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Synchrony and Joint Attention Development in Infancy:

A Transactional Approach

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Synchrony and Joint Attention Development in Infancy:

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by

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Abstract

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Joint attention is an early emerging skill that plays a critical role in early child development (Moore & Dunham, 1995). This shared engagement facilitates language acquisition (e.g., Morales, Mundy, & Rojas, 1998) and predicts social cognition in early childhood (Van Hecke et al., 2007). Thus, it is important to understand factors contributing to individual differences in joint attention development. One potential predictor is mother-infant synchrony, the extent to which mothers' verbal and nonverbal input is contingent upon their infants' focus (Siller & Sigman, 2002). Researchers found synchrony to be positively associated with the rate of language development (Akhtar et al., 1991). However, few studies have examined mother-infant synchrony longitudinally and whether synchrony influences individual differences in joint attention. The present study is one of the first to examine these relationships in depth prospectively. Twenty typically-developing infants (11 male) and their mothers participated at approximately 9, 12, and 15 months of age as part of a larger longitudinal study of infants at risk for

Autism Spectrum Disorders. Each dyad engaged in a 15-minute unstructured play session, which was coded for synchrony (Siller & Sigman, 2002). In addition, researchers administered the Early Social Communication Scales (ESCS; Mundy et al., 2003) with the infant, which was coded for Initiating Joint Attention (IJA) and Responding to Joint Attention (RJA). The results suggest that synchrony was stable within dyads across 9, 12, and 15 months. Surprisingly, higher 9-month synchrony was correlated with lower 12-month RJA. Growth curve modeling revealed significant growth in RJA, but not IJA, over time. However, synchrony scores did not significantly predict growth in IJA or RJA over time as predicted. These preliminary results suggest that synchrony is a relatively stable construct that likely reflects true differences between mother-infant dyads. Mothers following their child's lead more often at 9 months had infants exhibiting less RJA at 12 months. Contrary to our predictions, there were no other significant associations between synchrony and joint attention. These findings will be reexamined upon collection of additional data. Nonetheless, the current study helps to elucidate the nature of synchrony and joint attention over time in infancy.

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Chapter 1: Introduction

The development of social cognition and communication from infancy to toddlerhood involves an array of complex sequential processes. Sameroff first introduced the transactional model in 1975, stating, “the development of the child is a product of the continuous dynamic interactions of the child and the experience provided by his/her social settings” (2009, p. 6). Accordingly, he emphasized the importance of studying “the bidirectional, interdependent effects of the child and environment (Sameroff, 2009, p. 6). This is particularly relevant when examining the development of social cognition and communication, which by definition involve the child’s ability to interact with another person in his/her environment. As such, it is necessary to consider both child and caregiver characteristics, as well as the reciprocal effects and characteristics of the child-caregiver dyad, and how they contribute to the development of social cognition and communication.

Joint Attention

One key skill that emerges early in life and has a significant influence on subsequent development is joint attention (Moore & Dunham, 1995). Joint attention is the ability of an individual to coordinate his or her attention with that of a social partner in order to create a shared experience (Van Hecke & Mundy, 2007). There are two types of joint attention: initiating joint attention (IJA) and responding to joint attention (RJA). IJA involves the use of gestures and eye contact to direct another’s attention toward objects, events, and the self. RJA involves following the direction of the gaze and gestures of others in order to share a common point of reference. Both types of joint attention require a certain amount of social understanding and social intent. As such, joint attention does not include gestures and behaviors that serve solely to meet desires or needs. For example, a child who wants a cookie might point at it and then alternate his gaze from the cookie to his father's eyes. Rather than serving as a bid to share in an experience with his father, this serves to regulate his father's behavior in order to reach a goal. However, if the boy were to point and look at fireworks in the sky and then make eye contact with his father in order to share his excitement/interest in the fireworks, this would be joint attention.

In typically developing (TD) children, joint attention emerges between 3 and 9 months of age (Hood, Willen, & Driver, 1998; Toth, Munson, Meltzoff, & Dawson, 2006; Vercera & Johnson, 1995; Williams, Waiter, Perra, Perrett, & Whiten, 2005), and is largely developed by roughly 18 months (Scaife & Bruner, 1975). Using the Early Social Communication Scales (ESCS; Mundy, Delgado, Block, Venezia, Hogan, & Seibert, 2003), researchers recently found that IJA tends to increase substantially from 9 to 15 months, and then plateau somewhat thereafter. The authors also found that the proportion of RJA seemed to increase most dramatically from 9 to 12 months, but continued to increase gradually through 18 months. Most notably, although these trajectories were consistent across infants, the actual frequencies of IJA differed according to rates of cognitive development as measured by the Bayley Scales of Infant Development (Bayley, 1994; Mundy, Block, Delgado, Pomares, Vaughan Van Hecke, & Parlade, 2007).

Theoretically, it seems that IJA and RJA would be very important for early language development, specifically word learning and mapping. For example, a mother might point at a toy and label it (e.g., "it's a bus"), requiring her son to use RJA skills to follow her point, correctly identify the object she is labeling, and learn the word. A child might use IJA by pointing at an object in the sky, and her father might say "airplane." Baldwin (1995) suggested that these processes reduce referential mapping errors (when a child attributes a label to an incorrect object) in word learning. In fact, numerous studies have demonstrated that joint attention and vocabulary are highly correlated. In typical development, joint attention abilities predict the size of children's vocabulary in the first and second years of life (Morales, Mundy, & Rojas, 1998; Mundy & Gomes, 1998) and are correlated with later language ability (Morales, Mundy, Delgado, Yale, Messinger, Neal, & Schwartz, 2000; Toth et al., 2006; Ulvund & Smith, 1996). Evidence also suggests that deficits in joint attention are related to autism spectrum disorders (ASD), and have been found to discriminate between children with ASD versus children without ASD whose language is delayed (Loveland & Landry, 1986; Ventola et al., 2007). Much has been documented describing deficits in joint attention and language development in ASD relative to TD (Bacon, Fein, Morris, Waterhouse, & Allen, 1998; Charman et al., 1998; Dawson, Meltzoff, Osterling, & Rinaldi, 1998; Dawson et al., 2002, 2004; Mundy, Sigman, Ungerer, & Sherman, 1986; Sigman, Kasari, Kwon, & Yirmiya, 1992). Joint attention deficits are a key area of diagnostic assessment for the presence of ASD (e.g., Lord, Rutter, DiLavore, & Risi, 2002). Furthermore, researchers have demonstrated that early joint attention deficits in ASD are correlated with later social and communication symptom severity (Charman, 2003).

Synchrony

The transactional model would support parent involvement as being crucial for child development, and perhaps more specifically joint attention skill development. Keeping in mind the transactional model, one factor that may be important for the development of joint attention development is dyadic behavioral synchrony. The concept of dyadic synchrony has been defined in many different ways throughout the literature. For example, some researchers focus on qualitative, global measures of interactions, while others' definitions are much more quantitative and behavior-specific (e.g., Siller & Sigman, 2002). Some define dyads categorically as either synchronous or asynchronous (e.g., Harrist et al., 1994), while others use continuous ratings of synchrony. In addition, some definitions seem to emphasize the role of either the child or parent, while others take the interaction of both into account (see Fogel, 1993). For the purposes of the current study, we attempted to employ the definition and measure of synchrony that we hypothesize to be most pertinent to the development of infants' joint attention, and also that reflects continuity of transaction observed among dyads. Siller and Sigman (2002) define maternal synchrony as the degree to which a mother follows or redirects her child's focus of attention and action during play. Thus, synchronized behavior consists of following a child's focus and lead, while unsynchronized behavior consists of redirecting a child. This definition accounts for both partners in the interaction, which makes it more conducive to a transactional approach. In addition, it uses proportions (i.e., percent of maternal behaviors that were synchronized / percent of time child attended to toys) to quantify specific observable behaviors, making it less subjective. It also yields continuous scores of synchrony, allowing us to focus on levels of synchrony that are more sensitive to individual differences than categorical measures (synchronized vs. unsynchronized). Lastly, this measure of synchrony includes both verbal and nonverbal behaviors, taking into account gestures such as mothers' pointing that might be related to joint attention.

Harrist and Waugh (2002) explained that many conceptualizations of mother-infant synchrony confer the responsibility of maintaining synchrony upon the caregiver. They therefore posit "notions of caregiver sensitivity and responsiveness (e.g., Biringen, 1990; Smith & Pederson, 1988) become particularly salient for understanding synchrony during [infancy] (page 560)." A meta-analysis conducted in 1997 suggested that attachment security was strongly predicted by both parental synchrony and sensitivity (De Wolff & van Ijzendoorn; as cited in Harrist & Waugh, 2002). However, the only study to examine this question found that synchrony between toddlers and their mothers was not significantly associated with the emotional qualities (i.e., sensitivity) of the mother's interaction (Gamber, Neal-Beevers, & Stefanatos, 2012). In this study, the only subscale of Emotional Availability that was significantly associated with synchrony was Parental Structuring, a rating of how parents scaffold the interaction (Biringen, Robinson, & Emde, 1998). Thus, it seems that synchrony may be distinct from the emotional aspects of mother-child interactions such as maternal warmth, sensitivity, and involvement.

Since synchrony involves parents' coordinating their interaction with the child's focus of attention, and therefore likely facilitates interactions in which children are highly engaged and motivated, it seems that synchrony would be related to communication development. Accordingly, a handful of studies have examined this link, and have demonstrated the dyadic synchrony predicts language development in TD infants and toddlers. Specifically, studies of infants between 9 and 15 months have found that children's rate of language growth was higher when parents' interactions with them were synchronized with their child's focus of attention (Carpenter et al., 1998). Furthermore, researchers found that positive, meaningful changes in maternal behaviors contingent upon children's behavior at 13 months positively predicted the timing of children's language milestones (Tamis-LeMonda, Bornstein, & Baumwell, 2001). Finally, Siller and Sigman (2008) demonstrated a link between dyadic synchrony and language growth in young children with ASD between the ages of roughly 3.5 to 7.5 years. They found that parents' synchrony with their child's attention and activity during play, as well as children's level of RJA, predicted children's rate of language growth. Thus, synchrony may be an important predictor of early language development in both TD children and children with ASD.

Potential Associations Between Joint Attention and Synchrony

As described above, studies have separately examined the associations of (1) synchrony with language development and (2) joint attention with language development. Because joint attention facilitates language development, it could be that joint attention mediates the relationship between mother-infant synchrony and child language abilities.

Perhaps mother-infant synchrony might facilitate joint attention development, and both in turn might contribute to language development. Before understanding how synchrony, joint attention, and language development may all be related, a link between synchrony and joint attention must first be established. Aside from similar findings that joint attention and synchrony are each related to concurrent or future language, theoretical links between synchrony and joint attention have been posited. Harrist and Waugh (2002) described this theoretical link in their review of the synchrony literature, suggesting that the underlying mutual engagement of attention present within synchronous interactions may serve as a precursor to joint attention in newborns (see Brazelton et al., 1974, as cited in Harrist & Waugh, 2002). However, this association has not yet been adequately tested empirically.

Only two studies to date have tested potential associations between synchrony and joint attention development. Yirmiya and colleagues (2006) used a five-minute play sample to code mother-child dyadic synchrony with infants at risk for ASD at 4 months of age. They found that the majority of dyads were synchronous, but the high-risk group was less likely to exhibit the mother following the infant's lead. However, they found no relationship between atypical synchrony at 4 months and measures of joint attention at 14 months, regardless of participant group. These findings might be accounted for by the very young age of the first data collection and the methods used to code synchrony. Although it was not the focus of their analyses, Siller and Sigman (2008) also examined potential associations between synchrony and IJA. Their sample consisted of children with autism aged 2 to 5 years. They reported a significant positive correlation between

IJA and synchrony, but no significant associations between RJA and synchrony. Thus, only two studies to date have tested the link between synchrony and joint attention skill development, and they report different findings. Furthermore, these studies are methodologically limited in their capacity to speak to development due to their reliance on cross-sectional data, or in the case of Yirmiya and colleagues (2006), limited longitudinal data. In order to most accurately form conclusions and implications about the trajectory of skills (whether they significantly improve, remain largely stagnant, or actually diminish), it is necessary to have a minimum of three data points collected over time (see Zwaigenbaum et al., 2006). This question has not been adequately tested. Further work must be done to more closely examine whether synchrony accounts for some of the individual differences in joint attention abilities and growth observed between TD children.

Current Study

As part of a larger ongoing study, we gathered longitudinal data with mothers and TD infants at 9, 12, and 15 months to examine synchrony and the development of joint attention abilities in infants. This study focused on the following questions: (a) Is synchrony stable over time in mother-infant dyads? (b) Is there a relationship between the growth trajectory of joint attention and synchrony? (c) If synchrony does not appear to be stable, is there a critical period between 9, 12, and 15 months during which synchrony has relatively stronger effect on joint attention development than at other time points? Although we expect that synchrony scores might vary significantly in infancy versus later childhood, we hypothesized that synchrony would be stable within dyads during infancy

(9, 12, and 15 months). Next, we expect positive associations between synchrony and growth in IJA and RJA over time.

Chapter 2: Method

Participants and Procedures

Mother-infant dyads were recruited as part of a comparison sample for a larger longitudinal study of infants at varying degrees of risk for ASD. Participants were recruited through the database at the Children's Research Lab in the Department of Psychology at the University of Texas at Austin and the University of Texas Child Development Center. The database consists of birth records from the Texas Department of Health, and researchers are given the names and contact information for families eligible for the study. Contact was initiated by either calling the potential participant's family or by mailing a recruitment letter. Potential participants were then screened for eligibility via telephone. All infants were born at 37 weeks gestation or later, were exposed to English as their primary language, had an older full biological sibling who was typically developing, and had a biological mother willing to participate. Families were recruited to participate in 3 waves of data collection in the laboratory when the infants were approximately 9, 12, and 15 months of age. Infants were seen within approximately two weeks before and 2 weeks after each age point. The sample included 11 boys and 9 girls; descriptive information is presented in Table 1. All families participated at 9 months. At the time of analysis, 15 families had participated at 12 months, as 1 family withdrew from the study, 1 family missed their appointment, and 3 infants were too young. At the time of analysis, 12 families had participated at 15 months, as 1 family withdrew from the study, 1 family moved out of state, 1 family missed its appointment, 2 families did not complete the ESCS, and 3 infants were too young. Thus, only 12 families had complete data for all 3 ages. Mothers ranged between 30 and 41 years of age at Wave 1 (*M*=34.92, *SD*=3.74). The sample was predominantly Caucasian (90%; 5% Latino/Hispanic, 5% Other). The sample also reported a predominantly high annual household income (60% greater than $100,000, 20% $75,000-99,999, 15% $50,000-74,999, 5% $25,500-49,999). Each laboratory visit lasted from approximately 1.5 to 2.5 hours, and consisted of a larger battery of assessments not included in the current analyses. Families were compensated $30 for each visit. The complete list of assessments included in the larger study is presented in Table 2. The Institutional Review Board of the University of Texas approved this procedure.

MEASURES

Synchrony

Each mother and infant pair engaged in a free play session lasting about 15 minutes (*M* = 15.55, *SD* = 1.78), which took place in a room in the laboratory containing a standardized set of toys. These included a barn with miniature animals, a jack-in-the-box, a toy phone, nesting balls, and board books. They were instructed to play as they normally would at home for 15 minutes, but were given no further instructions or additional information. The play session was videotaped with parental consent, and later coded into three measures of synchrony, according to the methods used by Siller and Sigman (2008). Frequencies of each target behavior were used to calculate three composite scores indicating the extent to which mothers' verbal and nonverbal behaviors were synchronized with children's attention and actions. MS1 was calculated as the percentage of nonverbal indicating behaviors that were synchronized with children's attention, such as pointing at/showing/offering a toy that a child was looking toward. MS2 was calculated as the percentage of verbal utterances that were synchronized with children's attention, such as commenting on a toy with which the child was playing. MS3 was calculated as the percentage of verbal utterances that were synchronized with both children's attention and their action. For example, if a child was bouncing a ball and the mother commented on how fast it was bouncing, this would be synchronized with attention and action. However, if the mother instructed the child to roll the ball instead, this would be synchronized with the child's attention but not their action. If the mother commented on a book rather than the ball the child was looking at, this would not be synchronized with attention or action. All three measures of synchrony were designed to control for the mothers' opportunity to act in synchrony. By the researchers' definition, mothers have the opportunity to act in synchrony only when the child is attending to one of the target toys. Therefore, the three synchrony composite scores were computed by dividing the percentage of synchronized behaviors by the percentage of time children were attending to the toys. Previous research has demonstrated high inter-rater reliability using this coding system for synchrony, with intra-class correlations for each behavior code ranging from .75 to .96 (Siller & Sigman, 2008).

A team of research assistants coded the free-play videos for synchrony using video behavior analysis software (NOLDUS Observer XT 10.0 and 11.0, Noldus Information Technology). These coders were blind to the purpose and hypotheses of this study were trained to accurately identify the target behaviors. Multiple coders completed each video in 5 separate passes. These passes included (1) onset of maternal utterances,

(2) onset of maternal indicating behaviors, (3) child attention, (4) synchrony of maternal utterances, and (5) synchrony of maternal indicating behaviors. Interobserver reliability was established with Bridget Gamber using five videos. Twenty percent of videos from the study were double-coded for reliability. Inter-rater reliability was excellent (α = .86-.98).

Joint Attention

Joint attention was assessed using the ESCS (Mundy et al., 2003). The ESCS is a videotaped, semi-structured experimenter-child interaction paradigm that is designed for children between 8 and 30 months of age. It requires between 15 and 25 minutes to administer. During the ESCS, the child is seated across a table from the experimenter, either in the mother's lap or alone in a chair with the mother seated separately behind the child. A set of toys is placed next to the experimenter so as to be in plain view of the infant but out of reach. The toys and other materials used in the ESCS were selected to elicit social interaction, and include: a) small wind-up mechanical toys, b) hand-operated toys, including a balloon, c) turn-taking toys (e.g., a car and ball), d) a board book, e) a comb, hat, and sunglasses, and e) infant appropriate posters mounted on the walls to left, right and behind the child. During the interaction, the experimenter's actions include activating toys, singing songs, tickling the child, giving the child the book and pointing at pictures within it, and pointing to the posters on the wall. Toys were activated out of reach and given to the child either upon the child's request or after the toy had stopped and several seconds had passed without the child clearly requesting the toy. The experimenter's verbalizations are mostly responses to the child's actions and vocalizations. Following the ESCS assessment, the videotape recording was coded for observed nonverbal communication skills. Specifically, the behaviors coded include: (1) Joint Attention Behaviors (nonverbal behaviors to share the experience of objects or events with others); (2) Behavioral Requests (nonverbal behaviors to elicit aid in obtaining objects or events) and (3) Social Interaction Behaviors (turn-taking interactions). Since the focus of the current study is joint attention, only the scores for IJA and RJA were included in the analyses. Each child's IJA was calculated as the total frequency of eye contact with the examiner while manipulating a toy, alternating gaze from an active toy to the examiner's eyes, showing a toy to the examiner, pointing at a toy for the purpose of sharing, and pointing at a toy while making eye contact with the examiner for the purpose of sharing. Each child's RJA was calculated as the percentage of responses in which the infant correctly followed the examiner's point to images in a book or posters on the wall. The authors of the ESCS reported adequate interrater reliability (IJA = .80-.84, RJA = .86-1.0; Mundy et al., 2003).

Bridget Gamber and a team of 4 research assistants coded ESCS videos using video behavior analysis software (NOLDUS Observer XT 10.0 and 11.0, Noldus Information Technology). The research assistants were blind to the purpose and hypotheses of this study, although Ms. Gamber was not. Coders were trained to accurately identify the target behaviors using the coding manual. A single coder completed each video in one pass. Interobserver reliability was established using a set of 10 reliability videos provided by the creators of the measure (Mundy et al., 2003). Twenty percent of videos from the study were double-coded for reliability. Average inter-rater agreement was found to be excellent (IJA α = .96, RJA α = .99).

ANALYTIC APPROACH

First, SPSS version 19 was used to organize data and run descriptive analyses. In order to test the stability of synchrony across 9, 12, and 15 months of age, we conducted repeated measures ANOVAs. Next, we wanted to examine the association between synchrony and joint attention at each time point. Therefore, SPSS was used to conduct correlational analyses between synchrony at 9 months and IJA and RJA at all ages. We also used correlational analyses to test for associations between gender and age with predictors (MS1, MS2, and MS3) and outcome variables (IJA and RJA).

Subsequent analyses were conducted using R version 2.11.1. Our goal was to test the hypothesis that synchrony scores affect the growth rate of joint attention over time. The Hierarchical Linear Modeling (HLM) procedure was used to conduct growth curve analyses. This method accounts for repeated observations within individuals over time, and allows for the inclusion of individuals with missing data. In R the *nlme* package was used to run all growth curve analyses, the *psych* package was used for descriptive statistics, and the *ggplot2* package was used to create plots. Total IJA and RJA were entered as outcome variables in separate analyses. The three indices of synchrony, MS1, MS2, and MS3 were entered as continuous predictors in separate analyses. Age was entered as a continuous predictor and gender was entered as a fixed factor in all analyses. Since opportunities to engage in IJA might have been affected by the total testing time, the duration of administration of the ESCS was entered as a continuous predictor in analyses of total IJA. Since RJA is calculated as a proportion of responses to specific prompts, and therefore is assumed to be unaffected by the duration of ESCS, duration was not included in analyses of RJA.

Chapter 3: Results

Preliminary Analyses

Descriptive statistics for each predictor and outcome variable are shown in Table 1. Three separate repeated measures ANOVAs were conducted to test for change in each synchrony score over time. First, there was no significant effect of time on MS1, Wilk's Lambda = .86, $F(2,9) = .735$, $p = .51$. Next, there was no significant effect of time on MS2, Wilk's Lambda = .84, $F(2,9) = .85$, $p = .46$. Finally, there was no significant effect of time on MS3, Wilk's Lambda = .72, $F(2, 9) = 1.80$, $p = .22$. These results suggest that synchrony scores were stable within dyads over time. Therefore, only MS1, MS2, and M3 scores from 9 months were used as predictors in subsequent hierarchical linear models.

Pearson correlation analyses were conducted to examine whether age at assessment or gender were associated with any predictor or outcome variables. Female gender was negatively associated with Total IJA at 12 months ($r(13) = -.63$, $p <.01$) and RJA at 15 months ($r(11) = -.68$, $p < .01$). There were no other significant associations with age at assessment or gender.

Next, Pearson correlation analyses were conducted to examine associations among predictor and outcome variables. There were strong positive correlations between MS1 and MS2 ($r(18) = .92$, $p < .001$), between MS2 and MS3 ($r(18) = .96$, $p < .001$), and between MS1 and MS3 ($r(18) = .88$, $p < .001$), all observed at 9 months of age. Each synchrony score measures a different aspect of the interaction and therefore were included in the growth curve analyses, but were entered into separate models given the strong intercorrelations that were observed among the synchrony scores. Significant correlations were also observed among joint attention scores across time points. Total IJA at 9 months was positively related to Total IJA at 12 months, $r(13) = .44$, $p = .05$.

RJA at 12 and 15 months were also significantly positively correlated, $r(11) = .51, p < .05$.

Associations between synchrony at 9 months and joint attention at 9, 12, and 15 months were also examined using Pearson correlations. Total RJA at 12 months was negatively associated with MS2 ($r(13)=-.47$, $p < .05$) and MS3 ($r(13) = -.47, p < .05$). Thus, it seems that children whose mothers' verbal and nonverbal behaviors followed their focus of attention (and action, in the case of MS3) were less likely to follow the point of an examiner who redirected their attention. No other correlations reached statistical significance.

HIERARCHICAL LINEAR MODELING ANALYSES

Hierarchical linear models were constructed to test for possible main effects of age and synchrony, and also a possible interaction effect of age and synchrony on the development of: (1) IJA and (2) RJA between 9 and 15 months of age. It should be noted that the total duration of the ESCS was entered into models predicting IJA. IJA is a behavior frequency that might be affected by the opportunity to engage with the examiner, which in turn may be affected by the duration of the assessment. Total duration of the ESCS was not included in models predicting RJA, given that RJA is not based on frequency count, but rather percent correct (number of trials passed divided by number of trials administered).

Results from the analyses using MS1 as a predictor and IJA or RJA as the outcome are shown in Table 3. Results from the model using MS1 to predict IJA revealed no significant main effect for age ($t(24) = 0.21, p = .84$), no significant main effect for MS1 ($t(17) = 0.55, p = .59$) and no significant age x MS1 interaction ($t(24) = -0.42, p = 68$). The model using MS1 to predict RJA also revealed no significant main effect for MS1 ($t(17) = .21, p = .84$), nor was there a significant age x MS1 interaction (t(24) = -0.23, p = .82). As expected, however, a significant main effect for age was observed (t(24) = 5.66, p <.001). Individual and mean growth in RJA over time is illustrated in Figure 1.

Results from the analyses using MS2 as a predictor and IJA or RJA as the outcome are shown in Table 4. The results are similar to those for the models using MS1 as a predictor. For IJA, there was no significant main effect for age (t(23) = 0.18, p = .86), no significant main effect for MS2 (t(17) = 0.26, p = .80), and no significant age x MS2 interaction (t(23) = -0.29, p = .77). For RJA, there was no significant main effect for MS2 (t(17) = .08, p = .94), nor was there a significant age x MS2 interaction (t(24) = -0.20, p = .85). As expected, however, there was a main effect for age (t(24) = 4.58, p < .001).

Results from the analyses using MS3 as a predictor and IJA or RJA as the outcome are shown in Table 5. Once again, the results are consistent with those observed for MS1 and MS2. For IJA, there was no significant main effect for age (t(22) = 0.64, p = .53), no significant main effect for MS3 (t(22) = 0.88, p = .39), and no significant age x MS3 interaction (t(22) = -0.89, p = .39). For RJA, there was no significant main effect for MS3 (t(23) = 0.19, p = .85), nor was there a significant age x MS3 interaction (t(23) = -0.32, p = .75). As expected, however, there was a main effect for age (t(23) = 5.02, p < .01).

Chapter 4: Discussion

The current study examined mothers and their infants longitudinally from when infants were approximately 9 to 15 months of age. The study focused on (1) dyadic synchrony between mothers and infants over time (2) infant joint attention development over time, and (3) the potential effects of dyadic synchrony on the rates of growth in infant joint attention development. As predicted, synchrony was stable within dyads over time when infants were roughly 9, 12, and 15 months of age. To our knowledge, this is the first study to examine dyadic synchrony longitudinally in a typically developing sample of infants using the criteria set forth by Siller and Sigman (2008). The fact that there was little fluctuation in synchrony scores within dyads over time seems to suggest that synchrony is a relatively stable construct that likely reflects a true difference between mother-infant pairs. Thus, stability of dyadic synchrony was the first major finding of the current study. We hypothesize that if synchrony were examined longitudinally from infancy to later childhood, there would likely be changes over time. Specifically, we would expect synchrony to change as children develop and become more independent. A child who is 9 months old and cannot crawl or speak engages with the environment (including her caregiver) in a very different manner from a child who is 4 years old. Nonetheless, it is unclear whether synchrony might generally increase or decrease in later childhood.

It is worth noting that the mean synchrony scores found in the current study were somewhat higher than those reported by Siller and Sigman (2008). The higher scores in our sample might be due to it being easier for mothers to follow an infants' lead than an older child's lead. In addition, it may be easier to follow a typically developing child's lead than a child with an ASD. Further research is needed to test these potential explanations. However, the rank order among synchrony scores in our data matched the order of their data, in increasing order of M3, M1, and MS2 respectively. Taken together, these findings suggest that mother-infant synchrony might be higher overall in typically developing infants versus toddlers with ASD. Nonetheless, our study replicates the Siller and Sigman (2008) finding that mothers' verbal utterances are more synchronized with their children's behavior than mother's nonverbal indicating behaviors, such as pointing and showing.

After establishing the stability of synchrony, we examined associations between synchrony at 9 months and joint attention scores at 9, 12, and 15 months. Surprisingly, our correlational findings indicated that higher synchrony scores at 9 months were associated with lower RJA at 12 months. Thus, infants whose mothers followed their focus of attention and/or action more were less likely to follow the point of an examiner who redirected their attention. Some mothers are following their infant's lead more and redirecting him/her less early in infancy. One explanation might be that this reduced exposure to attentional redirection via verbal or nonverbal cues might contribute to a slower rate of development in following others' redirection and bids for joint attention. Nonetheless, it remains unclear whether higher synchrony and less redirecting is affected by individual characteristics of the mother, child, and/or a transaction between them both. None of the other correlations were statistically significant.

The main purpose of the study was to examine whether individual differences in synchrony could help to predict the rate of growth (slope) in infants' joint attention skills. We predicted that higher synchrony scores would promote greater growth in both IJA and RJA over time. First, we constructed hierarchical linear models predicting changes in IJA. Contrary to our predictions, we did not find significant change in total IJA over time. Due to this lack of variability in IJA over time, we were also unable to demonstrate a significant interaction effect of synchrony on the growth of IJA over time. However, it seems that IJA scores in our study are much lower compared to the results reported by Mundy and colleagues from a typically developing sample at the same ages (2007). Mundy and colleagues examined IJA at 9, 12, 15, and 18 months, and were therefore able to model nonlinear growth indicating a cubic effect of age on IJA. Our IJA scores were much lower, but seem to show the same pattern over time. The children in our study exhibited higher-level IJA behaviors less frequently than was observed in the Mundy study. As a result, the IJA scores in the present study mainly reflected the lowest levels of IJA skill, eye contact while manipulating an object.

We also constructed hierarchical linear models predicting changes in RJA. As predicted, we found significant growth in RJA from 9 to 15 months across infant participants. As illustrated by Figure 1, there was significant variability between infants in the rates of RJA growth. We then attempted to account for some of this variability using dyadic synchrony scores. However, contrary to our hypothesis that synchrony scores would positively predict the rate of RJA growth, age was the only predictor that reached significance. Our ability to test for the presence of nonlinear growth was limited due to having data at only three time points. Considering our findings as a whole, we were able to account for associations between synchrony and joint attention only when infants were 12 months of age (within one time point). However, our attempts to predict growth in IJA and RJA over time using synchrony scores did not yield significant results.

There were several limitations to the current study. First, our study was statistically underpowered, which might have led to a failure to detect true relationships between synchrony and joint attention via a Type II error. Our sample was limited to 20 mother-infant dyads, only 12 of which had analyzable data at all 3 waves. In addition, our study was limited to infants at 9, 12, and 15 months. This prevented us from making comparisons with the joint attention data at 18 months from Mundy et al (2007), and also made it more difficult to detect nonlinear growth over time. We plan to address these issues in the near future, as our study is ongoing. Within the next year, we will have collected additional data at 9, 12, 15, 18, and 24 months of age. With data from additional families and more waves of data collection within dyads, we hope to gain the statistical power required to observe significant associations between mother-infant synchrony and growth of joint attention during the first two years of life.

The IJA scores from our sample were lower than expected based on previous findings with typically developing samples (e.g., Mundy et al., 2003; Mundy et al., 2007). One potential cause might be the way we coded IJA; although we demonstrated high interrater reliability, our site might have coded IJA too strictly. Going forward, it may be necessary to have additional outside raters recode a portion of our videos to assure the reliability and validity of our joint attention data relative to gold-standard coders at other sites.

Another potential confounding factor could be that our sample was not truly a healthy control sample. These data come from a larger study comparing this sample to infants with an older sibling with an ASD. Infants in our study could not have a diagnosis of ASD or a sibling with ASD, but we did not screen for other developmental delays or diagnoses in the infants or siblings during study enrollment. In fact, one parent disclosed after the 15-month visit that the infant's older sibling had received intensive early intervention for delayed language. There are also maternal characteristics that might directly affect both dyadic synchrony and infant development. For example, analyses conducted for another study using this sample indicated that some mothers in our study were experiencing mild to moderate symptoms of depression and/or anxiety (Gamber & Neal-Beevers, under review). Many studies have demonstrated how maternal anxiety and depression can have negative consequences on caregiving, particularly within early mother-infant dyads. While some studies have reported that maternal depression is associated with withdrawal, others have found depressed mothers to have intrusive or less sensitive interactions with their infants (e.g., Field, 1992; Herrera, Reissland, & Shepherd, 2004). One study focusing on emotional congruence between dyads found that mothers with anxiety displayed exaggerated behavior during play (Kaitz et al., 2010). In addition, Zwaigenbaum and colleagues (2007) have cautioned that parents with early concerns might be more likely to enroll either as "typically developing/low-risk" or "high-risk" participants in studies designed to assess for developmental delay. It is still unclear how these potential confounding factors could have affected synchrony and joint attention scores in this study. To the extent that is appropriate and feasible, future studies should implement careful family screening procedures to help circumvent these issues.

Due to the transactional nature of dyadic synchrony and joint attention, future studies should consider characteristics of the caregiver and child that might impact results. Using the additional data currently being collected (see Table 2), we hope to shed light on some of these individual characteristics. For example, we will explore whether mothers' depressive symptoms, anxiety, parenting stress, caregiver burden, coping style, or self-compassion affect dyadic synchrony during play and/or infants' development. There are many child factors to consider as well. We will soon be able to account for child temperament, mental age, adaptive skills, and language development over time. Some of these factors might be treated as covariates (e.g., mental age), whereas others can also be tested as outcomes (e.g., language). With additional data, we plan to simultaneously test the relationships between synchrony, joint attention development, and language development.

Another valuable extension of the current study will be the addition of data from the comparison sample of infants at risk for ASDs. Related to increased familial risk is the broader autism phenotype, which refers to the tendency for first-degree relatives of individuals with an ASD to display symptoms or characteristics of autism. In some cases these characteristics are significant enough to warrant a diagnosis of an ASD in the first-degree relative, but it many cases the characteristics are subtle and subclinical. While there has been noteworthy progress within this area of research, much has yet to be examined and replicated that may provide insight into the early course of ASD. In particular, few studies to date have considered the transactional model and broader autism phenotype in order to examine how maternal behaviors (i.e., synchrony) affect infants at-risk for ASD and vice versa.

One study found that mothers of children with autism smiled and returned smiles significantly less than mothers of typically developing children (Adamson et al., 2001; Dawson, Hill, Spencer, Galpert, & Watson, 1990). Another study indicated that mothers of children with autism relied more on literal action than conventional action when seeking joint attention, strategies which are typically employed with typically developing infants of a much younger age (Adamson & Bakeman, 1984). Caregivers of children with autism have also been found to direct more utterances referencing something outside the child's focus than parents of typically developing children (Watson, 1998). Further research on mother-child dyads needs to be conducted to better understand the possible transactional mechanisms of joint attention impairment in ASD. The majority of the research in this area has found differences in the way that mothers of children with autism interact with their child with autism, but researchers have not sufficiently explored maternal behaviors toward their later-born children. A longitudinal approach examining differences in synchrony between high-risk families and low-risk families might be more informative that studies examining differences between parents in different outcome groups alone.

IMPLICATIONS

The current study is a first step to understanding mother-infant synchrony and joint attention development in infants. One key contribution of this work is the finding that synchrony appears to be relatively stable within dyads during infancy. Contrary to our predictions, the only statistically significant association between any of the synchrony scores and joint attention was a negative correlation. This indicated that mothers who followed their child's lead and were therefore more synchronized had infants who exhibited less responding to joint attention at 12 months. However, these findings must be interpreted in light of the limitations of the study, and will be reexamined upon gathering additional data from our larger study. While the current study begins to elucidate synchrony and joint attention in typical development, it will also allow the extension of this line of research to infants at risk for developmental delay. Further work should consider individual parent and child characteristics, as well as transactional processes such as synchrony and joint attention that could impact infants' long-term outcomes.

Measure	*M*	*SD*
Wave 1 (n=20)		
Age in months	9.11	0.30
Total RJA	1.97	6.27
Total IJA	4.75	3.42
MS1	1.13	1.05
MS2	1.39	0.95
MS3	0.98	0.75
Wave 2 (n=15)		
Age in months	12.13	0.27
Total RJA	37.62	30.89
Total IJA	6.13	3.83
MS1	2.19	0.85
MS2	1.15	0.25
MS3	0.67	0.15
Wave 3 (n=12)		
Age in months	15.41	0.41
Total RJA	64.93	32.78
Total IJA	4.67	3.58
MS1	1.99	0.85
MS2	1.19	0.51
MS3	0.68	0.30

Table 1: Descriptive Information.

Note: RJA = response to joint attention; IJA = Initiating Joint Attention; MS1 = synchronization score based on maternal indicating behaviors that were synchronized with children's attention; MS2 = synchronization score based on maternal verbal utterances that were synchronized with children's attention; MS3 = synchronization score based on maternal verbal utterances that were synchronized with both children's attention and their action. All synchronization scores were computed by dividing the percentage of synchronized maternal behaviors by the percentage of time children attended to toys.

Measure	Dimension
Background Information Questionnaire	Family demographic information
Maternal Synchrony (Siller & Sigman, 2008)	Mother-infant synchrony
Bayley Scales of Infant Development (Bayley, 2006)	Infant cognitive development, receptive language, expressive language
Autism Observation Scale for Infants (Luyster et al., 2009)	Infant autism symptoms
Empathy Task (Hutman et al., 2010; Zahn-Waxler et al., 1992)	Infant empathy
Early Social Communication Scales (Mundy et al., 2003)	Infant nonverbal communication; joint attention
Vineland Adaptive Behavior Scales (Sparrow, Cicchetti, & Balla, 2005)	Infant adaptive functioning
MacArthur Communicative Development Index – Words & Gestures Form (Fenson et al., 1994)	Infant receptive and expressive language
Infant Behavior Questionnaire (Garstein & Rothbart, 2003)	Infant temperament
Parent Concerns Questionnaire (Ozonoff et al., 2009)	Maternal concerns regarding infant development and/or behavior
Parenting Stress Index – Short Form (Abidin, 1995)	Maternal parenting stress
Center for Epidemiologic Studies Depression Scale (Radloff, 1977)	Maternal depressive symptoms
Autism Spectrum Quotient (Baron-Cohen et al., 2001)	Maternal characteristics of broader autism phenotype
Beck Anxiety Inventory (Beck, Epstein, Brown, & Steer, 1988)	Maternal anxiety symptoms
Brief COPE (Carver, 1997)	Maternal coping style
Caregiver Burden Index (Zarit et al., 1980; as adapted in Gallagher, Phillips, Oliver, & Carroll, 2008)	Maternal caregiver burden
Self-Compassion Scale – Short Form (Raes, Pommier, Neff, & Van Gucht, 2011)	Maternal self-compassion
Social Communication Questionnaire (Rutter, Bailey, & Lord, 2003)	Autism symptom screening for older sibling
Autism Diagnostic Observation Schedule (Lord, Rutter, DiLavore, & Risi, 2001; Luyster et al., 2009)	Autism diagnostic assessment for infant and older sibling

Table 2: Complete List of Measures in Present Study.

Predictor	Outcome	
	Total IJA	Total RJA
Intercept	3.34 (4.38)	-88.08*** (22.81)
ESCS Duration	0.00 (0.32)	N/A
Age	0.07 (0.32)	10.44*** (1.84)
Gender (0=Female/ 1=Male)	-1.84 (1.14)	-12.06 (9.21)
MS1	1.29 (2.36)	2.88 (13.95)
Age x MS1	-.08 (0.19)	-0.26 (1.12)

Table 3: Predictors of Joint Attention Including MS1.
Note. Values are parameter estimates (standard error).
***$p < .001$

Predictor	Outcome	
	Total IJA	Total RJA
Intercept	3.82 (5.28)	-86.55** (28.09)
ESCS Duration	0.00 (0.00)	N/A
Age	0.07 (0.39)	10.51*** (2.30)
Gender (0=Female/ 1=Male)	-1.64 (1.14)	-11.63 (9.01)
MS2	0.70 (2.74)	1.25 (16.23)
Age x MS2	-0.07 (0.23)	-0.27 (1.36)

Table 4: Predictors of Joint Attention Including MS2.
Note. Values are parameter estimates (standard error).
**p<.01, ***p < .001

Predictor	Outcome	
	Total IJA	Total RJA
Intercept	1.58 (4.93)	-88.61** (26.19)
ESCS Duration	0.00 (0.00)	N/A
Age	0.23 (0.36)	10.67*** (2.13)
Gender (0=Female/ 1=Male)	-1.57 (1.13)	-11.46 (9.04)
MS3	3.08 (3.51)	3.98 (20.95)
Age x MS3	-0.26 (0.26)	-0.56 (1.76)

Table 5: Predictors of Joint Attention Including MS3.
Note. Values are parameter estimates (standard error).
$^{**}p<.01$, $^{***}p < .001$

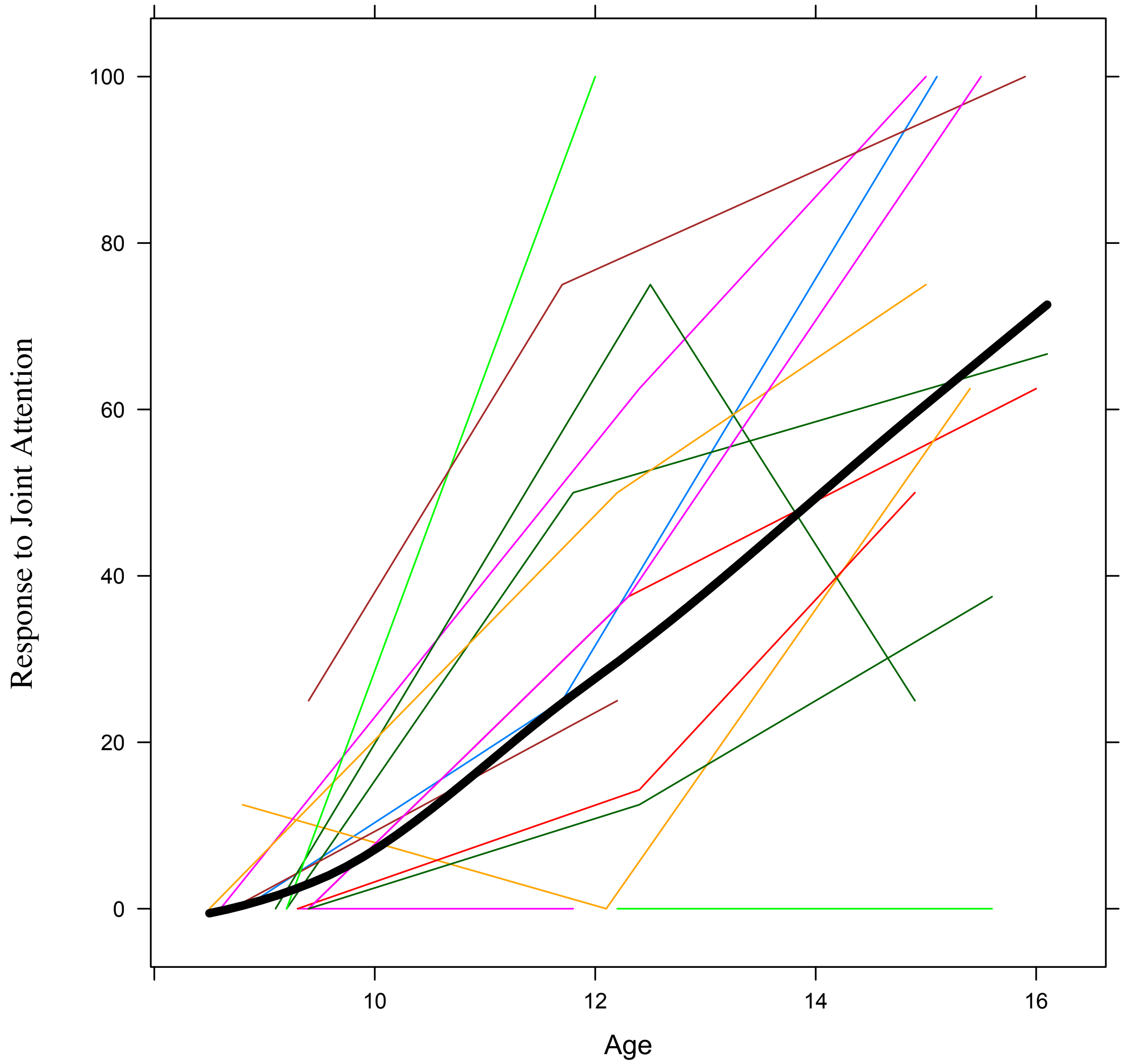

Figure 1: Individual and Mean Growth in Response to Joint Attention.

Note. Fit line for mean growth shown in black.

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