GESTURE AND LANGUAGE IN 2- AND 3-YEAR-OLDS AT HEIGHTENED RISK FOR AUTISM SPECTRUM DISORDER

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Gesture and language development are fundamentally intertwined in typically developing children. Key differences in communicative development are found in children who develop Autism Spectrum Disorder (ASD), making early communication an important focus in promoting early identification. Research has begun to examine the later born siblings of children with ASD, a population found to be at a higher risk of developing ASD and even greater risk for non-ASD language delay. This study investigates the use of gesture and language in children at heightened risk for ASD in order to identify differences based on diagnostic outcome at age 3 (ASD, language delay, or no diagnosis). Participants were 29 toddlers (15 male, 14 female) observed at ages 2 and 3 during 13 minutes of naturalistic semi-structured play with caregivers at home. Language and gesture were transcribed and analyzed in order to: 1) characterize language in the three outcome groups; 2) identify group differences in the way gesture is used in communication; and 3) examine types of gestures that were combined with language at both ages. Overall, the ASD group showed major differences from the language delay and no diagnosis groups. This group displayed reduced language skills, evidenced through fewer different words, shorter utterances, and less growth between 2 and 3 years. They also used proportionally more gesture-only utterances and did not show decreased use of gesture with age to the extent that the other groups did. Furthermore, the children diagnosed with ASD used fewer pointing gestures combined with language. These findings suggest that there are differences in

gesture and language use in toddlers at heightened risk for ASD based on diagnostic outcome at age 3; however, further research with larger sample sizes is needed.

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1.0 INTRODUCTION

The present study focuses on gesture and language in a specific population of 2- and 3-year-olds – those at a heightened risk (HR) for Autism Spectrum Disorder (ASD). Gesture and language are two separate modalities of communication, but their use is fundamentally intertwined. Both are communicative skills that allow infants to interact with people in their environments. Existing research has characterized the relationship between gesture and language in children who develop typically and has begun to highlight differences in children in the ASD and HR populations, but the gesture-language relationship in the latter two groups is less well understood. Enhancing our understanding of early developmental differences can aid in proper identification and intervention for children with delays or disorders. Providing timely intervention to children who can benefit from it not only works toward improved communicative success in early childhood, but also promotes later success in school and other endeavors that emphasize language and communicative skills.

1.1 GESTURE AND LANGUAGE IN TYPICAL DEVELOPMENT

Communication encompasses more than spoken language. Infants can communicate a wealth of information without speaking a single word, whether it be through other vocalizations, like crying, or communication that is entirely nonverbal. Nonverbal communication is comprised of a

variety of behaviors, including body movement, eye contact, and even tone of voice (Knapp, 1978). These behaviors contribute to everyday communication, either singly or in combination with spoken language.

Gesture is a form of meaningful nonverbal communication that consists of various hand, arm, head, and body movements. Gesture and language together form a single system where the two are used synchronously, coordinating in timing, meaning, and function (McNeill, 1992). The close connection between gesture and language is evident throughout development. Neurologically and developmentally, the systems of gesture, speech, and language are tightly interconnected (Iverson & Thelen, 1999). Patterns of gesture and language development in typical children reveal this association.

Although their use extends through adulthood, the use of gesture and language originates very early in life. Before infants can speak, they rely more on gesture, non-word vocalizations (sounds that do not constitute interpretable words), and eye gaze to communicate (Harding & Golinkoff, 1979). For instance, an infant who is hungry but cannot yet say so might reach in the direction of a food item and squeal while looking at a caregiver. This type of intentional communication (that which is directed toward a communication partner) emerges between 9 and 13 months of age, where gestures often precede an infant's first words (Bates, 1976; Iverson & Thal, 1998). Gestures can also symbolically represent conditions, desires, objects, and events (Acredolo & Goodwyn, 1988).

The earliest gestures that emerge tend to be deictic gestures, which refer to concrete items (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979). These consist of GIVE[1], SHOW, RITUALIZED REQUEST, and POINT gestures. Children use these gestures to share an item of

[1] Gesture types will be capitalized throughout the paper.

interest with another person, to signal desire by reaching toward an object, or to identify an object of interest. Of the deictic gestures, POINT gestures generally emerge later (Bates et al., 1979). Gestures such as POINT, GIVE, and SHOW have been found to signal desired items and initiate joint attention, a state in which both a child and a partner focus on the same objects or events. The interactions that occur during these moments of shared attention are meaningful for learning and communicative development (Tomasello & Todd, 1983). For example, an infant could point to a bird by a window, causing a nearby caregiver to notice and say, "bird." This labeling of objects in the environment provides infants with models of the way language is used, which contributes to their learning (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007).

In fact, infant communication in general elicits responses from caregivers, which in turn promotes successful language development. This exemplifies the importance of early communication for subsequent language development. Although caregivers may be equally responsive to their children, a child who communicates more will receive more feedback and therefore more language input. The responses received may also be qualitatively different based on the infants' communication (Leezenbaum, Campbell, Butler, & Iverson, 2014). This has implications for infants who communicate less frequently, which will be discussed later.

Even as infants begin to speak, gesture continues to be used in conjunction with language and plays a role in its development. After the emergence of gesture, communication advances quickly in the months to follow. First words generally emerge by 12 or 13 months, and the period of 13 to 18 months has been identified as a time of rapid developmental change in language (Bloom, 1993). Evidence also supports a major reorganization of the communicative system in the second year (Iverson, Capirci, & Caselli, 1994; Leezenbaum et al., 2014). One change that occurs is a shift in the relative frequencies of gesture types. Specifically, the use of

POINT gestures increases in the second year, while other types of gesturing, such as RITUALIZED REQUESTS, may decrease (Iverson et al., 1994). Aligned with an increase in the use of advanced POINT/SHOW gestures and a decrease in less complex GIVE/REQUEST gestures, there is also an increase in spoken words and a decrease in non-word vocalizations (Leezenbaum et al., 2014). This development in language ultimately broadens the range of meanings that infants can express.

In the second and third years of life, additional change takes place with the appearance of representational gestures (LeBarton & Iverson, 2015). These tend to emerge before a child acquires 25 different words in his or her spoken repertoire (Capone & McGregor, 2004). Two common forms are ICONIC and CONVENTIONAL gestures, and they are more complex than deictic gestures. ICONIC gestures depict actions or attributes of an object, like flapping motions for a bird. CONVENTIONAL gestures are culturally learned movements such as nodding the head yes. While deictic gestures have little meaning outside of the context of the objects to which they refer, representational gestures symbolize more advanced concepts.

Studies examining children's use of gesture and subsequent language development have suggested that gesture facilitates language development (Iverson & Goldin-Meadow, 2005). As evidence, items found in children's gestural repertoires appear later in their verbal lexicons. For example, if a child flaps her arms to signify "fly" and nods her head for "yes," she might later begin to use the spoken words "fly" and "yes." Similarly, children point to objects before producing the words for those same objects (Bates, 1976; Bates et al., 1979). A child who points to a doll early on might begin saying "doll" or "baby" when her language skills progress. This may be partly attributed to the responses elicited from other people, who often name the objects being pointed to. Consequently, the use of pointing is positively correlated with language gains

from 9 to 12 months (Bates et al., 1979). Taken together, these findings raise the possibility that children who actively communicate via gesture are setting themselves up for successful language development.

At around 18 months of age, children begin to combine gestures and words together (e.g., review by Capone & McGregor, 2004; Goldin-Meadow, 2015). The use of gesture as a supplement to single words enables infants to convey more complex communicative messages before they can express them verbally. POINT gestures often supplement spoken language in the second and third years of life (Iverson et al., 1994). For example, a child might point to the door while saying "go," perhaps expressing a desire to go outside. These supplementary gesture-plus-word combinations precede the appearance of two-word combinations (Iverson & Goldin-Meadow, 2005). The same messages conveyed by gesture-word combinations emerge later as two-word spoken utterances, so the child who pointed to the door while saying "go" might later begin saying "go out" or "go outside." Furthermore, the onset of two-word combinations can be accurately predicted by the appearance of gesture-plus-word combinations. Thus, in many ways, change in gesture predicts change in language.

In summary, gesture and language develop dynamically and rapidly. In typical development, the gesture-language system resembles the adult system as early as the second birthday (McNeill, 1992). At this time, there is a preference for spoken language, but gesture is still being used (Capone & McGregor, 2004). Although shifts in gesture use occur as language development progresses, gesturing does not disappear when language becomes more complex. In fact, when language does not develop as expected, the continued use of gesture might be especially pertinent.

1.1.1 Gesture as compensation for language delay

While one 2-year-old is already speaking in full sentences, another may only be able to say a few single words. Some children, such as this one, do not develop language at the typical rate and are considered "language delayed." Of those who exhibit delays early on, some will "catch up" to their peers, while others will have persisting difficulty (Thal, Tobias, & Morrison, 1991; Thal & Tobias, 1992). Early gesture delays can often predict resulting language delays, but research has identified an interesting phenomenon, namely that some children who are not acquiring language typically may resort to increased use of gesture to compensate for spoken language difficulties.

A recent study found that preschoolers with language impairment used gesture to compensate for these deficits (Iverson & Braddock, 2011). In comparison to a group of same-aged children with typical language (aged around 2.5-6 years), children with language impairment produced a significantly higher proportion of gesture-only communications. This could simply mean that language and language+gesture combinations were lacking. However, children with language impairment also used more conventional gestures and more gestures that added information to simultaneously spoken language. Within the group of children with language impairment, there was a relationship between poorer expressive language and higher frequency of gesture production, a relationship that was not present in the typically developing children. This study clearly illustrates the presence of compensatory gesture use, but the reason for it is not definitively known.

One possible explanation for this finding is that gesture frees up resources for other cognitive processes. Goldin-Meadow, Nusbaum, Kelly, and Wagner (2001) found evidence that gesturing may reduce cognitive demands when used while producing verbal explanations. Gesturing while speaking was found to save speakers cognitive effort, and therefore it was

concluded that gesture lessens demands on memory. For some children, conveying information in a gesture-plus-word combination may be cognitively less demanding than expressing it in two words (Iverson & Braddock, 2011). For this reason, gesture may be especially helpful for children who are having difficulty with language.

In a study of younger children with expressive language delay (aged 18-32 months, with a one-year follow-up), Thal, Tobias, and Morrison (1991) were able to pinpoint differences in those who caught up a year later versus those who did not. Prior to the follow-up, children who caught up had better language comprehension and increased gesture use compared to those who remained delayed. This result suggests that children who compensate with gesture are those who are more likely to have better language skills later on. A follow-up study confirmed this notion: children who later caught up used more gestures than language-matched controls (children with equivalent language abilities regardless of age; Thal & Tobias, 1992). It seems that children whose language abilities do not allow them to communicate at the level of their cognitive ability make use of additional gestural communication.

There are also children who are delayed in both gesture and language and do not appear to catch up to their peers. These children might be at risk for language impairment and may benefit from treatment and/or early intervention. Research has provided some promising findings; for example, tracking early gesture allows predictions of children's language acquisition, meaning that it could play a diagnostic role in assessing risk for language delay (Goldin-Meadow et al., 2014). However, a child who is delayed in both gesture and language could potentially be a member of another clinical population: children with ASD.

1.2 AUTISM SPECTRUM DISORDER AND COMMUNICATION

Autism Spectrum Disorder (ASD) is diagnosed by the presence of social communication deficits and repetitive or restricted behaviors and interests. The Diagnostic and Statistical Manual of Mental Disorders (DSM) V classifies it as a neurodevelopmental disorder (American Psychiatric Association, 2013). The diagnosis requires that the deficits in social interaction must be present at a young age, that they impair functioning in some way, and that general developmental or intellectual delay do not better explain them (American Psychiatric Association, 2013).

Difficulties with joint attention are an early hallmark of the social communication deficits prominent in ASD. Joint attention overall tends to be decreased, often with reduced use of eye contact (Wetherby et al., 2004). Delays in gesture, and specifically delays in use of POINT gestures, are another early indicator of ASD. The use of gesture to initiate social interactions is reduced in children with ASD as early as the first year of life (e.g., Watson, Crais, Baranek, Dykstra, & Wilson, 2013), and a similar trend is still present at age 2 (Mastrogiuseppe, Capirci, Cuva, & Venuti, 2015). This is meaningful because of the role that joint attention and social interactions have in communicative development.

Although ASD is defined by the presence of social communication deficits, other aspects of communication can appear disordered in this population. The coordination of gesture and language appears to be especially difficult in children with ASD, with differences remaining apparent through adolescence (Parladé & Iverson, 2015; de Marchena & Eigsti, 2010). Unlike language delayed children, those with ASD do not compensate with increased use of gesture (Sowden, Clegg, & Perkins, 2013), meaning they may be restricted in their ability to communicate needs and ideas. These differences impact opportunities for language learning and further development.

Based on the evidence, the gesture and language systems differ in children with ASD. However, the literature on gestures in ASD is incomplete and unclear, with many studies focusing on school-age children or using retrospective evidence from home videos. Mastrogiuseppe et al. (2015) examined gesture use by children with ASD in naturalistic contexts. They found differences when comparing children with ASD to typically developing children of the same developmental age (who performed similarly on communicative measures regardless of chronological age), such as that children with ASD produced fewer total gestures, fewer conventional gestures, fewer POINT and SHOW gestures, and a higher proportion of RITUALIZED REQUEST gestures. This evidence suggests that the communicative system is organized differently in those with ASD and needs to be better understood with further research.

1.2.1 Identification and diagnosis

ASD is usually not diagnosed before age 3 (Charman & Baird, 2002). Current knowledge does not allow for reliable diagnosis much earlier than this age, in part because it is difficult to distinguish between children with ASD and children with a language delay or disorder. This is problematic, because many parents notice concerns with infants in the first year and a half (e.g. Coonrod & Stone, 2004). This creates a large gap between the time of initial concern and time of diagnosis, during which significant development typically takes place. An ability to diagnose earlier could lead to earlier intervention and potentially better outcomes.

Studying early markers of ASD is a way to remediate this concern. Unfortunately, it is impractical to study early markers in the general population (Szatmari et al., 2016). An estimated prevalence of ASD of 1 in 88 (Baio, 2012) means that a very large group of infants would need to be followed prospectively in order to yield a substantial number of children who go on to be

diagnosed with ASD. Because of this concern, a more recent area of research utilizes a group of infants who have been found to have a higher risk for developing ASD.

1.3 CHILDREN AT HEIGHTENED RISK FOR ASD

Relative to children with no family history of ASD (low risk; LR), children who have an older sibling with ASD are more likely to be diagnosed with ASD. These younger siblings are considered to be at heightened risk (HR) for ASD. Estimates of the ASD recurrence rate within families vary. One widely cited study found a rate of 18.7% (Ozonoff et al., 2011). A review of multiple findings estimated a recurrence rate of 10-20% (Szatmari et al., 2016), significantly higher than the estimated 1 in 88 prevalence rate in the general population (Baio, 2012). Studying this population offers a solution to the practical constraints to studying early markers of ASD, because a group of participants will likely result in a much higher proportion that end up with a diagnosis of ASD. Studies of this younger sibling population have in fact yielded a higher rate of eventual ASD diagnoses than would be expected from the general population, and they have also revealed other differences in development[2].

[2] It is possible that HR children may be exposed to a qualitatively different communicative environment. The presence of a sibling with ASD might influence the language the younger child is exposed to, and there is evidence that mothers of children with ASD interact with them differently than mothers of typically developing children (Meirsschaut, Warreyn, & Roeyers, 2011). Parents of children with ASD are also found to be under heightened stress, which impacts their interaction and engagement (Meirsschaut et al., 2011). However, mothers of HR infants tend to be aware of the risks of communication or language delays and concerned about development, a

As a group, HR infants exhibit gesture and communicative delays and differences when compared to LR infants. In one study, HR infants had lower rates of spontaneous communication than LR infants at both 13 and 18 months (Winder, Wozniak, Parladé, & Iverson, 2013). Words, communicative non-word vocalizations, SHOW and POINT gestures, and gesture plus non-word vocalizations were all reduced in the HR infants, indicating that they communicated less often with their caregivers. These differences are important because they provide caregivers with fewer opportunities to respond, potentially impacting the communicative input the infants receive.

Other studies have confirmed that HR infants use fewer gestures to initiate joint attention (Cassel et al., 2007; Goldberg et al., 2005; Yirmiya et al., 2006). In addition to the lower rates of spontaneous communication, HR infants display differences in other developmental trends. In LR infants, there is an increase in the frequency of POINT and SHOW gestures and a decline in GIVE and RITUALIZED REQUEST gestures between 13 and 18 months of age, but these changes are not evident in the HR group.

Despite these findings, not all HR children exhibit differences from LR children. The HR group is very heterogeneous, as illustrated by a variety of developmental outcomes and discussed in two reviews of HR literature (Rogers, 2009; Szatmari et al., 2016). In addition to the approximately 20% of HR children who receive an ASD diagnosis (Ozonoff et al., 2011); about 20% will have some type of language delay without ASD (Yirmiya, Gamliel, Shaked, & Sigman, 2007), and around 56% do not receive any diagnosis, many appearing to be indistinguishable

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factor that might benefit the HR children (Ozonoff et al., 2011). While this issue is beyond the scope of the present study, it is certainly important to consider in future research.

from their LR peers (Parladé & Iverson, 2015). This diversity makes the younger-born siblings of children with ASD a population warranting further study.

Longitudinal studies of HR infants have revealed differences between those who receive an ASD diagnosis and those who do not. Early on, HR siblings who are diagnosed with ASD exhibit slower rates of growth in joint attention initiation than those without ASD (Ibanez, Grantz, & Messinger, 2013). This finding indicates that characteristics of HR children, when studied as a group, may be influenced or skewed by those who get an ASD diagnosis, because these children perform at a lower level than those with no diagnosis. One study of HR children exemplifies this fact; participants who were later diagnosed with ASD were near the bottom of the distributions in their measures of spontaneous communication frequency (Winder, Wozniak, Parladé, & Iverson, 2013).

As noted above, about 20% of HR children end up having non-ASD language difficulties (Yirmiya et al., 2007). The study upon which the current study is based (LeBarton & Iverson, 2015) examined differences in gesture among HR children with ASD, HR children with language delay, and those with no diagnosis. They found that the language delay group and the ASD group both had reduced used of POINT gestures compared to the no diagnosis group (LeBarton & Iverson, 2015).

This research calls into question the specificity of the difficulties experienced by those with ASD. In other words, are there characteristics of early communication that are unique to those with the eventual ASD diagnosis that do not merely suggest a delayed pattern of development? Because some HR infants manifest with language delays without ASD, they can serve as a clinical comparison group. In a study by Parladé and Iverson (2015), HR children who developed ASD displayed significantly slower growth in coordinated communication (i.e.,

combinations of communicative behaviors such as gesture and vocalization) than those without ASD, even when compared to those with language delay. The authors proposed that the HR infants with ASD seemed to have a unique difficulty coordinating vocalization with gesture. Although they did not have widespread difficulties in all social communication, they appeared to have difficulty coordinating more advanced behaviors. This distinction begins to paint a picture of the precise communication difficulties in children with ASD and suggests that there is more to learn about the nature of their gesture-language system.

There is currently little research on communicative development in HR children beyond the infancy period. One study found evidence of language difficulties in 24- and 36-month-old HR children who received an ASD diagnosis compared to those with no such diagnosis, but these differences were examined using only standardized assessments (Yirmiya et al., 2007). While such assessments are useful, they only capture performance on specific tasks and do not necessarily generalize to the abilities of infants in more natural settings. For this reason, additional research is needed that examines the relationship between gesture and language in HR children as it occurs in more naturalistic settings.

1.4 THE CURRENT STUDY

Typical gesture-language development can be described as an evolution from basic gestures, to gesture with some language, to predominantly language with continued supplemental gesture. This generalization is supported through decades of research with typically developing children. But what happens when development does not advance as usual? Some children present with language delays or other developmental disorders that can include language difficulties as

secondary problems. One such disorder is ASD. In children with ASD, the gesture-language system clearly diverges from the norm, but the specific difficulties that children with ASD have are only beginning to be understood. Research with HR children has revealed some similarities in this group, especially among HR children who eventually get a diagnosis of ASD. Much of the HR research thus far has focused on very early development or used limited data such as results from standardized assessments.

The current study focuses on an age group that is understudied (2- and 3-year-old HR children) and thus will contribute information about the language used in natural play settings in the home. In addition, understanding how gesture and language are used together will expand knowledge of communication in HR children, which has potential to aid in earlier diagnosis and intervention. The study has three primary research questions:

a) What are the characteristics of language used during naturalistic interactions at 2 and 3 years of age in children at heightened risk for ASD who vary in developmental outcome (ASD, language delay, no diagnosis)?

Hypothesis: It is expected that HR children receiving no diagnosis will display the most advanced use of language. This could manifest as a higher number of communicative utterances, a higher number of different words, and/or a higher mean length of utterance. The children diagnosed with ASD are predicted to have lower performance on all of these variables.

b) Are there differences in the way gesture is used in communication between those with ASD, language delay, and no diagnosis?

Hypothesis: The children with no diagnosis are expected to demonstrate the least reliance on gesture due to more advanced language skills. HR children with language delay may use more

gestures than the peers with no diagnosis, either to compensate for reduced language or simply as a result of being further behind in communicative development.

c) Are there differences in the types of gestures that are combined with language between those with ASD, language delay, and no diagnosis?

Hypothesis: It is predicted that there will be group differences in the gesture types most frequently used with language. The HR toddlers diagnosed with ASD may be limited in their use of gestures with language because of communicative delays or an altered gesture-language system. This difference could manifest as reduced use of more advanced gestures with language, such as CONVENTIONAL, POINT, or SHOW gestures (e.g., Mastrogiuseppe et al., 2015).

2.0 METHODS

2.1 PARTICIPANTS

The current study included 29 toddlers (15 male, 14 female) drawn from a larger longitudinal study of HR children. The larger study followed HR infants from 5 to 36 months of age, and data from 24 and 36 months were used in this study, as in the previous study by LeBarton and Iverson in 2015. To ensure availability of data on ASD symptoms and language ability collected at 36 months, only participants who had completed the full study were included. In addition, only children who had participated in a semi-structured play segment with a caregiver at both 24 and 36 months were included. Additional demographic information is provided in Table 1.

Table 1. Participant demographic information

Household linguistic characteristics	100% from monolingual English-speaking families
Pregnancy/birth	100% from uncomplicated, full-term pregnancy
Race/ethnicity	97% Caucasian; 90% non-Hispanic
Maternal education	27.6% high school or some college or trade school; 34.5% bachelor's degree; 37.9% post-bachelor's education

Participants were recruited from a University Autism Research Center, parent groups, and local agencies and schools providing services to families of children with ASD. Each participant had an older sibling with ASD whose diagnosis was confirmed independently before

entering the study using the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2009) and clinical judgment based on DSM-IV criteria.

2.2 MATERIALS

Two primary assessments were administered at 18, 24, and 36 months in the larger longitudinal study: the Mullen Scales of Early Learning (MSEL; Mullen, 1995) and the MacArthur-Bates Communicative Development Inventory (CDI; Fenson et al., 2007).

The MSEL is a standardized, experimenter-administered observational assessment. It contains five subscales: Gross Motor, Visual Reception, Receptive Language, Expressive Language, and Fine Motor (the latter four are considered cognitive subscales). The four cognitive subscales can be combined into an Early Learning Composite (ELC). Standard scores are available for the ELC (mean = 100, SD = 15); raw scores and standardized T-scores are available for each individual subscale (T-score mean = 50, SD = 10).

The CDI is a widely used parent-report measure of child communication and language development that has been validated with observational data (Fenson et al., 2007). Different versions are used based on child age and normed percentile scores are available for each version. The CDI-II was used at 18 and 24 months and the CDI-III was used at 36 months. In one case, the infant-based CDI-I was used at 18 months for a child with ASD who had limited language ability. The CDI-II Words Produced section contains all words from the CDI-I with the addition of more advanced words. This particular child produced very few words on the CDI-I Vocabulary checklist (11 words), so this child's information was included because ceiling effects were unlikely.

2.3 DIAGNOSTIC OUTCOME

After the 36-month visit, participants from the longitudinal study were classified into outcome categories. Membership into one of three mutually exclusive categories, ASD (HR-ASD), language delay (HR-LD), and no diagnosis (HR-ND), was determined at the University by a trained, experienced clinician blind to the study's previous data. Children were classified as HR-ASD if they scored above the corresponding threshold on the ADOS and met DSM-IV criteria for diagnosis, based on clinical judgment[3].

For children who did not meet criteria for an ASD diagnosis, language assessments were used for classification into HR-LD and HR-ND groups. One of two criteria had to be met for inclusion in the HR-LD group: (1) a standardized score less than or equal to the 10th percentile on the CDI at more than one time between 18 and 36 months (e.g., Weismer & Evans, 2002; Heilmann et al., 2005); and/or (2) a standardized score less than or equal to the 10th percentile on the CDI at 36 months and MSEL expressive or receptive language score greater than 1.5 standard deviations below the mean (e.g., Landa & Garrett-Mayer, 2006; Ozonoff et al., 2010). Any child who did not meet these criteria was classified in the HR-ND group. The distribution of children across outcomes is shown in Table 2.

[3] Eight of the participants received speech and language services through early intervention during the course of the study (1 HR-ND, 4 HR-LD, 3 HR-ASD).

Table 2. Distribution of diagnostic outcomes

	Male	Female
HR-ASD	4	3
HR-LD	6	7
HR-ND	5	4

2.4 PROCEDURE

The current study uses data gathered during visits to participants' homes at 24 and 36 months of age. The larger longitudinal study involved videotaping infants and their primary caregivers each month from the age of 5 months to 14 months; visits were then reduced to follow-up sessions at 18, 24, and 36 months. The sessions lasted 45 minutes and consisted of semi-structured play, standardized assessments, and naturalistic observation. The present study focused on a 13-minute semi-structured caregiver-child play segment conducted at both 24 and 36 months. Experimenters provided toys (teddy bear, bowl/spoon, barn set) to keep relative consistency in the play environment across participants. Caregivers were instructed to play as they normally would.

Informed consent was gathered for each infant before the first observation, and the study's procedures were approved by the University's institutional review board.

2.5 CODING

2.5.1 Language coding

Communicative language used by the children during the play sessions was transcribed in two separate passes. Language was considered communicative if context cues were present. Spontaneous verbalizations that were meaningful and intelligible were coded. Spontaneous language excludes direct imitation and rote, memorized routine; however, non-spontaneous speech such as singing, reading, praying, and imitating were labeled as such and coded separately, along with non-speech vocalizations such as babbling. Meaningful language was determined by the use of the same sound pattern on multiple occasions to represent a common meaning, whether it be an actual English word or a combination of speech sounds consistently used for the same referent (e.g., “bah” for ball). In the event of the latter, the ‘word’ had to share at least one syllable (for words made of 2+ syllables), or at least half of the phonemes, with the adult production. Unintelligible utterances were indicated but not transcribed.

Utterances were separated by conversational turn, complete sentence, or intonational contours and pauses. An utterance never consisted of more than one complete sentence or more than one conversational turn. Occasionally, a conversational turn contained more than one utterance. This was determined based on intonational contour, such that a pause or change in tone signaled a separate thought and thus was transcribed as a separate utterance.

Additional predetermined guidelines were followed to promote consistency across videos and across coders. For instance, specifications existed on how to transcribe stuttering, false starts, and language obscured by background noise. A list of standard spellings was generated for communicative sounds and words such as “hooray,” “mmm,” and “yeah.” Compound words and

multi-word phrases that were used more like a single word, such as “thank you” or “bye bye,” were coded to represent one word. This was because early in language development, children who are otherwise speaking only in single-word utterances are likely treating such phrases as single words. Prelinguistic babbling, laughing, crying, and other vegetative sounds were not transcribed.

Two individuals independently transcribed child language. One coder was blind to the outcome groups of the participants but had background knowledge about speech and language development due to enrollment in a Master’s program for speech language pathology (with less than 100 hours of clinical experience at the time of coding). Coders were trained to a criterion of 80% agreement was achieved on two consecutive videos before coding independently. Reliability was calculated for 20% of the tapes, randomly selected but evenly distributed between 24- and 36-month videos. Percent agreement for identifying utterances was 87.97% and percent agreement for identifying the words in utterances was 82.56%.

2.5.2 Gesture coding

All communicative gestures produced by children during the play segment were coded and classified by type. Gestures were deemed communicative based on observation of factors such as eye contact, body orientation, vocalization, and other verbal or nonverbal aspects of the interaction (Iverson et al., 1994); any contextual factors could be present to make this judgment. Basic manipulations of objects (unless used to GIVE or SHOW the object) and ritualized games (e.g., patty cake) were excluded, but otherwise, all communicative hand movements were coded (Ozcaliskan & Goldin-Meadow, 2005). Nodding or shaking the head was also considered a gesture.

Each communicative gesture was categorized as either CONVENTIONAL, POINT, SHOW, ICONIC, SIGN, REPRESENTATIONAL, or FUNCTIONAL ACT. CONVENTIONAL gestures are culturally prescribed gestures, such as nodding the head for "yes," shaking the head for "no," or waving to signify "hello." POINT and SHOW are fairly straightforward as their names suggest; pointing is directing the index finger toward a specific entity and showing involves holding up an object for others to see. ICONIC, CONVENTIONAL, and SIGN gestures are considered to be REPRESENTATIONAL gestures. ICONIC gestures use movements to depict an action or characteristics of an object. SIGNS are gestures standing for specific referents. FUNCTIONAL ACTS consist of GIVE and RITUALIZED REQUEST gestures, where a GIVE is presenting an object to another person and RITUALIZED REQUESTS are typically reaches in the direction of an object in a requesting manner. Some of the gestures in this study were coded specifically as REACH gestures. It is important to note that if a child obtained the object, the initial reach toward that object would not be considered a gesture. FUNCTIONAL ACTS were included because of their prominence in the ASD literature and representation in common assessments of HR and ASD children (e.g., Early Social Communication Scales; Mundy, Sigman, Ungerer, & Sherman, 1986).

Two individuals independently completed the gesture coding, one of whom was blind to group membership. To ensure reliability, 80% agreement on two consecutive videos was reached before coding independently. Reliability was regularly assessed by randomly selecting 10% of the videos to be double coded. Inter-coder agreement was 77.46% for identifying gestures and 96.23% for classifying gesture types and pointing form.

2.6 DATA REDUCTION AND ANALYSIS

This study was designed to address three main questions:

a) What are the characteristics of language used during naturalistic interactions at 2 and 3 years of age in children at heightened risk for ASD who vary in developmental outcome (ASD, language delay, no diagnosis)?

To address this question, language utterances transcribed in ELAN coding software (Max Planck Institute for Psycholinguistics, 2016; Wittenburg, Brugman, Russel, Klassmann, & Sloetjes, 2006) were converted for use in the software program Clan (CHILDES, 2016). Before analysis, utterances in which language was obscured by background noise or contained singing or other non-spontaneous language were removed from the transcripts. At 24 months, 8.33% of the utterances were removed for the HR-ND group, 6.60% were removed for the HR-LD group, and 15.56% were removed for the HR-ASD group. At 36 months, 3.61% were removed for the HR-ND group, 5.97% for the HR-LD group, and 13.26% for the HR-ASD group.

Number of different words used (NDW), mean length of utterance (MLU), and the percentage of utterances that were intelligible were calculated for each child at both ages. Number of different words (NDW) was found by taking the total number of words used and subtracting words that were used multiple times. A greater number of different words used by a child symbolizes more advanced development and provides a sample of the breadth of his or her vocabulary. MLU represents the average number of words that each utterance contains, where higher numbers are associated with longer utterances (i.e., more advanced language development). MLU was calculated by dividing the total number of words used by the number of language utterances. The percentage of intelligible utterances was calculated by dividing the

number of intelligible utterances by the total number of utterances (where intelligible meant that at least part of the utterance was able to be understood and transcribed; see above).

b) Are there differences in the way gesture is used in communication between those with ASD, language delay, and no diagnosis?

All utterances were classified as language only, gesture only, or language+gesture. The percent of language-only utterances was computed by dividing the number of language-only utterances by the total number of communicative utterances. The percentages of gesture-only and language+gesture utterances were calculated the same way, with the total number of communicative utterances as the denominator and the numbers of gesture-only utterances and language+gesture utterances in the numerators, respectively.

c) Are there differences in the types of gestures that are combined with language between those with ASD, language delay, and no diagnosis?

After identifying the utterances that consisted of language+gesture, the types of gesture used in these utterances were identified. For each participant, we counted the number of utterances in which each gesture type appeared. These counts were converted to percentages for each gesture type by dividing the numbers of utterances containing each type of gesture by the total number of language+gesture utterances (e.g., the number of POINT language+gesture utterances divided by the total number of language+gesture utterances). These percentages were then used to calculate group medians and average deviations.

3.0 RESULTS

The current study used a 2 X 3 repeated measures observational design to answer three primary questions about HR toddlers' use of gesture and language. Coding of gesture and language during 13-minute semi-structured play segments was analyzed to produce group differences used for statistical analysis. Median CDI and MSEL scores for the three groups of HR toddlers at 2 and 3 years of age are presented in Table 3 and Table 4 respectively.

Table 3. Participant characteristics at 24 months

Measure	Median	Av Dev	Range	Mean	SD
HR-ND (n = 9)					
CDI-II Percentile	45	15.63	0-65	43.13	21.37
2 year MSEL ELC Standard Score	100.5	8	92-117	103	9.52
2 year MSEL Receptive Language *T*-score	54	6.75	40-66	54.25	7.72
2 year MSEL Expressive Language *T*-score	49.5	5.25	38-63	50.25	7.27
HR-LD (n = 13)					
CDI-II Percentile	20	20.83	0-85	30.77	25.32
2 year MSEL ELC Standard Score	103	13.36	68-138	101.31	18.14
2 year MSEL Receptive Language *T*-score	56	12.65	20-77	50.85	16.9
2 year MSEL Expressive Language *T*-score	48	5.86	28-57	47.77	8.19
HR-ASD (n = 7)					
CDI-II Percentile	5	7.78	0-25	8.33	9.83
2 year MSEL ELC Standard Score	64	8.25	51-74	63.25	10.28
2 year MSEL Receptive Language *T*-score	20	4.32	20-34	23.6	6.07
2 year MSEL Expressive Language *T*-score	28	7.06	20-45	28.14	9.53

Table 4. Participant characteristics at 36 months

Measure	Median	Av Dev	Range	Mean	SD
HR-ND (n = 9)					
CDI-III Percentile	20	12.66	15-50	28.125	14.38
3 year MSEL ELC Standard Score	117	12	84-122	111.33	15.96
3 year MSEL Receptive Language *T*-score	53	7.83	35-70	54.44	10.25
3 year MSEL Expressive Language *T*-score	61	5.63	47-68	59.11	7.13
HR-LD (n = 13)					
CDI-III Percentile	5	3.55	0-10	3.85	4.16
3 year MSEL ELC Standard Score	94	18.51	61-129	99.62	22.41
3 year MSEL Receptive Language *T*-score	49	8.95	33-58	47.69	11.4
3 year MSEL Expressive Language *T*-score	54	8.66	31-65	51.46	10.67
HR-ASD (n = 7)					
CDI-III Percentile	0	5.56	0-20	3.33	8.16
3 year MSEL ELC Standard Score	55	14.08	49-97	64.4	19.39
3 year MSEL Receptive Language *T*-score	20	6.67	20-44	24	9.8
3 year MSEL Expressive Language *T*-score	30.5	8.33	20-52	31.5	11.9

3.1 RESEARCH QUESTION 1: LANGUAGE PRODUCED BY HR TODDLERS

Descriptive statistics for the five primary language variables at 24 and 36 months are presented in Tables 5 and 6, respectively.

Table 5. Language variables for outcome groups at 24 months

	HR-ND		HR-LD		HR-ASD	
Language at 24 months	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Total Communications	84.89 (36.16)	16-129	110.08 (49.55)	17-215	32.43 (21)	14-62
Language Utterances	79.11 (37.17)	15-129	107.54 (52.71)	1-215	29.57 (20.95)	12-58
Number of Different Words	18.89 (9.83)	3-36	28.31 (23.54)	0-87	2.57 (3.1)	1-8
Mean Length of Utterance	1.16 (0.14)	1-1.46	1.32 (0.34)	1-2.04	1.04 (0.07)	1-1.09
Percent Intelligible Utterances	48.53 (13.17)	32.89-66.38	42.5 (19.85)	0-64	21.7 (19.47)	0-45.95

Total Communications: all communicative gesture and language utterances. Language Utterances: the total number of utterances that contained language, before they were further reduced by removing background noise and non-spontaneous speech.

Table 6. Language variables for outcome groups at 36 months

	HR-ND		HR-LD		HR-ASD	
Language at 36 months	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Total Communications	159.11 (54.84)	99-255	147.23 (47.25)	70-210	62.14 (42.26)	4-120
Language Utterances	158.11 (55.96)	99-255	145.38 (48.67)	63-207	57.71 (45.13)	4-120
Number of Different Words	82.44 (36.66)	16-142	75.69 (29.37)	38-118	24.29 (23.39)	0-57
Mean Length of Utterance	2.04 (0.45)	1.19-2.54	1.97 (0.39)	1.39-2.61	1.28 (0.32)	1-1.75
Percent Intelligible Utterances	67.11 (13.14)	44.87-80.45	67.74 (13.65)	42.2-88.1	52.97 (27.36)	0-81.11

These data were subjected to 2 X 3 repeated measures analysis of variance (ANOVA) with Age (24, 36 months) as the within-subjects factor and Group (HR-ND, HR-LD, HR-ASD) as the between-subjects factor[4]. Analyses were run in IBM SPSS version 24 (IBM Corporation, 2016). A significance level of .05 was used for all analyses.

[4] Because of small sample sizes, Kruskal-Wallis nonparametric tests were conducted as a follow-up, and the results aligned in terms of which effects were significant.

Total Number of Communications

At 24 months, the HR-LD toddlers as a group displayed the highest mean number of total communications as well as the greatest variability, followed by the HR-ND toddlers. The HR-ASD group had by far the lowest average number of communications. All groups displayed increased means at 36 months, with the HR-ND mean surpassing that of the HR-LD group and the HR-ASD group remaining below the other groups.

Results from the ANOVA confirmed these patterns. There was a significant main effect of Age, $F(1, 26) = 23.95$, $p = .000$, indicating that for all 3 groups, the number of communications increased significantly from 24 to 36 months. There was also a significant main effect of Group, $F(2, 26) = 12.03$, $p = .000$. Tukey Post Hoc tests indicated that the HR-ASD group produced significantly fewer communications than both the HR-LD ($p = .000$) and HR-ND groups ($p = .000$). The Age X Group interaction was not statistically significant.

Number of Utterances Containing Language

Similar trends were apparent in the numbers of communications containing language. For this analysis, all utterances consisting of only gesture were excluded. At 24 months, HR-LD toddlers had the highest mean, followed by the HR-ND toddlers. The HR-ASD group had the fewest utterances on average. At 36 months, the HR-ND mean was the highest, followed by the HR-LD group, and finally, the HR-ASD group.

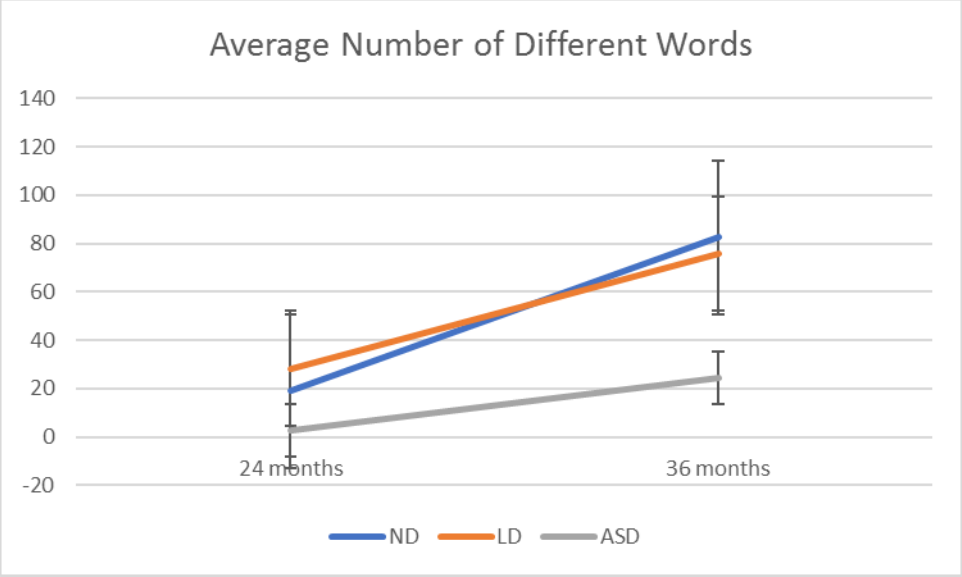
A repeated measures ANOVA revealed significant main effects of Age, $F(1,26) = 21.66$, $p = .000$, and Group, $F(2, 26) = 11.85$, $p = .000$. Number of utterances containing speech increased from 24 to 36 months; and Tukey Post Hoc tests indicated that the HR-ASD group produced significantly fewer utterances containing speech than the HR-LD ($p = .000$) and HR-ND groups ($p = .002$). The Age X Group interaction was not significant.

Number of Different Words

The HR-LD group had the highest mean NDW at 24 months, while that for the HR-ASD group was the lowest. The children diagnosed with ASD also appeared more homogeneous at 24 months, with a range of only 1-8 different words. The HR-ND toddlers showed the greatest increase in mean NDW from 24 to 36 months. At 36 months, the HR-ND mean was highest, the HR-LD mean was somewhat lower, and the HR-ASD mean was again the lowest.

There were significant main effects for Age, F (1, 26) =57.84, p = .000, and Group, F (2, 26) =10.04, p = .000. The Age X Group interaction was also significant, F (2, 26) =3.77, p = .037. The interaction is shown in Figure 1. Follow-up t tests indicated that there was a significant difference in NDW at 36 months between the HR-ASD and the HR-LD groups, t (17) = 3.809, p = .001; but the HR-LD group did not differ from the HR-ND group, t (20) = .386, p = .704.

Figure 1. Mean NDW for groups at 24 and 36 months

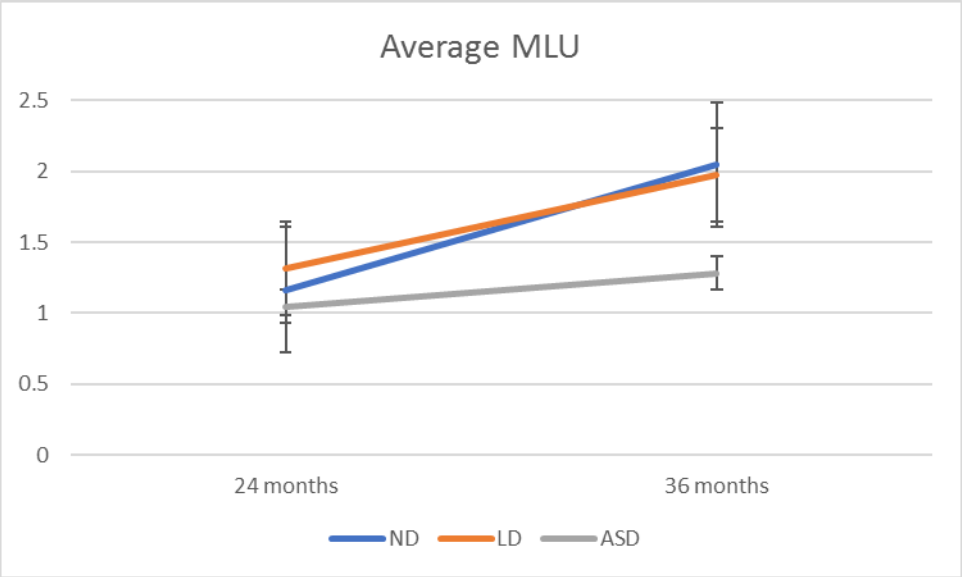


Mean Length of Utterance

MLU is a variable that increases slowly with development, so small differences can be meaningful for this variable. Means for MLU were closer together at 24 months and more divergent by 36 months. Although the group means were more similar at 24 months, the amount of variation differed. The HR-LD group had the highest mean at 24 months but also had a higher standard deviation. By 36 months, the HR-ND group had a slightly higher MLU than HR-LD, while the HR-ASD group exhibited less growth and had the lowest mean. In fact, the HR-ASD mean MLU did not increase significantly from 24 to 36 months.

An ANOVA revealed significant main effects for Age, $F(1, 23) = 56.62$, $p = .000$, and Group, $F(2, 23) = 4.81$, $p = .018$. The Age X Group interaction was also significant, $F(2, 23) = 3.87$, $p = .036$, and is graphed in Figure 2 below. Paired samples t tests indicated that this interaction was driven by significant increases from 24 to 36 months for the HR-ND group, $t(8) = -6.926$, $p = .000$, and the HR-LD group, $t(11) = -5.582$, $p = .000$, but a nonsignificant difference across ages in the HR-ASD group, $t(4) = -1.914$, $p = .128$.

Figure 2. Mean MLU for groups at 24 and 36 months



Percentage of Utterances that were Intelligible

The language samples at 24 months were, on average, less than 50% intelligible as transcribed for all outcome groups. All three groups had a higher mean percentage of intelligible utterances at 36 months compared to 24 months. The HR-ND mean was the highest at 24 months and almost equivalent to the HR-LD at 36 months. The HR-ASD means were the lowest at both ages, but the HR-ASD group more nearly approached the other group means at 36 months.

An ANOVA revealed a significant main effect of Age, $F (1, 26) = 29.97$, $p = .000$, indicating an increase in intelligibility from 24 to 36 months, and a significant main effect for Group, $F (2, 26) = 5.52$, $p = .01$. Tukey Post Hoc tests reveal that the HR-ASD group significantly differed from the HR-ND group ($p = .013$) and HR-LD group ($p = .021$). The Age X Group interaction was not significant.

3.2 RESEARCH QUESTION 2: GESTURE AND LANGUAGE USE

Because of the skewed nature of the distributions (i.e., some participants did not produce any gesture-only or language+gesture communications), medians were used as the measure of central tendency and nonparametric Kruskal-Wallis and Mann-Whitney U tests were used for statistical analyses. Table 7 below contains these group data at 24 months, followed by the same information at 36 months in Table 8.

Table 7. Communication as language-only, gesture-only, and language+gesture at 24 months

	HR-ND			HR-LD			HR-ASD		
	Median	Av Dev	Range	Median	Av Dev	Range	Median	Av Dev	Range
Lang.[5]	82.65%	12.03%	43.21%-100%	92.04%	14.89%	5.88%-100%	85.48%	10.43%	57.14%-96.55%
Gesture	2.40%	7.21%	0%-37.04%	0.88%	13.19%	0%-94.12%	6.45%	8.58%	0.81%-33.33%
L+G	13.79%	6.08%	0%-19.75%	2.86%	6.51%	0%-19.71%	6.67%	4.16%	0%-9.76%

Table 8. Communication as language-only, gesture-only, and language+gesture at 36 months

	HR-ND			HR-LD			HR-ASD		
	Median	Av Dev	Range	Median	Av Dev	Range	Median	Av Dev	Range
Lang.	93.22%	4.54%	86.14%-100%	94.27%	3.97%	82.86%-100%	95.18%	16.60%	50%-100%
Gesture	0.00%	1.65%	0%-8.33%	0.00%	2.34%	0%-10%	0.00%	16.77%	0%-47.37%
L+G	3.70%	3.99%	0%-13.86%	5.73%	2.89%	0%-8.69%	0.00%	1.86%	0%-4.82%

[5] "Lang." refers to language-only utterances; "Gesture" refers to gesture-only utterances; "L+G" refers to language+gesture utterances.

Language-Only Utterances

Language-only utterances comprised the majority of utterances for all groups at both ages, with the medians much higher than those for gesture-only or language+gesture. Although the HR-ASD group had the highest median at 36 months, it also had the largest average deviation and the largest range, with the lowest value at 50%. As a whole, the individuals in the HR-ASD group used a lower proportion of language-only utterances than the other groups. However, there were no statistically significant differences between the groups, as determined by Kruskal-Wallis tests.

Gesture-Only Utterances

All three groups had relatively low percentages of gesture-only communication, but the HR-ASD toddlers overall used proportionally more gesture-only communication than the other groups at both ages. At 36 months, the HR-ASD group had a higher average deviation and range than the other two groups, despite its median of zero. The HR-ND and HR-LD groups decreased in their percentage of gesture-only utterances at 3 years compared to age 2. Kruskal-Wallis nonparametric tests revealed a significant difference between outcome groups at 24 months, $K = 6.353$, $p = .042$, $df = 2$, but not at 36 months. Pairwise comparisons showed that this difference was driven by significant differences between the HR-LD and HR-ASD groups at 24 months, $K = -9.945$, $p = .036$, and nonsignificant differences between the HR-LD and HR-ND groups, $K = 4.286$, $p = .727$, and HR-ND and HR-ASD groups, $K = -5.659$, $p = .552$.

Language+Gesture Utterances

At both ages, groups tended to use more language+gesture utterances than gesture-only utterances. The HR-ND group appeared to use a higher percentage of language+gesture

utterances at 24 months, as evidenced by a higher median, but there were no statistically significant differences between the groups at either age.

3.3 RESEARCH QUESTION 3: TYPES OF GESTURE USED WITH LANGUAGE

The language+gesture utterances were classified according to the types of gestures they contained, enabling comparison across groups of which gesture types were more likely to be used in combination with language. Group median percentages, average deviations, and ranges for each gesture type are shown in Table 9 for 24 months and Table 10 for 36 months.

Table 9. Gesture types combined with language at 24 months

	HR-ND			HR-LD			HR-ASD		
Gesture Type	Median	Av Dev	Range	Median	Av Dev	Range	Median	Av Dev	Range
Conventional	30.50%	26.16%	0%-38%	31.50%	24.13%	0%-83%	50.00%	50.00%	0%-100%
Point	26.00%	20.44%	0%-81%	26.50%	24.47%	11%-100%	0.00%	0.00%	0
Show	3.00%	7.41%	0%-25%	14.50%	15.13%	0%-33%	0.00%	18.75%	0%-50%
Functional Act	0.00%	6.09%	0%-13%	0.00%	2.19%	0%-10%	0.00%	18.75%	0%-50%
Give	0.00%	0.00%	0	0.00%	0.00%	0	0.00%	37.50%	0%-100%
Representational	0.00%	0.00%	0	0.00%	1.53%	0%-7%	0.00%	0.00%	0
Reach	0.00%	4.16%	0%-19%	0.00%	0.00%	0	0.00%	0.00%	0
Sign	0.00%	3.94%	0%-18%	0.00%	0.00%	0	0.00%	0.00%	0

Table 10. Gesture types combined with language at 36 months

	HR-ND			HR-LD			HR-ASD		
Gesture Type	Median	Av Dev	Range	Median	Av Dev	Range	Median	Av Dev	Range
Conventional	20.50%	10.67%	0%-38%	25.00%	20.24%	0%-89%	25.00%	16.67%	0%-50%
Point	56.50%	12.83%	50%-75%	17.00%	24.20%	0%-83%	50.00%	33.33%	0%-100%
Deictic Show	12.00%	11.00%	0%-25%	12.50%	16.72%	0%-43%	0.00%	11.11%	0%-25%
Functional Act	0.00%	0.00%	0	0.00%	8.00%	0%-29%	0.00%	0.00%	0
Give	0.00%	0.00%	0	0.00%	0.00%	0	0.00%	0.00%	0
Representational	0.00%	1.11%	0%-4%	0.00%	3.60%	0%-20%	0.00%	0.00%	0
Reach	0.00%	0.00%	0	0.00%	3.60%	0%-20%	0.00%	0.00%	0
Sign	0.00%	0.00%	0	0.00%	5.22%	0%-29%	0.00%	22.22%	0%-50%

Overall, CONVENTIONAL, POINT, and SHOW gestures were used the most often in combination with language. At 24 months, there was a large difference between the HR-ASD group, which had zero POINT gestures used with language, and the other two groups, which had median values around 26%. A Kruskal-Wallis test revealed a significant difference between groups at 24 months for their use of POINT gestures, $K = 7.343$, $p = .025$, $df = 2$. There were no other significant group differences. Pairwise comparisons indicated that this difference was driven by significant differences between the HR-LD and HR-ASD groups at 24 months, $K = 9.312$, $p = .027$; all other comparisons were not significant.

4.0 DISCUSSION

This study sought to examine HR toddlers' use of gesture and language in a naturalistic play setting at two important age points during communicative development. The three research questions focused on (1) the characteristics of language used, (2) the use of gesture and breakdown of communicative utterances into modalities of gesture, language, or both; and (3) the types of gestures most likely to be combined with language. Strengths of this study's design were the setting of the home environment, the use of naturalistic play with a familiar caregiver, standardization of the toys and 13-minute time period, and the use of language and gesture transcriptions rather than standardized testing alone. Despite individual variation within groups, there were key differences between the HR-ND, HR-LD, and HR-ASD outcome groups at 24 and 36 months in the language and gesture variables considered here. The HR-ASD group strayed the furthest from the other groups, displaying reduced language skills, proportionally more gesture-only communication, and reduced use of POINT gestures with language. The HR-ND and HR-LD groups appeared surprisingly similar in their use of gesture and language. These findings and their clinical implications will be discussed below.

4.1.1 Gesture and language in HR toddlers

Data on language provided partial support for our initial hypothesis. HR toddlers with no diagnosis at age 3 were predicted to outperform the other groups in measures of language. Many HR toddlers have been found to be behaviorally indistinguishable from their typically developing peers (Parladé & Iverson, 2015), so their language development should look more advanced than those with language delay or ASD. By definition, children with "language delay" should have language that is less advanced than those without delays. The results did not support this hypothesis; the HR-LD group did not significantly differ from the HR-ND group and in fact performed higher on language measures at 24 months. We will return to possible explanations for this unexpected finding and its implications below.

A key result from this study that was consistent with the hypothesis was that the toddlers diagnosed with ASD demonstrated less advanced language development as well as reduced growth in language from 24 to 36 months when compared to the other two groups. Lower NDW and shorter MLU are particularly indicative of language development, but differences in the number of utterances was also revealing. The HR-ASD toddlers communicated less frequently than the other groups, which might be expected due to deficits in social communication as well as associated language delays (e.g., Wetherby et al., 2004; Watson et al., 2013; Mastrogiuseppe et al., 2015). This is also consistent with HR research that the children diagnosed with ASD exhibit lower spontaneous communication frequency (Winder, Wozniak, Parladé, & Iverson, 2013). Quantity does not equate to quality; a child who says "no" one hundred times in a session is unlikely to be more advanced than a child who has fewer, but longer, utterances. However, the combination of fewer utterances and shorter MLU suggests that the HR-ASD toddlers are

communicating much less than their peers, which then affects the responses they receive from people in the environment.

A second hypothesis of this study was that HR-LD toddlers might use increased gesture-only communication compared to the HR-ND group. Children with language delay have been found to use additional gesture as compensation (Iverson & Braddock, 2011). The results of this study did not support the prediction for HR-LD children, but it is possible that it could manifest later in childhood for some of the participants (Iverson and Braddock examined children ages 2.5-6 years, while the participants of this study were only 2-3 years old).

The HR-ASD toddlers, however, used proportionally more gesture-only communication than the other groups. This finding can be connected to some of the literature on early communicative development. Typically developing children gradually shift to a reduced reliance on gesture as their language development improves (Capone & McGregor, 2004), but the HR-ASD toddlers did not decrease in the gesture-only communication from age 2 to 3 to the extent that the other groups did. This suggests differing trajectories and rates of development.

As noted earlier, POINT gestures often co-occur with language in the second and third years of life (Iverson et al., 1994), so the HR-ND and HR-LD groups' use of POINT language+gesture utterances is consistent with the literature. Compared to the HR-ND and HR-LD groups, the HR-ASD group lacked the use of POINT gestures with language. This difference in POINT gestures is consistent with the hypothesis, but the HR-ASD group did not show significant differences in CONVENTIONAL or SHOW gestures used with language as was hypothesized. Because POINT gestures emerge later than other types (Bates et al., 1979), this could result from a delay in gesture development for the HR-ASD toddlers.

The difference in POINT gestures is meaningful in the context of language development. Parents and caregivers often respond to their children's POINT gestures, labeling the objects and thus providing language models (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007). POINT gestures can signal attention from others in general, creating states of joint attention that are meaningful for learning (Tomasello & Todd, 1983). Reduced use of POINT gestures, with or without language, can mean that the children with ASD are missing out on learning opportunities.

4.1.2 Diagnostic Outcome

The HR-LD group unexpectedly performed higher than the HR-ND group on language variables at 24 months, which may point to the ambiguity of the term "language delay." While most HR children diagnosed with ASD at age 3 are found to retain the diagnosis through middle childhood (Brian et al., 2015), some children diagnosed with a language delay catch up with their peers (Thal, Tobias, & Morrison, 1991; Thal & Tobias, 1992). The criteria for language delay in this study might have also contributed to the unexpected results. Perhaps the 10^{th} percentile was a relatively high cutoff point for language delay, meaning that some children who met the language delay criteria did not actually have clinically significant deficits in language. This may be reinforced by the fact that the MSEL language measures did not differentiate the HR-ND and HR-LD groups at 36 months. The findings might also highlight the importance of using language samples and/or additional observational data when identifying language delays, since this study relied on standardized assessments to classify the children.

4.1.3 Limitations

Although this study provides important initial insight into the gesture and language use of HR toddlers during naturalistic play, there are some limitations to be considered. Communication was sampled in a relatively brief, 13-minute play session. The home visits used to collect data in this study area also a strength of this research, but they limited the sample to participants within a reasonably accessible geographic area. Further study with larger group sizes could help diminish effects of individual variation that might have impacted the results. The results pertaining to language delay were unexpected, warranting further research to shed light on this population. Despite limitations, the findings of this study justify replication with more participants.

4.1.4 Clinical Implications and Future Directions

Findings from this research have two clinical implications. First, the HR-ASD toddlers, compared to the other HR toddlers, were communicating less frequently with less advanced language and a lesser use of POINT gestures with language. All of these factors influence the feedback they receive from caregivers, since engaging in joint attention and using POINT gestures are found to promote engagement with others (Tomasello & Todd, 1983; Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007; Iverson & Wozniak, 2016). These differences could affect their language environments and in turn their exposure to language-learning opportunities.

Second, differences in early use of gesture and language are important when thinking about early identification of children with ASD and language delays. The HR-ASD toddlers appeared to be behind their peers at 24 months and getting further behind as time passed, which is why early intervention is crucial to promoting the best outcomes for these children. Many

popular standardized assessments focus on language itself, with less attention to gesture or language+gesture communication. The results from this study and others suggest that more emphasis should be placed on gesture use as a differentiating factor.

This study also is revealing in terms of characterizing HR children as a population. Because of the increased risk for ASD and language delay and a possible altered language environment, these children should be closely monitored in early development. The limitations of this study illuminate the need for further research. The fact that the language delay group yielded unexpected results points to the fact that this population is not fully understood. Future study of HR-LD children can shed light on some of this discrepancy. With longer durations of video data and larger samples, the communication differences found in this study could manifest more clearly.

In sum, this study provides evidence that there are differences in the naturalistic use of gesture and language between HR toddlers who receive ASD diagnoses (at age 3) and those who do not. The toddlers diagnosed with ASD already appeared considerably different from the other groups at 2 years. This is consistent with previous research on older children with ASD in general, but this study shows that differences also exist specifically in the ways HR children use language with gesture in naturalistic play. The HR-ASD group was significantly different from the HR-LD group, suggesting that the ASD population is truly unique in some communicative characteristics, and not just further behind. With future investigation, the HR population can be better understood not only in terms of what puts them at increased risk for ASD, but what can be done to promote best surveillance and intervention methods for them.

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