2017-04-28

Attachment Security Differs by Later Autism Spectrum Disorder Outcome: A Prospective Study

Katherine Blair Martin
University of Miami, kbmartin.umiami@gmail.com

UNIVERSITY OF MIAMI

ATTACHMENT SECURITY DIFFERS BY LATER AUTISM SPECTRUM DISORDER OUTCOME: A PROSPECTIVE STUDY

By

Katherine Blair Martin

A DISSERTATION

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

Coral Gables, Florida

May 2017

UNIVERSITY OF MIAMI

A dissertation submitted in partial fulfillment of
the requirements for the degree of
Doctor of Philosophy

ATTACHMENT SECURITY DIFFERS BY LATER AUTISM SPECTRUM DISORDER OUTCOME: A PROSPECTIVE STUDY

Katherine Blair Martin

Approved:

_____	_____
Daniel S. Messinger, Ph.D. Professor of Psychology	Jennifer C. Britton, Ph.D. Assistant Professor of Psychology
_____	_____
Elizabeth Simpson, Ph.D. Assistant Professor of Psychology	Michael Alessandri, Ph.D. Clinical Professor of Psychology
_____	_____
Michael Cuccaro, Ph.D. Associate Professor of Human Genetics	Guillermo J. Prado, Ph.D. Dean of the Graduate School

MARTIN, KATHERINE BLAIR (Ph.D., Psychology)
Attachment Security Differs by Later Autism Spectrum Disorder Outcome: A Prospective Study (May 2017)

Abstract of a dissertation at the University of Miami.

Dissertation supervised by Professor Daniel S. Messinger.
No. of pages in text. (62)

Attachment in children with autism spectrum disorder (ASD) has typically been assessed retrospectively after diagnosis (> 30 months), primarily using non-standardized protocols, making it difficult to interpret and compare across studies in normative and atypical samples. We assessed attachment security prospectively at 15 months in high-risk infants with later (3 year) ASD (High-Risk/ASD, n=16), and high- (High-Risk/No-ASD, n=40) and low-risk (Low-Risk/No-ASD, n=39) infants without later ASD- using the standard Strange Situation Procedure. High-Risk/ASD infants were disproportionately more likely to be classified as insecure (vs. secure, 2-way) and insecure-resistant (vs. secure vs. avoidant, 3-way) than High-Risk/No-ASD and Low-Risk/No-ASD (2-way, 56.3%, 15.0%, 20.5% respectively; 3-way, 37.5%, 7.5%, 10.3%, respectively). Compared to high- and low-risk infants without later ASD, high-risk infants with later ASD did not show less intense attachment behaviors with their parents, but were more likely to display insecure-resistant attachment. High-risk infants with insecure attachments were 7.28 times more likely to receive an ASD diagnosis than high-risk infants with secure attachments. As an index of early social-emotional functioning, attachment security in high-risk infants may serve as a potential behavioral marker and target for intervention.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental disorder involving impairments in social-emotional functioning, including difficulties forming and maintaining relationships (American Psychiatric Association, 2013). Given social-emotional impairments in ASD, researchers have investigated the quality of the attachment relationship between children with ASD and their parents. However, no studies have prospectively assessed security of attachment in infants at familial risk for ASD, including those who go on to a later ASD.

Attachment security indexes an infant's expectations of appropriate parental availability and care, particularly during periods of stress. Early researchers suggested children with ASD did not exhibit attachment behaviors (e.g. proximity seeking, contact maintenance) and were unable to form affectionate bonds with parents (Kanner, 1943). More recent research suggests children with ASD demonstrate a clear preference for their parents over a stranger and increase proximity-seeking behaviors with their parent after separation (Shapiro, Sherman, Calamari, & Koch, 1987; Sigman & Mundy, 1989). However, children with ASD tend to exhibit fewer attachment behaviors and to a lesser degree than children without ASD (Dissanayake & Crossley, 1996; Rutgers, Van IJzendoorn, Bakermans-Kranenburg, & Swinkels, 2007; Sigman & Mundy, 1989). Meta-analytic results indicated that children with ASD were significantly less likely to be classified as securely attached (approximately 50%) than children without ASD (approximately 67%) (Rutgers, Bakermans‐Kranenburg, IJzendoorn, & Berckelaer‐Onnes, 2004). However, none of the studies compiled in the Rutgers et al. (2004) meta-

analysis utilized prospective, standardized assessments of attachment during infancy, making it difficult to interpret and compare across studies in normative and atypical samples. The gold-standard assessment of attachment security is the Strange Situation Protocol (SSP) and is typically administered between 12-15 months of age (Ainsworth, Blehar, & Waters, 1978). The SSP involves two brief separations from and reunions with the parent, which activates the children's attachment systems. During reunions with the parent, experts rate infant attachment behaviors (i.e. proximity seeking, contact maintenance, resistance, avoidance). These ratings, in turn guide the classification of infant attachment status (e.g., secure), which reflect expectations about the parent's availability. Secure infants (B) use their parents as a safe base from which to explore the environment. Insecure-avoidant (A) infants avoid their parents when reunited after separation. Insecure-resistant (C) infants seek contact upon reunion, but are not easily comforted. Infants are also orthogonally classified as disorganized (D), which indicates the absence of an organized attachment strategy and indexes the presence of unusual or contradictory behaviors.

Due to unstandardized assessments and methodological limitations, research from attachment classifications in children with ASD is not easily compared to research from attachment classifications in infants without ASD. First, studies of attachment in ASD have relied largely on modified versions of the SSP. Many studies of attachment security and ASD used unstandardized protocols, where older children with ASD were separated only once from their parents (Shapiro et al., 1987; Willemsen-Swinkels, Bakermans-Kranenburg, Buitelaar, IJzendoorn, & Engeland, 2000) or not separated at all (Dissanayake & Crossley, 1996; Rogers, Ozonoff, & Maslin-Cole, 1993). These

modifications may not have produced adequate activation of the attachment system, influencing the results of the studies.

In the Rutgers et al. (2004) meta-analysis of attachment security in ASD, all studies were conducted with children who were chronologically and mentally older than 24 months—which is, generously, the upper bound for which the SSP was designed (Ainsworth et al., 1978). Most importantly, all studies included in the Rutgers et al. (2004) meta-analysis of attachment security were conducted with children who had already received an ASD diagnosis. No studies utilized a prospective design in which infant security was assessed before children received an ASD diagnosis. These retrospective designs make it difficult to disentangle whether apparent attachment differences were directly associated with ASD symptoms or whether attachment differences were evident before ASD outcome.

We set out to fill this important methodological gap in the literature by prospectively examining attachment security in infants at familial risk for ASD (high-risk infants). High-risk infants, the infant siblings of children with ASD, are an ideal sample to study the association between attachment security in infancy and later ASD outcomes. Approximately 19% of longitudinally followed high-risk infants go on to develop the disorder themselves (Messinger et al., 2015). Thus, high-risk infants enable researchers to examine the emergence, development, and characterization of attachment security in infants who have high levels of familial-susceptibility to ASD (Baker, Messinger, Lyons, & Grantz, 2010). In a previous study of infant siblings of children with ASD, high-risk infant siblings were not more likely to be classified as insecurely attached to their parent as infant siblings of typically-developing children (John D Haltigan, Ekas, Seifer, &

Messinger, 2011). As diagnostic outcomes are now available in these infants, we sought to build upon this earlier study by examining attachment security in relation to later ASD outcome.

The current study examined infant siblings of children with and without ASD to determine whether attachment security at 15 months differs by later diagnostic outcome at 36 months (ASD or no ASD diagnosis). This prospective design allowed us to assess attachment security and its relation to ASD, using the standardized SSP at an appropriate developmental age for which the SSP was designed. We asked whether infants later diagnosed with ASD were more likely to be insecurely attached than infants without a later ASD. We also explored whether infants with later ASD displayed attachment behaviors to a lesser degree than infants without later ASD.

CHAPTER 2: METHODS

Participants and diagnostic procedure

Participants consisted of 95 infant-parent dyads enrolled in a longitudinal study examining the development of infants with and without an older sibling with ASD. Infant-parent dyads completed the Strange Situation Protocol at 15 months (*M*=15.1 months, SD=.4) and were assessed for an ASD diagnosis at 36 months. 91 infants and their mothers and 4 infants and their fathers were seen in the SSP (**Table 1**). Infants were excluded from the study if they had a gestational age below 37 weeks or major birth complications. Parents were reimbursed for their child's participation in the study. Recruitment and procedures were approved by the university's Internal Review Board and written parental consent was obtained before participation.

ASD outcome. The sample included infants with (high-risk, *n*=56) and without (low-risk, *n*=39) an older sibling with ASD. At 36 months, a DSM-IV-based clinical best-estimate ASD (yes or no) diagnosis was given to low- and high-risk infants by a licensed clinical psychologist. The diagnosis was informed by the 30-month Autism Diagnostic Observation Schedule (Lord et al., 2000) and the 36-month Autism Diagnostic Interview-Revised (Lord, Rutter, & Le Couteur, 1994). No low-risk infants received an ASD diagnosis. Of the 56 high-risk infants, 16 infants received an ASD diagnosis (**Figure 1**). We examined group differences in attachment security among three independent, outcome groups: high-risk children with a later ASD outcome (High-Risk/ASD, *n*=16), high-risk children without a later ASD outcome (High-Risk/No-ASD, *n*=40), and low-risk children (Low-Risk/No-ASD, *n*=39).

Procedures

Strange Situation Protocol (SSP). The SSP (Ainsworth & Wittig, 1969; Ainsworth et al., 1978) consists of eight 3-minute episodes. These episodes include brief periods of interaction between the parent and child, interaction between the child and an unfamiliar experimenter, and two episodes in which the parent leaves the child, each followed by a reunion episode.

Categorical attachment classification. Security of attachment was assessed using the SSP at 15 months (Ainsworth et al., 1978). An expert rater trained by L. Alan Stroufe scored infants on proximity seeking, contact maintenance, resistance, and avoidance behaviors from 1-7 for each reunion as well as disorganization from 1-9. Infants were then classified as Secure (B, *n*=72), Avoidant (A, *n*=10), or Resistant (C, *n*=13). Additionally, infants were orthogonally classified as Disorganized (D, *n*=22) using the (Main and Solomon (1990)) scoring system. The expert rater was blind to ASD-risk status. Twenty-five percent of the sample was double-coded by a second expert rater for reliability (4-way classification (A, B, C, D), 80% agreement, $\kappa = .63$).

Continuous dimensions of attachment security. As an supplement to categorical classification, attachment security was also examined as a continuous score along two dimensions: disorganized/resistance behaviors and approach/avoidance behaviors (Fraley & Spieker, 2003). The disorganized/resistance dimension was calculated as the mean of the z-scores for resistance ratings for each reunion (Reunion 1 and Reunion 2) and the disorganization ratings for the entire SSP. The approach/avoidance dimension was calculated as the mean of proximity seeking (reverse

coded), contact maintenance (reverse coded), and avoidance ratings for each reunion (Reunion 1 and Reunion 2).

Analytic approach. Attachment security was assessed at the 2-way (secure vs. insecure (resistant and avoidant) attachment; **Table 2**) and the 3-way (secure, resistant, avoidant; **Table 3**) levels. We examined attachment security classifications by outcome (High-Risk/ASD, High-Risk/No-ASD, Low-Risk/No-ASD) for the 2-way level (secure vs. insecure) using chi-square analyses. Due to small cell sizes, we examined attachment security classification by outcome group at the 3-way level (secure, resistant, avoidant) using Fisher's exact test. We separately assessed whether groups differed by disorganization classification (**Table 4**) using chi-square analyses. Follow-up analyses examined attachment classifications differences between High-Risk/ASD infants and High-Risk/No-ASD and Low-Risk/No-ASD infants separately. Thus, p-values were Bonferroni corrected to .025 for 2-way and disorganization analyses, and .0125 for 3-way analyses. Continuous scores of approach/avoidance behaviors and resistance/disorganization behaviors were examined for ASD outcome differences using analyses of variance (ANOVAs). Within each attachment classification, behavior ratings of proximity seeking, contact maintenance, avoidance, resistance, and disorganization were examined to determine whether infants with later ASD exhibited less intense attachment behaviors than infants without a later ASD.

CHAPTER 3: RESULTS

Categorical assessment of attachment security

Secure, insecure (2-way). A 2 (secure, insecure) by 3 (outcome group) chi-square test revealed a relationship between secure and insecure attachment classifications and the three outcome groups, $\chi^2(2, N = 95) = 11.09$, $p < .01$. High-Risk/ASD infants were disproportionately more likely to be classified as insecure than High-Risk/No-ASD infants, $\chi^2(1, N = 56) = 9.92$, $p < .01$, and Low-Risk/No-ASD infants, $\chi^2(1, N = 55) = 6.79$, $p < .01$ (**Figure 2**). 56.3% of High-Risk/ASD infants were classified as insecurely attached compared to 15.0% of High-Risk/No-ASD and 20.5% of Low-Risk/No-ASD infants. The follow-up odds ratio revealed high-risk infants with insecure attachments were 7.28 times more likely to receive an ASD diagnosis than high-risk infants with secure attachments.

Secure, resistant, avoidant (3-way). A 3 (secure, resistant, avoidant) by 3 (outcome group) chi-square test revealed a relationship between attachment classifications and the three outcome groups, $\chi^2(4, N = 95) = 12.15$, $p = .02$. High-Risk/ASD infants had a different distribution of attachment classifications than High-Risk/No-ASD infants, $\chi^2(2, N = 95) = 10.41$, $p < .01$ and Low-Risk/No-ASD infants, $\chi^2(2, N = 95) = 7.37$, $p = .01$ (**Figure 3**). A higher proportion (37.5%) of High-Risk/ASD infants had a resistant attachment classification than both High-Risk/No-ASD infants (7.5%), $p < .01$, and Low-Risk/No-ASD infants (10.3%), $p = .01$. High-Risk/ASD infants did not differ from High-Risk/No-ASD and Low-Risk/No-ASD infants in proportions of avoidant attachment classifications, ps>.05.

Disorganization. A 2 (disorganized or not disorganized) by 3 (outcome group) chi-square test revealed no association between disorganized classifications and the three outcome groups, $\chi^2(2, N = 95) = 0.81$, $p > .65$. High-Risk/ASD infants were not disproportionately more likely to be classified as disorganized than High-Risk/No-ASD, $\chi^2(1, N = 56) = 0.81$, $p = .40$, and Low-Risk/No-ASD, $\chi^2(1, N = 55) = 0.40$ $p = .53$, infants. 31.3% of High-Risk/ASD infants were classified as insecurely attached compared to 23.1% of High-Risk/No-ASD and 20.0% of Low-Risk/No-ASD infants.

Continuous assessment of attachment security

Dimensions of attachment security. A one-way ANOVA revealed that outcome groups differed along the disorganized/resistance dimension, $F(2, 92)=3.47$, $p=.03$ (see **Table 5** for means and standard deviations). Follow-up Bonferroni tests revealed High-Risk/ASD infants had higher disorganized/resistance scores than both High-Risk/No-ASD, $p=.04$, and Low-Risk/No-ASD infants, $p=.04$, infants (**Figure 4**). A one-way ANOVA indicated that outcome groups did not differ along the approach/avoidance dimensions, $F(2,92)=.79$, $p>.05$ (see **Table 5** for means and standard deviations). High-Risk/ASD infants did not show lower levels of attachment behaviors within the disorganized/resistance and approach/avoidance dimension than High-Risk/No-ASD and Low-Risk/No-ASD infants. In fact, High-Risk/ASD infants showed higher levels of disorganized/resistance behaviors than High-Risk/No-ASD and Low-Risk/No-ASD infants.

Ratings of individual attachment behaviors. One-way ANOVAs revealed no mean differences in behavior ratings of proximity seeking, contact maintenance, avoidance, and resistance in Reunion 1 and Reunion 2 by later ASD outcome within the

Secure, Avoidant, and Resistant classifications, *p*s>.10 (**Figure 5**). A one-way ANOVA revealed no mean differences in disorganization behaviors throughout the SSP by later ASD outcome within the Disorganization classification, *p*>.30. High-Risk/ASD infants did not show lower levels of attachment behaviors than High-Risk/No-ASD and Low-Risk/No-ASD infants.

CHAPTER 4: DISCUSSION

This is the first study to prospectively examine attachment differences in infants with and without a later ASD outcome. First, we found that high-risk siblings with later ASD (High-Risk/ASD) were more likely to display insecure attachment patterns than infants without later ASD (both High-Risk/No-ASD and Low-Risk/No-ASD). Specifically, a higher proportion of High-Risk/ASD infants had resistant classifications attachment—a type of insecure attachment—than High-Risk/No-ASD or Low-Risk/No-ASD infants. High-Risk/ASD infants did not differ from High-Risk/No-ASD and Low-Risk/No-ASD infants in their proportion of disorganized classifications. When assessing attachment security dimensionally, High-Risk/ASD infants, compared to High-Risk/No-ASD and Low-Risk/No-ASD infants, had higher disorganized/resistance scores, but did not differ in their approach/avoidance scores. Lastly, we explored the individual behaviors that inform attachment classification and found that High-Risk/ASD infants displayed similar levels of attachment behaviors compared to their peers.

This prospective study addressed central limitations in the literature on attachment security and its relation to ASD. First, we prospectively examined attachment security *before* infants received a diagnosis, ensuring that ASD symptomatology did not confound measures of attachment security. Previous retrospective designs made it difficult to disentangle whether apparent attachment differences were due to prevalent ASD symptoms. In addition, attachment security was assessed using the standardized SSP, incorporating two infant separations from and reunions with the parent—allowing raters to characterize attachment behaviors and classify attachment security in a standard fashion.

Categorical assessment of attachment security

The current prospective findings reveal a difference in attachment security by later ASD outcome, such that higher rates of insecurity were observed in the high-risk infants with later ASD compared to the low- and high-risk infants without later ASD. This suggests that ASD children, in infancy, present a different profile of overall attachment compared to their peers. Across all studies in the Rutgers et al. (2004) meta-analysis of attachment security, 47% of children with ASD were classified as insecure, a finding similar to the rate we found here (56%), and the meta-analysis yielded higher rates of insecurity in children with ASD than children without ASD. The current findings converge with previous findings indicating that infants with later ASD are disproportionately more likely to be classified as insecure than infants without later ASD.

Potential explanations for ASD-insecurity likely involve both infant (e.g. ASD symptomatology, temperament) and parent factors (e.g. parental sensitivity). Infants with later ASD outcomes and insecure attachments may display behaviors reflecting temperamental factors (e.g. high reactivity) or emerging ASD symptomatology (e.g. repetitive behaviors, low levels of eye contact) that interfere with their ability to establish a secure attachment with their parents. In normative samples, infant temperament is modestly associated with attachment security, such that infants with a more difficult temperament (e.g. high reactivity, negative affect, distress) are more likely to be classified as insecure (Groh et al., 2016). Future research could propitiously examine whether the factors that contribute to the development and characterization of attachment security in normative samples, such as temperament, are similar to the factors that contribute to attachment security in high-risk infants with a later ASD outcome.

The formation of secure attachments may also be related to other developmental variables related to ASD (e.g. IQ or developmental age). Sigman and Capps (1997) posited that the development of secure attachment in children with ASD may develop slowly or never be reached. In fact, Rogers et al. (1993) found a relationship between developmental functioning (a combination of developmental age, chronological age, and language skills) and attachment security in children with ASD. The Rutgers et al. (2004) meta-analysis also found an effect of mental development on attachment security in children with ASD. Children with ASD who had higher levels of developmental functioning were more likely to be classified as secure than children who had lower levels of developmental functioning. The high-risk infants with later ASD may have been the most developmentally impaired among infants in our sample, which could have influenced their attachment security. Assessing infant developmental functioning and following these infants longitudinally could provide answers as to whether their insecure attachments persist or whether they form a secure attachment at a later time point as their developmental functioning improves.

In addition to possible infant factors, parent factors, such as parental sensitivity, may be associated with attachment security in high-risk infants. Parental sensitivity refers to the parent's ability to correctly interpret and respond appropriately to the infant's behaviors and signals (Mesman, Oster, & Camras, 2012). In non-ASD samples, parental sensitivity is associated with attachment security, such that higher levels of parental sensitivity promote secure attachment (Wolff & IJzendoorn, 1997). However, in an ASD sample, the expected relationship between parental sensitivity and attachment security was not detected (Van IJzendoorn et al., 2007). Thus, it remains unclear whether parental

sensitivity contributes to the development of attachment security in a high-risk sample for ASD. If we assume that parental sensitivity fosters attachment security in high-risk siblings, interventions (Juffer, Bakermans-Kranenburg, & Van Ijzendoorn, 2012) could focus on this aspect of the parent-child relationship.

Parents of infants with later ASD may also be taxed in their ability to sensitively respond to their infants due to the increased emotional demands of parenting an older child with ASD and increased anxiety concerning the development of the infant at-risk for ASD (Benson, 2006; Naomi V. Ekas, Lickenbrock, & Whitman, 2010; Naomi V Ekas, Whitman, & Shivers, 2009; Whitman, 2004). In the current study, only high-risk infant siblings that went on to develop ASD exhibited higher proportions of insecure attachments. Parents of high-risk infants without a later ASD outcome have similar stressors as high-risk infants with a later ASD outcome, but these infants were not more likely than low-risk infants to be classified as insecurely attached. If sensitive parenting is able to foster secure attachment with infants with later ASD, this may function as a protective factor and provide them with a better trajectory for social-emotional development.

It is perhaps most probable that a combination of infant and parent factors contribute to a higher proportion of insecurity in infants with later ASD. Parents' reactivity to the temperamental difficulties and developmental impairments of their infants with later ASD may hinder their ability to sensitively respond to the needs of their infants and contribute to higher levels of insecurity in these infants. Future research could begin to understand the mechanism of early attachment formation by focusing on the

interactive processes (both parent and infant factors) that contribute to the development of attachment security in infants at high-risk for ASD.

This prospective study suggests that many infants with later ASD exhibit subtle, social-emotional difficulties well before the age of diagnosis, as evidenced by a high incidence of insecure attachments in early infancy. Thus, it may be important to examine social-emotional functioning earlier than 15 months to examine when High-Risk/ASD infants diverge from other high- and low-risk infants without ASD. The Face-to-Face/Still-Face (FFSF), a prominent measure of early social emotional functioning where an interaction between infant and parent is interrupted by a lack of parental responsivity, may be one future avenue that would allow us to examine potential antecedents of attachment security (Tronick, Als, Adamson, Wise, & Brazelton, 1979). During the FFSF, infants' ability to self-regulate is taxed during the cessation and resumption of parental responsivity, marked by an increase in negative affect. Particularly during reunion with their infant, parents must respond sensitively to the signals of the infant, which often includes distress. Whether parents and infants can meet the demands of these tasks may index the quality of early parent-infant interactive history and provide a window into the early development of attachment relationships (John David Haltigan, 2009). Future research might observe parent (parental sensitivity, contact with infant) and infant (fussiness, social smiling) factors at earlier time points and examine their relationship to later attachment and ASD outcome. Based on the findings in the present study, we might predict that infants who go on to develop ASD, compared to typically developing infants, may seek parental contact, but yet not be comforted as quickly or effectively by a caregiver, following a still-face episode.

Looking beyond the antecedents of attachment, it is important to consider what implications these findings have for development over time. While infants with later ASD were more likely to be classified as insecure than infants without a later ASD, 44% of them were securely attached to their parent. Secure attachment in the context of ASD may serve as a protective factor, leading to higher levels of social-emotional functioning. Likewise, insecure attachment classifications in non-ASD samples are associated with behavior problems (Fearon, Bakermans-Kranenburg, Van IJzendoorn, Lapsley, & Roisman, 2010; Madigan, Atkinson, Laurin, & Benoit, 2013), emotion regulation and expression, compliance with parents, and peer relationships (Kochanska, 2001a, 2001b; Matas et al., 1978; Schneider et al., 2001; Sroufe, 2005), which are all areas of concern in children with ASD. Following infants developmentally would allow researchers to address important questions about the implications of attachment security for later adjustment (Capps, Sigman, & Mundy, 1994).

Importantly, such a strategy might shed light on whether insecure attachment makes a difference in the trajectory of high-risk infants. High-risk infants with insecure attachments were 7.28 times more likely to receive an ASD diagnosis than high-risk infants with secure attachments. Thus, security of attachment at 15 months may have some diagnostic utility in its predictive value of later ASD. Further, high-risk infants with later ASD and early insecure attachments may incur an additive risk effect and show elevated levels of later social-emotional difficulties (e.g., with respect to. behavior problems, peer relationships, language level) compared to high-risk infants with later ASD and early secure attachments. Alternatively, insecure attachment may not confer additional risk over and above the severity of an infant's later ASD. Another possible

trajectory is informed by Bowlby (1982)'s theoretical framework that implicated early disruptions in attachment formation in the development of psychopathology. Thus, early insecure attachment in the context of emerging ASD may result in higher levels of later comorbid psychopathology, such as anxiety and attention deficit hyperactivity disorder, with ASD. If insecurity is implicated in a negative developmental cascade in high-risk infants, early identification and interventions might target this group of high-risk/insecure infants to minimize the additional risk factor of insecure attachment in the context of emerging ASD.

Exploring attachment classifications further, infants with later ASD were disproportionately more likely to have resistant attachment classifications than high- and low-risk infants without later ASD. Given the association between early temperament and resistant attachment classification (Groh et al., 2016), it is possible that high-risk infants with later ASD show early temperamental differences that affect the infants ability to establish secure attachments. Children with later ASD have been reported to exhibit a temperamental profile in infancy distinguished by lower positive affect, higher negative affect, and more difficulty controlling attention and behavior than children (both high- and low-risk) without later ASD (Bryson et al., 2007; Garon et al., 2009). This temperamental profile may render infants with later ASD outcomes more prone to resistant attachment classifications.

The Rutgers et al. meta-analysis did not focus on individual attachment classifications, but instead focused on the dichotomy of insecure and secure attachment in children with ASD (Rutgers et al., 2004). Thus, it remains important that future research continue to explore differences in attachment classifications by secure, avoidant, and

resistant, as it is possible that high-risk infants with resistant attachment classification have different trajectories than high-risk infants with avoidant classifications.

In previous research in non-ASD samples, 15-month resistant infants had lower social competence and lower expressive language at 3 years than secure infants (Belsky & Fearon, 2002). If this same pattern occurs in high-risk infants, infants with later ASD and early resistant classifications may incur an additive risk of attachment classification and ASD diagnosis for social competence and expressive language deficits. That is, high-risk infants with later ASD with early resistant classifications may show the more difficulty with social competence and expressive language than high-risk infants with later ASD with secure attachments. Resistance classifications are characterized by a clear pattern of infant clinging, over-dependency, and limited exploration (Cassidy & Berlin, 1994). Infants high in resistance quickly alternate between seeking contact and rejecting it, unable to utilize the comfort that is provided (Waters, Crowell, Elliott, Corcoran, & Treboux, 2002), resulting in a preoccupation with the parent and limiting the amount of exploration. In high-risk infants with later ASD, resistant attachment, marked by a dependency and need to cling to the parent, may contribute to children's insistence on sameness and routine in later development.

No group differences in disorganized attachment were noted. In previous studies, a higher percentage of children with ASD (> 31%) were classified as disorganized (Capps et al., 1994; Willemsen-Swinkels et al., 2000). Discrepancies in disorganized attachment between the current study and previous literature may reflect that our assessment of attachment security occurred before ASD diagnosis and before pervasive ASD symptomatology was present. Previous research has examined disorganized attachment in

older children who were diagnosed with ASD (Capps et al., 1994; Willemsen-Swinkels et al., 2000). Given that disorganized behaviors, such as freezing, head banging and motor stereotypies, overlap with ASD symptoms, the greater percentage of disorganization in children with ASD compared to children without ASD may have been attributable to prevalent ASD symptoms, and not disorganized attachment alone.

Continuous assessment of attachment security

To further explore the association between attachment security and later ASD beyond categorization, we next employed a dimensional approach (Fraley & Spieker, 2003). This approach revealed that High-Risk/ASD infants, compared to High-Risk/No-ASD and Low-Risk/No-ASD infants, had higher disorganized/resistance scores, but did not differ in their approach/avoidance scores. Thus, High-Risk/ASD infants did not show lower levels of attachment behaviors within these dimensions than their peers. In fact, High-Risk/ASD infants showed higher levels of disorganized/resistance behaviors than their peers. Again, these results suggest that infants later diagnosed with ASD already exhibit insecurity in their attachment behaviors with caregivers at 15 months of age, specifically in the way they organize their behaviors or resist their caregivers' contact/comfort attempts. As there were no differences in disorganized attachment classification by later ASD outcome, differences in the disorganized/resistant dimension were likely due to increased resistance scores in infants with later ASD who were overrepresented in the resistant classification. This suggests that ASD infants' heightened insecurity is reflected, in part, in higher rates of resistance behaviors, such that these infants may display more difficulties in utilizing the comfort provided by the than infants without later ASD.

However, these overall classifications and dimensions do not tell us what specific behaviors, or constellation of behaviors, may underlie these differences. Previous work has suggested that children with ASD exhibit attachment behaviors to a lesser degree (e.g. less proximity seeking and contact maintaining) than children without ASD (Dissanayake & Crossley, 1996; Rutgers et al., 2007; Sigman & Mundy, 1989). Therefore, we also examined individual ratings of four types of attachment behaviors within each attachment classification: proximity seeking, contact maintenance, resistance, and avoidance. By examining attachment behaviors within each attachment classification, possible differences in attachment behavior ratings were due to factors related to ASD outcomes and not factors related to attachment classification. Using this final approach, we found striking similarities in specific attachment behaviors between infants with later ASD and infants without later ASD. We found no evidence that High-Risk/ASD infants exhibit differences in these attachment behaviors compared to High-Risk/No-ASD and Low-Risk/No-ASD infants. These findings suggest that there are more similarities than there are differences when comparing ASD and non-ASD infants' attachment behaviors, and paint a somewhat hopeful picture that there may be some healthy attachment behaviors that may be nurtured.

While an earlier literature suggests children with ASD had lower levels of attachment behaviors than children without ASD (Dissanayake & Crossley, 1996; Sigman & Mundy, 1989), the current sample provides no evidence that infants with later ASD had lower levels of attachment behaviors than infants without later ASD. Early research that assessed attachment behaviors in children with ASD examined these behaviors in children already diagnosed with ASD (Dissanayake & Crossley, 1996;

Sigman & Mundy, 1989). It may be that these older children with ASD exhibited lower levels of attachment behaviors because of the interference of ASD symptoms. Our study attempts to control for this possibility by examining attachment behaviors before infants receive an ASD diagnosis. Thus, our study suggests that while infants with later ASD do exhibit differences in their attachment classifications than infants without later ASD, they do not differ in their individual attachment behaviors and are able to form attachments with their parents. As noted by Rogers et al. (1993) and confirmed in the current study, the presence of a familial risk for a developmental disorder does not prevent the development or behavior expression of attachment.

Limitations and future directions

Limitations of the current study include the absence of complete data on prior measures of developmental functioning and parental sensitivity or outcome measures of social-emotional functioning. Consequently, we were unable to explore the contribution of antecedent measures of developmental functioning (e.g. temperament, ASD symptomatology) and parental sensitivity. We were also unable to determine whether insecure attachment alters the trajectory of social-emotional development in high-risk infants and in the context of ASD. Nevertheless, the results of this study warrant follow-up in larger samples and call attention to the need to consider not only attachment security versus insecurity in ASD research, but also how security of attachment may alter the trajectory of social-emotional development, particularly in high-risk infants.

Early researchers suggested children with ASD did not exhibit attachment behaviors, and reported that children with ASD were unable to form affectionate bonds with parents (Kanner, 1943). These claims fostered research examining attachment

security in children with ASD as an early index of social-emotional functioning (Rutgers et al., 2004; Sigman & Mundy, 1989). The current study expands upon previous literature by prospectively examining attachment security in infants *before* diagnosis. These results add to the accumulation of research that refutes Kanner (1943) claims and instead indicate that infants and children with ASD *are* able to form an attachment relationship with their parents. Current findings on attachment security in infancy converge with previous findings in children, that approximately half of infants with later ASD are securely attached (Rutgers et al., 2004). However, infants with later ASD show a higher proportion of insecure attachment patterns, and specifically resistant attachment, than infants without later ASD. As an index of early social-emotional functioning, attachment security in high-risk infants with later ASD may serve as a potential target for intervention to help lay the foundation for later social development.

TABLES

Table 1. Infant gender

	Low-Risk/No-ASD	High-Risk/No-ASD	High-Risk/ASD	Totals
Boys	19	24	11	54
Girls	20	16	5	41
Totals	39	40	16	95

Note. Gender by later ASD outcome

Table 2. Secure and Insecure attachment classification

	Low-Risk/No-ASD	High-Risk/No-ASD	High-Risk/ASD	Totals
Insecure	8 (20.5%)	6 (15.0%)	9 (56.3%)	23
Secure	31 (79.5%)	34 (85.0%)	7 (43.8%)	72
Totals	39	40	16	95

Note. Frequency and proportion of secure and insecure attachment classification by later ASD outcome

Table 3. Secure, Resistant, and Avoidant attachment classification

	Low-Risk/No-ASD	High-Risk/No-ASD	High-Risk/ASD	Totals
Secure	31 (79.5%)	34 (85.0%)	7 (43.8%)	72
Resistant	4 (10.3%)	3 (7.5%)	6 (37.5%)	13
Avoidant	4 (10.3%)	3 (7.5%)	3 (3.2%)	10
Totals	39	40	16	95

Note. Frequency and proportion of secure, resistant, and avoidant attachment classification by later ASD outcome

Table 4. Disorganization attachment classification

	Low-Risk/No-ASD	High-Risk/No-ASD	High-Risk/ASD	Totals
D	9 (23.1%)	8 (20.0%)	5 (31.3%)	22
No D	30 (76.9%)	32 (80.0%)	11 (68.7%)	73
Totals	39	40	16	95

Note. Frequency and proportion of disorganization attachment classification (D) by later ASD outcome

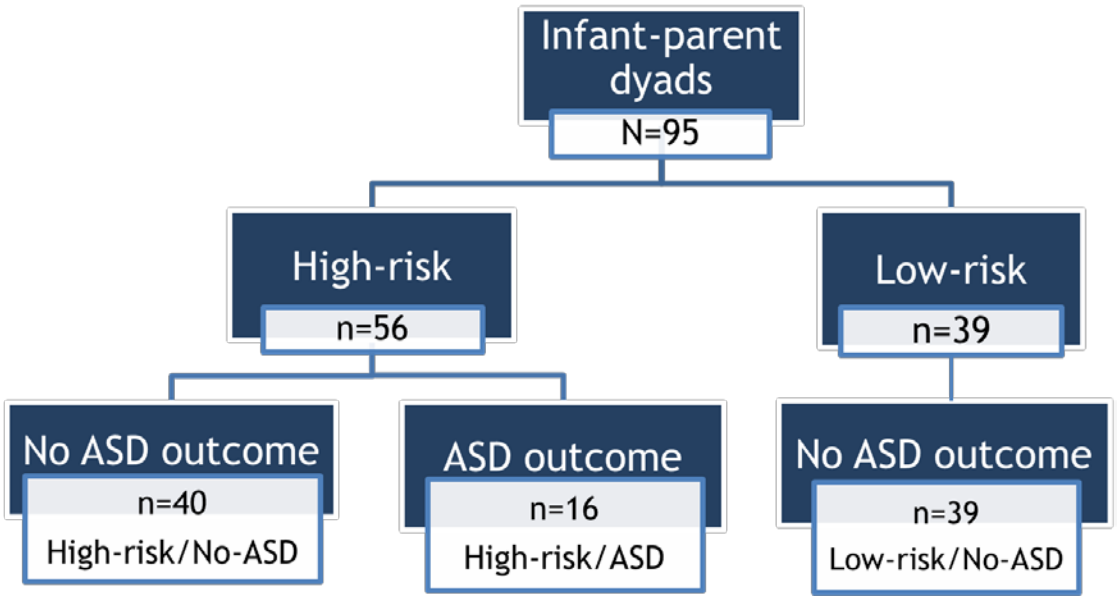
Table 5. Continuous dimensions of attachment behaviors

	Low-Risk/No-ASD Mean (SD)	High-Risk/No-ASD Mean(SD)	High-Risk/ASD Mean (SD)
Disorganized/ Resistance	2.28 (1.35)	2.28 (1.19)	3.24 (1.63)
Approach/ Avoidance	3.02 (1.21)	3.38 (1.47)	3.34 (1.31)
Totals	39	40	16

Note. Mean and Standard deviation of resistance/disorganization dimension and approach/avoidance dimension by later ASD outcome.

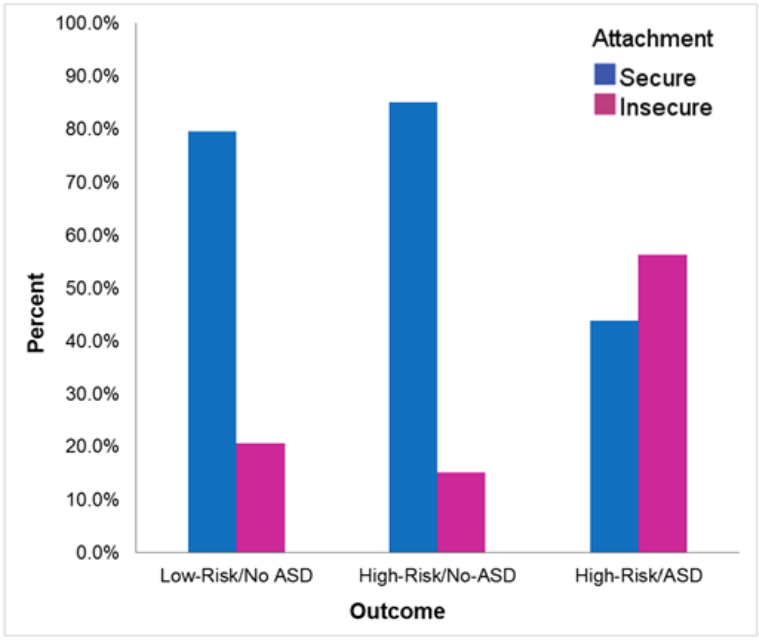
FIGURES

Figure 1. Participants



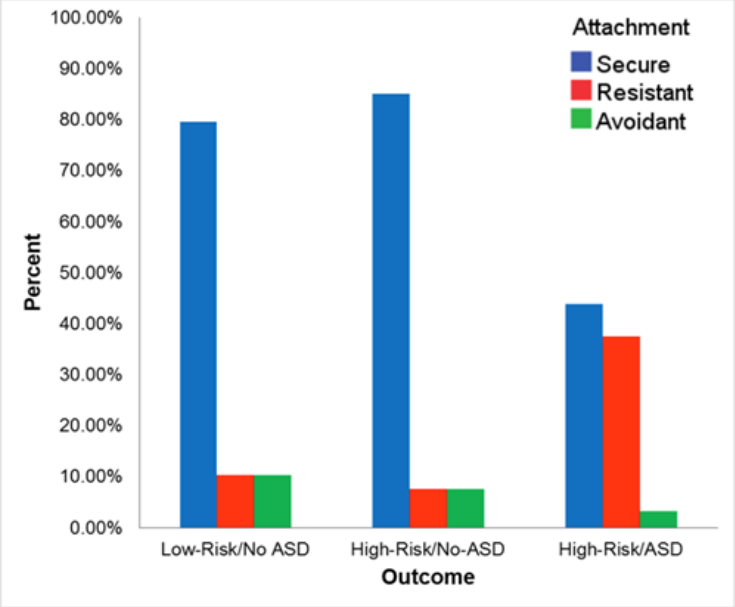
Note. No low-risk infants received an ASD diagnosis. Of the 56 high-risk infants, 16 infants received an ASD diagnosis. Attachment security will be assessed in three independent, outcome groups: low-risk children (Low-Risk/No-ASD, *n*=39), high-risk children without a later ASD outcome (High-Risk/No-ASD, *n*=40) and high-risk children with a later ASD outcome (High-Risk/ASD, *n*=16).

Figure 2. Secure vs. Insecure (2-way) attachment



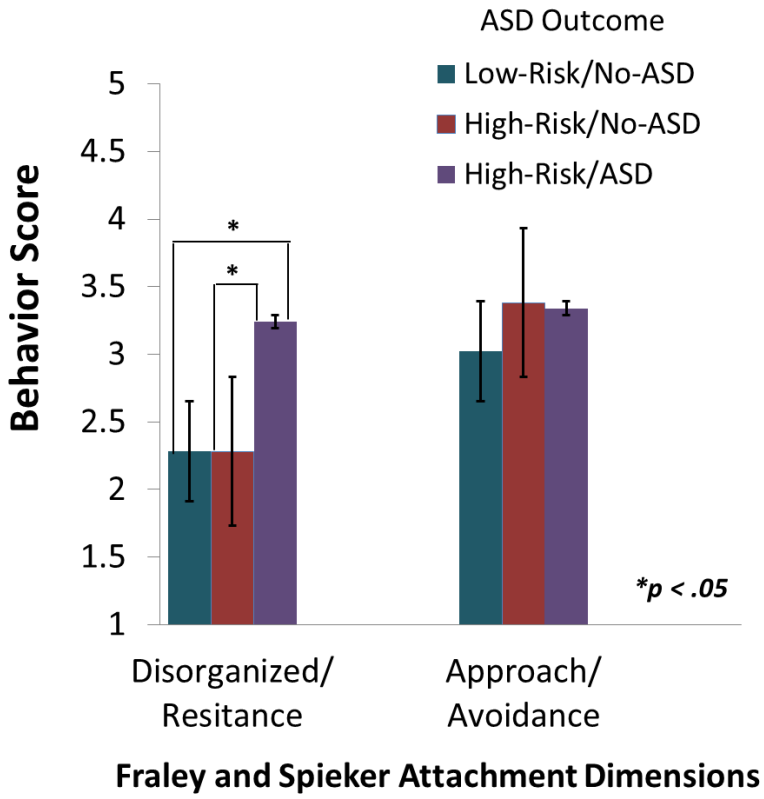
Note. 43.7% of infants with a later ASD outcome were classified as securely attached compared to 82.3% of infants without a later ASD. 56.3% of infants with a later ASD outcome were classified as insecurely attached compared to 17.7% of infants without a later ASD outcome.

Figure 3. Secure , Resistant, Avoidant (3-way) attachment



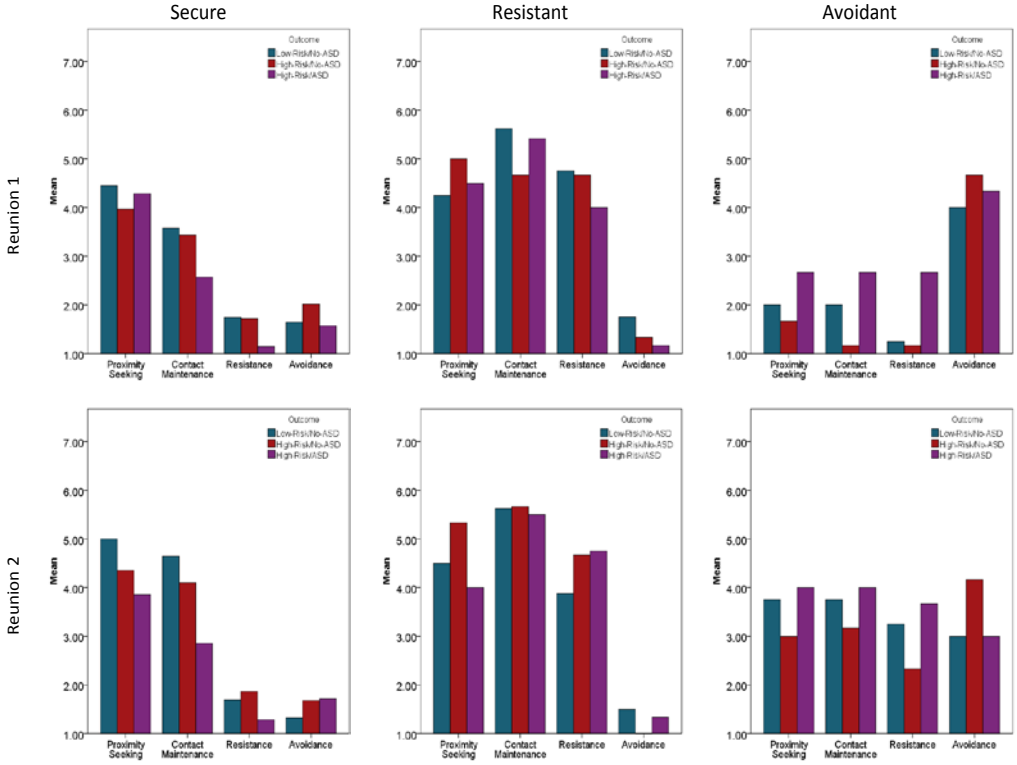
Note. 43.8% of infants with a later ASD outcome displayed a secure attachment compared to 82.25% of infants without a later ASD outcome. 37.5% of infants with a later ASD outcome displayed a resistant attachment compared to 8.9% of infants without a later ASD outcome. 3.2% of infants with a later ASD displayed an avoidant attachment compared to 8.9% of infants without a later ASD.

Figure 4. Fraley and Spiker attachment dimensions



Note. Infants later diagnosed with ASD (High-Risk/ASD) had higher disorganized/resistance scores than high-risk infants *(p*=.043) and low-risk infants (*p*=.044) without a later ASD.

Figure 5. Individual ratings of attachment behaviors



Note. Infants later diagnosed with ASD (High-Risk/ASD) did not differ in behavior ratings of proximity seeking, contact maintenance, avoidance, and resistance in Reunion 1 and Reunion 2 than infants not later diagnosed with ASD (High-Risk/No-ASD, Low-Risk/No-ASD) within the Secure, Resistant, and Avoidant classifications.

REFERENCES

Ainsworth, M., Blehar, M., & Waters, E. (1978). Wall. s.(1978). *Patterns of attachment: A psychological study of the strange situation*.

American Psychiatric Association, A. P. A. D. S. M. T. F. (2013). Diagnostic and statistical manual of mental disorders : DSM-5. from http://dsm.psychiatryonline.org/book.aspx?bookid=556

Baker, J. K., Messinger, D. S., Lyons, K. K., & Grantz, C. J. (2010). A pilot study of maternal sensitivity in the context of emergent autism. *Journal of Autism and Developmental Disorders, 40*(8), 988-999.

Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H. (2008). Oxytocin receptor (OXTR) and serotonin transporter (5-HTT) genes associated with observed parenting. *Social cognitive and affective neuroscience*, nsn004.

Bakermans-Kranenburg, M. J., & Van IJzendoorn, M. H. (2007). Research review: Genetic vulnerability or differential susceptibility in child development: The case of attachment. *Journal of Child Psychology and Psychiatry, 48*(12), 1160-1173.

Bates, J. E., Maslin, C. A., & Frankel, K. A. (1985). Attachment security, mother-child interaction, and temperament as predictors of behavior-problem ratings at age three years. *Monographs of the Society for Research in Child Development*, 167-193.

Behrens, K. Y., Haltigan, J. D., & Bahm, N. I. G. (2016). Infant attachment, adult attachment, and maternal sensitivity: revisiting the intergenerational transmission gap. *Attachment & human development, 18*(4), 337-353.

Belsky, J., & Fearon, R. P. (2002). Early attachment security, subsequent maternal sensitivity, and later child development: does continuity in development depend upon continuity of caregiving? *Attachment & human development, 4*(3), 361-387.

Bengel, D., Greenberg, B., Cora-Locatelli, G., Altemus, M., Heils, A., Li, Q., & Murphy, D. (1999). Association of the serotonin transporter promoter regulatory region polymorphism and obsessive-compulsive disorder. *Molecular psychiatry, 4*(5), 463-466.

Benson, P. R. (2006). The impact of child symptom severity on depressed mood among parents of children with ASD: The mediating role of stress proliferation. *Journal of Autism and Developmental Disorders, 36*(5), 685-695.

Bowlby, J. (1982). Attachment and loss: Retrospect and prospect. *American journal of Orthopsychiatry, 52*(4), 664.

Bryson, S. E., Zwaigenbaum, L., Brian, J., Roberts, W., Szatmari, P., Rombough, V., & McDermott, C. (2007). A prospective case series of high-risk infants who developed autism. *Journal of Autism and Developmental Disorders, 37*(1), 12-24.

Capps, L., Sigman, M., & Mundy, P. (1994). Attachment security in children with autism. *Development and Psychopathology, 6*(02), 249-261.

Casby, M. W. (2003). The development of play in infants, toddlers, and young children. *Communication Disorders Quarterly, 24*(4), 163-174.

Cassidy, J. (1994). Emotion regulation: Influences of attachment relationships. *Monographs of the Society for Research in Child Development, 59*(2-3), 228-249.

Cassidy, J., & Berlin, L. J. (1994). The insecure/ambivalent pattern of attachment: Theory and research. *Child Development, 65*(4), 971-991.

Chen, F., Barth, M., Johnson, S., Gotlib, I., & Johnson, S. (2011). Oxytocin receptor (OXTR) polymorphisms and attachment in human infants. *Frontiers in Psychology, 2*(200). doi: 10.3389/fpsyg.2011.00200

Clifford, S. M., Hudry, K., Elsabbagh, M., Charman, T., & Johnson, M. H. (2013). Temperament in the first 2 years of life in infants at high-risk for autism spectrum disorders. *Journal of Autism and Developmental Disorders, 43*(3), 673-686. doi: 10.1007/s10803-012-1612-y

Cox, M., & Crnic, K. (2002). Qualitative ratings for parent-child interaction at 3-12 months of age. *Unpublished manuscript, University of North Carolina at Chapel Hill*.

D'souza, U. M., & Craig, I. W. (2006). Functional polymorphisms in dopamine and serotonin pathway genes. *Human mutation, 27*(1), 1-13.

Dissanayake, C., & Crossley, S. A. (1996). Proximity and sociable behaviours in autism: Evidence for attachment. *Journal of Child Psychology and Psychiatry, 37*(2), 149-156. doi: 10.1111/j.1469-7610.1996.tb01386.x

Ekas, N. V., Lickenbrock, D. M., & Whitman, T. L. (2010). Optimism, Social Support, and Well-Being in Mothers of Children with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders, 40*(10), 1274-1284. doi: 10.1007/s10803-010-0986-y

Ekas, N. V., Whitman, T. L., & Shivers, C. (2009). Religiosity, spirituality, and socioemotional functioning in mothers of children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 39*(5), 706-719.

Erickson, M. F., Sroufe, L. A., & Egeland, B. (1985). The relationship between quality of attachment and behavior problems in preschool in a high-risk sample. *Monographs of the Society for Research in Child Development*, 147-166.

Fearon, R., Bakermans-Kranenburg, M. J., Van IJzendoorn, M. H., Lapsley, A. M., & Roisman, G. I. (2010). The significance of insecure attachment and disorganization in the development of children's externalizing behavior: a meta-analytic study. *Child Development, 81*(2), 435-456.

Feldman, R., Gordon, I., Schneiderman, I., Weisman, O., & Zagoory-Sharon, O. (2010). Natural variations in maternal and paternal care are associated with systematic changes in oxytocin following parent–infant contact. *Psychoneuroendocrinology, 35*(8), 1133-1141.

Fraley, R. C., & Spieker, S. J. (2003). Are infant attachment patterns continuously or categorically distributed? A taxometric analysis of strange situation behavior. *Developmental Psychology, 39*(3), 387.

Garon, N., Bryson, S. E., Zwaigenbaum, L., Smith, I. M., Brian, J., Roberts, W., & Szatmari, P. (2009). Temperament and its relationship to autistic symptoms in a high-risk infant sib cohort. *Journal of Abnormal Child Psychology, 37*(1), 59-78. doi: 10.1007/s10802-008-9258-0

Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the revised infant behavior questionnaire. *Infant Behavior and Development, 26*(1), 64-86.

Goldberg, S. (1997). Attachment and childhood behavior problems in normal, at-risk and clinical samples. *Development and Psychopathology*, 2, 15–30.

Goldberg, S., Grusec, J. E., & Jenkins, J. M. (1999). Confidence in protection: Arguments for a narrow definition of attachment. *Journal of Family Psychology, 13*(4), 475.

Goldsmith, H., & Rothbart, M. K. (1991). Contemporary instruments for assessing early temperament by questionnaire and in the laboratory *Explorations in temperament* (pp. 249-272): Springer.

Groh, A. M., Narayan, A. J., Bakermans-Kranenburg, M. J., Roisman, G. I., Vaughn, B. E., Fearon, R., & IJzendoorn, M. H. (2016). Attachment and Temperament in the Early Life Course: A Meta-Analytic Review. *Child Development*.

Haltigan, J. D. (2009). Emotional Communication and Attachment Security in Infants At Risk for Autism Spectrum Disorders (Dissertation thesis). Retrieved from scholarlyrepository.miami.edu.

Haltigan, J. D., Ekas, N. V., Seifer, R., & Messinger, D. S. (2011). Brief report: Attachment security in infants at-risk for autism spectrum disorders. *Journal of Autism and Developmental Disorders, 41*(7), 962-967.

Haltigan, J. D., Lambert, B. L., Seifer, R., Ekas, N. V., Bauer, C. R., & Messinger, D. S. (2012). Security of attachment and quality of mother–toddler social interaction in a high-risk sample. *Infant Behavior and Development, 35*(1), 83-93.

Hinde, R. A. (1982). Attachment: Some conceptual and biological issues. *The place of attachment in human behavior*, 60-76.

Hinshaw, S. P., Han, S. S., Erhardt, D., & Huber, A. (1992). Internalizing and externalizing behavior problems in preschool children: Correspondence among parent and teacher ratings and behavior observations. *Journal of Clinical Child Psychology, 21*(2), 143-150.

Juffer, F., Bakermans-Kranenburg, M. J., & Van Ijzendoorn, M. H. (2012). *Promoting positive parenting: An attachment-based intervention*: Routledge.

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child*, 2:217–250.

Lakatos, K., Toth, I., Nemoda, Z., Ney, K., Sasvari-Szekely, M., & Gervai, J. (2000). Dopamine D4 receptor (DRD4) gene polymorphism is associated with attachment disorganization in infants. *Molecular Psychiatry, 5*(6), 633.

Lewy, A. L., & Dawson, G. (1992). Social stimulation and joint attention in young autistic children. *Journal of Abnormal Child Psychology, 20*(6), 555-566.

Lord, C., Risi, S., Lambrecht, L., Cook Jr, E. H., Leventhal, B. L., DiLavore, P. C., . . . 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*(3), 205-223.

Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism Diagnostic Interview-Revised: a revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24*(5), 659-685.

Luijk, M. P., Roisman, G. I., Haltigan, J. D., Tiemeier, H., Booth-LaForce, C., Van Ijzendoorn, M. H., . . . Hofman, A. (2011). Dopaminergic, serotonergic, and oxytonergic candidate genes associated with infant attachment security and disorganization? In search of main and interaction effects. *Journal of Child Psychology and Psychiatry, 52*(12), 1295-1307.

Madigan, S., Atkinson, L., Laurin, K., & Benoit, D. (2013). Attachment and internalizing behavior in early childhood: a meta-analysis. *Developmental Psychology, 49*(4), 672.

Main, M., & Solomon, J. (1990). Procedures for identifying infants as disorganized/disoriented during the Ainsworth Strange Situation. *Attachment in the preschool years: Theory, research, and intervention, 1*, 121-160.

McArthur, D., & Adamson, L. B. (1996). Joint attention in preverbal children: Autism and developmental language disorder. *Journal of Autism and Developmental Disorders, 26*(5), 481-496.

Mesman, J., Oster, H., & Camras, L. (2012). Parental sensitivity to infant distress: what do discrete negative emotions have to do with it? *Attachment & Human Development, 14*(4), 337-348.

Messinger, D. S., Young, G. S., Webb, S. J., Ozonoff, S., Bryson, S. E., Carter, A., . . . Zwaigenbaum, L. (2015). Early sex differences are not autism-specific: A Baby Siblings Research Consortium (BSRC) study. *Molecular Autism, 6*(1), 32. doi: 10.1186/s13229-015-0027-y

Naber, F. B., Bakermans-Kranenburg, M. J., van IJzendoorn, M. H., Swinkels, S. H., Buitelaar, J. K., Dietz, C., . . . van Engeland, H. (2008). Play behavior and attachment in toddlers with autism. *Journal of Autism and Developmental Disorders, 38*(5), 857-866.

Network, N. E. C. C. R. (1997). The effects of infant child care on infant-mother attachment security: Results of the NICHD Study of Early Child Care. *Child Development*, 860-879.

Raby, K. L., Cicchetti, D., Carlson, E. A., Cutuli, J., Englund, M. M., & Egeland, B. (2012). Genetic and caregiving-based contributions to infant attachment unique associations with distress reactivity and attachment security. *Psychological Science, 23*(9), 1016-1023.

Raby, K. L., Roisman, G. I., & Booth-LaForce, C. (2015). Genetic moderation of stability in attachment security from early childhood to age 18 years: A replication study. *Developmental Psychology, 51*(11), 1645-1649. doi: 10.1037/dev0000053

Robbins, T., & Everitt, B. (1999). Interaction of the dopaminergic system with mechanisms of associative learning and cognition: implications for drug abuse. *Psychological Science, 10*(3), 199-202.

Rogers, S. J., Ozonoff, S., & Maslin-Cole, C. (1993). Developmental aspects of attachment behavior in young children with pervasive developmental disorders. *Journal of the American Academy of Child & Adolescent Psychiatry, 32*(6), 1274-1282.

Roisman, G. I., Booth-Laforce, C., Belsky, J., Burt, K. B., & Groh, A. M. (2013). Molecular-genetic correlates of infant attachment: A cautionary tale. *Attachment & Human Development, 15*(4), 384-406. doi: 10.1080/14616734.2013.768790

Rothbart, M. K. (1981). Measurement of temperament in infancy. *Child Development*, 569-578.

Rutgers, A. H., Bakermans-Kranenburg, M. J., IJzendoorn, M. H., & Berckelaer-Onnes, I. A. (2004). Autism and attachment: a meta-analytic review. *Journal of Child Psychology and Psychiatry, 45*(6), 1123-1134.

Rutgers, A. H., Van IJzendoorn, M. H., Bakermans-Kranenburg, M. J., & Swinkels, S. H. (2007). Autism and attachment The Attachment Q-Sort. *Autism, 11*(2), 187-200.

Shapiro, T., Sherman, M., Calamari, G., & Koch, D. (1987). Attachment in autism and other developmental disorders. *Journal of the American Academy of Child & Adolescent Psychiatry, 26*(4), 480-484.

Sigman, M., & Capps, L. (1997). *Children with autism: A developmental perspective* (Vol. 34): Harvard University Press.

Sigman, M., & Mundy, P. (1989). Social attachments in autistic children. *Journal of the American Academy of Child & Adolescent Psychiatry, 28*(1), 74-81.

Siller, M., & Sigman, M. (2002). The behaviors of parents of children with autism predict the subsequent development of their children's communication. *Journal of Autism and Developmental Disorders, 32*(2), 77-89.

Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1979). The infant's response to entrapment between contradictory messages in face-to-face interaction. *Journal of the American Academy of Child Psychiatry, 17*(1), 1-13.

Van IJzendoorn, M. H., Rutgers, A. H., Bakermans-Kranenburg, M. J., Swinkels, S. H., Van Daalen, E., Dietz, C., . . . Van Engeland, H. (2007). Parental sensitivity and attachment in children with autism spectrum disorder: Comparison with children with mental retardation, with language delays, and with typical development. *Child Development, 78*(2), 597-608.

Wan, M. W., Green, J., Elsabbagh, M., Johnson, M., Charman, T., Plummer, F., & Team, B. (2012). Parent–infant interaction in infant siblings at risk of autism. *Research in Developmental Disabilities, 33*(3), 924-932.

Waters, E., Crowell, J., Elliott, M., Corcoran, D., & Treboux, D. (2002). Bowlby's secure base theory and the social/personality psychology of attachment styles: Work (s) in progress. *Attachment & Human Development, 4*(2), 230-242.

Whitman, T. L. (2004). *The development of autism: A self-regulatory perspective*: Jessica Kingsley Publishers.

Willemsen-Swinkels, S. H., Bakermans-Kranenburg, M. J., Buitelaar, J. K., IJzendoorn, M. H. v., & Engeland, H. v. (2000). Insecure and disorganised attachment in children with a pervasive developmental disorder: Relationship with social interaction and heart rate. *Journal of Child Psychology and Psychiatry, 41*(6), 759-767.

Williams, E. (2003). A comparative review of early forms of object-directed play and parent-infant play in typical infants and young children with autism. *Autism, 7*(4), 361-374.

Williams, E., Reddy, V., & Costall, A. (2001). Taking a closer look at functional play in children with autism. *Journal of Autism and Developmental Disorders, 31*(1), 67-77.

Wolff, M. S., & IJzendoorn, M. H. (1997). Sensitivity and attachment: A meta-analysis on parental antecedents of infant attachment. *Child Development, 68*(4), 571-591.

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*(2–3), 143-152. doi: http://dx.doi.org/10.1016/j.ijdevneu.2004.05.001

SUPPLEMENTAL MATERIAL

Overview. Additional exploratory analyses were conducted to uncover the developmental contributors to and sequelae of attachment classifications in a high-risk sample for ASD. First, we explored the parent and infant contributions to attachment security in a subset of the original high-risk sample. A crucial issue is whether parent and infant factors play the same role in the development of attachment in high-risk infants with and without later ASD as it plays in non-risk samples. Determining the developmental contributors to attachment security may allow researchers to intervene on specific behaviors to increase the likelihood of secure attachments. Parent contributions included in our analyses are parental sensitivity ratings during free play. Infant contributions included in the analyses are infant play quality during free play and infant temperament through parental report on the Infant Behavior Questionnaire. Another critical issue is whether insecure attachments affect later social-emotional outcomes in high-risk infants with and without later ASD in the same manner that they do in non-risk samples. If insecure attachment in this high-risk sample affects later developmental sequelae, it may be important to establish early identification and interventions for infants at most risk for difficulties in later development. In a second subset of the original high-risk sample, we explored the role of attachment security on later behavior problems. Infant attachment security was examined with respect to later externalizing and internalizing behaviors through parental report on the Child Behavior Checklist. In addition, we review the literature on genetic factors and attachment security, which suggests the inadvisability of examining these associations in a sample of the current size

(no empirical analysis was undertaken). Overall, we set out to explore four important questions in the attachment/ASD literature:

1. Does parental sensitivity at 15 months of age have similar associations with attachment security in infants with and without later ASD?
2. Does the quality of infant play and infant temperament ratings (total distress) at 15 months have similar associations with attachment security in infants with and without later ASD
3. Are there similar associations between attachment security at 15 months and later Internalizing and Externalizing Behaviors at 36 months in infants with and without later ASD?
4. Are there genetic contributors to attachment security?

Methods

Participants. To address parent and infant contributions to attachment security, subsets of the original 95 infant-parent dyads with both a Strange Situation Protocol at 15 months, and an ASD diagnostic assessment at 36 months were included in supplementary analyses based on data availability (see **Table S1**). To address infant and parent contributions to attachment security, a subset of the original infant-parent dyads (n=93) also completed a free play at 15 months. To address the contributions of infant temperament to attachment security, a subset of the original infant-parent dyads (*n*=70) were included if they also had parental ratings of infant temperament using the Infant Behavior Questionnaire at 15 months. To address how attachment security and ASD risk affected later behavior problems, a subset of the original infant-parent dyads (*n*=69) were included if they had a parental ratings problem behaviors using the Child Behavior

Checklist at 36 months. For these exploratory analyses, differences in attachment security were assessed in two outcome groups: infants with later ASD (High-Risk/ASD) and infants without later ASD (High-Risk/No-ASD and Low-Risk/No-ASD). Differences in sample sizes were a result of protocol changes during the longitudinal study of infant development and missing data. Sample size distributions by ASD outcome and attachment security for each measure are reported in **Table S2-S5**.

Free Play (15 months). The quality of parent behavior during free play was rated (Cox & Crnic, 2002; NICHD Early Child Care Research Network, 1997) on a 1-7 scale for sensitivity, respect for child's autonomy, stimulation of cognitive development, detachment (reverse coded), positive regard, and hostility (reverse coded). Ratings were recorded on 7-point scales ranging from the absence of a behavior (1) to the distinct and abundant presence of the behavior (7) and were assigned based upon the entire 5-min play session. Subscales were averaged to create a Parent Mean Composite (mean average raters absolute *ICC*=.79) to index parental sensitivity. The quality of infant behavior during free play was rated (Cox & Crnic, 2002; NICHD Early Child Care Research Network, 1997) on a 1-7 scale for enthusiasm, negativity, persistence, affection toward parent, and social interest. Subscales were averaged to create a Child Mean Composite (mean average raters absolute *ICC*=.85) to index the quality of child's play behaviors.

Infant Behavior Questionnaire (15 months). The Infant Behavior Questionnaire (IBQ) is designed to assess infant temperament by asking caregivers about specific behaviors of their infants (Rothbart, 1981). The assessment has been validated for use with infants aged 3-15 months, and has good test-retest reliability (Goldsmith &

Rothbart, 1991). Caregivers are asked to respond to the items on the basis of their infant's behavior during the previous week or two weeks. The IBQ assesses infants' distress to limitations (Cronbach's alpha=.83) as indexed by baby's fussing, crying, or signs of distress when 1) in a confining place or position 2) involved in caretaking activities; 3) unable to perform a desired action (Gartstein & Rothbart, 2003).

Child Behavior Checklist (36 months). Parent-reported behavior problems were assessed within the Child Behavior Checklist (CBCL, Achenbach, Edelbrock, & Howell, 1987; Achenbach & Rescorla, 2000) at 36 months. The CBCL is a well-validated parent-report measure of children's behavior problems and yields subscales of Internalizing and Externalizing problems, normed by age and sex.

Results and Discussion

This section is organized conceptually. We examine parental contributions (parental sensitivity) and infant contributions (play quality and temperament) to infant attachment, as well as outcomes (Externalizing and Internalizing behaviors) associated with infant attachment security.

Parental contributions to infant attachment. Parental contribution was indexed by parental sensitivity in free-play (n=93, **Table S3)**. In non-ASD samples, parental sensitivity is associated with attachment security, such that higher levels of parental sensitivity promote secure attachment (d=.24; Wolff & IJzendoorn, 1997). The expected relationship between parental sensitivity and attachment security in normative samples was not found in a study investigating attachment security in 28-month-old children later diagnosed with ASD (Van IJzendoorn et al., 2007). Criteria for sensitive parenting may be inadequate for older children with ASD as children with ASD may need more explicit

parental input and an emphasis on nonverbal overtures than children without ASD. Within conventional criteria, these parents may appear more physically intrusive, even if it is an ideal style for the child with ASD (Van IJzendoorn et al., 2007). Here, we explored whether parental sensitivity at 15 months of age, before diagnosis and prevalent ASD symptomatology, during a 5-minute free-play had similar associations with attachment security in infants with and without later ASD.

A univariate ANOVA revealed that parental sensitivity (as indexed by the Parent Mean Composite) was not associated with security of attachment, $F(1, 92)= 2.44$, $p = .12$, $\eta_p^2 = .03$. That is, higher levels of parental sensitivity were not associated with infant security. There was no main effect of ASD outcome, $F(1, 92)= .04$, $p = .831$, $\eta_p^2 < .001$, such that parents did not differ on their level of sensitivity by later infant ASD outcome. There was no interaction of attachment security and ASD outcome on parental sensitivity, $F(1, 92)= 1.00$, $p = .32$, $\eta_p^2 = .01$. The absence of a main effect for security or an interaction between security and ASD outcome suggests that associations of parental sensitivity and attachment security at 15 months did not differ between infants with and without (high- and low-risk) later ASD.

Parental sensitivity did not differ by infants' later diagnosis of ASD. Parents of children with ASD in previous research have shown levels of sensitivity and synchrony with their children comparable to parents of typically-developing children (Siller & Sigman, 2002; Van IJzendoorn et al., 2007). Thus, these null effects utilizing a prospective design are consistent with prior literature comparing parents of children with and without ASD. Despite the stress involved in parenting a child with ASD and the additional stress of an infant with emerging ASD (Benson, 2006; Naomi V. Ekas et al.,

2010; Naomi V Ekas et al., 2009; Whitman, 2004), parents of high-risk infants with later ASD do not show differences in their ability to sensitively respond to their infants compared to parents of high- and low-risk infants without later ASD.

We did not find evidence for an association of parental sensitivity and attachment security. One possibility is that parental sensitivity may be less relevant to attachment security formation during the second year of life when infants display higher levels of autonomy and emotion regulation control (Casby, 2003; John D Haltigan et al., 2012; Hinde, 1982). Previous literature has focused on parental sensitivity before the evaluation of attachment security in the first year of life (Wolff & IJzendoorn, 1997). However, our measure of parental sensitivity was concurrent with the assessment of infant attachment in the second year of life. Given the lack of an interaction between attachment security and ASD outcome, the null findings were not specific to infants with later ASD. While we expected an association between concurrent parental sensitivity and attachment security (Behrens, Haltigan, & Bahm, 2016), these null findings highlight the supposition that parental sensitivity is not an exclusive contributor to the development of attachment security (Wolff & IJzendoorn, 1997). Other environmental contributions (like familial risk for ASD) may disrupt the association between sensitive parenting and early attachment security in infancy.

Infant contributions to attachment. In addition to examining associations of parental factors with infant attachment, we examined the infant contribution to attachment. Infant contributions were indexed by free play and temperament ratings. The quality of the relationship with a parent (e.g., secure attachment) may have an impact on the motivational aspects of play behavior (Naber et al., 2008). Research examining play

quality between infant-parent dyads during home observations indicates an association between concurrent measures of child's play quality and attachment security at 13 months (Bates, Maslin, & Frankel, 1985). Specifically, infants with secure attachments displayed more object communication (pointing out and bringing objects, and complying with positive requests). In an ASD sample, 24-month-old children with secure attachment showed more exploration and higher levels of play than children with insecure attachments (Naber et al., 2008). In normative samples, infant temperament is weakly associated with attachment security (***d*** = .14), such that attachment insecurity is associated with more negative temperament (e.g. high reactivity, negative affect, fussiness (Groh et al., 2016). Here, we examined the quality of infant play and infant temperament ratings (total distress) with respect to their associations with later attachment security and ASD outcome.

Infant play quality. To assess infant play quality, a subset of infant-parent dyads (n=93, **Table S3**) completed a free play session. A univariate ANOVA revealed no associations between infant play behaviors in free play and attachment security, $F(1, 92)= .39$, $p = .53$, $\eta_p^2 = .004$. Infants with secure attachments were not more likely to display high quality play behaviors than infants with insecure attachments. There was a main effect of ASD outcome, $F(1, 92)= 15.66$, $p < .001$, $\eta_p^2 = .15$, such that infants with later ASD displayed lower quality play with their parents (M=4.03, SD=.55) than infants without later ASD (M=4.71, SD=.68). There was no interaction of attachment security and ASD outcome on infant play behaviors, $F(1, 92)= .98$, $p = .32$, $\eta_p^2 = .01$. This suggests that associations of infant play behaviors and attachment security at 15 months were similar in infants with and without ASD.

The current sample did not yield an association between attachment security and infant play quality; infants with secure attachments did not display higher quality play behaviors during free play. Our findings are similar to John D Haltigan et al. (2012) who did not find associations between attachment security and social-interaction play quality in a non-ASD, high-risk sample. These null findings are consistent with a narrow view of attachment that conceptualizes the parent-child attachment relationship as distinct from other components of the relationship such as play (Goldberg, Grusec, & Jenkins, 1999; John D Haltigan et al., 2012). The current lack of association, bolsters the view that attachment security and infant play quality can be conceptualized as independent domains of socio-emotional functioning.

While associations between attachment classifications and play quality were not evident, an association of infant play quality and later ASD outcome was present; infants with later ASD had lower levels of play quality than infants without later ASD. These results are consistent with a robust literature showing both qualitative and quantitative differences in play behavior between infants with and without later ASD (Naber et al., 2008; Williams, 2003). Children with later ASD engage in lower levels and quality of play than children without ASD (Bryson et al., 2007; Wan et al., 2012). They specifically spend more time playing with toys to the exclusion of the parent (Lewy & Dawson, 1992; McArthur & Adamson, 1996; Williams, 2003), are less likely to comply (Williams, 2003; Williams, Reddy, & Costall, 2001), and have more repetitious play behaviors than other children (Bryson et al., 2007; Williams et al., 2001). In the current study, poorer quality play in infants with later ASD than infants without ASD may reflect emerging ASD symptomatology, characterized by deficits in social behavior.

Infant temperament. To assess temperament measures of infant distress to limitations, a subset of parents (n=70, **Table S4**) completed the IBQ. A univariate ANOVA revealed no associations between infant distress (as rated by the parent) and attachment security, $F(1, 69)= .28$, $p = .60$, $\eta_p^2 = .004$. Insecure infants were not more likely to display higher levels of distress than secure infants. There was no main effect of ASD outcome, $F(1, 69)= .85$, $p = .36$, $\eta_p^2 = .009$, such that infant distress as rated by the parent did not differ between infants with and without later ASD. There was no interaction of attachment security and ASD outcome on infant distress, $F(1, 69)= 1.73$, $p = .19$, $\eta_p^2 = .02$. That is, there was no evidence that the association between infant distress and attachment security at 15 months differed in infants with and without (high- and low-risk) ASD.

We did not find associations between infant temperament and attachment security, as insecure infants were not more likely to display a difficult temperament, marked by higher levels of distress, than secure infants. Given the fact that the overall meta-analytic effects of attachment security and temperament are weakly associated (d=.19; Groh et al., 2016), it is not surprising that we were unable to detect an effect given our sample size and distribution. Future research should be conducted with larger sample sizes to allows for finer grained analysis of individual items within the temperament dimensions to elucidate whether a combinations of items, dimensions, or latent profiles might be related to insecurity and emerging ASD (Clifford, Hudry, Elsabbagh, Charman, & Johnson, 2013; Zwaigenbaum et al., 2005).

Later social-emotional outcomes associated with infant attachment. Attachment classification is associated with behavior problems (Fearon et al., 2010;

Madigan et al., 2013), emotional regulation and expression (Cassidy, 1994), compliance with parents, and peer relationships (Kochanska, 2001a, 2001b; Matas et al., 1978; Schneider et al., 2001; Sroufe, 2005)—which are all areas of concern in ASD. Since Bowlby (1982)'s theoretical framework implicated early disruptions in attachment formation in the development of psychopathology, research has centered on associations between attachment security and clinically significant behavior problems (Erickson, Sroufe, & Egeland, 1985; Fearon et al., 2010; Madigan et al., 2013). A meta-analytic study found an association between attachment insecurity and externalizing problems, d=.31, such that infants with insecure attachments had greater levels of later externalizing problems (Fearon et al., 2010). A meta-analytic study indicated a small, but significant association between attachment insecurity and internalizing problems, d=.19, such that infants with insecure attachments had greater levels of later internalizing problems (Madigan et al., 2013).

Here, we examined associations between attachment security (at 15 months) and later Internalizing and Externalizing Behaviors (at 36 months) in a high-risk sample. We examined the additional risk factor of insecure attachment in high-risk infants with later ASD. High-risk infants with later ASD and early insecure attachments may show the most difficulty with later social-emotional behaviors (e.g. high levels of externalizing and internalizing behaviors) compared to high-risk infants with later ASD and early secure attachments. Two linear regressions examined whether infant attachment security (secure vs. insecure), infant ASD outcome (ASD vs. no ASD) and the interaction of the two predicted later Externalizing and Internalizing behaviors at 36 months. 69 parents

completed the CBCL (**Table S5**), which was used to assess infant problem behaviors (i.e. Externalizing, Internalizing).

Externalizing behavior. Combined in a linear regression, infant attachment security, ASD outcome, and the interaction of the two significantly predicted Externalizing behaviors at 36 months, $F(3, 66)= 3.81$, $p=.01$. There was a main effect of ASD outcome on Externalizing behaviors at 36 months, $\beta =.39$, $p=.01$, such that infants later diagnosed with ASD had higher levels of Externalizing behaviors ($M=52.33$, SD=14.3) than infants not later diagnosed with ASD ($M=41.16$, SD=9.32). There was no main effect of infant security on Externalizing behaviors, $\beta =.18$, $p=.19$, such that infant security at 15 months did not predict lower levels of Externalizing behaviors at 36 months. There was no interaction of infant security and later ASD outcome, $\beta = -.13$, $p=.45$. This suggests that the association between early attachment security and later Externalizing did not differ in infants with and without (high- and low-risk) ASD.

Internalizing behavior. Combined in a linear regression, infant attachment security, ASD outcome, and the interaction of the two significantly predicted Internalizing behaviors at 36 months, $F(3, 66)= 8.4$, $p <.001$. There was a main effect of later ASD outcome on Internalizing behaviors at 36 months, $\beta =.56$, $p < .001$, such that infants later diagnosed with ASD had higher levels of Internalizing behaviors ($M=55.00$, SD=10.85) than infants not later diagnosed with ASD ($M=38.85$, SD=8.88). There was no main effect of infant security on Internalizing behaviors, $\beta =.12$, $p=.34$, such that infant security at 15 months was not associated with lower levels of Internalizing behaviors at 36 months. There was no interaction of infant security and later ASD outcome, $\beta = -.12$, $p=.44$. That is, there was no evidence that the association between

early attachment security and later Internalizing behavior differed in infants with and without (high- and low-risk) ASD.

Surprisingly, our results do not support a differential effect of security on later behavior problems. Infants with secure attachments did not display lower levels of behavior problems than infants with insecure attachments. Our null findings are inconsistent with meta-analytic reviews that show an association of attachment security and later Externalizing and Internalizing behaviors (Fearon et al., 2010; Madigan et al., 2013). Despite the accumulation of results regarding the developmental consequences of attachment on behavior problems, the relationship between attachment security and later behavior problems is complex and often contradictory, especially in the domain of psychopathology (Fearon et al., 2010; Goldberg, 1997). The overall meta-analytic effects of attachment security and later behavior problems are significant (Fearon et al., 2010; Madigan et al., 2013), but longitudinal research examining these associations have yielded mixed results including no associations, positive associations, and interactions in almost equal measure (Fearon et al., 2010). Mixed findings can sometimes be attributed to differences in methods. For example, our null findings may be attributed to the fact that behavior problems were analyzed with respect to parental report. In the meta-analysis on attachment security and internalizing behaviors, observations of internalizing behavior yielded a significantly larger effect size than questionnaire measures (Madigan et al., 2013). Given that parent reports are prone to biases and discrepancies (Hinshaw, Han, Erhardt, & Huber, 1992), future research should assess infant behavior problems by both observational and parental measures.

As there was no interaction between attachment security and later ASD, there was no evidence that infants with insecure attachments and later ASD would show the highest level of behavior problems at 36 months. However, within the behavior problems subsample was underpowered to assess such an interaction, as only 4 infants received an insecure attachment classification of the 9 infants later diagnosed with ASD. Future research using a larger sample might profitably investigate whether insecure attachment confers an additional risk to social-emotional development within the context of emerging ASD

Limitations (power analyses). In the present study, the modest sample size and unequal distribution of attachment security may have limited the statistical power necessary to detect the infant and parent contributions to attachment security, as well as the sequelae of attachment security. Statistical power analyses in RStudio were performed to determine the power to detect an association for each variable of interest (see **Table S6** for power estimates). Post-hoc power analyses revealed that on the basis of the sample size, the population effect size estimate of the association of interest (d=.14; Groh et al., 2016), and α =.05, the statistical power to detect associations ranged from 12-26%. Consequently, power to detect existing associations in the current subsample was limited.

Genetic contributions to infant attachment. Research on the antecedents of infant attachment suggests a role for the environment (both shared and nonshared), but there is inconclusive evidence of a role for genetic factors (Luijk et al., 2011) . Researchers have examined dopaminergic, serotonergic, and oxytonergic polymorphisms

and their associations with infant attachment classifications with mixed findings (Luijk et al., 2011).

The dopaminergic system is involved in attentional, motivational, and reward mechanisms (Luijk et al., 2011; Robbins & Everitt, 1999). Common variations in dopaminergic gene DRD4 and DRD2 are associated with regulation of dopamine levels. Carrying the risk allele of these polymorphisms (7-repeat for DRD4, A allele for DRD2) has been related to variation in infant temperament (D'souza & Craig, 2006; Luijk et al., 2011). In a small, low-risk sample, children carrying the 7-repeat allele of DRD4 were at elevated risk for disorganized attachment compared to children not carrying the risk allele (Bakermans-Kranenburg & Van IJzendoorn, 2007; Lakatos et al., 2000). There was no association between the 7-repeat risk allele and secure, resistant, and avoidant attachment classifications. However, in two independent cohorts with over 500 infant-parent dyads, no relation was found between infant DRD4 and DRD2 genotype and infant attachment security (Luijk et al., 2011). The 7-repeat allele and the A-allele were not associated with Disorganization attachment or insecure attachment classifications.

The serotonin system is involved in affect and emotion regulation. The short allele of the serotonin transport gene (5-HTTLPR) is associated with less efficient transcription and serotonin uptake in the synapse (Bengel et al., 1999; Luijk et al., 2011). In a study of attachment (K Lee Raby et al., 2012), infants' 5-HTTLPR variation predicted infant distress levels, but not attachment security. Within secure attachment, the short risk allele for 5-HTTLPR was associated with subgroup classifications characterized by higher emotional distress (B3 & B4) at 12 months. Within insecure attachments, the short risk allele for 5-HTTLPR was associated with resistant attachment

classification compared to avoidant attachment classification at 12 and 18 months. These results suggest that the risk variant of 5-HTLLPR contributes to infants' emotional reactivity, but not their attachment security classifications.

The oxytonergic system is related to social and parenting behaviors and the A-allele is associated with the formation of social bonds in animals and humans (Bakermans-Kranenburg & van IJzendoorn, 2008; Feldman, Gordon, Schneiderman, Weisman, & Zagoory-Sharon, 2010; Luijk et al., 2011). In a small subsample, the A-allele of oxytocin was associated with attachment security in non-Caucasian infants, but this association was not evident in Caucasian infants (Chen, Barth, Johnson, Gotlib, & Johnson, 2011). In non-Caucasian infants, the A-variant was more likely to be associated with secure attachment than was the G-variant. However, in three larger samples of over 500 infants, this finding could not be replicated (Luijk et al., 2011; K. Lee Raby, Roisman, & Booth-LaForce, 2015). No relation between infant oxytocin genotype (A-variant) and infant attachment security were found.

Recent findings ((Luijk et al., 2011; Roisman, Booth-Laforce, Belsky, Burt, & Groh, 2013) indicate that the average effect of all polymorphisms examined in the literature on the genetic underpinnings of infant attachment security is approximately 0. The dopaminergic (DRD2, DRD4), serotonergic (5-HTTLPR), and oxytonergic (rs53576 SNP, rs2254298 SNP) polymorphisms tested were not associated infant attachment classifications. Furthermore, Luijk et al. (2011) and Roisman et al. (2013) did not report consistent GXE evidence that early parental sensitivity interacted with any of the polymorphism in prediction of attachment security.

Recent research cautions against candidate gene studies, as they have proven difficult to replicate (K. Lee Raby et al., 2015; Roisman et al., 2013). Future research that examines the interplay between infant and parent genotypes and infant and parent antecedents on the formation of attachment security should attend to their statistical power. Samples smaller than 600 children are not sufficient to detect candidate gene main effects and the smaller GeneXEnvironment effects (Roisman et al., 2013). To date, no research has examined candidate gene polymorphisms in the formation of attachment security in infants with later ASD, making it unclear whether candidate gene polymorphisms associated with attachment security would differ in this population.

Conclusions

Current findings on attachment security in infancy converge with previous findings in children, that approximately half of infants with later ASD are securely attached (Rutgers et al., 2004). However, infants with later ASD show a higher proportion of insecure attachment patterns, and specifically resistant attachment, than infants without later ASD. As an index of early social-emotional functioning, attachment security in high-risk infants with later ASD may serve as a potential target for intervention.

As a logical extension of these findings, additional analyses were conducted to uncover the developmental contributors and sequelae of attachment classifications in subsets of the current sample at high-risk for ASD. We explored concurrent measures of parent sensitivity, infant quality play, and infant temperament as important contributors to attachment security in a subset of the original high-risk sample. Limited by the modest sample size and unequal distributions of attachment security and ASD outcomes, these

analyses were underpowered to detect associations. We did not find associations between infant and parent contributors and attachment security. To examine the social-emotional outcomes of attachment security, we examined associations of attachment security and later behavior problems. Despite meta-analytic effects of attachment security and later behavior problems, we were unable to replicate effects in our high-risk sample, contributing to a research line characterized by heterogeneity in associations of attachments security and later outcomes. Thus, there still remains substantial work to be done to determine the developmental antecedents, concomitants, and sequelae of attachment security in samples of infants at high-risk for ASD.

Supplemental tables

Table S1. Data availability

	Procedure	Time Point	n	Construct
Infant Contributions	Free Play	15 months	93	Play Quality
	Infant Behavior Questionnaire	15 months	70	Temperament
Parent Contributions	Free Play	15 months	93	Parental Sensitivity
Infant Outcome	Child Behavior Checklist	36 months	69	Behavior Problems

Table S2. Breakdown of sample size by ASD outcomes and measure

Measure	Low-Risk/ No-ASD	High-Risk/ No-ASD	High-Risk/ASD	Totals
Free play	38	40	15	93
Infant Behavior Questionnaire	31	29	10	41
Child Behavior Checklist	31	29	9	69

Note. Sample size by later ASD outcome for each measure

Table S3. Breakdown of sample size by ASD outcome and attachment security

Free play	Low-Risk/ No-ASD	High-Risk/ No-ASD	High-Risk/ASD	Totals
Secure	31	34	7	72
Insecure	7	6	8	21
Totals	38	40	15	93

Note. Sample size by later ASD outcome and attachment security for free play measure

Table S4. Breakdown of sample size by ASD outcome and attachment security

Infant Behavior Questionnaire	Low-Risk/ No-ASD	High-Risk/ No-ASD	High-Risk/ASD	Totals
Secure	23	25	4	52
Insecure	8	4	6	18
Totals	31	29	10	70

Note. Sample size by later ASD outcome and attachment security for Infant Behavior Questionnaire measure

Table S5. Breakdown of sample size by ASD outcome and attachment security

Child Behavior Checklist	Low-Risk/ No-ASD	High-Risk/ No-ASD	High-Risk/ASD	Totals
Secure	25	26	5	56
Insecure	6	3	4	13
Totals	31	29	9	69

Note. Sample size by later ASD outcome and attachment security for Infant Behavior Questionnaire measure

Power analyses

	Parental Sensitivity	Infant Play Quality	Infant Temperament	Externalizing Behaviors	Internalizing Behaviors
n_1 Secure	72	72	52	56	56
n_2 Insecure	21	21	18	13	13
Population effect size	.24 (Wolff & IJzendoorn, 1997)	.23 (Bates et al., 1985)	.14 (Groh et al., 2016)	.31 (Fearon et al., 2010)	.19 (Madigan et al., 2013)
α	.05	.05	.05	.05	.05
Power estimate	25.7%	23.4%	12.8%	25.8%	15.1%

Note. Post-hoc power analyses were conducted in R studio for each association of interest. The statistical power to detect specific associations ranged from .12-.26.