THE DEVELOPMENT OF JOINT ATTENTION AND VOCALIZATION IN INFANTS AT HEIGHTENED RISK FOR AUTISM SPECTRUM DISORDER

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Perrine Heymann

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This thesis was presented

by

Perrine Heymann

It was defended on

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and approved by

Diane L. Williams, Ph.D, Associate Professor

Jennifer Ganger, Ph.D, Lecturer

Jessie Northrup, MS, Graduate Student

Thesis Director: Jana M. Iverson, Ph.D, Professor

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This study was designed to evaluate joint attention (JA) and vocalizations and their co-occurrence in infants who are at heightened risk for autism spectrum disorder (HR). This prospective longitudinal study examined 50 HR infants, with 9 who received an ASD diagnosis, 15 who received a language delay (LD) and 26 who received no diagnosis (ND) at 14, 18 and 24 months. The Early Social Communication Scales, a structured toy play segment that assesses initiation and response to different types of JA, was administered to each infant at each age point in the home. JA behaviors, vocalizations, and instances where they overlapped were coded from videos. Findings indicated that infants in all three outcome groups produced similar rates of JA behaviors, with the exception of initiating JA. Rates of vocalizations and vocalization quality increased over time in all outcome groups. However, there were still significant differences between outcome groups at 24 months in the types of vocalizations that were most frequently produced. The ASD group consistently produced a higher proportion of lower quality vocalizations compared to its LD and ND peers. Lastly, compared to their LD and ND peers, the ASD group consistently paired fewer vocalizations with a JA behavior. These findings highlight a specific delay in coordinating behaviors in infants who later receive an ASD diagnosis and the importance of observing these behaviors to better understand how JA and vocalizations develop in a HR population.

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PREFACE

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1.0 INTRODUCTION

Joint attention (JA), the mutual attention of at least two individuals to an object or event (Bruner, 1977; Scaife & Bruner, 1975), is an important developmental marker for later cognitive and language abilities and the ability to take others' perspectives (Mundy, Block, Vaughan, Delgado, Parlade, & Pomeras, 2007; Mundy & Vaughan, 2002; Charman, 1998). JA includes eye contacts (e.g., gaze shifting between a parent and an object) and gestures (e.g. reaches, gives, shows, points). The emergence of JA allows infants to interact with their environments in novel ways and affords sharing attention to objects outside their direct line of sight. Once JA emerges, infants move from making eye contact alone to producing gestures to producing gestures with eye contact. This progression allows infants to interact and communicate with their caregivers more efficiently and in more sophisticated ways (Bates, Benigni, Brentherton, Camaioni & Volterra, 1979; Mundy & Newell, 2007).

Previous studies examining JA have focused almost entirely on eye contacts and gestures. However, vocalizations are a key component of infants' communicative repertoires. Vocalizations develop simultaneously with JA, but they are generally not examined in studies of JA, despite the fact that JA has been associated with early language learning in infants in numerous studies (e.g., Baldwin, 1995; Carpenter, Mastergeorge, & Coggins, 1983). Infants who engage more frequently in JA have better language abilities when they are older (Toth, Munson, Meltzoff, & Dawson, 2006). However, there is great variability in JA development. Infants who are at risk for delayed JA are important to examine because they also exhibit later language and communication delays (Charman, 1998; Sullivan et. al., 2007). Thus, the present study is designed to examine the interplay between JA and vocalizations in infants at risk for language and communication delays.

1.1 JOINT ATTENTION AND VOCAL DEVELOPMENT IN TYPICALLY DEVELOPING INFANTS

The development of JA starts with object directed eye gazes that are directed to objects in front of the infant (Bakeman & Adamson, 1984). As infants get older, they start pairing object directed eye gazes with vocalizations, a behavior referred to as object directed vocalization (ODV). Producing ODVs enables infants to get their caregivers' attention in a way that simple object directed eye gazes may not (Goldstein, Schwade, Briesch & Syal, 2010). This is considered by some to be the earliest-appearing form of JA, a first step in the development of the ability to communicate about objects with a social partner (Wu & Gros-Louis, 2014).

JA begins to emerge prior to language in infants (Murray et al., 2008). At around 6 months, typically developing (TD) infants begin to follow the eye gaze of their caregiver to a new location. By 12 months, infants are able to utilize a variety of behavioral forms to establish JA (Carpenter, Nagell & Tomasello, 1998), including eye contacts between their caregiver and an object, and gestures such as reaches, points, and gives (with or without eye contact). These forms of JA are typically considered to serve two social functions: to establish joint attention (i.e., sharing experience of an object or event with another, e.g., by making eye contact with an adult while holding a toy) and to regulate another's behavior (i.e., altering the behavior of another to achieve a goal; e.g., by giving a toy to an adult in order to have it activated). Advances in JA allow infants to request and comment on objects beyond their reach, to interact more effectively with others, and to explore previously inaccessible aspects of their environment. However, at around 15-18 months of age, TD infants' JA production starts to decrease as a result of language development (Carpenter et. al. 1983). Infants no longer need to rely on eye gaze and gestures to communicate, as they are able to make more extensive use of language to engage with others.

While the literature on JA has focused primarily on nonverbal cues (eye contact, gestures), infants make extensive use of vocalizations during social interactions. There are significant developmental changes that occur in infants' vocalizations during the period when JA first emerges and begins to develop. Thus, for example, recent studies have focused on the importance of canonical syllables (CS; Paul, Fuerst, Ramsay, Chawarska & Klin, 2011; Oller, Eilers, Neal & Schwartz, 1999), or consonant-vowel (CV) units in which there is a smooth, fast transition between the consonant and vowel (e.g. baba, dada. mama). CS emerge at around 6 months of age, and by 10 months TD infants have good control over CS production (Oller et. al., 1999). CS are considered to be a major milestone of the first year because they are the building blocks that children use to form words (Paul et al., 2011). As infants get older, they start coordinating communicative behaviors, pairing CS vocalizations with communicative gestures (e.g., reaching, pointing) in naturalistic settings (e.g., Bates et al., 1979). TD infants use these vocalizations to engage with their caregiver in a way that gesture alone may not (Wetherby, Cain, Yonclas & Walker, 1988). While there is extensive research documenting relations between early JA abilities and later language (Morales et. al., 2000; Charman et. al., 2000;

Murray et. al., 2008), to date there has been very little work describing how infants pair vocalizations and JA behaviors in communicative contexts (Winder, Wozniak, Parlade & Iverson, 2012). The role that vocalization may play in the establishment of JA remains unclear, even for TD infants.

1.2 JOINT ATTENTION AND VOCALIZATION IN INFANTS WITH ASD AND HIGH RISK INFANTS

Autism spectrum disorders (ASD) are characterized by deficits in social communication and social interaction, repetitive behaviors and restricted interests and activities (DSM-V; American Psychiatric Association [APA], 2013). These deficits in social communication appear in the areas of JA and vocalization. Thus, for example, children with ASD tend to be delayed in language development and produce lower quality vocalizations (Goldberg et. al. 2005). Children with ASD demonstrate delays in JA, especially initiating JA (e.g., initiating eye contact with the caregiver; pointing to an outside frame of reference; showing an object; Toth et. al. 2006; Goldberg et. al. 2005; Charman, 1998) and responding to JA. These delays in JA not only affect the way children with ASD communicate with their caregivers; they also have implications for later language development. An ASD child who does not engage in eye contacts and who does not follow a parent's eye gaze may not have the same opportunities to learn word-object associations or receive the same sorts of linguistic input as TD children. This is suggested by the finding that children with ASD who have better JA abilities tend to have more advanced language with faster learning rates than their low JA peers (Toth et. al., 2006).

Delays in JA are also seen in infants who are later diagnosed with ASD. Longitudinal studies have found that infants who are later diagnosed with ASD have consistently lower JA abilities than their TD counterparts (Sullivan et. al., 2007). These differences are observed early on in infant development, which helps us understand differences in JA and how ASD infants develop the ability to use and engage in JA. Delays and low JA abilities can affect other aspects of the infant's development, for example later language learning **(**Loveland & Landry, 1986).

Along with delays in JA, infants later diagnosed with ASD tend to have language delays. These delays can be seen early on, as ASD infants produce more non speech vocalizations compared to their TD peers (Paul et. al., 2011). Delays are also apparent in the production of CS. Infants later diagnosed with ASD were significantly less likely to produce CS at 9-12 months than their TD peers (Paul et. al., 2011; Patten, Belardi, Baranek, Watson, Labban, & Oller, 2014; 2011). This late onset of CS is usually a predictor of late word development as well (Stoel-Gammon, 1989; Oller et. al., 1999). Vocalizations usually increase as infants get older, but this is not necessarily the case in ASD (Paul et. al., 2011). ASD infants at 12 months produced significantly fewer vocalizations directed at individuals compared to when they were 6 months (Patten et. al., 2014).

JA and language delays are not only observed in ASD infants; they have also been reported in infants who are at heightened risk (HR) for ASD (i.e., infants who have an older sibling already diagnosed with ASD). The recurrence rate for ASD in these infants is 18.7% (Ozonoff et. al., 2011). HR infants are also at risk for other developmental delays (Goldberg et. al., 2005), including language delay, though a majority of HR infants exhibit apparently typical development (Yirmiya, Gamliel, Pilowsky, Feldman, Baron-Cohen, & Sigman, M, 2006).

Several studies to date have indicated that HR infants exhibit delays in JA, and that their JA abilities tend to be more similar to those of children with ASD than to their low risk peers (LR) who have no siblings or family history of ASD (Goldberg et. al., 2005; Yirmiya et. al., 2006; Cassel et. al., 2007). In one study, HR infants produced significantly fewer initiating JA (IJA) and initiating behavioral responses (IBR) behaviors compared to LR infants and did not differ significantly from older children with ASD (Goldberg et at., 2005). Yirmiya et al. (2006) examined the types of IBR behaviors produced by infants and found that HR infants produce significantly fewer higher IBR behaviors (e.g., giving and pointing) than their LR peers.

Along with JA delays, HR infants who do not go on to receive an ASD diagnosis may exhibit a later onset in vocal development. Thus, HR infants when compared to LR peers did not differ in the number of vocalizations produced, but the quality and type of vocalization produced were significantly different (Paul et. al., 2011). HR infants produced more pre-speech like patterns (e.g. “aaaa” and “mmmm”) and fewer CS than their LR peers (Paul et. al., 2011; Patten et. al., 2014). Finally, as noted above, many HR infants exhibit early language delays and have delays in producing higher quality vocalizations. HR infants tend to be delayed in producing speech-like vocalizations (e.g. baba) and have a later onset of words in comparison to their LR peers (Stoel-Gammon, 1989; Oller et. al. 1999)

1.3 THE PRESENT STUDY

The evidence reviewed above highlights the important roles that JA and vocalizations play in development. But despite the fact that these behaviors develop simultaneously, little is known about their interplay in infant communication. The primary goal of the present study is to examine the development of JA and vocalizations longitudinally at 14, 18, and 24 months. In addition, it will analyze how infants coordinate JA behaviors with vocalizations and how this changes developmentally. These observations will provide a more representative picture of how JA develops and its interplay with vocalization. To date, no study has specifically examined co-occurrences between vocalizations and JA. By focusing on infants who are at heightened risk for ASD (HR infants), we will include infants who exhibit extensive individual variability in the behaviors under consideration and who have a variety of developmental outcomes, from infants who develop typically and have no ASD diagnosis (ND), to infants who develop language delays (LD), to infants who are diagnosed with ASD (ASD).

The study is designed to address three main questions:

1. *How does JA change developmentally in HR infants?*

TD infants follow a trajectory with JA behaviors increasing until about 18 months, after which they start to decrease. Previous research has shown that HR infants produce fewer overall JA behaviors, especially in initiating JA behaviors. In this study, JA will be examined at 14, 18, and 24 months to see whether this pattern holds longitudinally. It is hypothesized that the ND and LD group will exhibit an increase in JA abilities until 18 months and then decrease at 24 months. The ASD group is expected to produce fewer JA behaviors, such that over the three age points they will consistently produce a lower rate of JA.

2. *How does vocalization production differ in rate and quality over time in the HR infants?*

As described above, HR infants tend to be delayed in CS production and produce lower quality vocalizations. At 9-12 months infants later diagnosed with ASD were significantly less likely to be in the CS babbling stage (Patten et. al., 2014). Analyzing CS and other types of vocalizations (i.e., vowel-only, marginal syllables, words) in this study will allow for comparisons of HR infants who have no diagnosis, those who are language delayed, and those who are later diagnosed with ASD. It is hypothesized that the HR-no diagnosis group will produce more and higher quality vocalizations than their HR-language delay and HR-ASD peers.

ODVs involve the pairing of gaze toward an object with vocalization, may represent an early-emerging form of JA. We do not know the extent to which these are represented in the repertoires of HR infants, and especially HR infants who later receive an ASD diagnosis because to date there have been no studies on the production of ODV's by HR infants and infants who later receive an ASD diagnosis. It is hypothesized that HR-no diagnosis infants and HR-language delay infants will decrease the frequency of ODV's produced as they get older, while HR-ASD infants will consistently produce more ODV's. HR-no diagnosis infants and HR-language delay infants will be able to rely on other forms of communication behaviors as they get older like gestures and vocalizations to get their caregivers attention and will no longer need to use ODV's. While the HR-ASD group might have delays in these areas and produce more ODV's to communicate.

3. *What is the rate of co-occurrence between vocalizations and JA in the three outcome groups over time?*

Finally, temporal co-occurrences between JA and vocalizations will be examined in order to describe how vocalizations interact with JA behaviors. Previous research has found (Parlade & Iverson, 2015) that infants who later receive an ASD diagnosis have difficulties coordinating behaviors (e.g. pairing a vocalization with a gesture). Based on these findings it is hypothesized that the HR-no diagnosis and HR-language delay groups will coordinate proportionately more JA acts with vocalizations or words than the HR-ASD group.

2.0 METHODS

2.1 PARTICIPANTS

This sample was taken from a larger longitudinal study of HR infants conducted at the Infant Communication Lab at the University of Pittsburgh under the direction of Dr. Jana Iverson. The longitudinal study observed infants monthly at home from 5 to 14 months, with follow-up visits at 18, 24, and 36 months. This research focuses on a group of 50 later born siblings of children with a confirmed diagnosis of an Autism Spectrum Disorder (ASD; High Risk infants; HR) and on data collected at the 14-, 18- and 24-month observations. In order to be included in the present study, infants must have had data at all three age points.

Infants were recruited from the western Pennsylvania area by flyers, through professional referrals, word of mouth through the Autism Research Program at the University of Pittsburgh, parent support groups and local agencies and schools serving children with ASD. To be eligible for the study, each infant must have had an older sibling already diagnosed with ASD; diagnostic status was confirmed with the Autism Diagnostic Observation Schedule (ADOS; Lord et. al., 2000) administered by a trained clinician. The younger sibling was eligible only if their older sibling scored above the Autism cutoff on the ADOS. Informed consent was given by a parent before the infant was enrolled. All infants in this study were from full-term, uncomplicated pregnancies from primarily English-speaking, monolingual families. Forty-three infants were white or non-hispanic, four were Hispanic, two were Asian American and one infant was African American. Thirty-two percent of the infants were enrolled in some form of speech services between the ages of 14-36 months.

2.2 PROCEDURE

Home visits were scheduled as close as possible to monthly anniversaries of the child's birthday at a time of day when the child was the most alert and active. During each home visit, infants were observed in a naturalistic setting, while engaged in everyday household activities and in semi-structured play with a primary caregiver. Semi-structured play included play segments with the experimenter with specific sets of toys that were administered in the same order for each infant.

The Early Social Communication Scales (ESCS) was administered at each home visit beginning at 8 months. The ESCS is a 15-20 minute experimenter-administered semi-structured toy play interaction that assesses social communication in infants. Three main types of social communication are assessed: joint attention (e.g. eye contacts), behavioral requests (e.g. gives, reaches), and social interaction (e.g. turn taking behaviors with a ball or car; see Appendix A for a more detailed description). These are skills that typically develop between 8 and 30 months of age (Mundy, Sigman & Kasari, 1990). This study will examine two of these domains: Initiating Joint Attention (IJA), or behavior that elicits the experimenter's attention to the toy (e.g., eye contact from moving toy; points; shows), and Initiating Behavioral Requests (IBR), or behavior that elicits a response from the experimenter (e.g., reaches, gives). The same toys were presented at each visit and included wind-up toys, a puppet, a book, posters (placed on the walls in the participants' homes to help initiate JA responses), and social toys (e.g., sunglasses, a bowl and spoon, a comb and a hat). See Figure 1 for the complete set of toys.

The ESCS was administered at a table with the child sitting across the table from the experimenter. The experimenter presented each of the toys listed above, placing each in front of the child beyond their reach for a few seconds before placing it directly in front of the child. This segment was filmed with the camera focused on the table and the upper half of the child, with the profile of the experimenter in the corner so as to provide a frame of reference for coding eye contact and gestures. Children wore a wireless microphone hidden in a vest worn over their clothing with the receiver attached to the camera, allowing for high quality recording of vocalizations.

Figure 1: A Complete Set of ESCS Toys Used in this Study

Table 1: Completed Demographic Information based on Outcome Group

	ND	LD	ASD	Total
Gender				
Male	11 (42.3%)	6 (40%)	3 (33%)	20 (40%)
Female	15 (57.7%)	9 (60%)	6 (66%)	40 (60%)
Racial ethnic minority	0 (0%)	4 (26.7%)	3 (33%)	7 (14%)
Speech Intervention	1 (3.8%)	8 (53.3%)	6 (66%)	15(30%)
Mean age				
Mother	33.65	34.73	32	33.65
Father	36.57	37.87	34.78	36.57
Maternal Ed				
Grad school	12 (46.2%)	6(40%)	2 (22.2%)	20 (40%)
College/ some	13 (50%)	8 (53.3%)	3 (33.3%)	24(48%)
HS	1 (3.8%)	1 (6.7%)	4 (44.4%)	6 (12%)
Paternal Ed				
Grad School	6 (23.1%)	6 (40%)	4(44.4%)	16 (32%)
College/some	19 (73.1%)	8 (53.3%)	3 (33.3%)	30 (60%)
HS	1 (22.2%)	1 (22.2%)	2 (22.2%)	4 (8%)
Mean Paternal Oc. Prestige scores	53.8 (SD 14.95)	52.02(SD 14.52)	53.38 (SD 17.32)	53.27 (SD 15.31)

ASD- Autism Spectrum Disorder
LD- Language Delay
ND- No diagnosis
Grad School- Parents have their master's degree or Ph.D.
College/some- parents have graduated high school and have attended at least 2 years of higher education
HS- High School

2.3 OUTCOME CLASSIFICATION

At 36 months all infants were administered the Autism Diagnostic Observation Schedule (ADOS), which reliably differentiates children with ASD from children who might have other developmental delays or no ASD diagnosis (Lord et al., 2000). An ASD diagnosis was given if the HR infant's scores met or exceeded the cutoff for ASD on the ADOS and was confirmed by the clinician's judgment using the DSM-IV-TR criteria. Clinicians administering the ADOS and confirming the diagnosis were blind to all study data. Based on these criteria, 9 infants (M=6, F=3) were classified as ASD.

HR infants were identified as language delayed if they did not receive a diagnosis of ASD and either of the following criteria was met (Parlade & Iverson, 2015):

1. Standardized scores on the CDI-II and CDI-III at or below the 10th percentile at more than one time point between 18 and 36 months (e.g., Gershkoff-Stowe, Thal, Smith, & Namy, 1997; Heilmann, Weismer, Evans, & Hollar, 2005; Robertson & Weismer, 1999; Weismer & Evans, 2002)
2. Standardized scores on the CDI-III at or below the 10th percentile and standardized scores on the Receptive and/or Expressive subscales of Mullen Scale of Early Learning (MSEL; Mullen, 1995) equal to or greater than 1.5 standard deviations below the mean at 36 months (e.g., Landa & Garrett-Mayer, 2006; Ozonoff et. al., 2010).

Based on these criteria, 15 infants received a diagnosis of a language delay (LD; M= 9, F= 6).

Twenty-six infants (M=15, F=11) did not meet the criteria for ASD or LD and were classified as having no diagnosis (ND).

Demographic information for the three outcome groups is presented in Table 1. Mothers' years of education did not differ statistically between the groups, and neither did mean ages of mothers ($M_{ASD}=31$, $SD_{ASD}= 4.5$;$M_{LD}=34.73$ $SD_{LD}=3.36$; $M_{ND}=33.65$ $SD_{ND}=3.14$) or fathers ($M_{ASD}=34.78$ $SD_{ASD}=4.82$, $M_{LD}=37.26$ $SD_{LD}=3.91$, $M_{ND}=36.57$ $SD_{ND}=5.4$). Although information on family income was not available, parental occupation was identified for the purpose of providing a general index of socioeconomic status. The majority of mothers (56%) did not work outside the home, so paternal occupations were used to calculate Nakao-Treas occupational prestige scores (Nakao & Treas, 1994). In one LD family an occupational prestige score could not be calculated. Results from the remaining families indicated no statistical difference between groups ($M_{ASD}=60.35$ $SD_{ASD}=16.58$. $M_{LD}=54.51$ $SD_{LD}= 15.67$, $M_{ND}=49.92$ $SD_{ND}=14.95$).*ew*

2.4 OBSERVATIONAL CODING

Videos were coded using the ESCS coding scheme and a system developed for identifying and classifying infant vocalizations. All coding started at the beginning of each video or when the experimenter announced the start of the ESCS segment. Coding ended when the experimenter announced the end of the ESCS. Each video ranged from 15-20 minutes. All coders were trained to reliability based on criteria in Mundy et al. (2003)'s original study and were from the University of Pittsburgh. All coders were blind to the diagnostic outcome of the infants.

2.4.1 ESCS

ESCS coding followed procedures described in the ESCS manual (Mundy et. al., 2003; see Appendix A for additional details). IJA and IBR behaviors were categorized as low or high behaviors: low IJA (e.g. eye contact between an active toy and the experimenter), high IJA (e.g. points and shows), low IBR (e.g. eye contact from a non-active toy, reaches), high IBR (e.g. points and gives with and without eye contact). Lower-level behaviors develop earlier in infants and typically occur with greater frequency than higher-level behaviors (Bakeman & Adamson, 1984). Inter-rater reliability was assessed using intraclass correlation coefficients (ICCs) of the raw total counts between raters. For the ESCS agreement was at least 0.80 for each behavior category.

2.4.2 Vocalizations

All vocalizations produced by infants during the ESCS administration were coded. A vocalization was coded as a separate instance if there was a 1 second pause between vocalizations or an audible breath. All non-word vocalizations were categorized according to whether or not they contained a syllable. A vocalization was coded as vowel only (VO) if it was non-syllabic (e.g. aaaaa, oooooo). If a syllable was present in the vocalization it was categorized as a marginal syllable (MS) or a canonical syllable (CS). MS vocalizations contained a slow transition between vowels and consonants (e.g. mmwaa). A CS vocalization contained a fast and smooth transition between the consonant and vowel (e.g. maba, dadada). Infants were credited with producing a word if they produced either an English word (e.g., ball, monkey, butterfly etc.) or a vocalization that was consistently used to refer to a specific object (e.g. “baba” to reference the ball). Inter-rater reliability was assessed by taking the ICCs for the raw total count of vocalization coded by each rater. Reliability was .80 for each type of vocalization.

2.4.3 Object Directed Vocalizations

Object Directed Vocalizations (ODV) were also coded during the ESCS administration. A vocalization was considered to be an ODV if the infant was looking directly at the object for the entire duration of the vocalization. Vocalizations were coded as ODV only if the eye gaze was clearly seen throughout the entire duration of the vocalization and there was no shift in eye gaze from the object. If the eye gaze shifted at any point, the vocalization was not be coded as an ODV. Three different types of ODV’s were coded depending on the location of the object in front of the infant. They were categorized as: beyond the infant’s reach, within the infant’s reach, or in the hand. To be considered an in hand ODV, the infant had to have touched the object at some point during the vocalization (Goldstein et. al. 2010).

2.4.4 Co-Occurrence of JA and Vocalizations

Co-occurrence of JA and vocalizations was coded any time there was an overlap between a JA behavior and a vocalization. If an infant vocalized at any point during the JA behavior they were producing, it was considered to be JA+VOC. These co-occurrences were coded for both IJA and IBR behaviors.

3.0 RESULTS

The primary aim of this research was to examine the production of JA, vocalizations, and co-occurrences between them in infants who are at heightened risk for ASD. The study was designed to address three main questions: a) how does JA change developmentally in HR infants?; b) how does vocalization production differ in rate and quality over time in the HR infants?; and c) what is the rate of co-occurrence between vocalizations and JA in the three outcome groups over time?

Preliminary data analyses did not reveal any significant gender differences in any of the variables considered. Therefore, the analyses reported below were conducted with data collapsed across males and females. To address the research questions outlined above, I begin by reporting the results of infant JA production in the three groups of HR infants: ASD (*n=9*), LD (*n=15*), ND (*n=26*). This is followed by data on overall vocalization production and types of vocalizations produced. Lastly, I present data on vocalization and JA co-occurrences.

Table 2: Mean Rates (and Standard Deviations) of JA Behaviors per 10 Minutes and Numbers of Infants Producing JA Behaviors for Each Outcome Group at 14, 18, and 24 Months.

	ND		LD		ASD		95% CI
	M (SD)	# of infants	M (SD)	# of infants	M (SD)	# of infants	
Low IBR							
14	6.79 (5.06)	26	6.87 (7.16)	15	5.79 (2.87)	9	0.937
18	7.83 (4.80)	26	7.67 (4.32)	15	5.09 (2.57)	9	0.292
24	6.25 (3.0)	26	6.75 (4.98)	15	4.64 (4.19)	9	0.309
High IBR							
14	7.30 (6.08)	26	5.93 (3.81)	15	8.54 (4.89)	9	0.472
18	8.95 (6.10)	25	7.14 (6.99)	15	6.31 (3.99)	8	0.432
24	9.26 (5.65)	25	8.40 (6.38)	15	6.73 (3.33)	9	0.644
Low IJA							
14	8.86 (5.28)	26	8.46 (5.27)	15	8.81 (5.40)	9	0.88
18	8.82 (5.30)	24	8.23 (5.16)	14	8.87 (5.38)	9	0.988
24	8.82, (5.31)	26	8.25 (5.15)	15	8.79 (5.38)	9	0.139
High IJA							
14	1.68 (1.95)	25	1.76 (1.94)	11	1.60 (1.88)	4	0.003
18	1.69 (1.95)	19	1.68 (1.94)	12	1.59 (1.88)	3	0.032
24	1.68 (1.95)	25	1.70 (1.94)	10	.07 (1.88)	1	0

ND- No Delay
LD- Language Delay
ASD- Autism Spectrum Disorder
M- Mean
SD- Standard Deviation
# of infants- number of infants who produced the behavior
95% CI- 95% confidence interval

3.1 HOW DOES JA CHANGE DEVELOPMENTALLY IN HR INFANTS?

Four different scores were calculated from the ESCS for each infant by taking the sum of the total number of behaviors produced: low IBR, high IBR, low IJA, and high IJA (*see Appendix A for overview of behaviors*). Although there were no significant differences in observation length as a function of outcome group *($F(2,46)=1.820$, $p=.173$; $M_{ND}=16.95$, $SD_{ND}= 2.98$, $M_{LD}=16.94$, $SD_{LD}= 2.53$, $M_{ASD}= 15.39$, $SD_{ASD}= 3.17$)*, to control for slight differences in ESCS observation length, raw scores were converted to rates per minute by dividing each of the four scores by the total ESCS session length. Prior to analysis, distributions were examined for possible skew. All distributions, which possess an artificial lower bound at 0, were found to have a positive skew and were logarithmically transformed prior to conducting statistical analyses.

Mean rates, standard deviations, and 95% confidence intervals for each of the four categories of JA behavior are presented above in Table 2. Separate 3 x 3 repeated measures ANOVAs with Age (14, 18, 24 months) as the within subjects factor and Outcome Group (ND, LD, ASD) as the between subjects factor were performed for each type of behavior. As is evident in the table, infants in all 3 groups produced low IBR, high IBR and low IJA at similar rates across the observation period. ANOVAs did not reveal any significant group or age differences. These results are consistent with previous research on children with ASD (Charman, 1998; Mundy & Newell, 2007).

Mean rates, standard deviations, and confidence intervals for high IJA are also presented in Table 2. These data indicate that the ASD group consistently produced fewer high IJA behaviors then their LD or ND peers. A 3 (group) x 3 (outcome) repeated measures ANOVA revealed no significant effect of Age, $F(2,47) = .916$, $p= .396$, but there was a significant main effect of Outcome, $F(2,47) = 14.430$, $p=.00$. The Age by Outcome interaction was not significant. LSD post hoc tests were conducted to examine the nature of the effect of Outcome. The ASD group differed significantly from both the ND and LD groups *(p=.000, p=.001)*. However, the difference between the ND and LD groups was not significant *(p=.081)*.

As is also apparent in Table 2, the numbers of ASD infants producing high IJA behaviors was consistently low over the three age points. In addition, there was a developmental decrease in the ASD group, with 4 infants producing high IJA at 14 months but only one infant at 24 months. This pattern was only apparent in the ASD group; the ND and LD groups had no differences in the numbers of infants producing behaviors over time. Chi square tests indicated that at 14 months the numbers of children producing high IJA in the ASD group did not differ significantly from the LD group ($x^2(2,22)= 2.003$, $p= .157$), which did differ from the ND group ($x^2(2,39)= 4.62$, $p= .03$). The opposite pattern was evident at 18 months (ASD vs. LD ($x^2(2, 22) =5.227$, $p = 0.022$; *LD vs. ND* ($x^2(2,39)=0.247$, $p = 0.619$). By 24 months there were significant differences in the numbers of infants who produced high IJA behaviors between the ASD and LD groups ($x^2(2,22)=6.993$, $p=0.008$) and the LD and ND groups ($x^2(2,39)=6.6206$, $p= 0.010$).

3.2 HOW DOES VOCALZATION PRODUCTION DIFFER IN RATE AND QUALITY OVER TIME IN HR INFANTS?

Overall rates of vocalizations were calculated to examine developmental change over the three age points (14, 18 and 24 months) in the three groups (ND, LD, ASD). To control for slight differences in ESCS durations, vocalization rates were calculated by summing the total number of vocalizations at each time point and dividing this by the duration of the ESCS administration. All distributions, which possess an artificial lower bound at 0, were found to have a positive skew and were logarithmically transformed prior to analysis.

Table 3: Mean rates (and Standard Deviations) of Combined Vocalizations and Words Produced per Minute at 14, 18 and 24 Months.

	ND M (SD)	LD M (SD)	ASD M (SD)	95% CI
Rate of Vocalization				
14	1.82 (.58)	1.59 (.75)	1.0 (.10)	0.004
18	1.84 (.18)	1.46 (.18)	1.04 (.62)	0.036
24	2.00 (.69)	2.02 (.73)	1.41 (.58)	0.074

Mean rates, standard deviations, and confidence intervals for overall vocalizations are presented in Table 3. As is apparent in the table, overall the rate of vocalizations increased over time for each group of infants, but rates also varied by outcome. A 3 x 3 repeated measures ANOVAs with Age (14, 18, 24 months) as the within subjects factor and Outcome Group (ND, LD, ASD) as the between subjects factor revealed a significant main effect of Age, $F(2,47)= 5.921$, $p= .004$, and a significant main effect of Outcome, $F(2,47) = 6.054$, $p= 0.005$. The interaction of Age by Outcome was not significant, $F(4,96)= .765$, $p=.551$. LSD post hocs were examined collapsing across outcome group and focusing on age differences. The data in Table 3 indicated that there was a developmental increase in the rate of vocalization production, such that infants were producing a higher rate of vocalizations at 24 months compared to 14 and 18 months *(p=.003, p=.007).* The difference in the rate of vocalizations produced between 14 and 18 months was not significant *(p=.843).* The data also show that overall, the ASD group produced a lower rate of vocalizations *(M=1.15, SD=.18)* than their LD and ND peers (M_{LD}*=1.69,* SD_{LD}*= .141,* M_{ND}*=1.89,* SD_{ND}*= .107).* LSD post hocs confirmed this pattern, indicating that while there was no significant difference in the rate of vocalizations produced between the ND and LD groups *(p=.273),* both groups differed significantly from the ASD group *(p=.001, p=.024).*

As a result of the overall differences in the rates of vocal production, an additional set of analyses was conducted to see whether there were also differences in the types of vocalizations produced by infants in the three groups. Proportions were calculated for vocalization type (VO, MS, CS, word) by dividing the total number of vocalizations in each category by the total number of vocalizations and words produced. Mean proportions, standard deviations, and 95% confidence intervals for vocalization types are presented in Table 4. These data were arcsine transformed prior to completing separate 3 (age) x 3 (outcome) repeated measures ANOVAs with age (14, 18, 24 months) as the within subjects factor and Outcome Group (ND, LD, ASD) as the between subjects factor for each vocalization type.

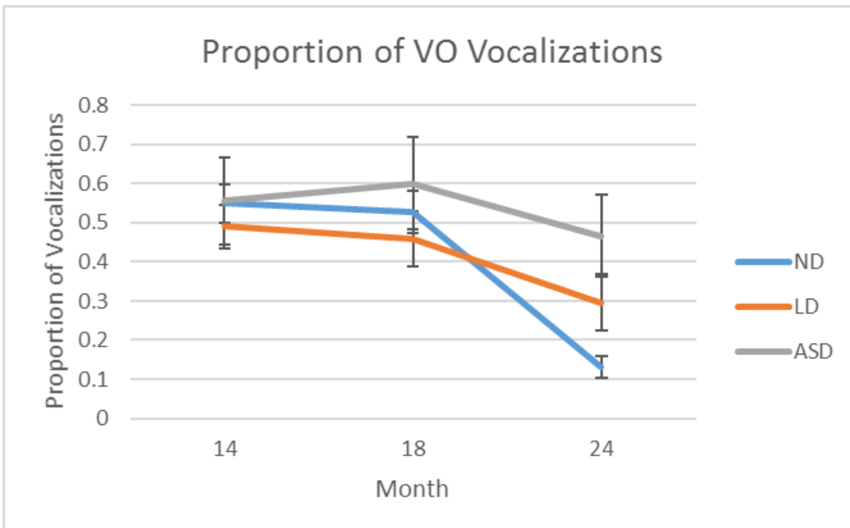
Table 4: Mean Proportion (and Standard Deviation) of Each Type of Vocalization Produced (VO, MS, CS, Word) at 14, 18 and 24 Months

	ND **M (SD)**	**LD** **M (SD)**	**ASD** **M (SD)**	**95% CI**
VO Proportion				
14	0.55 (0.24)	0.45 (0.23)	0.55 (0.31)	0.564
18	0.53 (0.27)	0.45 (0.26)	0.6 (0.33)	0.404
24	0.13 (0.14)	0.29 (0.26)	0.46 (0.29)	0.001
MS Proportion				
14	0.15 (0.11)	0.19 (0.09)	0.27 (0.19)	0.07
18	0.13 (0.09)	0.19 (0.14)	0.12 (0.15)	0.348
24	0.04 (0.05)	0.1 (0.06)	0.14 (0.13)	0.004
CS Proportion				
14	0.29 (0.2)	0.28 (0.18)	0.17 (0.15)	0.256
18	0.28 (0.2)	0.33 (0.22)	0.14 (0.15)	0.091
24	0.32 (0.14)	0.41 (0.23)	0.31 (0.17)	0.268
Word Proportion				
18	0.05 (0.09)	0.01 (0.02)	0.01 (0.04)	0.143
24	0.49 (0.23)	0.18 (0.15)	0.06 (0.14)	0.000

3.2.1 VO

The ANOVA carried out on the proportion of VO vocalizations indicated a significant main effect of Age, $F(2,46)= 12.520$, $p=.000$, and a significant main effect of Outcome, $F(2,46)= 3.276$, $p=.047$. The interaction was not significant, $F(4,46)= 1.872$, $p=.122$. LSD post hocs were examined collapsing across outcome groups and focusing on age differences. The data in Table 4 and Figure 2 indicates that there was a developmental decrease in the proportion of VO vocalizations, such that infants produced proportionally fewer VO vocalizations at 24 months compared to 14 and 18 months ($p=.000$, $p=.000$). The difference between VO proportions from 14 to 18 months was not significant (p=.864). The data also show that overall, the ASD group produced a higher proportion of VO vocalizations *(M=.54, SD= .32)* than their LD and ND peers *(M_{LD}= .40, SD_{LD}= .27, M_{ND}= .40, SD_{LD}= .30).* LSD post hoc tests confirmed this pattern, indicating that while there were no significant differences in the proportions of VO between the ND and LD groups (*p=.639*), both groups differed significantly from the ASD group (*p=.029, p=.020*).

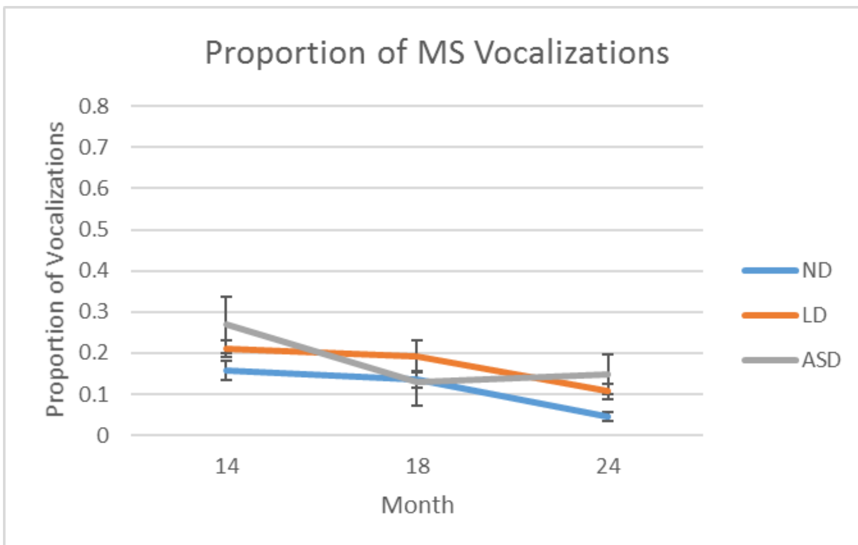
Figure 2: Mean Proportion of VO Vocalization Produced Over Time Between the Three Outcome Groups



3.2.2 MS

Analysis of the proportion of MS vocalizations indicated a significant main effect of Age, *F(2,46) = 11.098, p=.000*, and a significant main effect of Outcome, *F(2,46)= 4.907, p=.012*, but no significant interaction, *F(4,46)= 1.521, p=.202*. As is evident in Table 4 and Figure 3, overall, the proportion of MS vocalizations decreased over time. Post hoc comparisons showed a marginally significant decrease from 14 to 18 months in the proportion of MS vocalizations produced *(p=.051)*, and a significant decrease from 18 to 24 months *(p=.004)*. As is also evident, the ASD and LD groups overall produced higher proportion of MS vocalizations *(M_{LD}=.16, SD_{LD}=.11, M_{ASD}=.18, SD_{ASD}=.18)* than their ND peers *(M=.11, SD=.11)*. LSD post hoc tests indicated that ND group differed significantly from both the LD and ASD groups (*p=.016, p=.014*), and that the LD and ASD groups did not differ significantly from one another (*p=.701*).

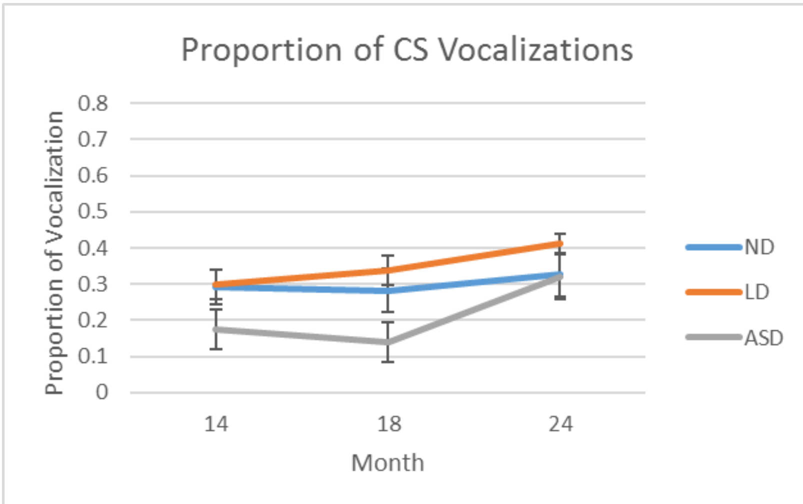
Figure 3: Mean Proportion of MS Vocalizations Produced Over the Three Age Points and Between Outcome Groups



3.2.3 CS

Analysis of the proportion of CS vocalizations revealed a significant main effect of Age, *F(2,46)= 4.901, p=.009*, and a significant main effect of Outcome, *F(2,46)= 3.78, p= .03*, but the interaction was not significant, *F(4,46)= 1.019, p= .402*. As can be seen in Table 4 and Figure 4 below, production of CS vocalizations generally increased with age. LSD post hoc tests showed no significant differences between 14 and 18 months *(p=.841)*, however, there were overall differences between proportions production at 24 months with both 14 and 18 months *(p=.012, p=.006)*. The data shows that overall the LD group produced the highest proportion of CS *(M=.388, SD=.039)* compared to their ND and ASD peers *(M_{ND}=.312, SD_{ND}= .029, M_{ASD}= .217, SD_{ASD}=.049)*. This pattern was shown in the LSD post hocs. There were only overall diagnostic differences between the LD and ASD groups (*p=.009*). The ND group did not differ significantly from the ASD or LD groups *(p=.122, p=.101*).

Figure 4; Mean Proportion of CS Vocalizations Between the Three Groups and Outcome Groups



3.2.4 Words

A 2 (age) x 3 (outcome) repeated measures ANOVA, with Age (18, 24 months) as the within subjects factor and Outcome Group (ND, LD, ASD) as the between subjects factor revealed significant main effects of Age, *F(2,47)= 50.368, p=.000*, and Outcome, *F(2,47)=15.166, p=.00*. These were qualified by a significant Age by Outcome interaction, *F(2,47)=18.123, p=.000*. Follow up t-tests indicated that while the proportion of words produced increased from 18 to 24 months in all 3 outcome groups, the increase was only significant in the ND *(t(25)=9.567, p=.000,)* and LD *(t(14)= 4.014, p=.001)* groups. By 24 months, the ND group produced the highest proportion of words *(M_{ND}=.19, SD_{ND}=.27)*, more than twice as high as LD infants *(M_{LD}=.07, SD_{LD}=.12)* and eight times higher than the ASD infants (*M_{ASD}=.02, SD_{ASD}=.09)*. This increase can be seen below in Figure 5.

Figure 5: Mean Proportion of Words Produced at 18 and 24 Months

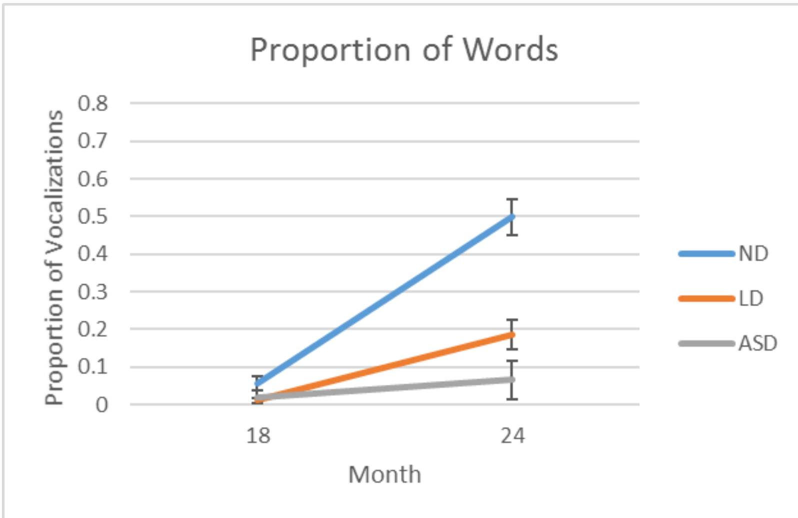


Table 5: Mean Proportion (and Standard Deviation) of ODV's at 14, 18 and 24 Months

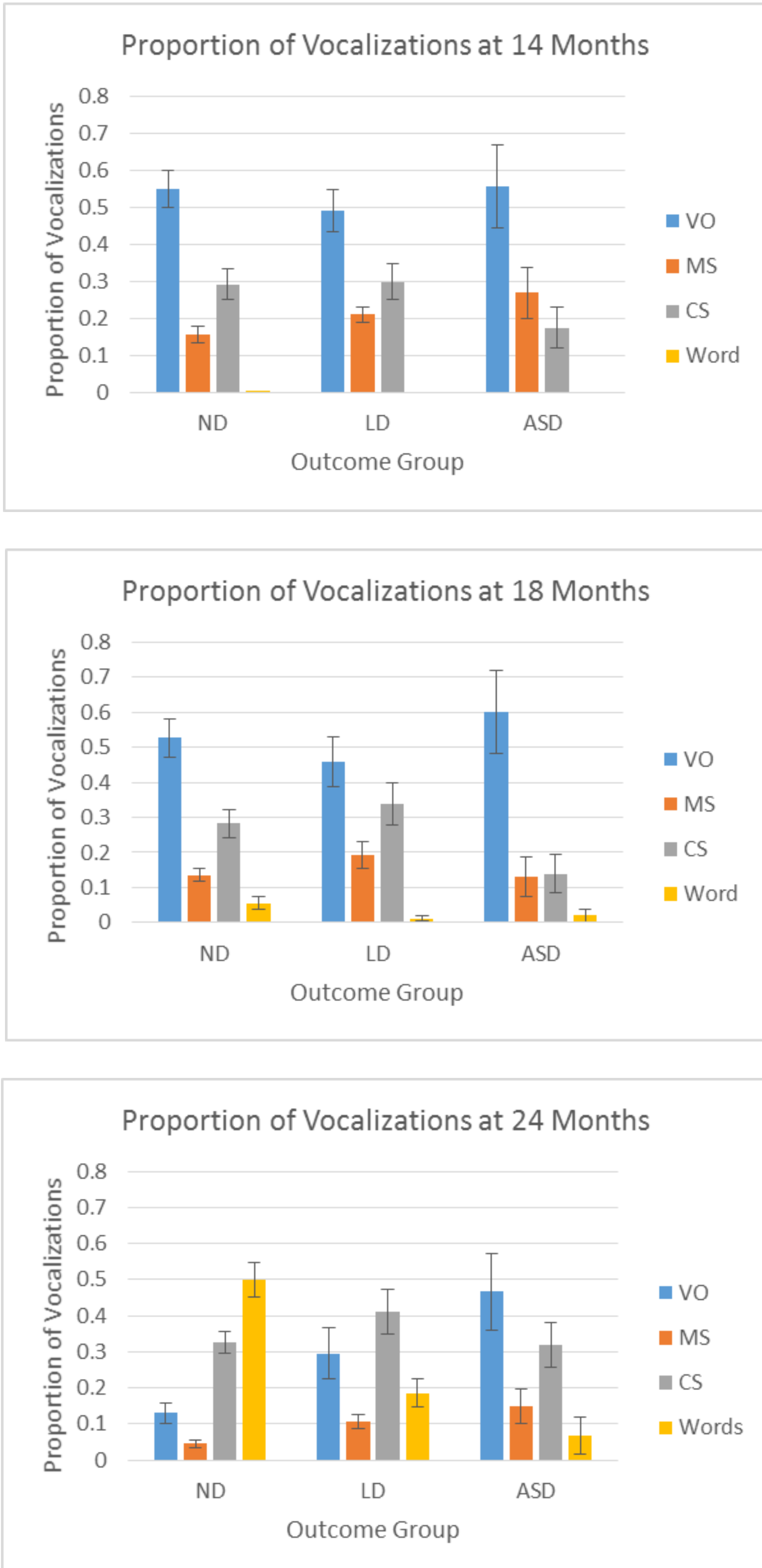
	ND M (SD)	LD M (SD)	ASD M (SD)	95% CI
ODV Proportion				
14	.22 (.13)	.21 (.12)	.09 (.11)	0.03
18	.25 (.29)	.19 (12)	.25 (.25)	0.695
24	.17 (.11)	.16 (.08)	.25 (.18)	0.15

3.2.5 ODV

The proportion of object directed vocalizations was calculated by dividing the total number of object directed vocalizations by the total number of vocalizations produced separately at each age. Means, standard deviations and 95% CI can be seen in Table 5. Overall the proportion of ODVs did not differ based on the infant's age or their outcome status. A 3 (age) x 3 (outcome) repeated measure ANOVA with age (14, 18, 24 months) as the within subjects factor and Outcome Group (ND, LD, ASD) as the between subjects found no main effect of Age, $F(2,47)=1.275$, $p=.284$, nor a main effect of Outcome, $F(2,47)= .239$, $p=.789$. There was no interaction of Age by Outcome, $F(4,94)= .051$, $p=.125$.

In summary, all infants developed more complex vocalizations over the 14- to 24-month period, but the quality of vocalizations varied as a function of group. These differences can be seen below in Figure 2. As is apparent, at 14 and 18 months all outcome groups are producing the highest proportion of VO. At 24 months the greatest difference in vocalization proportion is observed, the ND group is producing the highest proportion of words, while the LD group is producing mostly CS. The ASD group, even at 24 months is producing the highest proportion of VO vocalization. Even though each group demonstrated a developmental shift in the proportions of vocalization types produced, even at 24 months there were substantial differences in the quality of vocalizations produced by infants in each group.

Figure 6: Proportions of Each Type of Vocalization Produced by Each Outcome Group at 14, 18 and 24 Months.



3.3 WHAT IS THE RATE OF CO-OCCURRENCE BETWEEN VOCALIZATIONS AND JA IN THE THREE OUTCOME GROUPS OVER TIME?

The final set of analyses focused on the number of times that infants produced a JA behavior, asking how often they paired a vocalization with those behaviors, and what type of JA behavior (IJA or IBR) was more commonly paired with vocalizations. Co-occurrence of vocalizations and JA was examined by dividing the total number of JA behaviors that were paired with a vocalization by the total number of JA behaviors (with and without vocalization). These proportions were computed separately for IJA and IBR behaviors. Means, standard deviations and 95% confidence intervals of each category are presented in Table 6. Separate 3 (age) x 3 (outcome) repeated measures ANOVA's with age (14, 18, 24 months) as the within subjects factor and Outcome Group (ND, LD, ASD) as the between subjects were carried for each JA category.

Table 6: Mean Proportions (and Standard Deviations) of the Proportions of IBR and IJA Behaviors Paired with a Vocalization at 14, 18 and 24 Months.

	ND	LD	ASD	95% CI
IBR-Voc	**M (SD)**	**M (SD)**	**M (SD)**	
14	.46 (.33)	.30 (.23)	.11 (.10)	0.005
18	.52 (.35)	.34 (.30)	.21 (.25)	0.034
24	.59 (.35)	.60 (.30)	.19 (.17)	0.004
IJA-Voc				
14	.36 (.30)	.38 (.46)	.07 (.09)	0.062
18	.39 (.41)	.20 (.29)	.16 (.10)	0.16
24	.28 (.19)	.28 (.25)	.18 (.13)	0.459

3.3.1 IBR-Vocalizations Co-Occurrences

Analysis of the proportion of IBR behaviors paired with a vocalization showed a significant main effect of Age, $F(2,46)= 4.826$, $p=.01$, and Outcome, $F(2,46)= 7.974$, $p=.001$. There was no significant interaction, $F(7,94)= 1.372$, $p=.25$. As is evident in Table 6, the proportion of IBR-vocalization pairings increased across all three ages. Post hoc tests revealed that the proportions of IBR-vocalization pairings did not differ reliably between 14 and 18 months ($p=.245$), however, there was a nearly significant increase from 18 to 24 months ($p=.054$). As can also be seen, overall infants in the ND and LD groups ($M_{ND}=.48$, $SD_{ND}=.29$, $M_{LD}=.28$, $SD_{LD}=.26$) produced higher proportions of IBR-vocalization co-occurrences than did ASD infants ($M=.17$, $SD=.17$). LSD post hoc tests indicated that the ASD group differed significantly from the ND and LD groups ($p=.000$, $p=.018$), while the ND and LD did not differ significantly from one another ($p=.126$).

3.3.2 IJA-Vocalization Co-occurrences

The ANOVA carried out on the proportion of IJA behaviors with vocalizations found only a significant main effect of Outcome, $F(2,38)=3.322$, $p=.047$. As is evident in Table 6, overall the ND group produced the highest proportion of IJA behaviors paired with vocalizations, ($M=.41$, $SD=.58$), while the ASD group produced the lowest proportion ($M=.13$, $SD=.18$). The LD group proportions fell in between these two groups ($M=.42$, $SD=.58$). Post hoc tests indicated that the only significant difference in IJA-vocalization proportions was between the ND and ASD groups ($p=.015$). The ND group did not differ from the LD group ($p=.281$) and the LD group did not differ from the ASD group ($p=.191$).

4.0 DISCUSSION

The overarching goal of this research was to examine the development of JA, vocalization, and co-occurrences of the two in HR infants during the second year and to examine potential differences in these as they may relate to developmental outcome assessed at 36 months (ND, LD, ASD). Three main questions were addressed, and results relevant to each will be discussed in turn below.

The first question had to do with developmental change in the rate of JA behavior production. Results confirm previous findings suggesting that infants who later receive an ASD diagnosis have a specific impairment in initiating JA, especially in high IJA behaviors (Toth, et. al., 2006; Goldberg et. al., 2005; Charman, 1998). High IJA behaviors include pointing to an object that is not directly in front of them (e.g., pointing to the poster on the wall) and showing objects, and thus require not only getting the experimenter's attention, but redirecting it to another object that is not directly in front of them. It should be noted that the ND, LD and ASD groups did not differ significantly from one another in producing low IJA (eye contact between the object and the experimenter), low IBR (reaches with and without eye contact), or high IBR (points and gives, with or without eye contact) behaviors. Thus, infants who later received an ASD diagnosis engaged in and produced JA behaviors. They were able to direct the experimenter's attention to objects directly in front of them, however coordinating this attention with a behavior that directs attention to a new location or focus was where differences were apparent.

The second question addressed in the present study focused on HR infants' production of vocalization during a structured toy play setting and how this changed developmentally from 14 to 24 months. Overall rates of vocalizations differed between the three groups. The ND group produced the highest rates of vocalizations, while the ASD group produced the lowest rates. Examination of proportions of the types of vocalization produced showed that for HR infants as a group, vocalization quality changed over time, with the proportions of more advanced vocalizations (e.g., CS, words) increasing at each age point. However, there were still significant differences between the three outcome groups, especially at 24 months. There were clear differences this age in the type of vocalization that was most frequently produced by infants in the three outcome groups: the ND group produced predominantly words; the LD group primarily CS vocalizations, and the majority of vocalizations produced by the ASD group were VO. Thus, although the ASD group demonstrated an increase in the proportions of MS and CS vocalizations and words from 14 to 24 months, of all the vocalizations produced, VO were consistently the most frequent.

This relatively high proportion of lower quality vocalizations may affect ASD infants' interactions with their caregivers and the nature of the linguistic input they receive. Previous research has found that mothers respond more frequently to speech-like vocalizations (CS) compared to non-speech like vocalizations (VO; Gros-Louis, West, Goldstein & King, 2006; Gros-Louis, West & King, 2014). For example, if a child is looking at a ball and saying "baba," a mother will typically respond by saying "yes, that's a ball". However, if that same child is looking at the ball while vocalizing "aaaa," s/he might not get the same response; the mother might respond by giving the child the ball instead. As a result, ASD infants may not be getting the same type of language input as their LD and ND peers who are producing higher proportions of CS and words. ASD infants are delayed in vocalization development, which is apparent in the proportion of VO vocalizations they produce at 24 months. As a result of these delays, ASD infants might not be receiving the same input as their LD and ND peers, creating a different learning environment with fewer of the types of adult responses that are produced in response to higher quality infant vocalizations. This may result in a cascade that is perpetuated by both the infants' delay in more mature vocalizations and the parent's response to these vocalizations.

The third and final question addressed in this study had to do with the co-occurrence of JA behaviors with vocalizations. When comparing IBR- and IJA-vocalization coordination's, overall infants paired higher proportions of IBR behaviors with vocalizations than they did IJA behaviors. IBR behaviors are associated with more typical requesting behaviors like reaching and giving. These behaviors may more readily elicit a vocalization component than IJA, whose function is to comment and share experience with a social partner (Bates et. al. 1979).

There were also differences between the outcome groups in the proportions of JA behaviors paired with vocalizations. The ASD infants produced lower proportions of JA and vocalization coordination's overall than their LD and ND peers. This was true for IJA-vocalization co-occurrences, and it was especially apparent for IBR-vocalization co-occurrences. Despite the fact that infants who later received an ASD diagnosis did not differ from their LD and ND peers in the overall rate of IBR behaviors produced, they produced a lower proportion of IBR behaviors with vocalizations at all three ages.

Thus, it appears that for ASD infants, there is a specific difficulty with pairing and coordinating JA and vocal behaviors together. Although at first glance production of IBR behaviors appeared similar within the HR sample when only nonverbal behaviors were considered, when vocalizations are considered along with the nonverbal IBR behaviors, potentially important qualitative differences emerge. Adding a vocalization component enhances the quality of the JA and likely engages the experimenter or caregiver in a way that a simple reach or eye gaze cannot. Previous studies that have observed infants in a naturalistic setting have found that infants who later receive an ASD diagnosis have difficulty coordinating behaviors (vocalizations and gesture; Winder et al., 2012; Parlade & Iverson, 2015). This study extended this finding to a structured setting specifically designed to engage JA and coordinated behaviors. Even when infants were given direct opportunities to produce JA behaviors and vocalize, ASD infants did not do so with the same frequency as their LD and ND peers.

These findings help us understand how HR infants and infants who later receive an ASD diagnosis use vocalizations and JA together. Bakeman and Adamson (1984) have found that ASD infants who engage more in coordinated attention (behaviors and vocalizations) have an easier transition to face to face interactions during free play sessions with both their parents and their peers. These infants are able to coordinate their gestures and vocalizations to both object and their parents allowing for more interactions during free play. Observing JA-vocalization differences at an early age may help researchers and clinicians identify early markers for ASD. Infants who later receive an ASD diagnosis are consistently producing few IBR-vocalizations even compared to their LD peers. Being able to identify infants who are consistently producing relatively few coordinated behaviors as young as 14 months may allow for better identification and more targeted intervention.

While this study provided some initial findings regarding the development of JA, vocalization, and their temporal co-occurrence in HR infants and the ways in which these vary in relation to diagnostic outcome, several key questions remain to be addressed. First, given the relatively small sample size utilized here, a larger participant group is needed to replicate these results. Second, this study focused on the 14- to 24-months age range. These age points were chosen to observe a shift from vocalization and word production during these months. However, expanding the age range would provide a more representative picture of how vocalization changes within this HR sample. Previous studies with TD infants have found a decrease in nonverbal behaviors as infant's progress from the one word to the multiword stage (Wetherby et. al., 1988). As infants start using language more frequently, they rely less frequently on gestures to communicate. Such a decline was not observed in this study, but by broadening the age range and examining when each infant reaches these language milestones, we may be able to gather more precise information about how JA and vocalizations work together in the development of language.

APPENDIX A

ESCS DESCRIPTION

ESCS CODE SUMMARY OF BEHAVIOR	LEVEL	CODE	TASKS	DESCRIPTION
IJA	Lower	EYE CONTACT	OBJECT SPECTACLE	• child makes EC with tester while manipulating or touching an **inactive** mechanical toy • don't code eye contact elicited by movement or noise made by tester
IJA	Lower	ALTERNATES (REFERENCES)	OBJECT SPECTACLE	• child alternates a look between an **active** object spectacle and the **tester's eyes** • typically when an object is active on the table or in the tester's hands but also recorded if child looks up to tester after an object becomes active in own hands
IJA	Higher	POINTS	OBJECT SPECTACLE; BOOK	Before tester has pointed: • child points to an **active** toy OR • child points to pictures in book OR • child points to wall posters • may occur with or without eye contact
IJA	Higher	SHOW	OBJECT SPECTACLE	• child raises a toy upward toward tester's face • typically brief bids with child quickly retracting the proffered object • may be difficult to

				distinguish from GIVE (IBR) – if child resists when tester attempts to retrieve object coded as SHOW
IBR	Lower	EYE CONTACT	OBJECT SPECTACLE	• child makes EC with tester after an object spectacle has ceased OR • child makes EC after the tester has removed an object from the child • don't code eye contact elicited by movement or noise made by tester
IBR	Lower	REACH	OBJECT SPECTACLE	• child extends arm toward an out of reach toy • behavior is NOT scored if child simply reaches & obtains a toy • if child gets out of seat to get a toy, a REACH is only scored if child attempts to obtain a toy from within tester's grasp • a REACH bid ends when child retracts arm OR lays arm on table with hand closed for more than 2 seconds • interruptions & re-initiations of a REACH gesture with less than a 2 second interval are coded as one bid
IBR	Lower	APPEAL	OBJECT SPECTACLE	• child combines EC with REACHING • EC may be a brief event superimposed on a longer period of reaching • EC & REACH must be simultaneous at some point during bid

IBR	Higher	GIVE	OBJECT SPECTACLE; JAR	• child pushes object toward tester OR • child holds an object out toward tester (typically towards tester's hands or body) • may be rated as occurring with or w/out EC
IBR	Higher	POINTS	OBJECT SPECTACLE	• child uses an extended index finger to indicate a desired inactive object or event • if a POINT turns into a REACH or vice-versa, only give credit for the higher level behavior (e.g. POINT) • may be rated as occurring with or w/out EC

(Mundy et. al., 2003)

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