). The autism diagnostic observation schedule - generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders, 30*, 205-223.

Lord, C., Rutter, M., LeCouteur, A. (1994). Autism diagnostic interview revised: A revised version of a diagnostic interview for caregivers of children with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24*, 659-685.

Loveland, K. A., Tunali-Kotoski, B., Chen, Y.R., Ortengon, J., Pearson, D.A., Brelsford, K.A., et al. (1997). Emotion recognition in autism: Verbal and nonverbal information. *Development and Psychopathology, 9*(3), 579-593.

Ludemann, P. & Nelson, C.A. (1988). Categorical representation of facial expressions by 7-month-old infants. *Developmental Psychology*, *24*(4), 492-501.

Meltzoff, A., & Gopnik, A. (1993). The role of imitation in understanding persons and developing a theory of mind. In S. Baron-Cohen, Tager-Flusberg, H., Cohen, D. (Ed.), *Understanding other minds: Perspectives from autism* (pp. 333-366). Oxford, England: Oxford University Press.

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

Messinger, D.S., Fogel, A., Dickinson, K.L. (2001). All smiles are positive, but some smiles are more positive than others. *Developmental Psychology*, *37*(5), 642-653.

Messinger, D. S., Fogel, A. (2007). The interactive development of social smiling. In R. V. Kail (Ed.), *Advances in Child Development and Behavior* (pp. 327-366).

Messinger, D. S., Fogel, A., Dickson, L. (2005). All Smiles Are Positive, but Some Smiles Are More Positive Than Others. In P. Ekman, Rosenberg, E.L. (Ed.), *What the face reveals: Basic and applied studies of spontaneous expression using the facial action coding system (FACS)* (2nd ed., pp. 328-353). New York City: Oxford University Press.

Moore, D. G., Hobson, R.P., & Lee, A. (1997). Components of person perception: An investigation with autistic, non-autistic retarded and typically developing children and adolescents. *British Journal of Developmental Psychology, 15*, 401-423.

Moore, G., & Calkins, S.D. (2004). Maternal behavior mediates the relation between infant physiological and behavioral distress in the Still-Face paradigm. *Developmental Psychology, 40*, 1068-1080.

Moore, G. A., Cohn, J.F., Campbell, S.B. (2001). Infant affective responses to mother's still face at 6 month differentially predict externalizing and internalizing behavior at 18 months. *Developmental Psychology, 37*(5), 706-714.

Moses, L. J., Baldwin, D.A., Rosicky, J.G., & Tidball, G. (2001). Evidence for referential understanding in the emotions domain at 12 and 18 months. *Child Development, 72*, 718-735.

Mumme, D., & Fernald, A. (2003). The infant as onlooker: Learning from emotional reactions observed in a television scenario. *Child Development, 74*, 221-237.

Mumme, D., Fernald, A., Herrera, C. (1996). Infant responses to facial and vocal emotional signals in a social referencing paradigm. *Child Development, 67*, 3219-3237.

Narayan, S., Moyes, B., & Wolff, S. (1990). Family characteristics of autistic children: a further report. *Journal of Autism and Developmental Disorders, 20*, 523-535.

Nelson, C.A. & Tager-Flusberg, H. (2009). *Neurophysiological markers of autism risk*. Presented at the Baby-Sibling Research Consortium (BSRC), Miami, FL.

Ogai, M., Matsumoto, H., Suzuki, K., et al. (2003). fMRI study of recognition of facial expressions in high-functioning autistic persons. *Neuroreport, 14*, 559-563.

Olson, G., & Sherman, T. (1983). Attention, learning, and memory in infants. In M. M. Haith, & Campos, J.J. (Ed.), *Handbook of child psychology: Infancy and developmental psychobiology* (Vol. 2, pp. 1001-1080). New York: Wiley.

Orsmond, G. I., Krauss, M.W., Seltzer, M.M. (2004). Peer Relationships and social and recreational activities among adolescents and adults with autism. *Journal of Autism and Developmental Disorders, 34*(3), 245-256.

Oster, H. (1995). Baby FACS: Analyzing facial movement in infants.

Oster, H. (2005). The repertoire of infant facial expressions: An ontogenetic perspective In J. Nadel, Muir, D. (Ed.), *The future of emotions* (pp. 261-292). New York, New York: Oxford University Press.

Oster, H., & Ewy, R. (1980). Discrimination of sad vs. happy faces by 4-month-olds: When is a smile seen as a smile? Un-published manuscript, University of Pennsylvania, Philadelphia.

Osterling, J., Dawson, G. (1994). Early recognition of children with autism: a study of first birthday home videotapes. *Journal of Autism and Developmental Disorders, 24*(3), 247-257.

Osterling, J. A., Dawson, G., & Munson, J.A. (2002). Early recognition of 1-year-old infants with autism spectrum disorders versus mental retardation. *Developmental Psychopathology, 14*(2), 239-251.

Ozonoff, S., Pennington, B.F., & Rogers, S.J. (1990). Are there emotion perception deficits in young autistic children? *Journal of Child Psychology and Psychiatry, 31*, 343-361.

Pelphrey, K. A., Morris, J.P., McCarthy, G., LaBar, K.S. (2007). Perception of dynamic changes in facial affect and identity in autism. *SCAN, 2*(140-149), 140.

Pelphrey, K. A., Sasson, N.J., Reznick, J.S., Paul, G., Goldman, B.D., Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders, 32*(4), 249-261.

Phillips, A., Wellman, H., Spelke, E. (2002). Infants' ability to connect gaze and emotion expressions to intentional actions. *Cognition, 85*, 53-78.

Piaget, J. (1951). *Psychology of intelligence*. London: Routledge and Kegan Paul.

Pierce, K., Muller, R.A., Ambrose, J., Allen, G., Courchesne, E. (2001). Face processing occurs outside of the fusiform 'face area' in autism: evidence from functional MRI. *Brain, 124*, 2059-73.

Pierce, K., Haist, F., Farshad, S., Courchesne, E. (2004). The brain response to personally familiar faces in autism: findings of fusiform activity and beyond. *Brain*, *127*(12), 2703-2716.

Piggot, J., Kwon, H., Mobbs, D., et al. (2004). Emotional attribution in high-functioning individuals with autism spectrum disorder: a functional imaging study. *Journal of American Academic Child and Adolescent Psychology, 43*, 473-80.

Piven, J., Wzorek, M., Landa, R., Lainhart, J., Bolton, P., Chase, G.A., Folstein, S. (1994). Personality characteristics of the parents of autistic individuals. *Psychological Medicine*, *24*(3), 783-795.

Piven, J. (1999). Genetic liability for autism: the behavioural expression in relatives. *International Review of Psychiatry, 11*, 299-308.

Piven, J., Palmer, P., Jacobi, D., Childress, D., & Arndt, S. (1997b). The broader autism phenotype: evidence from a family study of multiple-incidence autism families. *American Journal of Psychiatry, 154*, 185-190.

Rapacholi, B. (1998). Infants' use of attentional cue to identify the referent of another person's emotional expression. *Developmental Psychology, 34*, 1017-1025.

Rochat, P., Striano, T., & Blatt, L. (2002). Four 6-month-olds respond to still-face irrespective of expression (happy, sad, neutral) while 2-month-olds disrupted less by happy expressions more evidence for early "contagion"? *Infant and Child Development, 11*, 289-303.

Rogers, S. (2009). What are infant siblings teaching us about autism in infancy? *Autism Research*, *2*, 125-137.

Rutter, M. (1978). Diagnosis and definition. In M. E. S. Rutter (Ed.), *Autism: A reappraisal of concepts and treatment*. New York: Plenum Press.

Saarni, C., Campos, J.J., Camras, L.A., & Witherington, D. (2006). Emotional Development: Action, Communication, and Understanding. In N. Eisenberg (Ed.), *Handbook of Child Psychology* (6th ed., Vol. 3, pp. 226-299). New Jersey: John Wiley & Sons, Inc.

Sameroff, A.J. & MacKenzie, M.J. (2003). Research strategies for capturing transactional models of development: The limits of the possible. *Development and Psychopathology*, *15*, 613-640.

Schultz, R. T., Gauthier, I, Klin, A., et al. (2000). Abnormal ventral temporal cortical activity during face discrimination among individuals with autism and asperger syndrome. *Archives of General Psychiatry, 57*(331-340).

Schwartz, G. M., Izard, C. E., & Ansul, S. E. (1985). The 5-month-old's ability to discriminate facial expression of emotions. *Infant Behavior and Development, 8*, 65-77.

Sigman, M., & Ungerer, J.A. (1984b). Cognitive and language skills in autistic, mentally retarded, and normal children. *Developmental Psychology, 20*, 293-302.

Singer, J. (1996). Cognitive and affective implications of imaginative play in childhood. In M. Lewis (Ed.), *Child and adolescent psychiatry: A comprehensive textbook* (2nd ed., pp. 202-210). Baltimore: Williams & Wilkins.

Soken, N. H., & Pick, A. D. (1999). Infants' perception of dy-namic affective expressions: Do infants distinguish spe-cific expressions? Child Development, 70, 1275-1282.

Sorce, J. F., Emde, R.N., Campos, J., & Klinnert, M.D. (1985). Maternal emotional signaling: Its effect on the visual cliff behavior of 1-year-olds. *Developmental Psychology, 21*(1), 195-200.

Spence, S. (2002). Social skills training in children and young people: theory, evidence, and practice. *Child and Adolescent Mental Health, 8*(2), 84-96.

Spitz, R. (1965). *The first year of life*. New York: International Universities Press.

Stern, D. N. (1985). Affect attunement. In J. D. Call, Galenson, E., & Tyson, R.L. (Ed.), *Frontiers of infant psychiatry* (Vol. 2, pp. 3-14). New York: Basoc Books.

Sternberg, C., & Campos, J. (1990). The development of anger expressions in infancy. In N. L. Stein, Leventhal, B., & Trabasso, T. (Ed.), *Psychological and biological approaches to emotion* (pp. 247-282). Hillsdale, NJ: Erlbaum.

Stone, W. L., Lemanek, K.L., Fishel, P.T., Fermandez, M.C., & Altemeier, W.A. (1990). Play and imitation skills in the diagnosis of autism in young children. *Pediatirics, 86*, 267-272.

Striano, T., & Bertin, E. (2004). Contribution of facial and vocal cues in the still-face response of 4-month-old infants. *Infant Behavior and Development, 27*, 499-508.

Trevarthen, C. (2005). Action and emotion in development of cultural intelligence: Why infants have feelings like ours. In J. Nadel, & Muir, D. (Ed.), *Emotional development: Recent research advances* (pp. 61-91). New York: Oxford University Press.

Trevarthen, C. (1977). Descriptive analyses of infant communicative behavior. In H. R. Schaffer (Ed.), *Studies of mother-infant interaction* (pp. 227-269). London: Academic Press.

Trevarthen, C. (1979). Communication and cooperation in early infancy: A description of primary intersubjectivity. In M. Bulow (Ed.), *Before speech: The beginning of interpersonal communication* (pp. 321-347). New York: Cambridge University Press.

Trevarthen, C., & Hubley, P. (1978). Secondary intersubjectivity: Confidence, confiders, and acts of meaning in the first year of life. In A. Lock (Ed.), *Action, gesture, and symbol: The emergence of language* (pp. 183-229). New York: Academic Press.

Tronick, E., & Cohn, J.F. (1989). Infant-mother face-to-face interaction: age and gender differences in coordination and the occurrence of miscoordination. *Child Development, 60*, 85-92.

Tronick, E. Z., Als, L., Wise, S., & Brazelton, T.B. (1978). The infant's response to entrapment between contradictory messages in face-to-face interaction. *Journal of American Academy of Child Psychiatry, 17*, 1-13.

Tomasello, M., & Carpenter, M. (2007). Shared intentionality. *Developmental Science, 10*(1), 121-125.

Volkmar, F. R. (1987b). Social development. In D. Cohen, & Donnellan, A. (Ed.), *Handbook of Autism and Pervasive Developmental Disorders* (pp. 4160). New York: Wiley.
Volkmar, F. R., & Mayes, L.C. (1990). Gaze behavior in autism *Developmental Psychopathology, 2*, 61-79.
Volkmar, F. R., Cohen, D.J., & Paul, R. (1986). An evaluation of DSM-III criteria for infantile autism. *Journal of the American Academy of Child Psychiatry, 25*, 190-197.
Volkmar, F. R., Klin, A. (2005). Issues in the Classification of Autism and Related Conditions. In F. R. Volkmar, Paul, R., Klin, A., Cohen, D. (Ed.), *Handbook of Autism and Pervasive Developmental Disorders* (3 ed., Vol. 1, pp. 5-39). New Jersey: John Wiley & Sons, Inc.
Wang, L., McCarthy, G., Song, A.W., Labar, K.S. (2005). Amygdala activation to sad pictures during high-field (4 tesla) functional magnetic resonance imaging. *Emotion, 5*, 12-22.
Waters, E., Matas, L., & Sroufe, L.A. (1975). Infants' reactions to an approaching stranger: Description, validation, and functional significance of wariness. *Child Development*, *46*(2), 348-356.
Weeks, S. J., & Hobson, R.P. (1987). The salience of facial expression for autistic children. *Journal of Child Psychology and Psychiatry, 28*, 137-152.
Weinberg, K., Tronick, E.Z., Cohn, J.F., & Olson, K.L. (1999). Gender differences in emotional expressivity and self-regulation during early infancy. *Developmental Psychology, 35*(1), 175-188.
Werner, H., & Kaplan, B. (1963). *Symbol formation: an organismic-developmental approach to language and the expression of thought*. New York: John Wiley & Sons, Inc.
Werner, E., Dawson, G., Osterling, J., Dinno, N. (2000). Brief report: Recognition of autism spectrum disorder before one year of age: A retrospective study based on home videotapes. *Journal of Autism and Developmental Disorders*, *30*(2), 157-162.
Wing, L. (1985). Autistic Disorders Checklist in Children.
Wing, L., & Gould, J. (1979). Severe impairments of social interaction and associated abnormalities in children: Epidemiology and classification. *Journal of Autism and Developmental Disorders, 9*, 11-29.
Yirmiya, N., Gamliel, I., Pilowsky, T., Feldman, R., Baron-Cohen, S., Sigman, M. (2006). The development of siblings of children with autism at 4 and 14 months: social engagement, communication, and cognition. *Journal of Child Psychology and Psychiatry, 47*(5), 511-523.
Young, G.S., Merin, N., Rogers, S.J., & Ozonoff, S. (2009). Gaze behavior and affect at 6 months: predicting clinical outcomes and language development in typically developing infants and infants at risk for autism. *Developmental Science*, *12*(5), 798-814.
Young-Browne, G., Rosenfield, H., & Horowitz, F.D. (1977). Infant discrimination of facial expressions. *Child Development, 48*, 555-562.
Zwaigenbaum, L., Bryson, S., Rogers, T., Roberts, W., Brian, J., Szatmari, P. (2005). Behavioral manifestations of autism in the first year of life. *International Journal of Developmental Neuroscience, 23*, 143-152.