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Developmental Patterns of Responding to Joint Attention in Infants Prenatally Cocaine Exposed and Predictions to Language

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DEVELOPMENTAL PATTERNS OF RESPONDING TO JOINT ATTENTION IN INFANTS PRENATALLY COCAINE EXPOSED AND PREDICTIONS OF EARLY LANGUAGE OUTCOMES

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The current study examined the development of responding to joint attention (RJA), a prelinguistic skill, in a sample of children prenatally cocaine exposed. The sample used was part of a larger population of children randomly assigned to three levels of intervention. The growth of RJA in the current sample was best characterized by two linear growth groups determined by a semi-parametric growth modeling program. Each trajectory group was differentially associated with three language outcomes. Gender, treatment group, and birthweight were three risk factors that influenced the likelihood of belonging to either growth cluster. RJA's predictive significance in terms of concurrent and subsequent language was also established, accounting for the variance associated with contemporaneous measures of cognition. The findings (regarding the relationship between RJA and language) were consistent with previous research examining joint attention behaviors in other types of samples. Additionally, this study contributed uniquely to the body of research on joint attention by exploring the growth of RJA, a precursor of language, in a sample of children at risk for language impairment.

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Chapter 1 Introduction

Joint attention (JA), a skill which typically emerges during the first year of life, refers to a child's capacity to coordinate attention with a play partner in relation to an object or an event. This skill is particularly invaluable as it has been associated with a number of outcomes including language, cognition, and social emotional characteristics in studies with typically developing (Delgado et al., 2002; Markus, Mundy, Morales, Delgado, & Yale, 2000; Morales et al., 2000), atypically developing (Harris, Kasari, & Sigman, 1996), and at risk populations (Acra, 2006; Neal, 2002; Ulvund & Smith, 1996). The presence of joint attention may indicate an awareness of events being shared as well as the understanding of intentionality, and as such these behaviors constitute the base for the sharing of mental states (Corkum and Moore, 1998). Joint attention is more than a shared experience; it represents, as cited in Tomasello and Carpenter (2007), a mutual understanding between child and play partner that such sharing is taking place. The proposed study will examine the development of a particular form of joint attention, responding to joint attention (RJA), in a sample of children at risk for language delay as a result of prenatal cocaine exposure.

An Overview

The terms protoimperative and protodeclarative have been used to refer to the functions served by different aspects of joint attention. As cited in Wachs and Chan (1986), protoimperative functions serve instrumental purposes such as obtaining help in acquiring an object. Protodeclarative functions instead refer to those aspects of joint attention that serve to engage another's attention for the purpose of social sharing (Warren, Yoder, & Leew, 2002).

These instances of social sharing are particularly important for the development of communication (Deak, Walden, Yale, & Lewis, in press), as they provide an opportunity for learning language by facilitating word-object mapping (Morales et al., 2000). In other words, coordinated attention may help enhance the lexicon by reducing the probability of mapping errors, allowing the child to correctly identify the referent object and make accurate mental connections about that object's label. As such, joint attention functions as a prelinguistic framework that "scaffolds" language for the developing child (Tomasello & Farrar, 1986). In other words, instances of joint attention provide an opportunity in which children can learn to derive meaning about themselves and their surroundings with the help of a knowledgeable play partner (Walden & Ogan, 1988).

A number of studies have found a link between joint attention skills and subsequent language development measures (Markus et al. 2000; Morales et al., 2000; Morales, Mundy, and Rojas, 1998; Tomasello, 1988; Tomasello and Farrar, 1986; Ulvund and Smith, 1996). Tomasello and Carpenter (2007) refer to joint attention as a "shared space of common psychological ground" that facilitates a number of socially embedded activities including language. As cited in Corkum and Moore (1998), joint attention skill plays an important role in the development of communication and language skills as it allows the child access to lexical information about referent objects or events that are shared in a social context.

Preceding the development of this skill, the infant's attention is limited to dyadic interactions, where the infant becomes focused on either play partners or objects but cannot engage in attention shifting (Bakeman & Adamson, 1984). Infants gradually progress to triadic interactions in the first year of life, where the focus of attention is shared with another person, with a higher capacity in this skill already at 6 months predicting receptive language at 12 months and expressive language at 18 months (Morales, et al., 1998).

Assessing Joint Attention

Studies have measured joint attention skills during child-caregiver interactions (Bakeman and Adamson, 1984; Tomasello & Farrar, 1986) during play interactions with unfamiliar adults, and during semi-structured play assessments (Coggins & Carpenter, 1981; Delgado et al., 2002; Mundy & Gomes, 1998).

During child-caregiver interactions at 13 months, frequency of maternal utterances referring to objects within the child's focus of attention was significantly correlated with lexical development at 24 months (Dunham & Dunham, 1992). Harris, Kasari, and Sigman (1996) found that receptive language gains were positively related to length of joint attention episodes in typically developing children during similar play paradigms. In Down syndrome children, the same researchers found a negative association between receptive language gains and play episodes in which caregivers redirected the child's attention away from toys. Similarly, Tomasello and Farrar (1986) found that instances where the mother followed rather than redirected the infant's focus of attention were positively correlated with subsequent lexical development at 21 months.

During play interactions with an unfamiliar play partners, where 18- month-old infants were assigned to one of two groups (attention following or attention switching), Dunham, Dunham, and Curwin (1993) provided evidence for the *attentional mapping hypothesis* proposed by Tomasello. The argument here is that infants will more likely acquire new vocabulary when the adult's reference follows into the child's already established focus of attention, as this process lowers the chance that the child will make a word-object mapping error.

Other studies (Delgado et al., 2002; Morales et al., 2000; Ulvund & Smith, 1996; Watt, Wetherby, & Shumway, 2006) have used semi-structured assessments such as the Early Social Communication Scales (ESCS; Mundy, Hogan, Doehring, 1996) and the Communication and Symbolic Behavior Scales Profile (CSBS; Wetherby & Prizant, 1993) to examine the relationship between individual differences in joint attention skills and language outcomes. For instance, acts of joint attention and word comprehension measured at 24 months via the CSBS were related to expressive language at approximately 33 months, when controlling for other prelinguistic communication factors (Watt et al., 2006).

Using the RJA task of the ESCS, Delgado et al. (2002) found that individual differences in 15-month-old infants' ability to respond to joint attention outside of their visual field predicted expressive language at 24 months. Morales et al. (2000) used the ESCS and found unique relationships between an aggregate measure of responding to joint attention and subsequent language, even after controlling for other measures of language. Ulvund and Smith (1996) found that individual differences in 13-month ESCS joint attention measures were linked to subsequent language scores up to 5 years of age. Morales et al. (2000) referred to a study by Markus, Morales, & Mundy, which revealed that though a significant relationship between measures of infant RJA skill at 12 months (via the ESCS) and aspects of child-caregiver joint attention at 18 months existed, each of these measures were uniquely associated with language outcomes. Regardless of the paradigm used to measure joint attention, the literature has established that individual differences in this skill can serve as an index of language development.

Responding to Joint Attention (RJA): A Special Skill

Adamson and Bakeman (1991) use the term "shared attention" to refer to episodes in which infants and their play partners are being responsive to each other as a result of a common social interest. According to the authors, episodes of shared attention provide a setting that facilitates "mutual regulation, communicative intentions, and collective meaning". Referring to Vygotsky's 'zone of proximal development', Adamson and Bakeman (1991) describe the importance of attention sharing in terms of providing the child with opportunities for dynamic problem solving under the guidance of a more skilled play partner.

As cited in Mundy, Card, and Fox (2000) responding to joint attention (RJA) is one protodeclarative aspect of joint attention which refers to an infant's ability to follow the gaze, head turn, or pointing gesture of a play partner regarding an object or event, for the purpose of sharing that experience. Essentially, the skill is informally thought of as the infant's ability to respond to the joint attention bid of a play partner. RJA can be thought of as a vehicle for referential forms of understanding that enable the child to create a lexical repertoire about the world (Baldwin, 1993).

RJA can be measured with a semi-structured assessment, such as the Early Social Communication Scales (ESCS). In the ESCS, the RJA score is a percentage which reflects the number of times a child correctly responds to the joint attention bid of a play partner over the total number of trials administered during the RJA task.

RJA and Language Development

Studies with typically developing and at risk populations have provided evidence for the predictive ability of RJA in terms of language outcomes. For instance, early measures of RJA predicted subsequent receptive language above and beyond contemporaneous measures of cognition and language, in sample of typically developing toddlers (Mundy & Gomes, 1998). In a study by Ulvund and Smith (1996) of low-birth-weight Norwegian infants, 13-month RJA measures were among the prelinguistic factors positively associated with language scores at age two. Morales et al. (2000) found that a 6 to 18-month aggregate measure of RJA provided unique information about receptive and expressive language at 30 months, even when controlling for a 24-month language parent report, in a sample of normally developing children. Another study found a positive relationship between 12-month RJA and expressive language at 18, 21, and 24 months in a normal sample of children (Markus et al., 2000). All of these studies provided evidence that children who had higher RJA scores, measured at an earlier point, were exhibiting greater language development at a later point.

RJA and Other Outcomes

Aside from being considered an index of subsequent language development, RJA has been linked to other factors such as behavioral outcomes. RJA measured at 18 months was predictive of teacher-rated school problems and both teacher-rated and parent-rated social competence in the first grade, via RJA's relationship to first grade cognitive and language scores (Acra, 2006). In this mediation model, Acra showed that higher 18-month RJA scores were related to a higher language-cognition composite score, which was in turn related to lower ratings of school problems and higher ratings of social competence in the first grade. Another study found that higher RJA scores averaged across 12 to 18 months were associated with lower ratings of withdrawn behaviors and higher ratings of social competence at 36 months (Sheinkopf, Mundy, Claussen, & Willoughby, 2004). Both of these studies focused on a sample of children at risk due to prenatal cocaine exposure.

RJA Development in Normal Samples

The developmental trajectory of RJA in typically developing populations has been relatively well documented by different studies (Bakeman & Adamson, 1984; Corkum & Moore, 1998; Delgado et al, 2002; Morales et al, 2000). Between 12 and 18 months, typically developing infants gradually progress from only being able to follow the visual gaze of adults regarding objects within their visual field to eventually responding to joint attention bids with objects outside of this field (Deak, Flom, & Pick, 2000; Delgado et al., 2002).

Corkum and Moore (1998) refer to Butterworth and colleagues, stating that as early as six months of age an infant is able to respond to joint attention bids within his visual field, so long as the object is within the infant's "path of scanning". Approaching 18 months, infants progress to searching for targets outside this field and "path of scanning" (Corkum & Moore, 1998).

While some researchers (Morales et al., 2000; Mundy & Gomes, 1998) have found evidence for the stability of this skill during the first two years of life in typically developing infants, others (Markus et al., 2000) have not. As cited in various studies (Bakeman & Adamson, 1984; Corkum & Moore, 1998; Markus et al., 2000; Morales et al., 2000), empirical work and theory suggest that sometime between 12 and 18 months of age, joint attention skills consolidate in typically developing children. Mundy et al. (2000), however, refer to a few studies which suggest that RJA, compared to other types of joint attention skills such as IJA, may consolidate even earlier, during the 6 to 15-month period. This may imply that individual differences in joint attention, specifically RJA skill, may be less relevant in terms of providing important predictive information about subsequent developmental outcomes as the skill reaches "asymptotic levels" toward the end of this consolidation period (Morales et al., 2000). The same researchers have suggested that this period of consolidation may be an ideal time to assess individual differences in the skill so as to obtain the most informative predictions about later language.

Many studies have focused on RJA skills within samples of normally developing children (Corkum and Moore, 1998; Delgado et al., 2002; Morales et al., 2000; Morales, Mundy & Rojas, 1998; Slaughter & McConnell, 2003), while less work (Acra, 2006; Neal, 2002; Sheinkopf et al., 2004) has been done in trying to understand the significance of this prelinguistic ability in at risk populations. As RJA has been linked to concurrent and subsequent measures of language development in previous studies, it is believed that a better understanding of this skill's developmental course, will offer new insights that might serve to identify children at risk for severe language impairment and inform language interventions designed to target vulnerabilities in this population.

Prenatal Cocaine Exposure: A Special Type of Risk

In general, the research on prenatal cocaine exposure (PCE) has shown that the effects of PCE on child developmental outcomes are mostly subtle (Frank, Augustyn, Grant Knight, Pell, & Zuckerman, 2001; Frank et al., 2005; Richardson, Conroy, & Day, 1996). Some studies, however, have found evidence for a unique link between prenatal cocaine exposure and child outcomes (Bennett, Bendersky, & Lewis, 2002; Bandstra et al. 2002; Lewis et al., 2004; Morrow et al., 2004; Singer et al., 2004). For instance, though PCE was not a significant predictor of intelligence in girls, it significantly predicted poor IQ and verbal reasoning in boys (Bennett et al. 2002). In this study, the interaction of gender and prenatal cocaine exposure explained an additional 19% of the variance accounted for in IQ at age four, after controlling for neonatal medical problems, environmental risks, maternal characteristics, prenatal use of cocaine and other substances.

Results from two longitudinal studies revealed a specific cocaine effect on language, concluding that children who had been prenatally exposed to cocaine lagged behind the non-cocaine exposed control group even when controlling for potential confounding demographic and biological factors (Bandstra et al. 2002; Lewis et al. 2004). Compared to children who were not cocaine-exposed, the PCE group had significantly lower language scores at age four, controlling for potential confounders such as prenatal use of other drugs as well as demographic, environmental and medical factors (Lewis et al., 2004). Longitudinal analysis revealed a consistent effect on language associated with cocaine use across ages 3 to 7, with the cocaine-exposed group lagging behind the non-exposed group by one-fifth of a standard deviation, controlling for child gender, age of visit, prenatal exposure to other drugs, and other potential demographic confounders (Bandstra et al., 2001). As cited in Bandstra et al. (2001), even subtle findings represent a significant economic impact on society in terms of the amount of resources allocated to prevent or intervene in the language delays of these prenatally cocaine exposed children.

RJA in PCE Sample: Study Rationale

The study of RJA within a sample of children prenatally cocaine exposed (PCE) will prove quite useful, as this skill's development is less understood in this population relative to typically developing populations. Though prior research on this population has focused on the relationship between RJA and language (Acra, 2006, Neal 2002; and Sheinkopf et al., 2004), no study has thus far examined the developmental trajectory of joint attention nor the relationship between RJA growth and language. A study about the development of RJA and its relationship to language development within a PCE sample is significant. For one, it will provide a reference point, so that RJA development in the PCE sample can be compared to RJA development in typically developing samples. It will also provide unique information about the relationship between RJA growth and language development. Finally, it will verify whether individual differences in RJA measured at different time points contribute unique information about concurrent and subsequent language, above and beyond general cognition. Additionally, understanding the developmental trajectory of RJA may eventually help researchers identify an optimal period for assessing individual differences that predict future language. Ultimately, this research may help inform language interventions to more appropriately address deficits in populations at risk for language impairment.

Specific Research Aims and Hypotheses

The present study had several aims: (1) to determine the growth of RJA during the first two years of life by exploring potential developmental trajectories and to determine how language outcomes are associated with those potential trajectories; (2) to examine the likelihood of belonging to one trajectory group versus another based on a list of socio-demographic variables; and, (3) to investigate the predictive ability of RJA measures at 12, 15, 18, and 24 months in terms of concurrent and subsequent language outcomes at 3 and 6 years of age.

Some of the research aims were examined with specific hypotheses whereas others were exploratory in nature. Regarding research aim # 1, RJA was expected to have an overall linear growth pattern; however, determining the number and nature of RJA growth trajectories and examining how these patterns were associated with subsequent language was exploratory. The age at which RJA becomes a consolidated skill was also examined to describe how this ability develops in a PCE population. With respect to research aim # 2, no specific hypotheses were made but the relationships between certain socio-demographic variables and patterns of RJA development were described. With respect to research aim # 3, it was hypothesized that RJA measures would significantly predict concurrent and subsequent language even after controlling for cognitive skills.

Chapter 2 Methods

Participants

Participants included 245 children who participated in an early intervention program from birth to three years for children who were prenatally cocaine exposed. Children had been assigned to one of three levels of the intervention: (1) Primary Care (PC) or basic medical attention (2) Home-Bound (HB) or early intervention services twice a week for 1 ½ hours at home, and (3) Center-Bound (CB) or early intervention services at the center from Monday to Friday for 5 hours a day. Upon qualifying, infants were randomly assigned to either the HB or the CB condition. Once randomization to these two conditions was complete, additional referrals were assigned to the PC or control condition.

The final sample consisted of 51.4% (n = 126) girls and 48.6% (n = 119) boys. Most of the children, 59.6% (n = 146), were part of the Center-Bound condition, while the remaining 27.8% (n = 68) and 12.7% (n = 31) were part of the Home-Bound and Primary Care conditions, respectively. This reduced sample remained predominantly African-American 69.4 % (n = 170), with Hispanics making up the second largest group of children 12.6 % (n = 31) and 7.8 % Whites making up the third (n = 19). Specific information about sample demographics is provided in Table 2.1.

Of the 210 children with recorded birthweights, 26.7% (n = 56) were considered low birthweight (less than 2500 grams). Out of the 231 children who had information on number of custody changes, 32% (n = 74) experienced two or more custody changes during the three years of intervention. Additionally, 229 children had data on gestational age with little over three-quarters of the sample born full-term.

Referral type consisted of two levels - voluntary and involuntary. Referrals obtained from all other venues such as drug treatment programs, hospitals, and social services programs were listed under voluntary referral. The involuntary category contained all children whose parents were mandated to attend the intervention program by either Department of Children and Families (DCF) or the Dependency Court. About 23% of the sample was referred by the court or DCF.

Measures

Regular assessments were conducted at 12, 18, 24, 36 months of age and at first grade to measure development of language and cognition. Information was collected via parent and teacher reports in addition to standardized assessments. RJA was measured at 12, 15, 18, and 24 months and constituted the predictor variable. Table 2.2 shows sample means and standard deviations for each time measure of RJA.

Receptive-Expressive Emergent Language, Second Edition (REEL-2; Bzoch & League, 1971). In this study language outcomes at 12 and 18 months were gathered via the REEL-2. This instrument consists of parent and teacher reports which can help identify children at risk for language impairment. The REEL-2 assesses receptive and expressive language in children up to three years of age and shows test-retest reliability of .71-.80 (Hohm, Jennen Steinmetz, Schmidt, & Laucht, 2007). Only teacher reports of expressive and receptive language were used in the current study.

Reynell Developmental Language Scales (RDLS; Reynell & Huntley, 1987). The 24 and 36-month language outcomes consisted of the RDLS, a standardized assessment which requires the child to answer questions and respond to oral instructions. The RDLS provides information about children's language performance relative to his/her peers.

Furthermore, it contains normative data for children in the current age group. Reliability estimates for ages 1 to 5 range from .80 to .93. The receptive and expressive quotients were used to measure language in the current study.

Differential Ability Scales (DAS; Elliott, 1990). The DAS is a standardized instrument for assessing ability and achievement. It has been normed on approximately 3,500 children and adolescents representing the 1988 U.S. census, and is appropriate for use with preschool and school age populations. Test-retest reliability ranges from .79 to .94. The Verbal Ability subscale of the DAS was used as a first-grade language measure.

Woodcock Language Proficiency Battery-Revised (WLPB-R; Woodcock, 1991). The WLPB-R measures abilities in three areas of language – oral, written, and reading. This instrument is appropriate for ages 2 and older and has been normed on a sample of over 6,000. Median test reliability estimates for the different subtests of the Woodcock range from .81 to .93. Oral Vocabulary, Picture Vocabulary, Letter Word Identification , and Word Attack were all used as first grade language measures.

Bayley Scales of Infant Development, Second Edition (BSID-II; Bayley, 1993). The BSID-Second Edition is a standardized assessment used to assess infant's level of performance on cognitive and motor tasks relative to his/her peers (mean = 100, standard deviation = 15). Reliability estimates for the MDI up to age 4 range from .78 to .93. Only the Mental Development Index (MDI), a measure of general cognitive ability, was used as a control variable when examining the predictive significance of RJA.

Early Social Communication Scales (Mundy, Hogan, & Doehring, 1996). The ESCS is a brief semi-structured play assessment used to measure early social communication behaviors, like various aspects of joint attention. It is typically administered in a small room where the examiner and child sit at a table across each other with toys placed to the right of the child but out of his/her reach. In the RJA task, the examiner uses posters that are located to the right, left, and behind the child. The assessment normally takes about twenty minutes.

Procedure

RJA was coded in the context of ESCS. This instrument has shown substantial inter-rater reliability for the RJA task (see Mundy et al., 2007). During the RJA task the child was required to respond to the joint attention bid of the examiner regarding three posters, two of which were located 90 degrees to the left and to the right of the child, and one of which was located directly in back of the child. At the beginning of the task, the examiner sang a song to the infant and then proceeded to tickle the child three times, to engage the child's attention at midline. Then the examiner pointed and looked at picture that was to her left (or the child's right), calling the child's name three times. If the child's first look was in the same direction as that of the examiner, the trial was scored as correct or one; otherwise the trial was scored zero. Once the examiner performed the first trial, she repeated the same procedure in the other directions, to the right and back. Toward the end of the ESCS, the examiner performed another set of left, right, and back RJA trials, so that each direction had a total of two pointing and looking trials. The RJA score constituted the total number of correct trials (those receiving a score of 1) over total number of trials administered.

Ten percent of the total sample was evaluated for inter-rater reliability. The total reliability score was calculated for each pointing direction. Estimates for all left, right, and back trials ranged from .88 to .90

Chapter 3 Results

Growth of RJA

Analysis of stability. Correlations of the RJA measures across the first two years of life were conducted to replicate analyses in the Morales et al. (2000) and Mundy et al. (2007) studies (see Table 3.1). With the exception of the 24-month measure, all other RJA measures were positively associated with each other, with Pearson correlations ranging from .258 to .445 (p <.001). The ability to respond correctly on bids of joint attention appeared to be consistent across 12 to 18 months of age in this sample.

Determining developmental growth. Developmental trajectories were determined with PROC TRAJ, which uses a maximum likelihood estimator to find the number of groups necessary to best summarize the various patterns of growth in a given sample. The Bayesian Information Criterion (BIC) score was used to select the number and nature of the trajectories. Different models were specified until the lowest BIC score was obtained, indicating best model fit based on the available data (see Table 3.2). The most parsimonious model, yielding the smallest BIC score, comprised two groups each with linear trajectories (see Figure 3.1). In order to reflect the differences in their intercepts (or their RJA abilities at 12 months), the resulting groups were labeled the Low Starters and the High Starters. Group one, or the Low Starters, consisted of 32% of the sample. The intercept of the Low Starters was not significantly different from zero, p = .025, whereas that of group two, or the High Starters did differ from zero, p = .001. However, both linear trajectory slopes were significantly different from zero, p = .001, indicating growth across the four time points (see Table 3.3).

Group differences by developmental growth clusters. To see if there were significant group differences in mean RJA scores in any of the four time points, an

Analysis of Variance (ANOVA) was run for each time measure of RJA, with PROCTRAJ group membership as the independent variable and RJA score at each time point as the dependent variable. The ANOVAs examining RJA at 12, 15, and 18 months showed significant differences based on the trajectory group variable with the High Starters consistently obtaining higher RJA means at each time point (see Table 3.4). Group differences were not observed on the 24-month RJA means, indicating that the Low Starters appear to have caught up to the High Starters by age two. Comparison scores from a typically developing sample and from a sample at-risk for delay based on cognition scores from Mundy et al. (2007) were also provided.

ANOVAs were used to determine whether group differences existed on any of the language outcomes at 36 months and in the first grade with trajectory membership as the grouping variable. Significant group differences were found on the 36-month RDLS receptive language scores, $F(1, 185) = 10.3$, $p < .01$, on first grade Letter Word Identification, $F(1, 73) = 4.1$, $p < .05$, and on first grade Word Attack, $F(1, 72) = 4.5$, $p < .05$, with the High Starters outperforming the Low Starters on all three outcomes. The means and standard deviations of each group on these language outcomes were listed in Table 3.5. No significant group differences based on trajectory clusters were found for any other language outcome at age three or in the first grade.

Consolidation. An analysis of consolidation, or obtaining 83.33% or higher on the RJA task, was considered in light of some limitations with this sample. First, I only used RJA scores that were based on a complete administration of RJA (2 right, 2 left, and 2 back trials). Therefore the sample was reduced from 245 to 196 children, who had available RJA scores at 12 months. Additionally, I had to find a way to address consolidation in this sample that was laden with missing RJA data across the 15 to 24-month time frame. Therefore, obtaining the percentage of children who reached consolidation by dividing the number of children who reached consolidation at each age by the total number of cases available at that particular age was not a viable solution in light of the fact that this sample had unequal counts of RJA data at each time point (196 at 12 months, 111 at 15 months, 185 at 18 months, and 76 at 24 months). In other words, a higher percentage of children consolidating at 15 months compared to 12 months might simply be indicative of the fact that there were only 111 children with available 15-month RJA scores compared to 196 children who had 12-month RJA score. These differences in sample sizes at each age reduces the external validity of consolidation results for this population in that any conclusions based on these percentage scores would be misleading because they would be based on only a small proportion of the sample (e.g., only 74 children at 24 months).

To deal with these issues, I obtained the cumulative percentage based on the 196 children who had six RJA trials at 12-months. Children who correctly responded to five of six trials at later ages were added to the number of children who had already reached consolidation at an earlier time point and this number was divided by 196 to obtain the percentage of children who had reached consolidation for the given age. Consolidation percentages were as follows: by 12 months, 10%; by 15 months, 17.9%; by 18 months, 48%; and by 24 months 59.2% had achieved consolidation (see Figure 3.2).

Describing Developmental Growth: Socio-demographic Variables

Non-parametric chi-square tests were performed to examine the extent to which certain variables influenced trajectory membership. Socio-demographic risk variables included gender, gestational age, birth weight, treatment group, number of custody changes, and referral type. There were more boys (n = 46) than expected in the Low Starter group and more girls (n = 94) than expected in the High Starter group, $\chi^2(1, N = 245) = 4.96, p < .05$. There were more Center-Bound (n = 105) and Primary Care children (n = 25) than expected in the High Starter group and more Home-Bound children (n = 6) than expected in the Low Starter group, $\chi^2(2, N = 245) = 9.10, p < .05$. For the birthweight category, children were divided into two groups, those in the Low birthweight group, weighing less than 2500 grams, and those in the normal birthweight category, weighing 2500 grams or greater. There was a trend for more low birthweight children (n = 23) than expected to be part of the Low Starter group, and more normal-birthweight children (n = 112) than expected to be part of the High Starter group, $\chi^2(1, N = 210) = 3.66, p = .056$. Neither gestational age nor referral type (whether it was voluntary or involuntary) yielded significant chi-square tests with respect to trajectory group membership.

The Relationship between RJA and Language

Language outcomes. All means and standard deviations for all the language measures for the entire sample were listed in Table 3.6. Correlations between RJA and the language outcomes were provided in Tables 3.7 and 3.8.

Concurrent language measures consisted of the REEL-2 at 12 and 18 months and the RDLS at 24 months. Subsequent language measures consisted of the expressive and receptive quotients of the 36-month RDLS. To reduce the number of language regressions, an exploratory factor analysis was conducted to determine whether the first grade language outcomes could all be combined into one factor. Based on an Eigen value of 3.3, one Verbal Factor was extracted from this analysis. It comprised the following measures: the Verbal Ability subscale of the DAS as well as Oral Vocabulary, Picture Vocabulary, Letter Word Identification, and Word Attack from the WLPB-R.

Predictor group differences on language outcomes. ANOVAs were first performed on each of the language outcomes to determine any group differences on the language outcomes based on gender, race, birthweight and treatment group. Significant differences based on these predictor variables were observed on the REEL at 12 and 18 months and on the RDLS at 36 months. Means and standard deviations for the different levels of each grouping variable are provided in Tables 3.9 and 3.10. Girls had higher expressive, $F(1, 186) = 5.0$, $p < .05$, and receptive, $F(1, 186) = 5.5$, $p < .05$, language scores at12 months and higher expressive, $F(1, 180) = 7.1$, $p < .01$, and receptive, $F(1, 180) = 4.5$, $p < .05$, language scores at 18 months. There were also significant differences based on treatment group for expressive, $F(2, 108) = 18.8$, $p < .01$, and receptive, $F(2, 108) = 16.0$, $p < .01$, language at 24 months. Post-hoc tests revealed that the Center and Home-Bound children had higher expressive and receptive language than the Primary Care children.

Significant group differences were found on expressive language at 36 months based on birthweight, $F(1, 162) = 13.9$, $p < .01$. There were also significant group differences found on receptive language at 36 months based on gender, $F(1, 185) = 5.2$, $p < .05$, and birthweight, $F(1, 162) = 15.5$, $p < .01$. Boys were once again outperformed in language by girls, and children whose birthweight exceeded 2500g had higher language than those in the low birthweight category. No group differences were observed on the Verbal Factor.

Concurrent language regressions. A first set of regressions was performed to examine whether RJA skills were related to concurrent language outcomes, controlling for MDI and for gender, birthweight, and treatment group when appropriate (see Table 3.11). RJA at 12 months was a significant predictor of expressive, $F(3, 181) = 5.9$, $p < .01$, and receptive, $F(3, 181) = 7.1$, $p < .001$, language at 12 months controlling for gender and concurrent MDI. RJA was not a significant predictor in any of the other concurrent hierarchical linear regressions.

Subsequent language regressions. A second set of regressions was performed to examine whether RJA skills were related to subsequent language outcomes at 36 months, controlling for MDI score and for gender, birthweight, and treatment group when appropriate (see Table 3.12). The 36-month language regressions also controlled for RJA at 12 months because of its significant correlation to the outcomes. RJA at 12 months was a marginally significant predictor of expressive language at 36 months, controlling for birthweight and MDI at 12 months, $F(3, 155) = 6.4$, $p < .001$. RJA at 12 months was a marginally significant predictor of receptive language at 36 months, controlling for gender, birthweight, and MDI at 12 months, $F(4, 154) = 8.9$, $p < .001$. RJA at 18 months was a significant predictor of receptive language at 36 months, controlling for gender, birthweight, MDI at 18 months, and RJA at 12 months, $F(5, 135) = 10.3$, $p < .001$.

A final set of regressions was performed to examine whether RJA skills were related to language in the first grade, controlling for MDI only (see Table 3.14). Only RJA at 18 months, was a significant predictor of the Verbal Factor, $F(2, 59) = 5.1$, $p < .01$. A follow-up analysis was done to see what specific language measures were driving the significance in this last regression. Controlling for concurrent MDI, RJA at

18 months was a significant predictor of Oral Vocabulary, $F(2, 64) = 4.7$, $p < .05$, Letter Word Identification, $F(2, 65) = 6.9$, $p < .01$, and Word Attack, $F(2, 64) = 4.0$, $p < .05$.

Chapter 4 Discussion

This study examined the growth of responding to joint attention (RJA) in a sample of children at risk for language delay as a result of prenatal cocaine exposure. These children were part of a larger population of children participating in a birth-to-three intervention and had been randomized to either a Primary Care, Home-Bound, or Center-Bound condition. A study about the growth of RJA in a sample of children at risk for language delay is significant in terms of shedding light on the development of a skill that has consistently been tied to language outcomes in previous studies with in other samples of children.

Growth of RJA

Data from the current study provided support for the relative stability of RJA. The pattern of intra-correlations obtained was similar to that observed in Mundy et al. (2007), where RJA was stable across time. The lack of association between the 24-month RJA and all the previous RJA measures may not necessarily point to a lack of individual differences at 24 months. Instead, the fact that few 24-month RJA measures were available relative to other time points, may have affected the calculation of the correlations, such that the resulting correlations may reflect a subset of children that do not represent the larger sample.

This study also attempted to understand the growth of RJA in this sample. PROCTRAJ was used to identify individual trajectories and to group each individual to prototypic group curves that best represented the given data. The best fitting and most parsimonious model revealed two distinct linear growth clusters - the Low Starters and the High Starters, named this way because of the degree of disparity between their points of inception. Though the High Starters maintained a clear advantage over the Low Starters in terms of RJA means across the 12 to 18-month time margin, by 24 months the Low Starters appeared to have caught up to the High Starters based on the fact that significant group differences on RJA had disappeared. Furthermore, the High Starters' RJA growth appeared comparable in nature and in magnitude to that of a typically developing subsample in the Mundy et al. (2007) paper. Unfortunately, only the growth of RJA growth across the 12 to 18-month time frame could be compared, as no 24-month measure was included in the Mundy et al. (2007) study, and no nine-month RJA was included in the current study. An interesting finding was that the Low Starters performed poorly on RJA even when compared to another at-risk sample from the same study.

A caveat regarding missing data needs to be considered when interpreting the consolidation analysis. The fact that this sample had unequal number of RJA scores available across the four different time points precludes a reliable explanation about the nature of consolidation in this particular sample. Nevertheless, one can still note an upward trend in the number of children who were achieving consolidation from 12 months to 18 months. By 24 months, a little less than half of the sample still had not consolidated. Then again, the 15 and 24-month time points had the greatest amount of missing RJA data points, and this needs to be taken into account when considering why so many of these children are still not achieving this skill.

Additionally, while new cases of children who at each time point achieved consolidation were examined, the child's score in subsequent time points following consolidation was not, to see whether the score had changed. However, making assumptions about whether a child achieves and then loses a skill based on fluctuating scores across time is beyond the scope of this paper.

Socio-demographic Variables

This study was also concerned with understanding whether certain socio-demographic variables conferred a risk or advantage with respect to trajectory group membership. Being a girl, having normal birth weight, or being part of the Center-Bound condition was advantageous in terms of the variables that tended to characterize the High Starter group, who of the two trajectory clusters seemed to have the most promising RJA growth and language outcomes. In contrast, the Low Starter group was characterized by children who were male, low birth weight, and part of the Home-Bound condition. This could mean that in the current sample of children who are already at risk due to prenatal cocaine exposure there could be additional factors placing children at a relative disadvantage compared to their peers. Risk factors in this context refer to the aforementioned set of characteristics that seem to raise one's probabilities of belonging to the Low Starter group, who are clearly performing worse than their High Starter peers in the RJA task across time.

The Relationship between RJA and Language

The High Starters also had an advantage in a few language measures, outperforming the Low Starters in receptive language at age three, and in pre-literacy measures in the first grade. Given the strong support for the association between RJA and subsequent language development, this finding was expected. It is therefore not surprising to see that children who had an advantage in RJA prior to age two also had an advantage in at least some dimensions of future language.

The concurrent and subsequent predictive significance of RJA in this sample was established, even when controlling for the variance associated with cognition. RJA at 12 months was in fact a significant predictor of concurrent teacher reports of receptive and expressive language scores. The 12-month RJA measure's ability to provide incremental variance in the 36-month measures of receptive and expressive language was also established. These findings are consistent with previous research that has provided support for the unique predictive significance of RJA to language while considering the role of cognition (Mundy et al., 2007; Neal, 2002). While cognition does explain some of the variance observed in language, there may be a unique relationship between language and RJA that cannot be fully explained by looking at cognition alone. In fact, Mundy et al. (2007) found strong support for a theoretical model of joint attention that posits that different dimensions of joint attention and language share a unique association that cannot be completely justified by a general aspect of cognitive development but rather by divergent processes that are reflected in each dimension of the skill.

RJA at 12 months was not the sole significant predictor in this study. In fact, RJA at 18 months was a significant predictor of receptive language scores at age three and of the Verbal Factor in the first grade, also controlling for a general measure of cognition. It is important to recognize that RJA at 18 months only predicted the receptive portion of the three year language outcome. At least one other study (Mundy, Kasari, Sigman, & Ruskin, 1995) found evidence that RJA was associated with receptive language, whereas initiating joint attention (IJA), another dimension of joint attention, was associated with expressive language. It may be that in our sample RJA at 12 months is more of a general indicator of overall language development than is a later measure of RJA. It could also be that at 18 months other dimensions of joint attention not explored in the current study are more informative of expressive language than is RJA.

Additionally, 18-month RJA was a significant predictor of the first grade Verbal Factor. A subsequent analysis revealed that RJA at 18 months provided unique information about expressive language and measures of emergent literacy in the first grade, when accounting for the variance associated with cognition. This is a particularly significant finding given the little attention that has been given to the relationship between RJA and pre-literacy factors among other language outcomes (Acra, 2006).

Limitations

Despite the promising results about the development of RJA in this at risk sample, several limitations need to be considered while making any interpretation or recommendation. For one, the sample analyzed contained a sizeable amount of missing data across different variables. This fact could have limited the statistical power to obtain significant findings in some of the language regressions where the sample was reduced from an original 245 children to at times less than 50 children, as was the case in the 15 and 24-month RJA regressions. A similar problem related to this is the running of numerous regressions and the possibility of capitalizing on the alpha value. However, because of the exploratory nature of this study in that RJA's predictive relationship with concurrent and future measures of language development needed to be examined, a composite measure of language could not be created. Future studies may consider running principal component analyses to abridge the number of outcome variables and thus reduce Type I error.

Although RJA's predictive significance above and beyond cognition was established, the same cannot be said with respect to previous measures of RJA. In other words, none of the regressions controlled for previous RJA. The exception is 12-month RJA, which was used as the control variable in the regression exploring 18-month RJA's predictive ability to the three-year language outcomes. Controlling for 15-month RJA and 18-month RJA, even when they were significantly correlated with the language outcome, would have considerably reduced the sample size in some of the regression analyses. Thus, one cannot establish that RJA at 18 months has incremental validity over and above 15-month RJA, nor can it be ruled that RJA at 15 or 24 months provides unique predictive information about language were a larger number of 15 and 24-month RJA data points available.

Missing data was not a problem for PROCTRAJ, a data-driven program that uses maximum likelihood to deal with this issue. However, this program has some disadvantages of its own that are worth mentioning. PROCTRAJ creates prototypic growth clusters that can best describe a given sample, but these clusters do not reflect individual differences. Thus, some individual RJA trajectories may not be best represented by the final growth model, which consisted in this case of two groups each possessing a positive linear development. Additionally, PROCTRAJ's data-driven quality makes it difficult for the researcher to make any assumptions about the population from which the analysis sample was derived. Therefore, any implication about the growth of RJA, based on the statistics discussed herein, are limited to this chosen sample.

Another issue that cannot be discarded is practice effects. Children in this sample had been exposed to the RJA task on at least two separate occasions, so one cannot discard the possibility that children who are improving overtime are simply learning the task rather than acquiring a skill. Whether better scores, as time progresses, are indicative of RJA approaching consolidation or simply a child's ability to remember a particular task needs to be explored further. Future studies may consider measuring RJA with different paradigms at each time point.

Examiner effects, including the issue of fidelity of instrumentation, were also not taken into account. Providing control of these issues would have been a particularly daunting task given the number of assessors who administered the ESCS. Though the RJA task is easily administered and coded, one cannot ignore the possibility that particular examiner characteristics and the degree to which they strayed away from the correct administration procedure could have easily affected child responses on the RJA task of the ESCS. Subsequent studies may want to build in methodological controls by reducing the number of test administrators and examine the statistical influence of examiner effects.

Implications and Future Directions

In spite of these limitations, this study reported findings that are useful and consistent with the joint attention literature – that RJA's growth is mostly linear and that it is associated with language above and beyond cognition. Also, given RJA's relationship to language development, the study of RJA is useful for further understanding language delay in this at risk sample of children. For one, this study helped identify two groups of children whose RJA trajectories were similar in nature but very different in magnitude. Those children in the group that had fewer correct trials at 12, 15, and 18 months did not perform as well in certain language outcomes. One may assume that in this already at risk sample there is a subgroup of children who do relatively worse, performing below their peers in a pre-linguistic factor and eventually in associated language outcomes. With further study, researchers could learn to use RJA as a criterion to identify children who can potentially lag behind in future language measures.

It is important to note that though RJA had a relationship with language in this study, generally speaking children in this sample showed language delay. For example, these children performed about two standard deviations below the mean on the 24-month language measures and about one and one third standard deviations below the mean on the 36-month language measures. Though the High Starters had a trajectory similar to that of a typically developing sample of children, the High Starters did not show significant differences in most language measures compared to their Low Starter peers, which raises an important point about RJA and joint attention in general. Having a relative advantage in RJA development may be necessary but not sufficient in preventing language delay. Logically, language development is influenced by many intrinsic and extrinsic factors and RJA is just a part of the story.

Additionally, a relative advantage in RJA skill development may not necessarily represent a substantial benefit to a child who is part of at risk sample. Though some of these children may possess better RJA development, their at-risk status raises a red flag that cannot be ignored, in terms of providing these children with additional resources that can allow them the opportunity to perform comparatively to their non-at risk peers. To better understand the differences in language development between this at risk population and others, future studies may consider including a typically developing comparison group.

The current study provides information about RJA growth from 12 months to two years. Given that previous research has provided evidence for the presence of this skill prior to 12 months, future studies may also consider adding more RJA measures, particularly those in the six to 12-month time period. Looking at RJA development prior to 12 months in this same population can better inform researchers about the onset of this skill and periods of greatest growth.

Though the findings supported RJA's ability to provide unique information about future language, considering the variance associated with cognition, this study did not establish RJA's ability to perform similarly with respect to contemporaneous measures of language. In other words, RJA's ability to provide incremental variance in the prediction of language when accounting for concurrent language was not explored. Morales et al. (2000) found evidence that an aggregate measure of RJA was able to do this in a typically developing sample. Replication of this study in similar populations is highly recommended to further establish RJA's predictive power and to corroborate its potential use as a standard by which potential language problems can be identified at an early age.

Conclusion

The present study revealed two distinct linear patterns of RJA growth in a sample of children prenatally exposed to cocaine who were participating in an early intervention program. These two groups, one which got almost half the RJA trials correct at 12 months and one which displayed only one of six correct RJA trials at the same age, were differentially associated with language outcomes at ages three and six. Gender, birthweight, and treatment group were found to make a difference in terms of affecting the likelihood of belonging to either trajectory group. This study was also able to establish the predictive significance of RJA with respect to concurrent and subsequent language. Furthermore, the findings established that this relationship remained significant even after accounting for the variance associated with cognition. This study has contributed to general body of research on joint attention, providing unique information about the growth of RJA in sample of children at risk due to prenatal cocaine exposure. Future studies should continue to investigate the relationship between joint attention behaviors and language to help advance the area of language intervention with this population of children at risk for language delay.

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Figures

Figure 3.1

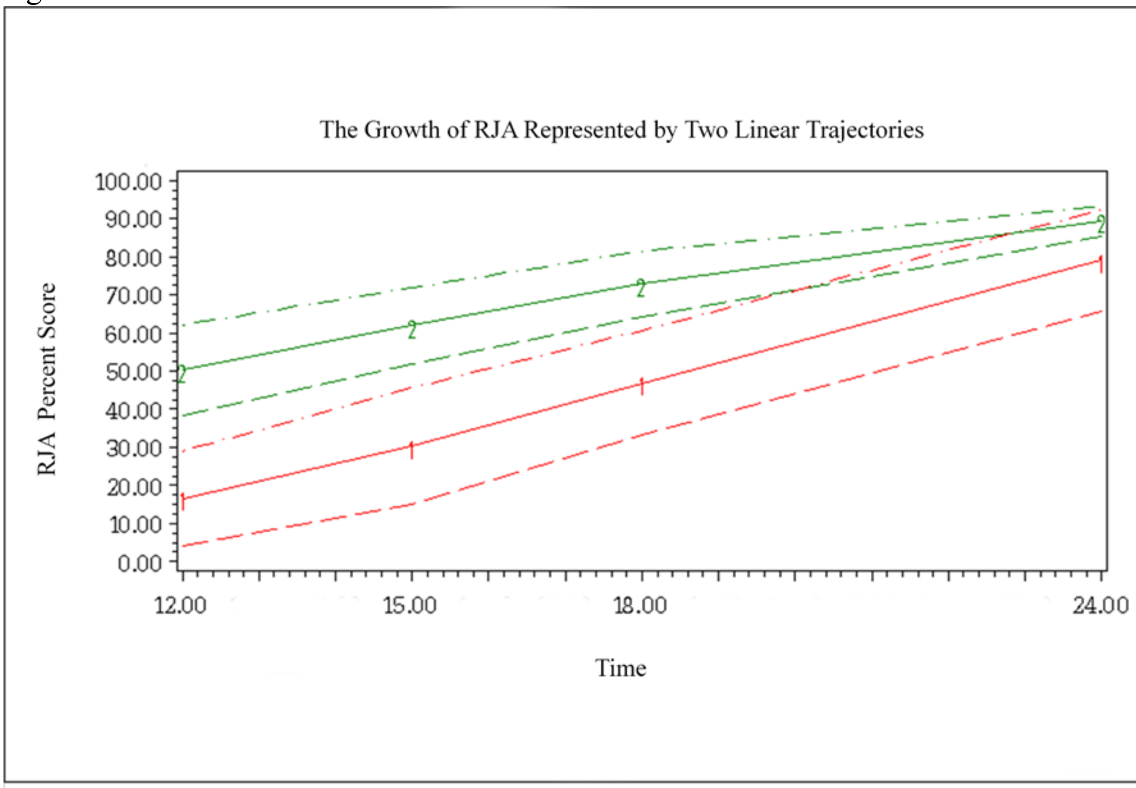
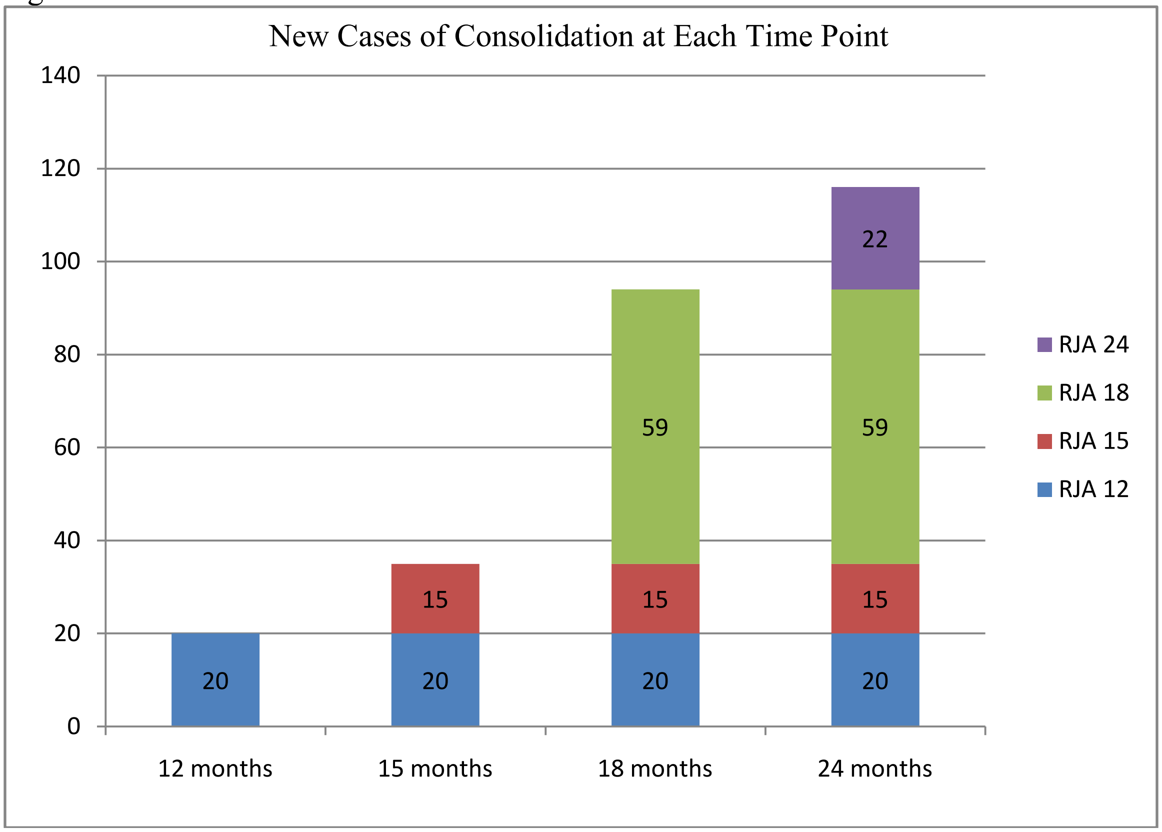


Figure 3.2


New Cases of Consolidation at Each Time Point
140
120
100
80
60
40
20
0
12 months
15 months
18 months
24 months
20
20
15
20
15
59
20
15
59
22
RJA 24
RJA 18
RJA 15
RJA 12

Tables

Table 2.1

Demographics

	Center *n (%)*	Home *n(%)*	Primary *n(%)*	Total *n(%)*
Gender				
Male	68(46.6)	40(58.8)	11(35.5)	119(51.4)
Female	78(53.4)	28(41.2)	20(64.5)	126(48.6)
Ethnicity				
African American	107(73.3)	42(61.8)	21(67.7)	170(69.4)
Hispanics	16(11.0)	12(17.6)	3(9.7)	31(12.6)
White	7(4.8)	8(11.8)	4(12.9)	19(7.8)
Other	15(10.3)	5(7.4)	3(9.7)	23(9.4)
Unknown	1(0.7)	1(1.5)	0(0)	2(0.8)
Birthweight				
<2500g	33(26.4)	18(31.0)	5(18.5)	56(26.7)
2500g- 4310	92(73.6)	40(69.0)	22(81.5)	154(73.3)
Gestational Age				
Premature	32(23.2)	12(19.4)	8(27.6)	52(22.7)
Full term	106(76.8)	50(80.6)	21(72.4)	177(77.3)
Referral Type				
Voluntary	112(81.8)	48(70.6)	22(71.0)	182(78.1)
Involuntary	25(18.2)	20(29.4)	9(29.0)	54(22.9)
Custody Changes				
0-1	85(63.4)	47(70.1)	25(83.3)	157(68.0)
2-6	49(36.6)	20(29.9)	5(16.7)	74(32.0)

Table 2.2
RJA Percent Correct, Means and Standard Deviations

RJA Measure	Sample Size	Mean	Standard Deviation
12 months	245	37.18	27.81
15 months	125	52.61	28.35
18 months	218	65.01	27.55
24 months	84	83.89	17.64

Note. Total number of RJA scores available for analysis varied across time points.

Table 3.1
Correlations among the Four Measures of RJA

	12 m RJA	15 m RJA	18 m RJA	24 m RJA
12 m RJA	1			
15 m RJA	.35**	1		
18 m RJA	.26**	.45**	1	
24 m RJA	.15	-.16	.07	1

**p<.01

Table 3.2
Model Bayesian Information Criteria (BIC)

Number of Groups	Order	BIC
1	1	-2685.02
2	**1, 1**	**-2674.82**
2	2, 1	-2677.50
2	1, 2	-2688.59
3	1, 1, 1	-2694.78

Table 3.3
Maximum Likelihood Estimates for Each Trajectory Group

Variable	Low Starters ML Estimate	SE	High Starters ML Estimate	SE
Intercept	8.59	7.43	50.23**	3.90
Linear Slope	19.00**	2.54	12.98**	1.40

**p<.001.

Table 3.4

RJA Differences by Trajectory Group

	12 months		15 months		18 months		24 months	
	M (SD)	F	M (SD)	F	M (SD)	F	M (SD)	F
Low Starters	12.6 (15.0)	140.7*	24.9 (21.5)	83.6*	40.6 (27.3)	120.4*	78.6 (19.3)	2.7
High Starters	48.7 (24.8)		64.3 (22.1)		76.1 (19.3)		85.8 (16.8)	
TD[a]	51.7 (23.1)		66.8 (21.9)		72.0 (18.8)		- -	-
ARDD[b]	40.2 (23.4)		53.3 (26.9)		59.4 (26.8)		- -	-

Note. There were significant group differences on RJA at 12, 15, and 18 months.

a Typically-developing sample taken from Mundy, Block, Delgado, Pomares, Van Hecke, and Parlade (2007), which only had RJA data available up to 18 months of age.

b At risk, developmentally delayed sample from, Mundy, Block, Delgado, Pomares, Van Hecke, and Parlade (2007).

Table 3.5

Language Differences by Trajectory Group

	36-month RDLS Receptive		1st grade Letter Word I.D.		1st grade Word Attack	
	M (SD)	F	M (SD)	F	M (SD)	F
Low Starters	77.4 (11.9)	10.3	95.3 (18.7)	4.1	95.3 (15.7)	4.5
High Starters	84.9 (16.0)		104.7 (18.7)		101.0 (17.0)	

Note. Group differences, based on trajectory grouping were not found on any of the other language measures.

Table 3.6
Language Measures, Means and Standard Deviations

Measure	Sample Size	Mean	Standard Deviation
12 months (REEL)			
EXP	188	80.73	18.28
REC	188	96.57	20.29
18 months (REEL)			
EXP	182	81.64	21.98
REC	182	93.12	20.69
24 months (RDLS)			
EXP	111	67.36	27.81
REC	111	70.56	28.10
36 months (RDLS)			
EXP	187	79.53	17.51
REC	187	82.57	15.23

Table 3.7

Correlations between RJA and Concurrent Language

	12 months		18 months		24 months	
	EXP	REC	EXP	REC	EXP	REC
12 m RJA	.25**	.26**	-	-	-	-
18 m RJA	-	-	.20*	.09	-	-
24 m RJA	-	-	-	-	.20	.11

Note. REEL-2 teacher reports of expressive and receptive language were used as the 12 and 18-month language measures. The RDLS expressive and receptive scales were used as the 24-month language measures. Correlations that are not applicable are not listed. $^*p < .05$. $^{**}p < .01$.

Table 3.8
Correlations between RJA and Subsequent Language

	36 months		1st grade
	EXP	REC	Verbal Factor
12 m RJA	.19**	.21**	.17
15 m RJA	.16	.25*	.15
18 m RJA	.18*	.29**	.31**
24 m RJA	.10	.16	.11

Note. The RDLS expressive and receptive scales were used as the 36-month language measures. The Verbal Factor was used as the first-grade language measure and consisted of the Verbal Ability subscale of the DAS as well as Oral Vocabulary, Picture Vocabulary, Letter Word Identification, and Word Attack from the WLPB-R.
*$p < .05$. **$p < .01$.

Table 3.9

Predictor Group Differences on the REEL-2

	12 months		18 months	
	EXP	REC	EXP	REC
	M (SD), F	*M (SD), F*	*M (SD), F*	*M (SD), F*
Gender				
Male	77.8 (17.3), 5.0	93.2 (22.3), 5.5	77.3 (21.6), 7.1	89.8 (21.4), 4.5
Female	83.7 (18.8)	100.0 (17.6)	85.8 (21.6)	96.3 (19.5)

Note. Means and standard deviations were not reported for group differences that were not significant.

Table 3.10

Predictor Group Differences on the RDLS

	24 months		36 months	
	EXP	REC	EXP	REC
	M (SD), F	*M (SD), F*	*M (SD), F*	*M (SD), F*
Gender				
Male	-	-	-	80.0 (15.0), 5.2
Female	-	-	-	85.0 (15.1)
Treatment Group				
Center-Bound	75.2 (19.5), 18.8	77.2 (21.0), 16.0	-	-
Home-Bound	74.2 (13.6)	79.2 (14.5)	-	-
Primary Care	41.3 (38.5)	45.8 (38.4)	-	-
Birthweight				
< 2500g	-	-	71.0 (21.5), 13.9	74.9 (17.9), 15.5
2500-4310g	-	-	82.8 (16.1)	85.6 (14.1)

Note. Means and standard deviations were not reported for group differences that were not significant.

Table 3.11
Concurrent Language Hierarchical Linear Regressions

Outcome	Variable	Step	β	T-statistic	$R^2\Delta$
12 months					
EXP					
	Gender	1	-.13	-1.84	.029
	MDI 12	2	.06	.88	.008
	12-month RJA	3	.23**	3.23	.053
REC					
	Gender	1	-.15*	-2.12	.032
	MDI 12	2	.16*	2.26	.033
	12-month RJA	3	.20**	2.80	.039

*p<.05. **p < .01.

Table 3.12

Subsequent Language Hierarchical Linear Regressions

Outcome		Variable	Step	β	T-statistic	$R^2\Delta$
36 months						
	EXP					
		Birth Weight	1	.28**	3.64	.083
		MDI 12	2	.07	.86	.006
		12-month RJA	3	.15 [a]	1.96	.022
	REC					
		Gender	1	-.21**	-2.77	.150
		Birth Weight	1	.31**	4.23	.150
		MDI 12	2	.13	1.73	.018
		12-month RJA	3	.14[b]	1.94	.020
	REC					
		Gender	1	-.16*	-2.16	.148
		Birth Weight	1	.28**	3.71	.091
		MDI 18	2	.23**	2.89	.091
		12-month RJA	3	.06	.79	.011
		18-month RJA	4	.18*	2.21	.026
1st grade						
	Verbal Factor					
		MDI 18	1	.22	1.85	.066
		18-month RJA	2	.29*	2.39	.082
	Oral Vocabulary					
		MDI 18	1	.21	1.74	.068
		18-month RJA	2	.25*	2.10	.060
	Letter-Word ID					
		MDI 18	1	.23*	2.03	.089
		18-month RJA	2	.30*	2.59	.085
	Word Attack					
		MDI 18	1	.16	1.33	.047
		18-month RJA	2	.26*	2.16	.065

[a]$p = .052$. [b]$p = .055$. *$p < .05$. ** $p < .01$.