MATERNAL GESTURE USE IN TODDLERS WITH LANGUAGE DELAY: RELATIONSHIP TO LANGUAGE DEVELOPMENT AND AUTISM SPECTRUM DISORDER RISK

by

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ABSTRACT

Prior to the onset of spoken words, infants acquire gestures through early social interactions with their parents. Research on typically developing children has demonstrated an important relationship between maternal gesture use and child gesture and language development. Specifically, the variety and frequency of maternal gesture use has been shown to function as a scaffold for the development of language and an infant's own gesture development.

This study examined gesture use in mothers of toddlers with expressive and receptive language delay during a naturalistic interaction with their young children. Maternal gestures were coded using a detailed coding scheme, according to category, specific type, and the presence or absence of co-occurring speech. The relationship between maternal gesture, child language, child gesture, and autism spectrum disorder (ASD) risk status was also examined. Participants included 54 parents of toddlers enrolled in a longitudinal study of language delay as a risk factor for ASD (language delay (LD) = 27, typically developing (TD) = 27).

Results suggested similar gesture profiles across groups of mothers. Mothers of toddlers in the LD and TD groups were found to use gestures at the same frequency and convey a similar number of meanings though gesture (Wilks' $\Lambda = 0.99$, $F\ (2, 51) = 0.273$, $p = 0.76$, partial $\eta^2 = 0.01$). Mothers in both groups used more deictic gestures than other gesture types $F\ (1.39, 72.23) = 88.63$, $p < 0.01$, partial $\eta^2 = 0.63$. Across all groups, mothers were observed to combine a greater percentage of gestures with speech (> 70%) and the gestures tended to emphasize the message conveyed in speech. Results for mothers in the language delay group revealed a significant negative relationship between maternal gesture and concurrent child receptive language ($p = 0.04$) as well as a significant negative relationship to a change in expressive language over time ($p = 0.02$). Maternal gesture in the TD group was positively related to concurrent child gesture ($p = 0.04$). This research demonstrated that mothers of toddlers with severe language delays are similar in their gestural communication to mothers of typically developing infants.

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1. INTRODUCTION AND LITERATURE REVIEW

In typically developing infants, gestures are used as a means to communicate prior to the onset of spoken words. Further, gestures play a critical role in language development and have been shown to be an early predictor of language outcomes (e.g., Goldin-Meadow, 2008; Watt, Wetherby, & Shumway, 2006). Research suggests early gestures may play a similar role in preceding and facilitating the development of language in young children with language and other developmental delays (Luyster, Lopez, & Lord, 2007; Rowe & Goldin-Meadow, 2009). Given that many communicative gestures develop prior to expressive (spoken) language, identifying deficits and patterns of gesture use among infants with language delay can inform clinical diagnostic practices including early differential diagnosis among other developmental delays or neurodevelopmental disorders such as autism spectrum disorder (ASD), as well as offer a potential target for early intervention practices.

In looking at the association between language and gesture use in infants with an expressive language delay, researchers have concluded that these “late talking” toddlers do not differ from their typically developing peers in their use of communicative gestures (Hawa & Spanoudis, 2013). In fact, some researchers have reported that late talkers use more communicative gestures than do their typically developing peers, theorizing that late talkers must rely on nonverbal means of communication due to the delays in their expressive language ability (Thal & Tobias, 1994). Furthermore, findings in the late talker literature reveal that many late talking toddlers show significant gains in expressive language and reach average age ranges in their expressive language skills by the time they enter school (Rescorla, 2009). These findings, however, differ significantly for children with both expressive and receptive language delays, and evidence suggests that toddlers with deficits in both expressive and receptive language are at an increased risk for persistent language impairments and other developmental delays well into their school years (Ellis & Thal, 2008). Thus, increased understanding of how gestures are related to language in children with language delays may inform clinical practice within this and other diagnostic groups.

Infants acquire gestures through early social interactions with their parents (Namy, Acredolo, & Goodwyn, 2000; Namy & Nolan, 2004; Namy, Vallas, & Knight-Schwartz, 2008) and as such, parents play an important role in influencing the development of gesture and language in their infants. For example, an increase in parent gesture has been shown to increase the gesture use of typically developing 11-month-old infants (Goodwyn, Acredolo, & Brown, 2000). Given the delayed language development observed in infants with expressive and receptive language delays as well as other developmental disorders including ASD, and the known deficits in gestural use in neurodevelopmental disorders, it may be that these infants do not acquire gestures through this natural social interaction with their parents.

Investigating the gesture use of parents of toddlers with language delay is important for understanding how these parents use gesture and the role gestural input may play in the language and social communication development of their young children. Findings from the current study contribute to the scientific literature by increasing understanding of how parents of toddlers with language delay use gestures in communicative interactions with their children. Further, with the recent trend toward parent-directed interventions for young children with developmental disorders (e.g., Rogers et al., 2014), there is a need to establish additional parent-focused intervention methods. Findings from this study may provide information about potential intervention components related to parental gesture use that may facilitate early language skills in children with language delay, ASD, and other developmental disabilities.

The objective of this dissertation was to understand how parents of children with an expressive and receptive language delay use gestures when communicating with their young children as well as how parents may facilitate the emergence of gestures in their young children. Patterns of gesture use by mothers of children with an expressive and receptive language delay were compared to mothers of typically developing toddlers. The relationship of parent gestural communication to child language, gesture, and social communication (i.e., ASD risk) was also a focus of this dissertation. Risk for ASD was examined given that one of the primary concerns reported by parents of children later diagnosed with ASD is a delay in language development (Coonrad & Stone, 2004). The review that follows provides an overview of the research regarding gesture use in infants with typical development and those with language or other developmental delay including ASD, followed by a review of the literature on maternal gestures. A discussion regarding how this study contributes to the literature follows this review.

Language Delay Defined

Delays in speech and language development are relatively common in early childhood, with prevalence rates reported between 5-12% in children between 2 and 5 years of age (Law, Boyle, Harris, Harkness, & Nye, 2000). Delays in speech development are characterized by impairments in articulation, fluency, or tone of voice while delays in language are defined as impairments in comprehension or use of spoken or written language (Wallace et al., 2015). Language includes receptive (understanding) and expressive (production) communication.

There is some variability in how a delay in language is defined in the literature. In typical development, first spoken words emerge between 12 and 18 months of age, with a lack of words by 18 months indicating a delay (Tager-Flusberg et al., 2009). Low expressive vocabulary has often been used as the marker for a delay in language (Bavin & Bretherton, 2013). The term "late talkers" is typically used to classify children with a delay in expressive language before age 3 (Rescorla & Dale, 2013). Some studies, however, have included children with a receptive and expressive delay in their late talker definition (e.g., O'Neill & Chiat, 2015). The term "late language emergence" has also been used to describe toddlers who have no known developmental disorders but who do not reach age expected milestones for expressive vocabulary by 24 months (Taylor, Zubrick, & Rice, 2013). While some children start with a delayed language developmental trajectory but eventually "catch up," others may slow down after a period of normal language development (Bavin & Bretherton, 2013). Identifying those "late talking" children for whom there is no clear explanation for the delay (e.g., deafness, Down syndrome, intellectual disability, ASD) is especially important, as it is this subset of late talkers who are at greater risk for later language impairment (Bavin & Bretherton, 2013).

Clinical Features of Language Delay

A majority of language delays are idiopathic; however, language delay may co-occur with other developmental delays or be secondary to neurodevelopmental disorders. Although outcomes of children with language delay are variable, at least half of children with these delays have been found to be at risk for persistent speech and language disorders, learning disabilities, and ASD (Dworzynski et al., 2007). With increased frequency, children with language delays are being referred for an ASD evaluation (Howlin, 2003; Kjelgaard & Tager-Flusberg, 2001), and a delay in spoken language is often the first concern reported by parents of children who are later diagnosed with ASD (Coonrod & Stone, 2004). Approximately 28% of children diagnosed with ASD fail to develop language (Sigman & Ruskin, 1999; Tager-Flusberg, Paul, & Lord, 2005), which puts these children at higher risk of poor outcomes later in life (Billstedt, Gillberg, & Gillberg, 2007). As language delay can be a secondary characteristic of other developmental disorders including ASD, intellectual disability, and/or hearing loss, a comprehensive developmental evaluation is typically recommended for accurate differential diagnosis (Mclaughlin, 2011).

Although language delay is frequently observed in children with developmental disorders including ASD, a delay in language is not specific to the diagnosis of any developmental disorder and may in fact be indicative of other developmental delays including specific language impairment. Thus, it is imperative that the development of toddlers with language delays be studied extensively. Research with a particular emphasis on the development of nonverbal communication, such as gestures, may offer a unique perspective on early risk factors that may help differentiate language delay from other developmental delays.

Defining Gestures

Gestures are a form of intentional communication in which a nonvocal action, such as pointing, is used to designate an object, event, person, or location (Iverson et al., 1998). Gestures include actions such as showing, giving, reaching, pointing, and waving. Gestures are typically directed towards another person in order to assist in the delivery of the communicative message. Wetherby and Prizant (2002) define gestural communicative acts as those gestures that are typically produced by the hands and/or fingers, are directed toward another person, and serve a communicative function (e.g., to request or comment on an object).

Gesture Categories

Gestures are typically broken down by category. Research regarding adults' use of gestures shows that there are essentially four categories: deictic, representational, conventional, and emphatic gestures (Iverson, Longobardi, Spampinato, & Caselli, 2006). Deictic gestures point out or indicate a referent in the immediate environment. Deictic gestures include acts such as pointing, reaching, showing, and giving. Deictic gestures express the communicative intent to direct attention to an object, location, person, or event. Representational gestures stand for a specific referent and the semantic content does not change with context. Representational gestures include acts such as pretending a hand is a cup, arms are a plane, or fingers are a spider. The purpose of a representational gesture is to offer clues or hint at spoken language (Iverson et al., 2006). Conventional gestures are differentiated from representational by their culturally defined form (Cartmill, Beilock, & Goldin-Meadow, 2012). The meaning of a conventional gesture is culturally defined such that conventional gestures do not represent or stand for a specific object or referent; rather, they represent the form and meaning consistent within a particular cultural context and are often used socially. Examples of conventional gestures include nodding the head yes, shaking the head no, and shrugging the shoulders for "I don't know." Emphatic gestures serve to highlight aspects of accompanying speech, and therefore, do not represent or stand for an object, have no semantic meaning, and are not linked to a specific hand shape or facial expression. Emphatic gestures are typically executed in rhythmic fashion (i.e., beats). Emphatic gestures are used to emphasize specific elements of speech and include actions such as bringing a fist to an open palm to stress feeling strongly about something or waving arms enthusiastically while speaking (O'Neil, Linnell, & Fluck, 2005, Iverson et al., 2006).

Gesture Tokens and Types

For analytic purposes, gestures are frequently classified as tokens and types (Iverson & Goldin-Meadow 2005; Rowe & Goldin-Meadow 2009; Talbott, Nelson, & Tager-Flusberg, 2013). Tokens refer to the sheer number of gestures produced, while types refer to the various meanings conveyed by the gestures. For example, if a mother points to an airplane, a book, and then again to an airplane, she has produced three gesture tokens, but only two gesture types. The tokens define frequency of gestures while the types account for the different meanings conveyed (e.g., “Look at the airplane!” and “Look at the book!”). An analysis of gesture tokens and types can lead to an understanding of important patterns in gestural use across various populations including variety in meaning and frequency of gesture use.

Gestures in Typical Development

Developmental Sequence of Gesture

Important aspects of gesture acquisition in typical development include the developmental sequence of gesture type and function, and the relationship between gesture, language, and social communication development. Prelinguistic forms of communication, such as gestures, are used by infants well before spoken language develops. In fact, gestures serve as the first evidence of symbolic capacity in the language system (Fenson et al., 1994). While there is significant variability in the acquisition of gestures, it is typically reported that infants begin to communicatively use gestures around 6 months of age and acquire a substantial number of gestures between 6 and 9 months of age (Capone & McGregor, 2004; Crais, Douglas, & Campbell, 2004). Crais et al. (2004) described the developmental sequence of gesture acquisition in infants. The first gestures to emerge are termed “primitive conventional” and include emotional gestures for the purpose of social interaction (e.g., leaning body towards another person), and contact gestures for the purpose of protesting (e.g., pushing an object away). “Showing off” gestures, including repeating behaviors that have successfully gained adult attention in the past, also emerge around 6 months of age (Capone & McGregor, 2004).

These early gestures serve to get and maintain the attention of another person or adult. Around 7-8 months of age, a whole hand reach emerges as the first deictic gesture. Between 8-9 months, other deictic gestures for the purpose of requesting, such as giving an object to another person, “arms up” to be picked up, and “waving” and “clapping” in social games, emerge.

Between 9 and12 months, other deictic gestures such as pointing and showing emerge. Deictic gestures in this phase are executed for a variety of purposes including to request and/or comment on an object (joint attention). Conventional gestures, such as “clapping” and “waving,” which were previously used in the context of social games, are now used in novel settings and include intentions such as greeting or sharing enjoyment (Capone & McGregor, 2004).

Between 12-15 months of age, infants begin to pair gestures with verbal speech. Conventional gestures such as “blowing a kiss,” “shaking head,” and “nodding” emerge during this period as well. During the 15-18 month period, the catalog of conventional gestures continues to grow and includes “shrugging shoulders” and “finger to lip for shhh.” Somewhere around the onset of the 25-word milestone, representational gestures emerge. These gestures include actions such as “arms out” to represent flying, or “hand cupped to mouth” to represent drinking. Representational gestures are very much language symbols in that the interpretation of the gesture is not dependent upon the referent being present. For example, when we hear the word “plane,” and once we have a symbolic understanding of the meaning of the word, the presence of a picture of a plane nor an actual plane is required for us to comprehend the word. Similarly, with representational gestures, once the gesture is in our repertoire, we can understand the gesture of “arms out” as standing for flying.

Bridge Hypothesis in Gesture Development

The development of language and gesture are closely entwined, such that it is theorized that gesture is predictive of later language development and serves as a communicative bridge to spoken language. This so-termed “bridge hypothesis” states that the purpose of the gesture is to aid the gap between the infants understanding (comprehension) of language and their ability to produce (express) spoken words (Fenson et al., 1994; Luyster, Lopez, et al., 2007). Empirical support for the “bridge hypothesis” is evident in a study by Fenson et al. (1994) in which the relationship between comprehension, expression, and gesture was examined. The researchers found that when production of verbal speech (expressive language) was controlled for, a relationship between comprehension and gesture was evident; however, no relationship between expressive language and gesture production was found when comprehension was held constant. Therefore, the presence of expressive (spoken) language serves as a developmentally appropriate substitute for gestural communication and once the infant is able to verbally label a referent, they may prefer to do so.

Gesture Use in Infants With Language or Other Developmental Delays

Gesture Use in Children With Delayed Language

Children with delayed language development are at increased risk for persistent problems including neurodevelopmental delays such as ASD. Specific impairments in the development of receptive (Ozonoff et al., 2010; Zwaignebaum et al., 2005) and expressive language (Iverson & Wozniak, 2007; Ozonoff et al., 2010; Zwaignebaum et al., 2005) have been documented in children later diagnosed with ASD. Gesture and language are both symbolic representations of intention and closely linked in the attainment of developmental milestones. Thus, understanding how gesture and language are related in populations with language or other developmental delays can help inform clinical diagnosis and treatment. Thal and colleagues studied gesture use longitudinally in a sample of late talkers (Thal & Bates, 1988; Thal, Tobias, & Morrison, 1991; Thal & Tobias, 1992). They found that delays in gesture development were linked to delays in receptive language, while children with an expressive language delay exhibited no differences in gesture production compared to typically developing peers. Findings from the Thal studies seem to support the hypothesis that gesture use and language comprehension (receptive ability) are closely linked cognitive processes (Thal & Tobias, 1994).

Gesture Use in Children With Down Syndrome

It has been hypothesized that children with Down syndrome (DS) prefer gestural communication to expressive language and this preference may be linked to the difficulties in speech characteristic of this disorder (Chan & Iacono, 2001). Other data suggest that a gestural advantage does not exist in this population and instead their level of communicative gestures is consistent with expressive language level expectations (Iverson, Longobardi, & Caselli, 2003). In a sample of 36-month-old Italian children with DS (n = 20), there was substantial individual variability in gesture use; however, much of the gesture processes described in this sample were found to be similar to that seen in typical development, with gestures relating to receptive language and not expressive ability (Zampini & O'dorico, 2009). Further, gestural communication has been shown to be an important precursor to expressive language development in children with DS (Iverson et al., 2003).

Gesture Use in Children At-Risk for ASD

Decreased gesture use is a core deficit observed in toddlers later diagnosed with ASD (Mitchell et al., 2006; Shumway & Wetherby, 2009) and as such, much of the literature on gestural communication in delayed populations has been conducted in children later diagnosed with ASD. Social communication deficits are widely reported in the literature as a distinguishing feature of ASD and are not specific to language ability (Tager-Flusberg, Joseph, & Folestein, 2001). Infants who are at increased risk for developing ASD have been found to display both a delay in spoken language and nonverbal communication, including gesture production (Paul, Fuerst, Ramsay, Chawarska, & Klin, 2011).

Wetherby et al. (2007) found that toddlers with ASD produced significantly fewer gestures overall than typically developing toddlers, as well as toddlers with developmental delay (DD), suggesting that this deficit in gesture use is more profound in children diagnosed with ASD than nonspectrum DD. Another study found that 30-month-old toddlers with ASD produced significantly fewer gestures than their typically developing peers when matched on expressive language ability (Ozcaliskan, Adamson, & Dimitrova, 2015). One study that explored gesture use in infants at-risk for ASD due to genetic liability, found that decreased use of "early" gestures (e.g., pointing, showing) and "late" gestures (e.g., object-directed actions, play, and imitation) at 12 and 18 months was a distinguishing feature of children later diagnosed with ASD (Mitchell et al., 2006). Similar to the findings by Mitchell et al. (2006), Veness et al. (2012) found that at both 12 and 24 months of age, children later diagnosed with ASD produced significantly fewer gestures than their typically developing peers. In a retrospective study of 9-12-month-old infants diagnosed with ASD, Colgan et al. (2006) found that a decreased variety in type of gestures used was significantly associated with a later diagnosis of autism. Taken together, a decreased use of gesture may be one of the earliest indicators of ASD and predictive of ASD symptom severity (Mitchell et al., 2006; Watson et al., 2013; Winder et al., 2013). However, among children with ASD, there is significant variability in the use of communicative gestures and these differences have been linked to later impairments in language (Charman et al., 2005).

Findings on the specific gestures that may distinguish toddlers with ASD from matched control groups of DD and typically developing children, however, are mixed. For example, pointing, but not showing, has been found to distinguish toddlers with ASD from DD based on parent report at 20 and 42 months of age (Cox et al., 1999), whereas showing, but not pointing, was found to distinguish ASD from DD in an observational study of 20-month-old toddlers later diagnosed with ASD (Wetherby et al., 2004). In a study of 2- and 3-year-old high genetic risk infants, children with ASD were shown to produce significantly fewer point gestures than those with language delay or no diagnosis (LeBarton & Iverson, 2015). Furthermore, a significant difference was found in the number of point gestures produced by the LD group when compared to the no diagnosis group such that the LD group produced fewer point gestures at 24 months. In a study by Osterling, Dawson, and Munson (2002), showing and pointing gestures were observed so infrequently across the TD, DD, and ASD groups in 1-year-old children, that the group differences could not be analyzed. Ozcaliskan, Adamson, and Dimitrova (2015) found that 30-month-old infants with ASD produce significantly fewer deictic gestures than their typically developing peers when matched on expressive language level. These toddlers also displayed deficits in conventional and "give" gestures; however, this finding was specific to a requesting communicative context and was not found in a commenting communicative context (Ozcaliskan, Adamson, & Dimitrova, 2015). While a core deficit in deictic gestures is supported in the literature, further research is needed to identify the specific gestures that are impaired in children with ASD.

Although the role of gestural deficits in informing diagnostic and phenotypic profiles of ASD is of obvious importance, the literature on gestures in ASD is scarce and contradictory. However, amid the contradictory findings around specific gestures that may differentiate ASD from nonspectrum DD including language delay, it appears as if early differences in gesture use are a distinguishing feature of ASD when compared to typical development, and may help differentiate ASD from DD at some point in the second year of life.

Association Between Gesture and Language in Children With Language or Other Developmental Delays

Similar to the findings in typical development, research shows a relationship between gesture and language in children with language and other developmental delays.

Gestures have been found to be important to language development given that these skills complement spoken language and are used as a means to communicate outside of spoken language (Watt et al., 2006).

Gesture and Language: Children With Language Delays

In a study of toddlers between 24 and 36 months of age with either expressive language delay (ELD; *n* = 12) or receptive and expressive language delay (R/ELD; *n* = 10), a significant relationship between receptive language ability, symbolic comprehension, and gestures was reported (O'Neill & Chiat, 2015). Toddlers with higher receptive language ability showed higher levels of symbolic comprehension and gesture use. Similar to the findings in the Thal studies, expressive language ability was not found to be related to gesture use or symbolic comprehension. When comparing toddlers with ELD to those with R/ELD, the groups were found to significantly differ in their total number of gestures used, with toddlers in the R/ELD group using a fewer number of gestures overall (*r* = -0.84).

Gesture and Language: Children With Down Syndrome

Down syndrome is characterized by delayed language development; however, once acquired, language development seems to follow the same trajectory as seen in typical development (Iverson et al., 2003). Children with DS typically display a language profile in which comprehension is commensurate with cognitive ability, but expressive language development progresses at a much slower rate than observed in typically developing children (Iverson et al., 2003). Some studies of children with DS show no differences in gestural production when compared to typically developing peers (Iverson et al., 2003) and gestural production has been shown to be related to language ability (Zampini & D'Odorico, 2009). In a study of twenty 36-month-old children with DS, gesture production was found to be related to concurrent receptive but not expressive language; however, gesture production at 36 months was significantly related to vocabulary production at 42 months, a relationship mediated by receptive language ability (Zampini & D'Odorico, 2009). These findings support the "bridge hypothesis" described in typically developing children in that gestures serve as a bridge between word comprehension (receptive language) and word production (expressive language).

Gesture and Language: Children With ASD

An abnormal developmental trajectory in the acquisition of gestures in children with ASD suggests that the relationship between gesture and language may also be impacted. Gordon and Watson (2015) found that across all groups ("autism," "autism spectrum," and "non-spectrum"), early gestures at 13 months were significantly associated with expressive and receptive language scores at 22 months. In a study by Luyster et al. (2007), language outcomes of 18-month-old toddlers later diagnosed with ASD were evaluated in order to identify important predictors. The study found that gestures, response to joint attention, and cognitive ability were the most significant predictors of receptive language ability at 33 months. Imitation, gestures, and cognitive ability were found to be the most significant predictors of expressive language ability at 33 months (Luyster et al., 2007). Within the area of gestures, it was the collection of different types of gestures used (as reported on the MCDI) that proved to be the most significant predictor of concurrent and later language. Additionally, how frequently gestures were used to communicate has also shown to predict later language ability (Charman et al., 2005).

Evidence from the literature on children later diagnosed with ASD suggests a link between gesture use and language ability, similar to that found in typical development. In a study of 30-month-old children with ASD, deictic gestures, but not other gesture types, were shown to predict children's vocabulary development 1 year later in both the ASD and typically developing groups (Ozcaliskan, Adamson, & Dimitrova, 2015). These findings suggest that deictic gestures play an important role in children's vocabulary development in both typical and atypical development. A study on gesture and language in preschool age children with ASD found that receptive language ability was correlated with gesture use and expressive language independently; however, expressive language was not related to gesture use when receptive language was held constant (Luyster et al., 2007). That is to say, even amongst atypical populations, gestures seem to serve as a critical link to spoken language and that one gesture type in particular (deictic) may serve as the bridge to later vocabulary development.

Parental Influences in Gesture Development

Theoretical Framework

There is a substantial literature base examining the influence of environmental inputs on the language development of infants and toddlers. Vygotsky and Bruner demonstrated that learning takes place within a social context in which a more experienced communicative partner (e.g., the parent) compensates for his or her less experienced partner (e.g., the infant) in order to facilitate skill acquisition (Bruner, 1981). The development of expressive and receptive language begins with affective face-to-face interactions between infants and caregivers in the first few months of life (Hoff, 2006). Around 6 months of age, infants develop the ability to coordinate attention between a referent and a communicative partner (Mundy & Sigman, 2006; Trevarthen & Hubley, 1978), and by 13 months, children can engage in coordinated joint attention episodes (i.e., the child shifts gaze between the adult and the object of interest; Bakeman & Adamson, 1984; Mundy & Sigman, 2006).

The transactional model of development (Bronfenbrenner & Morris, 1998; Sammeroff & Fiese, 2000; Sammeroff & Mackenzie, 2003) also emphasizes the importance of early parent-child interactions. This model is well established in the literature on typically developing children (Feldman & Greenbaum, 1997), suggesting that social and communicative development occurs within a series of bi-directional shared exchanges between the child and the experience provided by his or her social context (e.g., parents). These bi-directional exchanges are viewed as critical for early learning and disruptions to this interaction, including impairments in the infant's social communication, may disrupt parent responsiveness and lead to an increasingly atypical social development course (Dawson, 2008).

Modifications in Communicative Interaction Style

When interacting with young children, parents modify their interaction style in a fairly consistent manner. For example, adults use "motherese," "child-directed speech," or "baby talk," which includes speech that is characterized by relatively simple words, a shorter mean length of utterance (MLU), and variable patterns of intonation (Snow, 1995). In addition to modifying their speech when communicating with young children, research has found that parents adjust their use of gestures ('gesturese'), such that they tend to produce fewer overall gestures that are specific to the particular context and reinforce the message conveyed in the speech (Bekken, 1989; Iverson et al., 1999; O'Neill et al., 2005). This pattern is qualitatively different from the types of gestures produced in adult interactions where gestures tend to be more abstract (e.g., emphatic) and add information to the message not conveyed in speech (Bekken, 1989). Shatz (1982) described the gestures adults use toward children between 19 and 34 months of age as being similar to, but simpler than, those used in interactions with other adults.

These modifications of speech and gesture appear to scaffold, or support, language acquisition and reflect the sensitivity of parents to an infant's limited receptive vocabulary. By using modified speech and gestural patterns, parents aim to provide contextual and verbal cues to promote understanding. These adaptations in communication are continually changed in order to reflect the developmental age of the child (Shatz, 1982), expressive language level (Iverson, Capirci, Longobardi, & Caselli,1999; Namy & Nolan, 2004; Namy et al., 2000), and receptive language level (Namy & Nolan, 2004; Namy et al., 2000, Schmidt, 1996).

These studies on "gesturease" also found that when mothers gestured in interactions with their young children, those gestures were almost always accompanied by speech (Bekken, 1989; Iverson et al., 1999; O'Neill et al., 2005). As described by Iverson et al. (1999) and O'Neil et al. (2005), gestures function to (a) emphasize or convey the same information as the verbal portion of an utterance, (b) disambiguate or identify the precise referent of the verbal portion of the utterance, (c) add information to the message not communicated in speech, or (d) contradict information communicated in speech. These patterns of gestural communication are indicative of sensitivity to the infant's limited comprehension of verbal information and may help to provide the infant with contextual clues to the spoken language (Iverson et al., 2006).

Patterns of Maternal Gesture Use

A description of maternal gestural patterns when communicating with their typically developing infants was provided by O'Neill et al. (2005). Twelve mother-child dyads were videotaped in two 5-minute sessions (e.g., free play session and a counting task) when the children were 20 months old. During the structured counting task, the child was instructed to count the toys in a basket and mothers were told they could give as much guidance and support as needed. Across both tasks, gestures accounted for 29% (free play) and 28% (structured counting task) of all maternal communication, thus gesture rates were fairly high across contexts. Across both tasks, deictic gestures were the most frequent type with pointing accounting for a majority of deictic gestures. The majority of gestures produced in both sessions served to identify the referent of the accompanying speech (disambiguate) with no significant differences found across tasks (O'Neill et al., 2005). The mothers in this sample produced simultaneous speech and gesture in 25% of their communicative acts, thus accounting for a marginal portion of their child directed speech.

Maternal Gesture and Child Language and Gestural Development

Previous research has highlighted the importance of maternal gesture on a child's gestural and language development. Several studies have demonstrated the association between a mother's use of gestures and the infant's gesture production in typical development, which indirectly influences the child's vocabulary size (Goldin-Meadow et. al, 2007; Iverson & Goldin-Meadow, 2005; Rowe & Goldin-Meadow, 2009; Rowe et al., 2008). Namy, Acredolo, and Goodwyn (2000) examined how 14-month-old infants (n = 80) understand the verbal and gestural production of their mothers and studied whether these productions aid the infant's acquisition of gestures. Namy and colleagues demonstrated the importance of spontaneous communications from mothers to their children during two different contexts (i.e., a picture book task and free play session; Namy et al., 2000). Specifically, parents produced verbal and gestural labels during the session; however, gestures were produced at a much lower rate than verbal labels. Gestural labels were defined as "gestures that depicted some feature or aspect of the indicated object" (p. 69). This definition of gestural labels excluded all deictic gestures. The infants were found to produce very few gestural labels during these interactions, yet all infant gestural labels were imitations of those previously produced by the parents. Furthermore, the infants did not produce verbal labels, suggesting that infants may find gestural input interesting and are likely to imitate. This suggests that frequency of gestural input produced by the parents directly impacts the acquisition of gestures by the infants. Results showed a strong correlation between the amount of mothers' gesture production and subsequent gesture production by the infants. The Namy et al. (2000) study also showed that infants spontaneously imitate gestures produced by the mothers

(Namy et al., 2000). This study also demonstrated that while parents use gestures less than verbal labels, they still produce a significant amount of gestural input to their infants.

In a longitudinal study of 17 parent-child dyads by Namy and Nolan (2004), the relationship between parental verbal and gestural labeling and child vocabulary development was studied. Each parent-child dyad completed a 10-minute free play session in the laboratory when the child was 12, 18, and 24 months of age. Videotaped sessions were coded for parent production of verbal labels and gestures. In this study, gestural labeling was significantly lower at 24 months than at 12 or 18 months. This finding suggests that there is a developmental change in the parent's use of gestures and that as the child becomes more verbal, the parent's use of gesture as a scaffold for language decreases.

A longitudinal study (Zammit & Schafer, 2011) of maternal communicative behaviors in 10 mother-child dyads investigated the role of specific types of maternal gesture and word learning behavior in 10-month-old infants. Each dyad was videotaped in two experimental conditions and one unstructured play session on a monthly basis from 9 months until 26 months of age. During the experimental sessions, the mothers were asked to talk about specific nouns for 20 seconds each and all observations were coded for speech and gesture production by the mothers. In one experimental condition, parents were presented with a succession of words projected onto a wall and asked to talk about the word with their child for 20 seconds. In the second condition, a picture of the target noun (e.g., a picture of an apple) was projected onto the wall where the mother was again instructed to speak with her child about the word for 20 seconds. Results of the experimental session found that mothers used verbal labels without accompanying gestures more frequently during the word task than during the picture task. During the picture task, the mothers were more likely to combine speech and deictic gestures. A significant association between total maternal communicative acts and comprehension of target nouns by the child was found, suggesting that children of mothers who produced a large number of communicative acts were more likely to learn words earlier than those children whose mothers produced fewer communicative acts. When controlling for sheer number of communicative acts, the researchers found a significant relationship between the mother's use of iconic gestures (i.e., representational gestures) when paired with verbal labeling and the child's acquisition of comprehension of target nouns, suggesting that some mothers use gesture in order to aid a child's receptive vocabulary growth.

Iverson et al. (1999) demonstrated that the frequency of maternal gesture use is related to concurrent gesture use in young children. In this study, 12 Italian mother-child dyads participated in two videotaped interactions in the home when the child was 16 and 20 months old. Each videotaped observation lasted around 45 minutes and mothers were instructed to play with their child as they normally would across three different contexts (play with new objects, play with familiar objects, and meal/snack time). Overall, when the mothers produced gestures, the majority of these gestures were classified as deictic with pointing as the most commonly used deictic gesture and acted to reinforce the message conveyed in speech. Further, maternal gesture was found to be related to concurrent child gesture and verbal production across observations.

Because a majority of parent's gesture is produced with simultaneous language (Iverson et al., 1999; O'Neill et al., 2005), it is difficult to ignore the influence of maternal language on infant language development. Research examining typically developing children has found a strong relationship between maternal gesture use and child language development; however, a direct link between gesture use and child language is not supported in the literature. Instead, the variety and frequency of maternal gesture use has been shown to function as a scaffold for the development of language (Goodwyn et al., 2000; Namy & Nolan, 2004; Namy et al., 2000; Rowe & Goldin-Meadow, 2009) and an infant's own use of gesture (Iverson et al., 1999).

Maternal Gesture Use in Children With Language or Other Developmental Delay

Maternal Gesture Use and Fragile X Syndrome

Given that infants with atypical development may not communicate the same way as their typically developing peers, it is expected that mothers of these infants may alter their communicative styles in ways that mothers of typically developing infants do not. In a study of mothers of children with Fragile X syndrome (FXS; Hahn, Zimmer, Brady, Romine, & Fleming, 2014), 30-minute videotaped home observations were collected during the child's 3rd year of life and again at 5 and 6 years of age. In this study, the authors reported a significant relationship between maternal gesture use and expressive language during the toddler period. Furthermore, a significant relationship between maternal gesture use during the toddler period and expressive and receptive language later in childhood (5 years) was also found. Thus, the language outcomes of children with FXS whose mothers used more gestures during the toddler period were significantly greater than those who did not gesture as much. The results of this study support the notion that even in atypical development, and when language is severely delayed, there is a strong relationship between parental communicative input and child language.

Maternal Gesture Use and Down Syndrome

Iverson et al. (2006) examined gesture production in five mothers of children with Down syndrome (mean chronological age = 47.6 months; mean mental age = 22.4 months) during a 30-minute videotaped free play session in their homes. As seen in children with FXS, children with DS show significant impairments in cognitive and language development. In this sample, mothers of children with DS were matched to mothers of typically developing children on child expressive language levels. In both groups, a significant proportion of the mother's overall gesture production consisted of deictic gestures. Mothers of children with DS, however, were shown to produce significantly fewer points and substantially more shows than the mothers of typically developing children. Mothers of children with DS also produced fewer representational and conventional gestures than mothers of typically developing children. These findings support the notion that mothers of children with DS simplify their communicative patterns when interacting with their children in a manner that is not observed in mothers of children with typical development, despite being matched on expressive language levels.

Maternal Gesture Use and Late Talkers

During a structured spatial relationship task in the laboratory, a sample of nine German late-talking children (aged 22-25 months) and their mothers were videotaped in order to assess the role of gestural input on comprehension of instructions (Grimminger, Rohlfing, & Stenneken, 2010). Mothers of the late-talking children were found to gesture more than mothers of typically developing children, and also held their gestures for longer durations. Similar to the findings reported in other populations, the mothers of late-talkers produced deictic gestures at a significantly higher rate than other types of gestures (accounting for 74% of all gestures). Within the category of deictic gestures, the majority were pointing gestures (97%). Overall, the results show that the mothers of late-talking children produce more gestural scaffolds than mothers of typically developing children, as the mean proportion of gesture to speech was higher in the late talking group. Thus, the literature suggests that when mothers are communicating with their late-talking children, they seem to aid comprehension of the verbal message by using visual (gestural) cues (Grimminger et al., 2010).

Maternal Gesture Use and ASD Infant Siblings

The results from two studies examining maternal gesture use in infants at risk for ASD based on having an older sibling diagnosed with ASD are mixed. One study found no differences between mother's gesture profiles in the ASD risk and typically developing groups (Mitchell, 2013). Another group (Talbott, Nelson, & Tager-Flusberg, 2015) found that mothers of high-risk infants gestured more frequently than mothers of low-risk typically developing infants. Further, in this sample, results showed that maternal gesture use at 12 months of age was positively associated with infants' language scores at 18 months of age. Findings from the Talbott et al. (2015) study indicated that mothers of high-risk infants (i.e., high risk based on genetic liability) might gesture more often in order to provide additional support to infants who demonstrate difficulties in communication. Given the known genetic risk of having one sibling with ASD, it may be that known risk status is influencing the way parents behave during early communicative interactions with their children (Talbott et al., 2015). That is to say that mothers of high-risk infants may use some of the communicative modifications they have learned from interacting with the older sibling with ASD, in their interactions with the high-risk infant.

Purpose of the Study

Overall, research on typically developing children has demonstrated an important relationship between maternal gesture use and child gesture and language development. There is limited research, however, examining maternal gesture use and its relationship to both language and social communication development in young children with delays. The purpose of this study was to examine the gesture profiles of mothers of toddlers with an expressive and receptive language delay who thus are at increased risk for persistent difficulties including ASD. In addition to examining maternal gesture profiles, the relationship between maternal gesture and child gesture, language, and ASD risk was examined. To date, no studies have been published that have examined maternal gesture use in toddlers who are at risk for developing ASD due to a receptive and expressive language delay. Infants who are at increased risk for developing ASD, however, have been found to display both a delay in spoken language and communication, including gesture production (Paul et al., 2011). Given this pattern of delayed communication associated with ASD, investigation of the relationship between maternal gesture use and language development may be expressly important in children at increased risk for the disorder.

Research Questions

The following research questions were examined for this dissertation:

1. As compared to mothers of typically developing toddlers, do mothers of toddlers with a language delay use gestures at the same frequency (MG Tokens) and convey a similar number of meanings (MG Types), in a naturalistic interaction with their toddlers?
2. As compared to mothers of typically developing toddlers, do mothers of toddlers with a language delay display the same frequency of gesture categories (i.e., deictic, representational, conventional, emphatic) in a naturalistic interaction with their toddlers?
3. As compared to mothers of typically developing toddlers, do mothers of toddlers with a language delay differ in the frequency of gesture strategies (i.e., to emphasize meaning, disambiguate, add information, or contradict verbal information) to convey information between gesture and spoken language?
4. Does maternal gesture use during the toddler period correlate with child receptive and expressive language development, and gesture use in typically developing children?
5. Does maternal gesture use during the toddler period correlate with child receptive and expressive language development, and gesture use in toddlers with language delay?
6. In toddlers with language delay, does maternal gesture use correlate with ASD risk as measured on the Autism Diagnostic Observation Schedule (ADOS)?
7. As compared to mothers of toddlers with a language delay, do mothers of children

who meet research cutoff for ASD risk on the ADOS-2 Toddler module use gestures at the same frequency (MG Tokens) and convey a similar number of meanings (MG Types) in a naturalistic interaction with their toddlers?

8. As compared to mothers of toddlers with a language delay, do mothers of toddlers do mothers of children who meet research cutoff for ASD risk on the ADOS-2 Toddler module display the same frequency of types of gestures (i.e., deictic, representational, conventional, emphatic) in a naturalistic interaction with their toddlers?
9. As compared to mothers of toddlers with a language delay, do mothers of children who meet research cutoff for ASD risk on the ADOS-2 Toddler module display the same frequency of gesture strategies (i.e., to emphasize meaning, disambiguate, add information, or contradict verbal information) to convey information between gesture and spoken language?

2. METHOD

Participants

Two groups of mother-toddler dyads participated in this study: one with expressive and receptive language delay ($n = 27$) and one typically developing control group ($n = 27$). Participants were initially recruited through the Utah Toddler Study, a larger longitudinal research project examining language delay as a risk factor for ASD in young children. This longitudinal study was conducted in the University of Utah Early Childhood Communication Laboratory under the direction of Stacy Manwaring. Collaborators in the Pediatrics and Developmental Neuroscience Branch of the intramural program of the National Institute of Mental Health (NIH) in Bethesda, Maryland conducted a similar study and the two sites shared data in order to have a larger comparison sample. The current study included a subset of participants from the larger study.

Inclusion/Exclusion Criteria

Inclusionary criteria were set at the onset of the larger longitudinal study. All children who participated in the study were screened for the following exclusionary criteria: (1) primary language other than English, (2) prematurity at birth (gestational age < 36 weeks), (3) birth weight significantly below normal for gestational age (small for gestational age), (4) significant birth trauma, motor, or other medical impairment deemed responsible for delays, and (5) known genetic disorder. Based on an evaluation at 18 months of age (+/- 2 months), children were categorized into two groups: language delay (LD) or typically developing (TD) control. Language delay was defined as expressive and receptive language scores in the "Very Low" range (≥ 2 standard deviations below the mean) on the Mullen Scales of Early Learning (MSEL; Mullen, 1995). Children in the TD group demonstrated development within the age expected range on the MSEL (scores on all four domains of the Mullen Scales of Early Learning ≤ 1.25 standard deviations below the mean (*T*-scores ≥ 37), had no known neurodevelopmental disorder, and had no first-degree relatives diagnosed with ASD.

Additional inclusionary criteria were established for the participants in the current study. Toddlers included in the final sample had (a) completed a parent-child interaction at the 18-month study visit, and (b) completed direct measures at 18- and 24-month time points.

Current Study Participants

Data from a total of 89 toddlers, 29 LD and 60 TD, were included in the initial matching pool for this study. Children in the TD group were matched to the LD group on age, gender, and maternal education level (SES). After matching, the final sample consisted of a total of 54 toddlers, 27 identified as LD and 27 TD. As part of their participation in the larger study, consent was obtained in person prior to completing the child's first evaluation.

Demographic information for the mothers included in the final sample is reported in Table 1. For a small number of toddlers (5 LD, 5 TD), fathers participated in the parent child interaction and were included in these analyses. For ease of interpretation, all parents are referred to as “mothers.” Mothers ranged in age from 23-44 years, with similar mean ages in each group (*t* (49) = -0.84, *p* = 0.41). The majority of the mothers in both groups completed a higher education degree (college degree or graduate school); thus, both groups had similar education levels (SES; $\chi^2 = 3.64$, $p = 0.30$).

Table 2 outlines the demographic information for toddlers included in this study. The toddlers ranged in age from 16-22 months at the time of the 18-month study visit and 23-28 months at the 24-month visit with similar means at each time point ($\Lambda = 0.99$, $F(2, 51) = 0.11$, $p = 0.90$). The majority of the toddlers in the sample were White, non-Hispanic/Latino. The LD group included more African American/Black participants than did the TD group; however, toddlers did not differ significantly on race ($\chi^2 = 7.89$, $p = 0.10$) or ethnicity ($\chi^2 = 1.40$, $p = 0.50$).

A summary of toddler developmental characteristics obtained at the 18- and 24-month visits is detailed in Table 3. As expected, toddlers in the LD group had significantly lower scores than the TD group on verbal mental age (*t* (52) = 12.62, $p \leq 0.01$), expressive (*t* (52) = 11.88, $p \leq 0.01$) and receptive (*t* (52) = 11.20, $p \leq 0.01$) language. Additionally, the LD group was significantly different than the LD group on 18-month child nonverbal mental age (*t* (52) = 5.25, $p \leq 0.01$), total gesture on the CSBS (*t* (52) = 5.27, $p \leq 0.01$), and early gestures on the MCDI (*t* (45) = 6.18, $p \leq 0.01$).

Measures

Parent-child Interaction

Maternal gestures were coded from videotaped mother-child play interaction collected when the children were 18 months of age. During the free play session, the mother and child were provided with a variety of age-appropriate toys (books, toy farm set with animals, toy garage and cars, cooking set with food and baby doll, foam blocks, shape sorter, and a plastic ball) and instructed to "play as you normally would" for 15-minutes.

Mullen Scales of Early Learning

The Mullen Scales of Early Learning (MSEL; Mullen, 1995*)* is a standardized developmental assessment for children birth to 68 months of age. Four cognitive domain scores (Fine Motor, Visual Reception, Expressive Language, and Receptive Language) as well as Gross Motor skills are measured. Internal consistency reliability for the Mullen has median values ranging from 0.75 to 0.83 with internal reliability of the Mullen Early Learning Composite score having a median value of 0.91. Test-retest reliability ranges from 0.71 to 0.96, and shows a high degree of stability over time in children under 24-months of age. The Mullen is highly correlated with other measures of language ability in young children with correlations ranging from 0.65 to 0.82 (Mullen, 1995).

Communication and Symbolic Behavior Scales Developmental Profile

The Communication and Symbolic Behavior Scales Developmental Profile-Behavior Sample (CSBS; Wetherby & Prizant, 2002) is a norm-referenced assessment that measures the communication and symbolic ability of children under 2 years of age. The CSBS Behavior Sample is a semistructured, videotaped assessment conducted by a trained clinician with a parent present. The CSBS Behavior Sample takes approximately 30 minutes to administer and consists of play activities designed to elicit spontaneous social communication behaviors, including gestures. Three composite scores (Social, Speech, and Symbolic) and a Total Score are derived from the individual scales on the Behavior Sample. Predictive validity of the CSBS-DP behavior sample and outcome measures at 24 months accounted for between 34 and 53% of total variance in receptive and expressive language (Wetherby et al., 2002).

McArthur Communication Developmental Inventory Words and Gestures

The McArthur Communication Developmental Inventory Words and Gestures Form (MCDI-WG; Fenson et al., 2003*)* includes a 396 item vocabulary checklist in which parents indicate which words their child understands and uses as well as an inventory of the child's use of early and late communicative gestures. There are 63 total gestures inlcuded on the MCDI-WG checklist which are organized into five categories: first communicative gestures (including deictic and representational), games and routines, actions with objects, pretending to be a parent, and imitating other adult actions. Early communicative gestures include the items in the first communicative gestures and games and routines categories, while late communicative gestures are comprised of actions with objects, pretending to be a parent, and imitating other adult actions. Results of a large-scale standardization study yielded high levels of reliability and validity for all subscales. Internal consistency for the gesture subscales was reported as Chronbach's $\alpha = 0.79$.

<u>Autism Diagnostic Observation Schedule, 2nd Edition</u>

The Autism Diagnostic Observation Schedule, 2nd Edition *(*ADOS-2; Lord et al., 2012*)* is a semistructured observation designed to assess social and communicative functioning as well as restricted interests and repetitive behaviors in individuals suspected of having ASD. The ADOS-2 consists of five modules (Toddler and 1-4), one of which is selected according to the child's language and developmental level. The children in this study were administered the Toddler Module as is appropriate for children under 30 months of age. The Toddler Module algorithm yields domain scores in the area of Social Affect and Restricted, Repetitive Behaviors, as well as a total score that defines research cutoff, which indicates risk for ASD diagnostic status.

Design

This study used a descriptive design examining between and within group differences. Data were obtained longitudinaly across two observations, 6 months apart (mean of 5.89 months). Maternal and child gesture use were measured at Time 1 (18-month visit) and toddler expressive and receptive language were measured at Time 1 and Time 2 (24-month visit). ASD risk status was measured at Time 2.

<u>Procedure</u>

As described, this dissertation was part of a larger longitudinal project at the University of Utah. The purpose of the larger longitudinal study was to examine toddlers with significant receptive and expressive language delay for outcomes such as ASD, and compare them to a group of typically developing infants with no history of delay. A subset of participants from the larger study were included in the current project. As part of their participation in the larger project, toddlers were evaluated at 18 and 24 months of age. At the 18 and 24 month visits, trained research staff conducted a comprehensive developmental evaluation and the mother and toddler also engaged in a 15-minute parent-child interaction during the evaluation. The current project was approved by the Institutional Review Board at the University of Utah on May 2, 2016.

Maternal Gesture Coding

Maternal gesture use was coded from the video recorded parent-child interaction obtained at the 18-month visit. A novel maternal gesture coding scheme was developed based on extensive review of the literature on maternal gesture use (see Appendix A). The coding scheme was based on adaptations of previous coding schemes described across the literature on maternal gestures (e.g., Iverson et al., 1999; Iverson et al., 2006; O'Neil et al., 2005; Zammitt et al., 2011). Maternal gestures were coded according to category (e.g., deictic, representational, conventional, etc.), and specific type (e.g., pointing, waving, etc) using ELAN, a computer-based coding software (version 4.9.1; Lausberg & Sloetjes, 2009). All communicative maternal gestures were coded. For each gesture coded, a subsequent code was assigned addressing whether or not the gesture was accompanied by maternal speech, and the relationship between the gesture and speech (e.g., adding, disambiguating, emphasizing, or contradicting). Further, presence of toddler attention was coded for each gesture produced by the mother. For deictic gestures, toddler attention was defined as the child looking at the referent or the gesture (e.g., the mother's hand during the production of a point gesture). For representational, conventional, and emphatic gestures, toddler attention was defined as looking towards the mother while she was gesturing. A description of each maternal gesture code with an example is provided in Table 4.

Reliability

Two students (one graduate and one undergraduate) were recruited to code the mother-child play interaction videos. The coders were blind to group membership and videos were randomly assigned to coders and counterbalanced across clinical groups so that one coder did not code all of the mothers in the LD group. The PI coded for reliability in addition to a subset of samples exclusively from the NIH site in order to control for bias as the PI was one of the clinicians for participants at the University of Utah and thus was not blind to diagnostic outcome. Training sessions were conducted with the coders in which the definitions of each of the types of gestures and informational relationship between speech and gesture were reviewed. The coders then practiced coding via preselected training samples until they reached 80% reliability on three consecutive training videos for each of the following variables: (1) gesture identification, (2) gesture type, (3) occurance of speech, (4) informational relationship between speech and gesture, (5) referent/gloss, and (6) child attention to the gesture. All coding disagreements were reviewed with the PI and other coders. After meeting initial reliability on three consecutive training samples, coders began coding the data for included participants.

Interrater reliability was calculated using percentage agreement for 44.23% of the video samples. While Cohen's kappa is frequently used as a calculation of reliability, several limitations prohibit its applicability in this circumstance. Most notably, the kappa technique is limited when behaviors are observed at very low or high rates. Specifically, if a behavior is not frequently observed, yet interobserver agreement is acceptable, the value of kappa may indicate poor reliability (Cunningham, 2009). Table 5 shows percent agreement for the reliability variables of: identification of a gesture, gesture type, referent, speech identification, and informational relationship between gesture and speech. Initially, reliability on the informational relationship variable fell below 80% (78.57 %) for five samples. As a result, the PI conducted an additional training session including a review of operational definitions, video examples of each code, and independent coding of samples that were compared across both coders and the investigator for reliability. After reliability was reestablished, the coders reviewed all previously coded samples and corrected the informational relationship variable when warranted.

Dependent Variables

Maternal Gesture

Maternal gestures were derived from the 15-minute parent-child interaction at the toddler 18-month study visit. Frequency of maternal gesture was defined as the total number of gestures produced (MG Tokens). In additional to Tokens, the number of different meanings conveyed through gesture (MG Types) was also calculated by summing the number of different referents identified by a deictic gesture or the number of different meanings (gloss) conveyed by a representational or conventional gesture. For example, if a mother pointed to a book, then nodded her head yes, then pointed back to the book, that was counted as three gesture Tokens and two gesture Types. Gestures broken down by category (gesture category; i.e., deictic, conventional, representational, emphatic) and the relationship between gesture and speech (gesture strategy; i.e., gesture only, emphasizing, disambiguating, adding, contradicting) were also assessed.

Child Language

Toddlers' language skills were assessed at 18 and 24 months of age using standardized observational methods and parent informant measures. Standardized observational measures of language included expressive and receptive language age equivalent scores from the MSEL. The language change score from 18 to 24 months was calculated by subtracting the 18-month age equivalent score from the 24-month age equivalent for both expressive and receptive language separately thus representing the gain (or loss) in language skills over a 6-month time period.

Child Gesture

Child gestures were derived from the CSBS Behavior Sample. Gestures on the CSBS Behavior Sample are defined as a nonvocal behaviors directed towards another person which serve a communicative function. The total gesture score from the CSBS Behavior Sample, which is comprised of the total number of gestures a child uses out of 8 (gives, shows, pushes/pulls away, reaches, points, waves, nods head, and shakes head), and the number of distal gestures (out of 6), was included in this study.

The MCDI-WG provided parent report of the range of symbolic and communicative gestures used by the toddlers. The Early Gesture raw score was included for analyses, with the gestures measured on this subscale primarily communicative (e.g., pointing to request) and previously identified as strong predictors of child language in children with developmental delays (Luyster et al., 2008).

ASD Risk

Risk for ASD was based on ASD symptoms at 24-months of age evaluated using research cutoffs for ASD and nonspectrum on the Toddler Module of the ADOS-2. Separate algorithms are provided based on age and language level. Research cutoffs of a total score of 12 for toddlers with a chronological age of 12-20 months/Nonverbal (fewer than 5 words produced; 12-20/Nonverbal) and 10 for toddlers between 21-30 months/Some Words (5 or more words produced; V21-30) was used in determining ASD risk (Luyster et al., 2009). A validation study (Luyster et al., 2009) examining the predictive validity of these cutoff scores indicated good sensitivity (0.91 12-20/Nonverbal algorithm and 0.88 V21-30 algorithm) and specificity (0.91 12-20/Nonverbal; 0.91 V21-30). Toddlers in the LD group were further classified into two subgroups, LD-High Risk ASD (ADOS-2 Toddler Module 24-month algorithm score met research cutoff) or LD-Low Risk ASD (ADOS-2 Toddler Module 24-month algorithm score below research cutoff).

Table 1
Summary of Parent Demographics

Parent Demographic	LD (*n* = 27)	TD (*n* = 27)
Age in years (*M*, *SD*)	34.32 (4.61)	33.19 (5.01)
Gender (*n*, %)		
Male	5 (18.52%)	5 (18.52%)
Female	22 (81.48%)	22 (81.48%)
Parent Education (n, %)		
High School	1(3.70%)	0 (0%)
Some college	4 (14.81%)	1(3.70%)
College degree	9 (33.33%)	9 (33.33%)
Graduate school	12 (44.44%)	17 (62.96%)

Table 2
Summary of Toddler Demographics

Toddler Demographic	LD (*n* = 27)	TD (*n* = 27)
Age in months (*M*, *SD*)		
Age at 18 month visit	18.78 (1.53)	18.67 (1.27)
Age at 24 month visit	24.67 (1.11)	24.56 (.80)
Gender (*n*, %)		
Male	19 (70.37%)	19 (70.37%)
Female	8 (29.63%)	8 (29.63%)
Race (*n*, %)		
African American/Black	5 (18.52%)	0 (0%)
Asian	1(3.70%)	0 (0%)
Table 2 cont.		
White	19 (70.37%)	22 (81.48%)
Table 2 cont.		
Multiple Races	2(7.41%)	4 (14.81%)
Other/Unknown	0 (0%)	1(3.70%)
Ethnicity (*n*, %)		
Latino or Hispanic	3 (11.11%)	2 (7.41%)
Not Latino or Hispanic	21 (77.78%)	24 (88.89%)
Unknown	3 (11.11%)	1 (3.70%)

Table 3

Summary of Toddler Developmental Characteristics

	LD (*n* = 27)		TD (*n* = 27)	
Measure	18-month	24-month	18-month	24-month
MSEL (*M*, *SD*)				
Nonverbal Mental Age[a]	16.67(3.29)	22.19(4.34)	20.59(2.06)	27.48(2.72)
Verbal Mental Age[b]	9.48(2.71)	16.56(4.80)	19.44(3.08)	28.52(4.16)
Expressive Age Equivalent	9.37(2.79)	15.78(4.32)	17.48(2.19)	28.11(5.66)
Receptive Age Equivalent	9.44(3.47)	17.30(6.61)	21.33(4.29)	28.78(3.49)
EL Change Score[c]	6.41 (4.06)		10.63 (4.61)	
RL Change Score[d]	7.85 (6.59)		7.44 (3.58)	
CSBS-DP behavior sample				
Total Gesture[e]	8.96 (4.54)		15.00(3.75)	
MCDI-Words and Gesture				
Early Gestures[f]	8.80 (3.38)		14.36(2.70)	
ADOS-2 Toddler Module				
Social Affect		8.56 (6.28)		
Restricted Repetitive Behavior		2.70 (2.43)		
Total Score		11.26(8.12)		

[a] Nonverbal mental age is an average of the Visual Reception and Fine Motor scales.
[b] Verbal mental age is an average of the Receptive and Expressive Language scales.
[c] Difference score of 24mo EL-18mo EL AE
[d] Difference score of 24 mo RL- 18 mo RL AE
[e] Raw score (out of 16)
[f] Raw score (out of 18)

Table 4

Descriptions and Examples of Maternal Gesture Codes

Gesture Code	Description	Examples
Deictic	Indicate an object, location, or event. Used to refer to the object, location, or event by directly touching it or indicating it to the referent. Express the parent's communicative intent to call attention to certain objects, locations, people, or events.	POINT to an object/event or person. REACH to an object to express desire to obtain the object. GIVE an object to another person. SHOW an object to another person.
Representational	Represent a specific referent and the meaning does not differ across contexts. "Stand for" some referent.	TIPS OF FINGERS TOUCH IN A CIRCLE for "ball"; ARMS OUT TO SIDE "airplane".
Conventional	Meaning of the gesture is culturally defined and consistent across time.	HEAD NOD ("yes"); HEAD SHAKE ("no"); PALM UP ("give it to me")
Emphatic	Serve to highlight aspects of accompanying speech. Typically executed in rhythmic fashion when two adults are speaking to one another. Used to emphasize specific elements of speech	FIST TO OPEN PALM to stress feeling strongly about something.
Gesture Strategy		
Gesture Only	Gesture was executed with no accompanying speech	PALM UP with no accompanying speech
Emphasizing	Gesture conveyed the same message as speech	Saying "no" while SHAKING HEAD; SHOWING a bananna while saying "bananna".

Table 4 cont.

Gesture Code	**Description**	**Examples**
Disambiguating	Gesture identifies the precise referent of the speech; Gesture clarifies speech.	“Do you see this” while SHOWING a toy bear; “This one” while POINTING to a car.
Adding	Gesture conveys information not provided in the accompanying speech.	SHOWING a toy cow while saying “moo”; POINTING to a picture of a boy and saying “sad”.
Contradicting	Gestural information is unrelated to the verbal utterance.	SHAKING HEAD while saying “I know”. BECKONING while counting “one, two”.

Table 5
Percentage Agreement for Maternal Gestures

Code	Percent Agreement
Gesture Identification	86.38
Gesture Type	93.89
Gesture and Speech or Gesture Only	91.10
Informational Relationship between Speech and Gesture[a]	87.64
Referent/Gloss	93.40
Child Attention to the Gesture	82.26

[a]Informational Relationship percent agreement is reported for post-training samples.

3. RESULTS

Preliminary Data Analyses

Statistical tests were conducted using the Statistical Package for the Social Sciences (SPSS) version 20. Potential sources of bias including violations of normality, homogeneity of variance, linearity, independence, and outliers were evaluated prior to selecting a statistical model (parametric versus nonparametric). Results of analyses of normality are presented within each research question including identification of outliers, skewness, and kertosis. Variables for which skewness and kurtosis values fell outside of the range +2 to -2 are reported (George & Mallery, 2010). For all analyses, α was set at < 0.05.

Data Analyses

Parametric Tests

Simple effect contrasts (e.g., one dependent variable) were conducted with independent sample *t*-tests or one-way analysis of variance (ANOVA). A multivariate analysis of variance (MANOVA) was used to evaluate hypotheses with more than one depenedent variable. Effect sizes for parametric tests were reported as Cohen's *d* where 0.2 is considered a small effect size, 0.5 a medium effect, and 0.8 large (Cohen, 1992).

Profile Analysis

Research questions that addressed between and within group comparisons were analyzed using a profile analysis. A profile analysis is a special application of a mixed model ANOVA (Shelton, 1998). The profile analysis was selected as the most approriate statistical method to address research questions related to group differences on gesture type and gesture-speech relationship, as both of these contrasts involved several dependent variables measured on the same scale (i.e., frequency). Profile analysis is commonly used to identify patterns in several subscales of one instrument and may be helpful in identifying group differences in data when traditional statsitical methods may not be effective or effects are more subtle. Data are visually inspected to answer the following questions: (1) are the profiles parallel; (2) if the profiles are parallel, are they coincident (i.e., is one group higher or lower on average); and (3) if the profiles are coincident, are they level/flat (i.e., do each of the variables occur at the same frequency)? A significant group effect suggests that the profile is different for the two groups and the actual nature of the differences is then investigated with further analyses, including univariate tests. If no significant group effect is found, it still leaves the possibility that there are level differences between the groups (within-group differences). Effect size is reported as partial eta squared (η^2) where values of 0.01, 0.06, and 0.14 are considered small, medium, and large effect sizes, respectively (Green & Salkind, 2003).

Results are presented below in order of research question as outlined in the Introduction section. Mothers of LD toddlers were compared to TD on the following: (a) the number of total gestures produced during the 15-minute PCI, (b) the number of different meanings conveyed by the gestures, (c) the distribution of frequency of total gesture by gesture category (i.e., deictic, conventional, representational, emphatic), and (d) the informational relationship between gesture and speech (i.e., gesture only, emphasizing, disambiguating, adding, contradicting). Comparisons between mothers of toddlers in the LD group who met research cuttoff on the ADOS-2 at 24 months (High Risk ASD) and mothers of toddlers in the LD group who did not meet research cutoff (Low Risk ASD) were conducted on the same variables. Group differences in maternal gesture and the informational relationship between gesture and speech are reported first, followed by an analysis of the relationship between maternal gesture and child gesture and language. A comparison of High Risk ASD and Low Risk ASD subgroups is presented last.

Group Differences in Maternal Gesture

A one-way MANOVA was used to determine whether mothers of LD toddlers differed from mothers of TD toddlers on the number of gestures produced (MG Tokens) and number of different meanings conveyed through gesture (MG Types) at the 18-month time point. Preliminary assumption checking revealed that within the TD group, the MG Types variable was platykurtic with few scores at the tail of the distribution; there were no univariate or multivariate outliers as assessed by boxplot; and there was homogeneity of variance-covariance as assessed by Box's M test ($p = 0.25$).

Descriptive statistics for maternal gesture variables are presented in Table 6. Results of the MANOVA yielded no significant effect of group on the number of gestures produced by the mothers or the number of different meanings conveyed by the gestures, Wilks' $\Lambda = 0.99$, $F(2, 51) = 0.27$, $p = 0.76$, partial $\eta^2 = 0.01$. Specifically, mothers of toddlers in the LD group used an average of 28.26 (14.49) gestures conveying an average of 14.04 (4.57) different meanings and mothers in the TD group used 30.70 (17.40) gestures conveying 15.11 (6.23) different meanings during the 15-minute PCI.

Group Differences by Gesture Category

To examine the hypothesis that mothers of toddlers in the LD group would display similar frequency distributions of gesture by category, a profile analysis was conducted. The independent variable was group (LD, TD) and the dependent variable was frequency of gesture by category (deictic, representational, conventional). The distributions of all gesture categories were not normal for both groups. Within the TD group, the distribution of representational gestures was leptokurtic and positively skewed. Within the LD group, the distribution of representational gestures was leptokurtic. As ANOVA is considered a robust test against the normality assumption, no transformations were completed. Two significant outliers within the representational category were identified but were not removed from the data as they were determined to be representative of the data and thus accurate data points. The assumption of homogeneity of variances was violated for conventional gestures, thus a Welch correction was performed. Maulchly's test of sphericity indicated that the assumption of sphericity was violated for the two-way interaction $\chi^2(2) = 29.57$, $p < 0.01$, so a Greenhouse-Geisser correction was used.

Table 7 shows the mean frequencies of gesture by category. As only one emphatic gesture was observed in the TD group and no emphatic gestures observed in the LD group, emphatic gestures were not included in the profile analysis.

Two-way interaction effects. The profile plots of gesture by category for each group are displayed in Figure 1. There was no statistically significant interaction between group and gesture category, F (1.39, 72.23) = 0.83, p = 0.40, partial $\eta^2 = 0.02$ and thus the profiles were found to be parallel.

Between-group effects. The main effect of group showed that there was not a statistically significant difference in mean gesture frequency between groups F (1, 52) = 0.31, p = 0.58, partial $\eta^2 = 0.01$ and thus the profiles were found to be coincident.

Within-group effects. The main effect of frequency of gesture by category showed that there was a statistically significant difference in mean gesture use by category F (1.39, 72.23) = 88.63, $p < 0.01$, partial $\eta^2 = 0.63$ and thus the means were not equal across gesture categories. Mothers in both groups had higher rates of deictic gestures than representational or conventional. Post-hoc pairwise comparisons were then conducted to determine whether the mean frequency of deictic gesture was significantly different than conventional or representational gestures. A Bonferroni correction was conducted by dividing 0.05 by 2 comparisons resulting in a test $\alpha = 0.025$. Within the LD group, mothers used significantly more deictic gestures than representational (t (26) = 7.94, $p < 0.001$, d = 3.11), or conventional (t (26) = 5.60, $p < 0.001$, d = 2.20). Within-group comparisons for mothers in the TD group revealed a similar pattern with mothers using significantly more deictic than representational (t (26) = 8.18, $p < 0.001$, d = 3.21) or conventional (t (26) = 5.23, $p < 0.001$, d = 2.05).

Deictic gesture use. The majority of gestures used across both groups of mothers were deictic. Therefore, an exploration of the specific deictic gesture types was also completed. Table 8 provides a summary of the mean frequency of all individual deictic gestures for each group.

Figure 2 displays the percentage of different types of deictic gestures used by each group. Overall, mothers in both groups used a greater percentage of deictic gestures that came into contact with the referent (shows, gives, and proximal points) than those used to indicate a referent at a distance (distal point, reach).

Group Differences in Gesture-Speech Relationship

To determine if the hypothesis that mothers in the LD group would display similar patterns of informational relationship between gesture-speech (gesture strategies), a profile analysis was conducted. The independent variable was group (LD, TD) and the dependent variable was frequency of the gesture-speech strategy (gesture only, emphasizing, disambiguating, adding, contradicting). For the LD group, the distribution of scores on gesture only were found to be positively skewed and leptokurtic. Within the LD group, the distribution of scores on gesture+contradicting was leptokurtic. In the LD group, one outlier was found in the gesture only distribution but was not removed from the data. No significant outliers were identified in the TD group. As the assumption of homogeneity of variances was violated for gesture and adding, a Welch correction was performed. The assumption of sphericity was not violated χ^2 (9) = 10.96, p = 0.28.

Table 9 shows the mean frequency of the gesture-speech relationship by category. Overall, the majority of gestures produced by mothers in both groups were accompanied by speech, 72.35% in the LD group and 83.59% in the TD group.

Two-way interaction effects. The profiles of gesture and speech strategy for each group are displayed in Figure 3. A statistically significant interaction between group and gesture-speech strategy was found F (4, 208) = 3.15, p = 0.02, partial $\eta^2 = 0.06$ meaning that the profiles of gesture strategies deviate significantly from parallelism. Given that the profiles are not parallel, the tests for coincident and levels are not meaningful. Instead, simple effect analyses were performed to determine the source of the deviation from parallelism.

Between-group effects. The profile analysis yielded a plot that suggested that mothers in the LD group had a higher frequency of gestures produced without speech (gesture only) than mothers in the TD group. Further, the profile plot also suggested that mothers in the LD group had a lower frequency of gestures that added information to the message conveyed in speech than did mothers in the TD group. Two post-hoc analyses were conducted to investigate these hypotheses. A Bonferroni correction was applied to set α for each test at 0.025 (0.05 divided by two comparisons). Results of the one-way ANOVA revealed that the difference between the LD and TD group on gesture only was not significant F (1, 52) = 3.87, p = 0.06, d = 0.55. The difference between groups on gestures that added information to speech was not statistically significant, Welch's F (1, 41.44) = 3.51, p = 0.07, d = 0.52.

Relationship to Child Gesture and Language

Pearson r correlations were conducted to examine the relationship between maternal gesture use and child language and gesture. Table 10 displays the intercorrelations of each of these variables.

LD group. MG Tokens were significantly negatively correlated with concurrent toddler receptive (p = 0.04) but not expressive (p = 0.71) language. Toddlers whose mothers had higher gesture total scores had lower receptive language scores. MG Tokens was also significantly negatively related to toddler expressive language change score (p = 0.02) but not receptive (p = 0.76). Toddler's whose mothers had higher gesture total scores made less gains in expressive language from 18-24 months. No significant relationship was found between MG and child gesture.

TD group. MG Tokens were significantly positively related to concurrent child gesture on the MCDI (p = 0.04). No significant relationship between MG and child language was found within the TD group.

Maternal Gesture Use and ASD Risk at 24-Months

Pearson r correlations were conducted to examine the relationship between maternal gesture use and toddler ASD risk at 24-months within the LD group. No significant relationship between MG Tokens (r = 0.35, p = 0.08) or MG Types (r = 0.19, p = 0.35) was found to ASD symptoms.

Maternal Gesture Use in Toddlers With LD: Comparison of High and Low ASD Risk Subgroups

Of the 27 toddlers in the LD group, 13 met research cutoff for ASD risk on the ADOS-2 Toddler module at 24 months. Mothers of these 13 toddlers (High Risk ASD) were compared to the 14 toddlers who were below cutoff for ASD on the ADOS-2 (Low Risk ASD). A one-way MANOVA was used to determine whether mothers in the Low Risk ASD subgroup differed from mothers in the High Risk ASD subgroup on MG Tokens or MG Types at the 18-month time point. Preliminary assumption checking revealed the distributions of each variable within each subgroup were normal; there were no univariate or multivariate outliers as assessed by boxplot; the assumption of homogeneity of variance-covariance as assessed by Box's M test was violated ($p = 0.01$) so Pillai's Trace statistic was interpreted.

No significant effect of group was found for MG Tokens or Types, $V = 0.20$, $F(2, 24) = 3.05$, $p = 0.07$, partial $\eta^2 = 0.20$. As shown in Table 11, mothers in the High Risk ASD subgroup were observed to use an average of 33.77 (17.03) gestures conveying an average of 15.08 (5.09) different meanings and mothers in the Low Risk ASD subgroup used 23.14 (9.67) gestures conveying 13.07 (3.97) different meanings during the 15-minute PCI.

Maternal Gesture Categories in Toddlers With LD: Comparison of High and Low ASD Risk Subgroups

A profile analysis was conducted to examine the hypothesis that mothers in the High Risk ASD subgroup would display a similar profile of gesture categories as mothers of toddlers in the Low Risk ASD subgroup. Preliminary assumption checking revealed that within the Low Risk ASD subgroup, the distribution of conventional gestures was platykurtic. No significant outliers were found within either subgroup. As the assumption of homogeneity of variances was violated for representational gestures, a Welch correction was performed. Maulchly's test of sphericity indicated that the assumption of sphericity was violated for the two-way interaction $\chi^2(2) = 29.96$, $p < 0.01$, so a Greenhouse-Geisser correction was used. Table 12 shows the mean frequency of gesture by category.

Two-way interaction effects. The profiles of gesture by category for each subgroup are displayed in Figure 4. There was no statistically significant interaction between group and gesture categories, F (1.17, 29.19) = 3.57, $p = 0.06$, partial $\eta^2 = 0.13$ and thus the profiles were found to be parallel.

Between-group effects. The main effect of group showed that there was not a statistically significant difference in mean gesture frequency between groups F (1, 25) = 4.05, $p = 0.06$, partial $\eta^2 = 0.14$ and thus the profiles were found to be coincident.

Within-group effects. The main effect of frequency of gesture by category showed that there was a statistically significant difference in mean gesture use by category F (1.17, 29.19) = 51.57, $p < 0.01$, partial $\eta^2 = 0.67$ and thus the means were not equal across gesture category. The profile analysis revealed a profile plot suggesting that mothers in both subgroups had higher rates of deictic gestures than representational or conventional. Post-hoc pairwise comparisons were then conducted to determine whether the mean frequency of deictic gesture was significantly different than conventional or representational gestures. A Bonferroni correction was conducted by dividing 0.05 by 2 comparisons resulting in a test $\alpha = 0.025$. Within the High Risk ASD subgroup, mothers used significantly more deictic gestures than representational (t (12) = 5.82, $p < 0.001$), or conventional (t (12) = 4.54, $p < 0.001$). Within group comparisons for mothers of toddlers in the Low Risk ASD subgroup revealed a similar pattern with mothers using significantly more deictic than representational (t (13) = 6.45, $p < 0.001$) or conventional (t (13) = 3.84, $p = 0.002$).

Deictic gesture use. An exploration of deictic gesture types was conducted for mothers in the High Risk ASD and Low Risk ASD subgroups. Table 13 provides a summary of the mean frequency of all individual deictic gestures for each subgroup. Mothers of toddlers in the High Risk ASD subgroup were found to produce significantly more gives than mothers in the Low Risk ASD subgroup, t (25) = -3.26, p = 0.003, d = -1.24.

Figure 5 displays the percentage of different types of deictic gestures used by mothers in each subgroup. Overall, mothers in both subgroups displayed more shows, gives, and proximal points than deictic gestures that indicate a referent at a distance (distal point, reach).

Maternal Gesture-Speech Relationship in Toddlers With LD:

Comparison of High and Low ASD Risk Groups

To determine if the hypothesis that mothers in the High and Low Risk ASD subgroups would display similar distributions of gesture strategies, a profile analysis was conducted. For the High Risk ASD subgroup, the distribution of scores on gesture only were found to be positively skewed and leptokurtic. Gestures that emphasized, added, and disambiguated speech were found to be platykurtic. Within the Low Risk ASD subgroup, the distribution of scores gesture strategies fell within the acceptable range of normality. In the High Risk ASD subgroup, one outlier was found in the gesture only distribution but was not removed from the data. No significant outliers were identified in the Low Risk ASD subgroup. As the assumption of homogeneity of variances was violated for gesture and adding, a Welch correction was performed. The assumption of sphericity was violated χ^2 (9) = 22.48, p = 0.01 so a Greenhouse-Geisser correction was used.

Table 14 displays the mean frequency of gesture strategies used by each subgroup. Overall, the majority of gestures produced by mothers in both subgroups were accompanied by speech, 74.98% in the Low Risk ASD subgroup, and 70.38% in the High Risk ASD subgroup.

Two-way interaction effects. The profiles of gesture strategy for each subgroup are displayed in Figure 6. No statistically significant interaction between group and gesture strategy was found F (3.16, 78.90) = 2.11, $p = 0.10$, partial $\eta^2 = 0.08$ meaning that the profiles of gesture strategies were parallel.

Between-group effects. The main effect of group showed that there were no statistically significant difference in mean gesture strategy frequency between groups F (1, 25) = 4.05, $p = 0.06$, partial $\eta^2 = 0.14$ and thus the profiles were found to be coincident.

Within-group effects. The main effect of frequency of gesture by gesture strategy showed that there was a statistically significant difference in mean gesture use by strategy F (3.16, 78.90) = 21.61, $p < 0.01$, partial $\eta^2 = 0.46$, thus the means were not equal across gesture strategies. The profile analysis revealed a profile plot suggesting that mothers in the High Risk ASD subgroup produced more gestures without accompanying speech (gesture only) and gestures that emphasized speech than other gesture strategies (adding, contradicting). To investigate this, a series of paired sample *t*-test comparisons were conducted. Alpha of 0.05 was achieved by setting each test at $\alpha = 0.013$ (0.05/4 comparisons). The results indicated that in the High Risk ASD subgroup, gestures were more often used in isolation (gesture only) than to add meaning (t (12) = 3.37, $p < 0.01$, d = 1.08) or to contradict the verbal message (t (12) = 4.32, $p < 0.01$, d = 1.51). When a gesture was combined with speech, mothers in the High Risk ASD subgroup were more likely to emphasize the message conveyed in speech than add information (t (12) = 4.73, $p < 0.01$, $d = 1.81$), or contradictory to the message conveyed in speech (t (12) = 7.03, $p < 0.01$, $d = 2.56$).

Toddler Attention to Maternal Gesture

While not an initial research question, toddler attention to maternal gestures was examined as a potential variable that may be influencing the relationship between maternal gesture use and toddler language and gesture. A post-hoc one-way ANOVA was conducted. Toddlers in both groups (LD and TD) showed similar levels of attention to maternal gesture production. Specifically, toddlers with LD attended to 68.28% of gestures compared to 70.53% in the TD group, F (1,52) = 0.46, $p = 0.50$, $d = 0.19$. Child attention to maternal gesture was also investigated within the LD group (High and Low Risk ASD subgroups). As the test for homogeneity of variances was significant, a Welch correction was used. Toddlers in both subgroups showed similar levels of attention ($M_{ASD} = 70.44$, $SD = 6.96$; $M_{LD} = 66.29$, $SD = 13.44$; F (1,19.81) = 1.04, $p = 0.32$, $d = 0.41$).

Table 6
Group Means by Maternal Gesture Frequency

	Group		Effect size (d) [a]
	LD (*n* = 27)	TD (*n* = 27)	LD-TD
Maternal Gesture Tokens (*M*, *SD*)	28.26 (14.48)	30.70(17.40)	0.15
Maternal Gesture Types (*M*, *SD*)	14.04 (4.57)	15.11 (6.23)	0.2

[a]Effect size based on Cohen's d ≥.20 is small, .50 is medium, and .80 is large

Table 7.
Group Means by Maternal Gesture Category

		Group		Effect size (d)
		LD (*n* = 27)	TD (*n* = 27)	LD-TD
Deictic	*M* (*SD*)	21.44 (13.62)	20.30(12.01)	0.09
	% of Total Gesture	75.87	66.12	
Representational	*M* (*SD*)	0.74 (1.35)	1.56 (3.50)	0.31
	% of Total Gesture	2.62	5.08	
Conventional	*M* (*SD*)	6.07 (4.23)	8.81 (7.50)	0.45
	% of Total Gesture	21.48	28.69	
Emphatic	*M* (*SD*)	0.00 (0.00)	.04 (0.19)	0.45
	% of Total Gesture	0	0.13	

Note. Due to rounding, percentage of total gesture in the LD group adds up to 99.97 and 100.02 in the TD group.

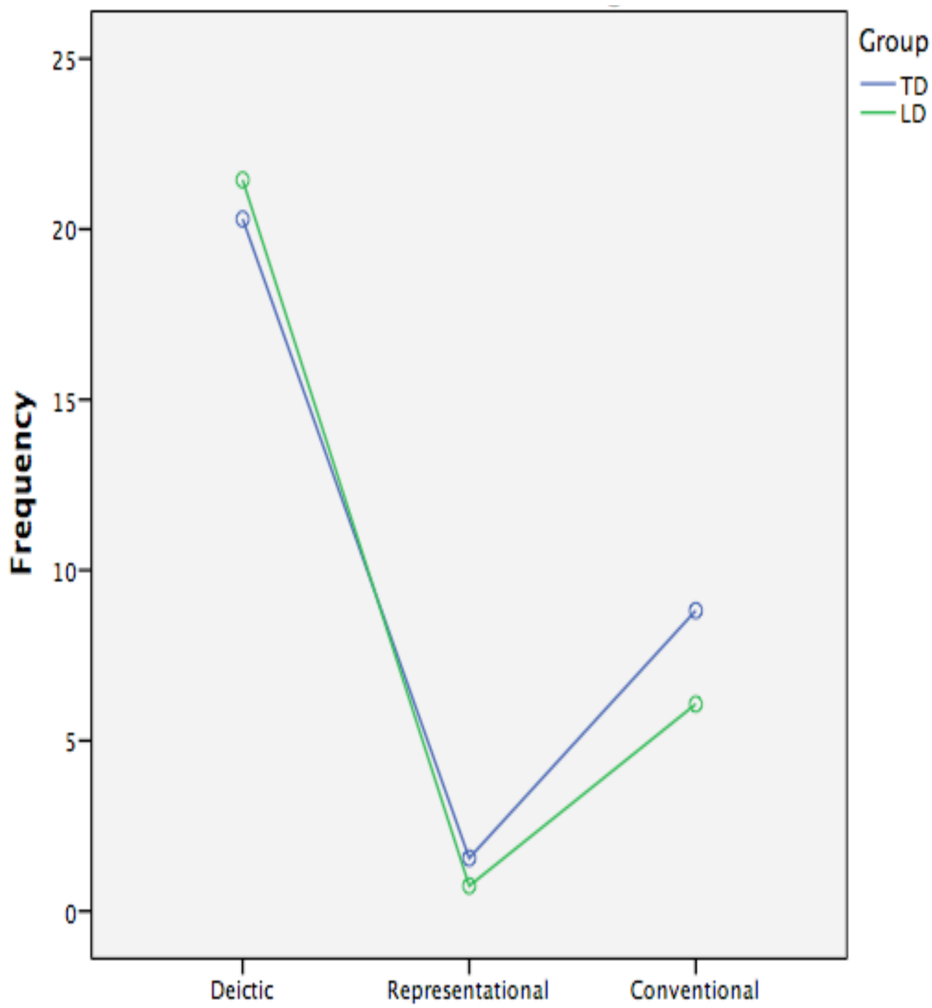

Figure 1. Distribution of Maternal Gesture by Category.

Table 8

Mean Frequency of Deictic Gestures Across Groups

	LD (*n* = 27)		TD (*n* = 27)		Effect size (d)
Measure	*M*	*SD*	*M*	*SD*	LD-TD
Proximal Point	6.04	4.83	8.00	6.32	-0.35
Distal Point	1.89	1.46	2.63	2.76	-0.34
Give	4.33	3.55	2.67	3.00	0.51
Reach	.07	.27	.33	.62	-0.54
Show	9.15	8.33	6.63	5.67	0.35

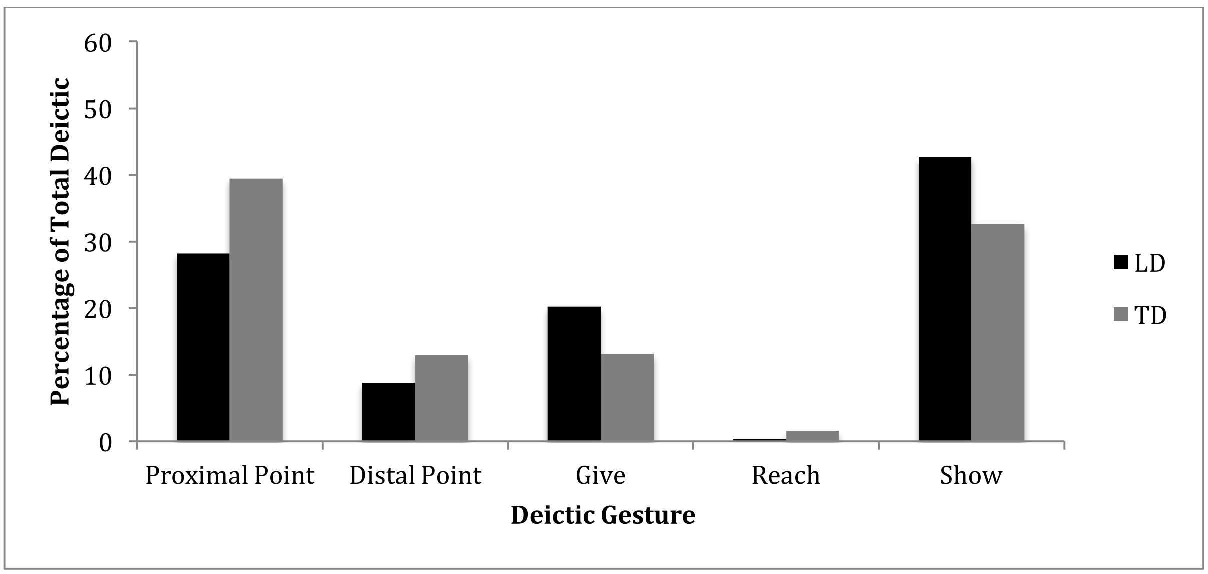

Figure 2. Percentage of Deictic Gestures in LD and TD Groups

Table 9.
Relationship Between Speech and Gesture

		Group		Effect size (d)
		LD (*n = 27)*	TD (*n = 27)*	LD-TD
Gesture Only	*M* (*SD*)	7.81 (6.58)	5.07 (3.03)	0.53
	% of Total Gesture	27.63	16.51	
Emphasizing	*M* (*SD*)	9.63 (5.70)	10.33 (6.43)	0.12
	% of Total Gesture	34.07	33.65	
Disambiguating	*M* (*SD*)	6.93 (4.78)	7.37 (5.85)	0.08
	% of Total Gesture	24.52	24.01	
Adding	*M* (*SD*)	2.52 (2.86)	4.59 (4.99)	-0.51
	% of Total Gesture	8.91	14.95	
Contradicting	*M* (*SD*)	1.37 (1.42)	3.37 (3.90)	-0.68
	% of Total Gesture	4.85	10.98	

Note. Due to rounding, percentage of total gesture in the LD group adds up to 99.98 and 100.1 in the TD group.

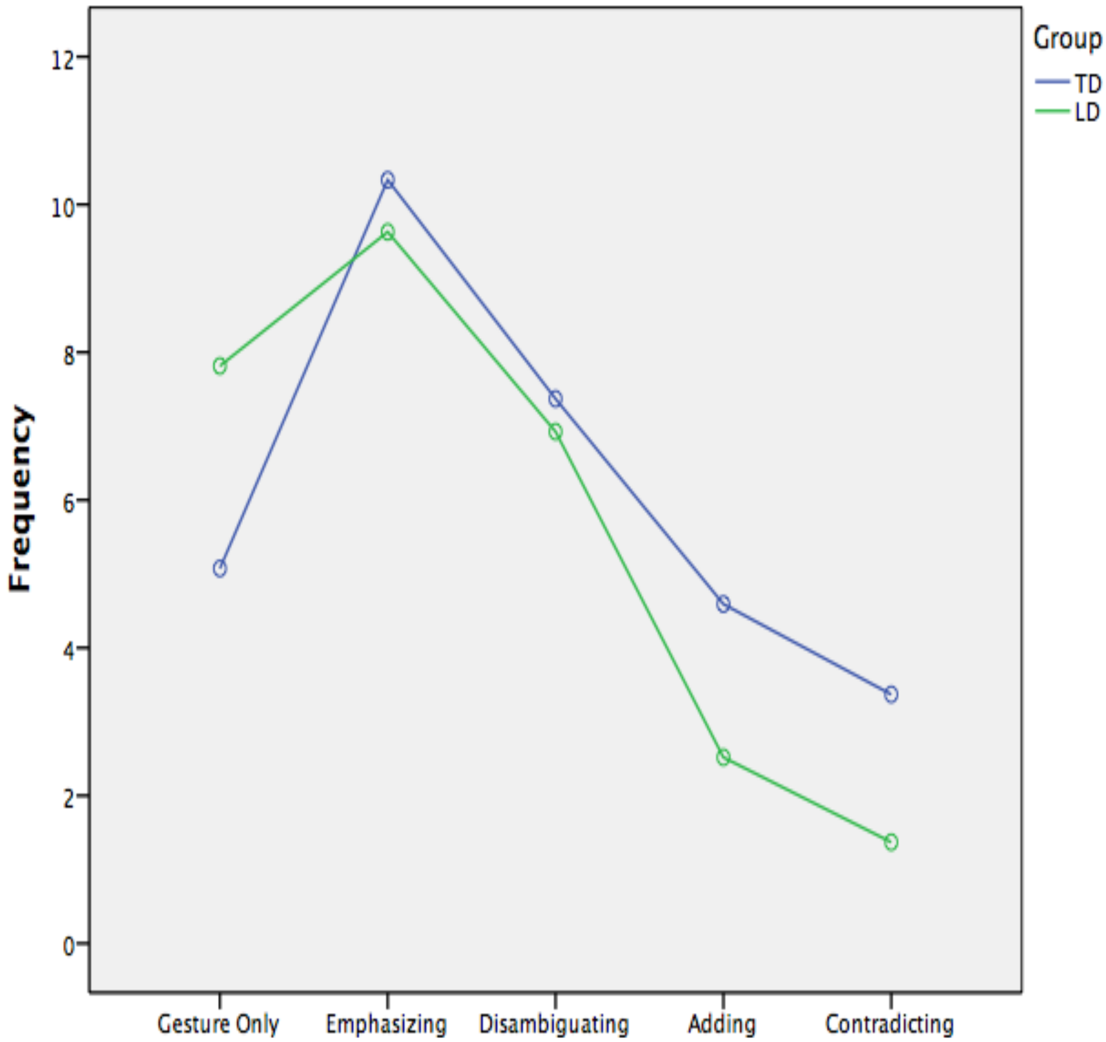

Figure 3. Profile Plot of Gesture Strategy

Table 10

Pearson Product Correlations Between MG Use and Child Gesture and Language in Children With LD and TD

Group		1	2	3	4	5	6	7	8
LD	1. MG Tokens		0.896**	-0.421*	-0.381	-0.075	-0.405*	-0.456*	-0.061
	2. MG Types			-0.282	-0.213	-0.107	-0.334	-0.19	0.087
	3. Toddler 18 mo CSBS Gesture				0.604**	0.415*	0.656**	0.444*	0.266
	4. Toddler 18 mo MCDI Early Gestures					0.341	0.573**	0.404*	0.053
	5. Toddler 18 mo EL						0.527**	-0.248	-0.24
	6. Toddler 18 mo RL							0.112	-0.258
	7. Toddler 18-24 mo EL Change Score								0.533**
	8. Toddler 18-24 mo RL Change Score								
TD	1. MG Tokens		0.892**	-0.023	0.448*	-0.11	0.073	0.113	0.179
	2. MG Types			-0.022	0.337	-0.117	0.004	0.186	0.184
	3. Toddler 18 mo CSBS Gesture				0.006	0.1	0.002	-0.123	-0.032
	4. Toddler 18 mo MCDI Early Gestures					0.15	0.194	0.117	0.194
	5. Toddler 18 mo EL						0.773**	0.296	-0.495**
	6. Toddler 18 mo RL							0.448*	-0.619**
	7. Toddler 18-24 mo EL Change Score								-0.001
	8. Toddler 18-24 mo RL Change Score								

** Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant and the 0.05 level (2-tailed)

Table 11.
Mean Frequency of Maternal Gesture Across the Low and High Risk ASD Subgroups

	Group		Effect size (d)
	Low Risk ASD (*n = 14)*	High Risk ASD (*n = 13*)	High Risk-Low Risk
Maternal Gesture Tokens (*M*, *SD*)	23.14 (9.67)	33.77(17.03)	0.77
Maternal Gesture Types (*M*, *SD*)	13.07 (3.97)	15.08 (5.09)	0.44

Table 12.
Group Means by Maternal Gesture Category in the High and Low Risk ASD Subgroups

		Group		Effect size (d)
		Low Risk ASD (*n = 14)*	High Risk ASD (*n = 13)*	High Risk - Low Risk
Deictic	*M* (*SD*)	16.57 (9.33)	26.70(15.81)	0.78
	% of Total Gesture	71.61	79.06	
Representational	*M* (*SD*)	0.43 (.65)	1.08 (1.80)	0.48
	% of Total Gesture	1.86	3.2	
Conventional	*M* (*SD*)	6.14 (3.18)	6.00 (5.28)	0.03
	% of Total Gesture	26.53	17.77	

Note. Due to rounding, percentage of total gesture in the ASD-risk group adds up to 100.03.

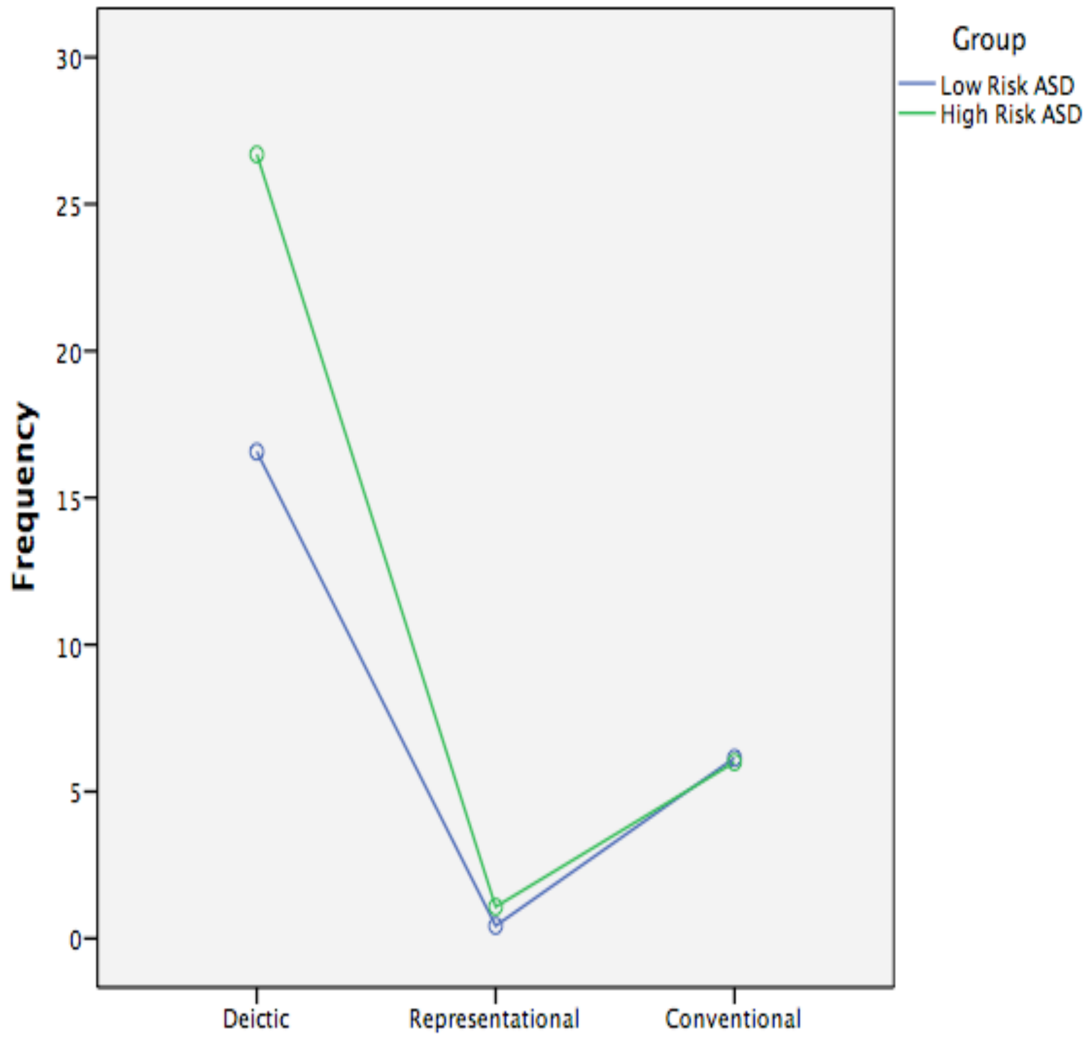

Figure 4. Distribution of MG by Category Within the High and Low Risk ASD Subgroups.

Table 13.
Mean Frequency of Deictic Gestures Across High and Low Risk ASD Subgroups

	Low Risk ASD (*n* = 14)		High Risk ASD (*n* = 13)		Effect size (d)
Measure	*M*	*SD*	*M*	*SD*	High Risk-Low Risk
Proximal Point	5.29	3.69	6.85	5.87	0.32
Distal Point	1.93	1.14	1.85	1.82	-0.05
Give	2.50	2.35	6.31	3.64	1.24**
Reach	0.07	0.27	0.08	0.28	0.04
Show	6.86	5.02	11.62	7.00	0.78

** $p<.01$

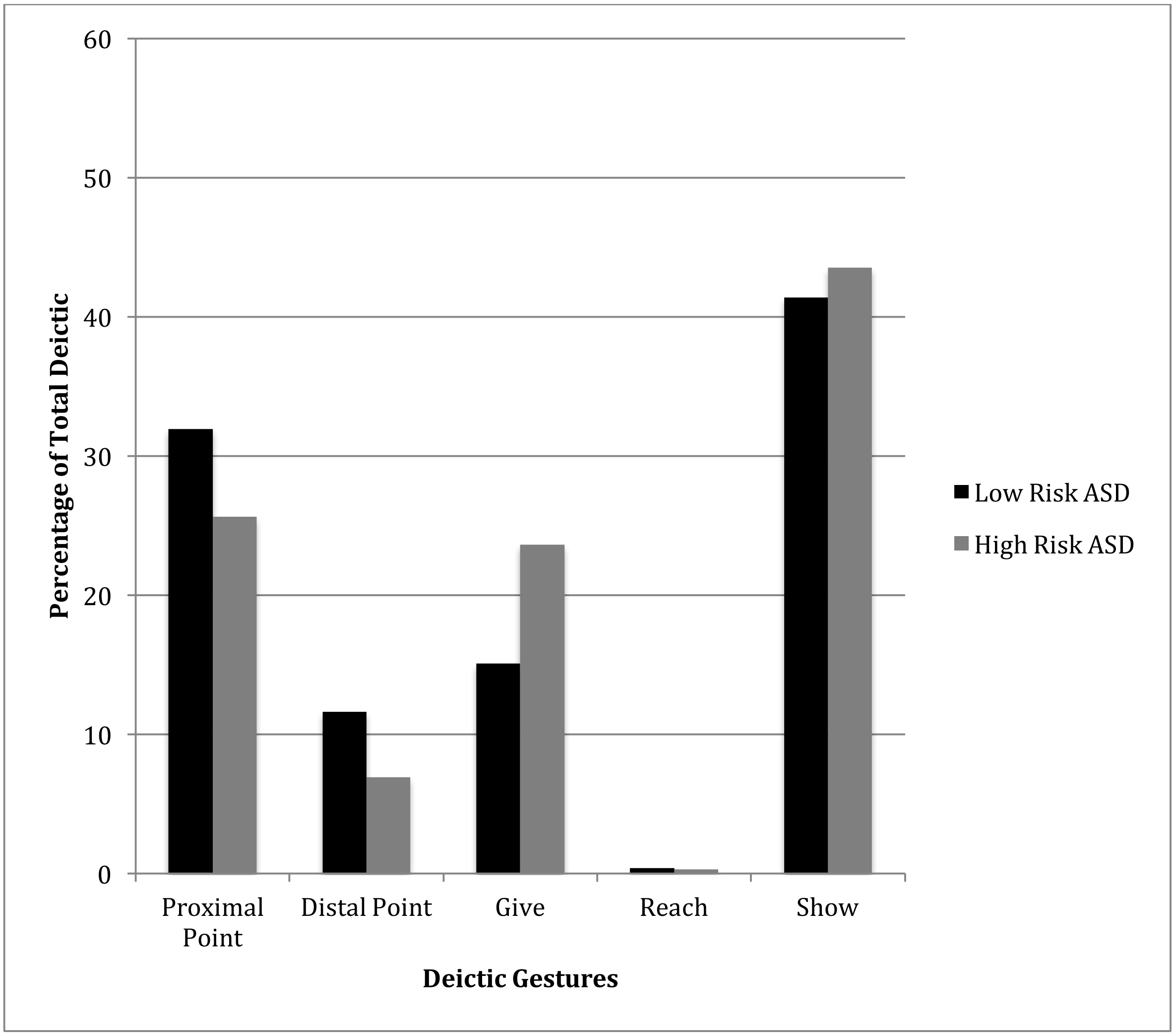

Figure 5. Percentage of Deictic Gesture Types in ASD High and Low Risk Subgroups

Table 14.
Mean Frequency of Relationship Between Gesture and Speech for High and Low Risk ASD Subgroups

		Group		Effect size (d)
		Low Risk ASD (*n= 14)*	High Risk ASD (*n = 13)*	High Risk-Low Risk
Gesture Only	*M* (*SD*)	5.79 (3.73)	10.00 (8.30)	2.38
	% of Total Gesture	25.02	29.61	
Emphasizing	*M* (*SD*)	7.43 (4.69)	12.00(5.90)	3.13
	% of Total Gesture	32.11	35.53	
Disambiguating	*M* (*SD*)	6.14 (4.33)	7.77 (5.26)	1.24
	% of Total Gesture	26.53	23.01	
Adding	*M* (*SD*)	2.07 (1.54)	3.00 (3.83)	1.16
	% of Total Gesture	8.95	8.88	
Contradicting	*M* (*SD*)	1.71 (1.38)	1.00 (1.41)	-1.87
	% of Total Gesture	7.39	2.96	

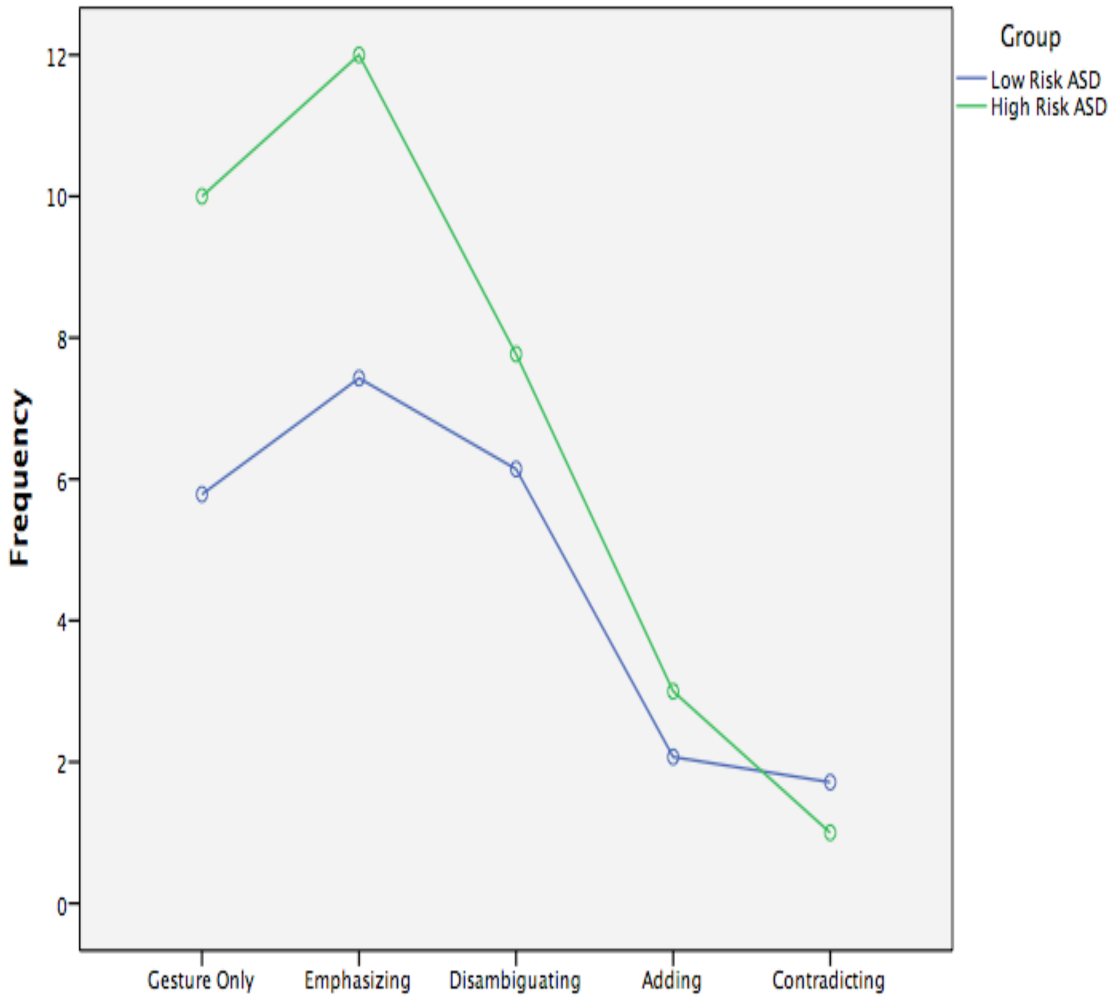

Figure 6. Profile Plot of Gesture Strategies in Low and High Risk ASD Subgroups.

4. DISCUSSION

This study examined how mothers use gestures in a naturalistic interaction with their young children with and without language delay, and explored relationships between maternal gesture use and concurrent child language and gesture, as well as a change in child language between 18 and 24 months. Previous research has demonstrated the importance of environmental inputs on the language development of infants and toddlers, as well as the reciprocal nature of communication between a young infant and his or her social partner (Broffenbrenner & Morris, 1998; Bruner, 1981). There is substantial literature among typically developing populations demonstrating that mothers modify their communication patterns, including gestures, to facilitate language development in their young children (e.g., Goldin-Meadow et al., 2007; Iverson et al., 1999). However, previous studies of maternal gesture in delayed populations have limited interpretive power due to lack of a comparison population (Hahn et al., 2014), small sample sizes (Iverson et al., 2006), structured tasks designed to elicit gestures (Grimminger et al., 2010), or have conflicting results (Mitchell, 2013; Talbott, Nelson, & Tager-Flusberg, 2015).

This is the first study to report on maternal gesture use in a population of toddlers at-risk for ASD due to a significant receptive and expressive language delay. Given this unique risk population, maternal gesture use was examined in two different developmentally delayed populations, severe receptive and expressive language delay and High Risk ASD. Further, this study utilized a novel maternal gesture coding scheme, which provided a detailed picture of how mothers gesture in a naturalistic play interaction with their young children without influencing how the mothers communicated. Given the limited and conflicting literature on maternal gesture in developmentally delayed populations, this study sought to clarify how mothers of young children with developmental delays use gestures to communicate and whether the gestural input received by toddlers at increased risk for ASD due to a delay in receptive and expressive language differs from typically developing toddlers. This discussion will highlight the findings on gestural frequency, categories of gesture, relationship between gesture and speech, and impact on child language and gestural development

Overall Frequency of Maternal Gesture

Mothers of 18-month-old toddlers with LD produced a similar number of gestures (Tokens) and conveyed a similar number of meanings (Types) through gesture as mothers of TD toddlers. Findings within the LD group were similar, such that mothers of toddlers in the High Risk ASD subgroup gestured at a similar rate as mothers in the Low Risk ASD subgroup. While these results did not support the hypothesis that mothers of toddlers with LD would produce a greater number of gestures than mothers of TD toddlers, the proposed hypothesis is not unsupported in the literature (Grimminger et al., 2010; Talbott et al., 2015). There are two studies that have reported an increased use of maternal gesture in samples of children with developmental delay compared to typically developing toddlers (Grimminger et al., 2010; Talbott et al., 2015). This increased use of maternal gestures has been attributed to the influence of the older sibling's diagnostic status affecting the way the mothers interacted with the younger children (Talbott et al., 2015) and the verbal ability of the child (Grimminger et al., 2010). Further, differences in the age of the children could contribute to findings, such that previous studies have examined children at younger ages (12 and 15 months; Mitchell, 2013; Talbott et al. 2015), compared to the present study. Given that child language is rapidly developing during this period and parents are modifying their communication, including gestures, to meet the communication level of their child, differences in maternal gesture may be sensitive to the age and language ability of the child.

The lack of power to detect meaningful group differences in this sample does cloud the interpretation of lack of group differences in overall frequency within the LD group. While mothers of toddlers in the High Risk ASD subgroup were not significantly different from the mothers in the Low Risk ASD group, the moderate effect size found in MG Tokens suggests that mothers in the High Risk ASD subgroup may produce more gestures than those mothers in the Low Risk ASD subgroup; however, a larger sample size would be needed to before reaching any conclusions. This hypothesis is supported by results of Talbott et al. (2015) in which mothers of high-risk infant siblings gestured more than the mothers of low-risk controls. While Talbott and colleagues interpreted these findings as influenced by diagnostic status of the older sibling, the findings from the current study differ in a few significant ways. First, risk status was defined as a significant receptive and expressive language delay and as such, many of the children in the High Risk ASD subgroup are not infant siblings. Secondly, if maternal gesture is a responsive behavior, it may be that previous experience with an older sibling was not as influential a factor on maternal gestural communication as is current language ability of the child.

Deictic Gesture Use

Examination of maternal gesture use across the four main categories of deictic, representational, conventional, and emphatic gesture revealed that mothers of LD and TD toddlers used significantly more deictic than other gesture types. This pattern was also observed when the LD group was divided to examine Low Risk compared to High Risk ASD. Specifically, deictic gestures accounted for > 66% of total gesture in all groups. These results are consistent with previous findings in both typical and developmentally delayed populations (e.g., Iverson, 1999; Ozcaliskan et al., 2005; Talbott et al., 2015) and support the hypothesis that mothers of children with LD would have similar profiles of gesture types as compared to mothers of TD toddlers. Mothers in both groups also displayed negligible rates of emphatic gestures, supporting the idea that mothers simplify their communication patterns when interacting with their young children. Specifically, emphatic gestures are more abstract and are mostly unrelated to the message conveyed in speech, whereas deictic, conventional, and representational gestures are related to the immediate context and attempt to clarify or emphasize the message conveyed in speech (Iverson et al., 1999).

Detailed analyses of deictic gestures revealed that while not statistically significant, the distribution of deictic gestures in the LD group differed from the pattern observed in the TD group. Specifically, shows accounted for nearly half of all deictic gestures in the LD group but only about a third of deictic gestures in the TD group. Within the LD group, mothers of toddlers in the High Risk ASD subgroup used significantly more give gestures than mothers in the Low Risk ASD subgroup. Further, mothers in the High Risk ASD subgroup demonstrated increased production of shows when compared to mothers in the Low Risk ASD subgroup, although this was not significantly different. Gives and shows are unique such that the referent is in direct contact with the gesture and thus the relationship between the gesture and the referent is much more concrete than points or reaches, where the referent may be some distance away from the gesture and thus require a higher level of coordinated attention. This pattern is similar to the results found by Iverson and colleagues (2006) in which mothers of children with Down Syndrome were observed to produce significantly more shows than mothers of typically developing children. This simplified gestural communication may be produced in response to the child's delayed language development. Given the significant differences found within the LD High and Low ASD Risk subgroups, this pattern may also be attributed to parent observations of delays or difficulties in joint attention, a deficit well documented within the ASD literature (e.g., Mundy & Crowson, 1997; Mundy et al., 1990).

Maternal Gesture Use: Relationship to Co-Occurring Speech

The majority (> 72% in both groups) of gestures produced by mothers of toddlers in both the LD and TD groups were accompanied by speech. Within the LD group, gestures with speech accounted for > 70% of all gestures produced by mothers in the High and Low Risk ASD subgroups. All gestures accompanied by speech were classified as either emphasizing the meaning of speech, disambiguating (clarifying) the referent, adding information to the verbal message, or contradicting verbal message. Across all groups (TD, LD, Low Risk ASD, High Risk ASD), mothers were more likely to use speech to emphasize the message conveyed by the gesture than to clarify (disambiguate), add information, or contradict the message conveyed by the gesture. For example, mothers were more likely to point to a block and say “block” than they were to point to a block and say “that one” (disambiguating), “it’s hard” (adding), or “get the bowl” (contradicting). This finding was consistent across gesture categories with deictic, representational, and conventional gestures all more likely to be accompanied by a reinforcing (emphasizing) message in speech. This pattern is consistent with previous findings in both typical (Bekken, 1989; Iverson et al., 1999; O’Neil et al., 2005) and delayed populations (Iverson et al., 2006; Mitchell, 2013), and is once again reflective of the simplified communication pattern mothers use when communicating with young children.

While the majority of gestures in all groups were produced with speech, a nonsignificant but moderate effect size, however, suggest mothers of LD toddlers produced more gestures without speech (27.63%) than mothers of TD toddlers (16.51%). This difference appears to be driven by moderate effects found within the LD group with mothers in the High Risk ASD subgroup producing a higher percentage of gestures without co-occurring speech (29.61%) than mothers in the Low Risk ASD group (25.02%). Mothers of LD toddlers, and specifically High Risk ASD toddlers, may have talked less overall during the PCI compared to mothers of TD toddlers; however, maternal speech outside of gesture use was not measured in this study, so this hypothesis would need to be investigated in future research. If mothers of toddlers with LD produced similar overall rates of speech as mothers of TD toddlers, this pattern of producing more gestures without co-occurring speech could be another way in which mothers simplify their communication patterns in order to reduce the cognitive demand required to interpret both the verbal message and co-occurring gestural message.

Patterns of Relationships Between Maternal Gesture Use and Child Development

In the TD group, maternal gesture use (MG Tokens) was positively correlated with concurrent toddler gesture on the MCDI. While a direct association between maternal gesture and child language was not found in this TD sample, it is important to point out that no relationship between toddler gesture and language was found either. One possible reason for the null findings is that the majority of the toddlers in the TD group scored at or near the ceiling of the gesture subscale on the CSBS and MCDI. This restricted range in scores most likely reduced the correlation and it is possible that if there were a greater range of scores within the TD group, the correlation between gesture scores and language may have been larger. Placing the statistical limitations aside, this finding differs from previous research on typically developing children (for a review see Ozcaliskan & Dimitrova, 2013) in which parent gestures have been shown to influence child vocabulary development, typically by influencing child gesture production. One possible explanation for this finding is that the children in the TD group are not producing as many gestures at this point in their development, as they are more proficient in verbal communication; thus, the relationship between child gesture and language may be decreased. This interpretation would be supported by the bridge hypothesis and findings in the typical literature where as a child becomes more proficient in expressive language, they may prefer communicating verbally and possibly at the expense of gestural communication (Fenson et al., 1994).

Given the similar rates of overall gesture production by mothers in both the LD and TD groups, one might have anticipated similar results within the LD group; however, a different pattern emerged altogether. Specifically, a negative relationship between MG Tokens and concurrent child gesture was found, such that mothers who gestured more frequently had toddlers with lower gesture scores. This finding differs from those reported by Talbott and colleagues (2015) in which a significant positive relationship between maternal gesture and infant gesture was found in the high-risk infant sibling (non-ASD) group. One important difference that may be impacting the interpretability of the findings from this study is that child gesture as measured on the CSBS is limited to only those gestures produced during a communicative act. That is to say, it is possible that a different (perhaps positive) relationship may have been found if child gesture had been measured on a similar scale (i.e., frequency of overall gesture) as maternal gesture. Even though Talbott (2015) used the CSBS as one context for measuring child gesture, they coded all child gesture produced during the sample as opposed to using the standardized scoring measure as done in the present study.

In relation to language, increased maternal gesture use at 18 months was negatively correlated with concurrent receptive, but not expressive, language in toddlers with LD. Further, increased maternal gesture use was negatively correlated with a change in expressive language between 18-24 months. Mothers of toddlers with significant receptive language delays may produce more gestures to help facilitate comprehension for their children. That is to say, this negative correlation between maternal gesture and child receptive language may be a product of maternal responsiveness. Given that child gesture in the LD group was significantly positively related to concurrent expressive and receptive language, as well as positively related to a change in expressive language, it is possible that the higher rate of maternal gesture may be positively related to a gain in child gesture at 24 months as evidence from the typical literature describes that children model their gestural production after their parents (Ozcaliskan & Goldin-Meadow, 2005). Without measuring child gesture longitudinally, however, it is difficult to reach any definitive conclusions as to whether children with language delays acquire gesture through gestural models in the same way as their typically developing peers.

Taken together, the pattern of relationships between maternal gesture use and concurrent child gesture and language found in the LD group indicated that mothers who gesture more have children who produce fewer gestures, have lower receptive language abilities, and make less gains in expressive language over a 6-month period. As previously described, child gesture and receptive language ability are closely linked processes such that delays in gesture are often accompanied by delays in receptive language (O'Neill & Chiat, 2015; Thal & Tobias, 1994). The children in this study were selected in part based on having a receptive language delay and thus, the lower gesture scores on standardized measures within the LD group and the lack of relationship between maternal and child gesture is not surprising. The negative relationship between maternal gesture and toddler gestural and receptive language strengthens the case for gestural communication as a responsive behavior and seems to indicate that mothers are sensitive to developmental differences in communicative ability.

Clinical Implications

Results of this study have several important clinical implications. First, this study provides a deeper understanding of the communicative exchange between mothers and their young children. The findings that parents of TD toddlers and toddlers with severe language delays use gesture at a similar frequency and convey a similar number of meanings through gesture suggest that children with developmental delays receive similar gestural input from their mothers. What remains unclear, however, is whether children with significant LD acquire gestures through the models produced by their parents. The positive relationship between maternal and child gesture observed in the TD group but not in the LD group would suggest that it may be that children with language delays may require higher frequencies of gestural input (i.e., more gestural models) in order to encourage gestural use themselves. As we know from the TD literature, children acquire gestures by modeling their parents (Özçalışkan & Dimitrova, 2013) and gestures are closely related to language development. One important clinical application of this study may be teaching parents to incorporate gestures that help clarify the communicative environment as part of providing a language rich environment. For example, child directed interventions including Parent-Child Interaction Therapy (PCIT; Schuhmann, Foote, Eyberg, Boggs, & Algina, 2010) teach parents to reflect or paraphrase what the child is communicating. In addition to narrating the child's attentional focus, parents could be encouraged to emphasize their speech with gestures.

Further, results of the detailed analyses of deictic gestures have potential implications related to child social communication ability affecting parents' gestural communication strategies. For example, parents may be sensitive to delays in joint attention and thus adapt their communication to use more gestures that come into contact with the referent and thus require less coordination of attention than those that indicate a referent at a distance. A parent of a child with a significant language delay may be more likely to pick up a referent and give it to their child rather than point to a referent across the room, thereby increasing the likelihood that the communicative message is understood. Parent-mediated interventions may consider a gradual increase in the distance between the referent and the gesture so as to encourage joint attention development, a skill closely related to language development (Bottema-Beutel, 2016).

Limitations and Future Research Directions

This study examined a unique sample of toddlers with significant receptive and expressive language delays; however, several limitations should be considered when interpreting results. Although this study included a larger sample size than previous studies, the sample was still small, limiting the statistical power of the analyses and the ability to detect significant group differences. Many of the null findings may have been related to this reduced power and future studies examining maternal gesture in larger groups may be able to answer research questions about group differences more conclusively.

This study was also limited by its one-sided approach to the dyadic nature of communication. Maternal gestures were coded separately from child gesture and without a clear picture of a complete communicative exchange (i.e., when a mother gestures, how does the child respond and when a child gestures, how does the mother respond), it is difficult to draw conclusions as to the influential nature of maternal gesture on child communication. Child gesture variables were also drawn from two standardized measures and thus were not measured on a similar scale as maternal gestures. Further, results from this study seem to suggest that maternal gestures are altered in response to child communication abilities; however, detailed coding of maternal responses to child gesture were not completed. It is possible that maternal gestures that occur immediately after or preceding a communicative act by a child have a more direct impact on child language development as opposed to overall frequency of maternal gesture. Future research should focus on the bi-directional communicative exchange among parents and their young children.

While child attention to parent gesture was coded, this study did not screen out those gestures produced by the mothers when the child was not attending to the gesture. While no group differences in child attention were found, a detailed analysis of those gestures that children attend to may be more informative for child language and gesture outcomes. Longitudinal changes in maternal gesture were also not a focus of this study, and future research may investigate how maternal gesture may change as deficits in social communication or ASD symptoms unfold.

Another significant limitation of this study is that no transcriptions of speech or measure of maternal vocabulary was collected. A measure of maternal language, especially during the 15-minute PCI, may have helped to clarify findings, especially within the LD group, where mothers were found to use more gestures without speech than those in the TD group. Future research may consider adding a variable of overall rate of maternal speech (i.e., words per minute) to their coding scheme in order to assess whether mothers of children with LD are simply talking less overall, or just simplifying the message conveyed through gesture.

As 13 of the 27 toddlers in the LD group met research criteria for High Risk ASD at 24 months, the descriptions of the LD group may be confounded by the High Risk ASD subgroup. Future analyses of the three groups (ASD low risk, ASD high risk, and TD) may help to clarify which maternal gestural behaviors are specific to mothers of children at increased risk for ASD. Future studies examining parent communicative behaviors may benefit from an enhanced understanding of maternal clinical symptoms including measures of broad autism phenotype characteristics.

Finally, the detailed coding of maternal gestures was cumbersome. The reliability process took upwards of 6 months and repeated trainings were required throughout the coding process to maintain reliability. In addition, coding of maternal gestures from the 15-minute PCI videos took 1 hour on average to complete. Future researchers interested in utilizing this coding scheme might consider the time commitment required for coding prior to beginning data collection.

Conclusions

This study provides important information in understanding how mothers communicate nonverbally when interacting with their young children. The frequency of gesture in mothers of children with severe language delays does not appear to be different than those mothers of toddlers who are typically developing. Despite the lack of difference in maternal gestural behaviors, toddlers with severe language delays seem to be impacting the way their mothers communicate such that lower receptive language scores are positively related to higher frequency of parent gestures. Further, mothers of children with severe language delays modify their gestures in relatively distinct ways including using more gestures that are in contact with the referent and reducing the demand of processing two modes of communication simultaneously by producing more gestures in isolation of speech. While more work is needed to understand how parents respond to gestures produced by their children and, in turn, how children respond after a parent has gestured, the results of this study provide further evidence as to how child risk status may influence parent behavior.

APPENDIX A

MATERNAL GESTURE CODING SCHEME

Toddler Study Parent Gesture Coding Manual

General Rules for Coding Gestures

1. ***Coding conventions.*** Coding conventions spelled out in this coding manual are just that, conventions. They are not arbitrary but they are also never perfect. First and foremost, coding conventions are adopted with a view to clarity, relative ease of decision making in coding, and achieving reliability for what is coded (even if occasionally a particular behavior is missed). In other words, coding conventions are designed to maximize the likelihood that what you have called an X really is an X, even though this may mean that an occasional X is not coded.

2. ***Clear codability.*** If there is evidence of a gesture on the part of the parent, then ask yourself whether one of the target behaviors (e.g., Show, Reach, Give, Point, Vocalization) is *clearly codable*? Clearly codable means that the behavior has to be there *as behavior*, i.e., the relevant *form* of behavior as described in the manual below must be present. *Actions that serve a given function but without the required form do not count as gesture*. If a gesture is not clearly codable, don't code it. It is better to omit coding a gesture than to categorize it haphazardly with insufficient information. Also, if you do not have the information to code all parameters (e.g, function, vocal, etc) related to the gesture (because the video cuts out, etc.) do not code the gesture.

Examples: Do NOT code any of the following:

- Any behavior that is obscured because of circumstances such as the camera view being partially blocked or the hand of the parent being slightly out of view. You must be certain of the behavior in order to code it.

3. ***Successive behaviors.*** Sometimes a parent will display multiple gestures in succession. In these instances code each distinct communicative behavior as separate, in the order in which they occur.

Example: The parent goes immediately from a point (deictic) to a hand extended (conventional). Code each of these as two separate gestures (deictic then conventional)

Example: The parent goes from a Show to a Give by holding up an object to show it to the child, and then after a short pause (of the show) gives the object to the child. Code these as two separate gestures: Show then Give. (See Show definition below.)

4. Simultaneous behaviors. Sometimes a parent will display multiple gestures simultaneously (e.g., point and head nod; showing two objects). In these instances code each distinct gesture as separate (on two lines). Do your best to determine if one gesture started before the other and code that gesture first. If you cannot determine this, still code both gestures separately.

5. ***Reliability.*** The first goal of any coding manual is to achieve reliability. When a behavioral event seems ambiguous, ask yourself: "Would someone else code this behavior?" If the answer is that you don't know or are not sure, don't code it. Don't guess.

6. Sample Start/Stop: Parent-child interaction: Begin coding as soon as the parent and child are in view (and after the clinician has given the parent instructions and has left the room). Stop coding when the clinician enters the room to end the interaction***. Note: In ELAN, mark the start/stop annotation window the length of one second.*** **CODE ALL GESTURES PRODUCED BY THE PARENT DURING THE SAMPLE.**

GESTURES

Gestures are a form of intentional communication. They are voluntary and can sometimes hold specific meanings. There are four main types of gestures: deictic representational, conventional, and emphatic gestures. When unsure if something is a gesture or not, it is crucial to ask yourself whether or not it is apparent that the parent is trying to COMMUNICATE something (you may use context as an aid).

DEICTIC GESTURES

Deictic gestures are gestures that indicate an object, location, or event. Deictic gestures are used to refer to the object, location, or event by directly touching it or indicating it to the referent. They express the parent's communicative intent to call attention to certain objects, locations, people, or events.

1. Point: With clear articulation of the index finger the parent points to an object or event. *Points should only be coded when the index finger is extended and adjacent fingers are noticeably inclined downward toward the palm*. (Note: the thumb may or may not be fully inclined downward to the palm, but cannot be extended fully in the same direction as the index finger.)

Point vs. touch. A point should only be coded if the parent is communicating with someone, not if they are just putting their finger on an object for their own purposes. In other words, touches are only counted as Points when the parent is using the pointing finger touch to call the child's attention to the object touched (example: the parent taps on the object with an extended index finger).

Note re: coding points in books: When pointing to pictures in a book and the parent successively points to multiple referents or locations, the parent does not have to lift his/her finger from the page to code as two (or more) different points. To differentiate points, the parent must briefly pause (with index finger) on a picture before changing location to a new picture.

1a. Distal vs. Proximal Point. Once you have coded a point gesture, code whether it was distal (the parent was not touching the object being pointed to) or proximal (the object was < 6inches from the index finger or contact was made with the object). *Example: Distal point – the parent points to an object across the room. Proximal point: the parent* *is holding a book and points to a picture in the book, with a finger touching the book or the parent taps a block to call the child's attention to the object.*

Note re: Proximal Points: If the index finger does not make contact with the item but is within touching distance, the point should be coded as proximal and not distal. Example: The parent is pointing to animals in a book but the index finger does not physically touch the page.

2. Reach: The parent extends his/her arm(s) with an open turned down palm or repeated opening/closing of the hand to indicate desire for or interest in an object, person, location, or event. Do not score if an object is actually touched. *Example: The parent reaches towards a toy the child is holding but does not actually touch the toy.*

3. Give: The extension of the arm with object in hand with the intention for the other person to take the object. The parent hands the object to the child in an act of sharing. A give requires arm extension and hand-to-hand exchange. If the parent is holding an object and the child reaches out and takes the object, this is not a Give.

> A Give must be a "handing to". Rolling a ball or a car is never a Give.
> A parent taking an object out of the child's hand is never a Give.

4. Show: The parent presents the object in the general direction of the child. The object should be presented relatively still for a second or two. For a show to be coded, the parent does not have to hold the object directly in the child's line of sight but they must give clear evidence of trying to attract the child's attention to the object.

Shows and Gives may occur successively. To code both the Show and the Give, you must have the following evidence: the Show gesture must contain upward arm movement and/or an upward facing palm or the object being shown must be placed within the child's line of sight.

Modifier for deictic gestures:

1. Referent: This is used to denote what is being referred to (held up, pointed at, etc.). This could be an object (be specific and consistent in labeling), event, or person (specify child, clinician, etc). If the referent is not in view on camera but the adult or child names the referent, code the specific referent the adult or child provides. If no one provides the name of the referent that is off screen, or if no one provides context for what the referent is, code "off screen". If the parent gestures (e.g. gives, shows, points) to more than one referent simultaneously, code the referent as the one that occurs first in alphabetical order.

Note re: coding referent when the object (referent) goes off screen: If the parent begins gesturing before the object goes off screen (even if there is only a very brief overlap), code the object as the referent. If the object goes off screen prior to the gesture being initiated, code the referent as off-screen. If a parent gestures to an object, person, etc that is off screen but then immediately goes and obtains or touches the object, code that object as the referent. Do not code the object as the referent if the parent gestures to something off screen and there is a delay between that gesture and when the parent goes to obtain an object.

Referent is coded from a dropdown list (and may also be found in Appendix A). If a specific referent is not in the dropdown list Referent list, code "OTHER REFERENT" from the referent list and type the name of the referent in the text box under "other referent".

2. Other Referent Context: This is used to provide evidence for anything you code as a referent that is not found in the dropdown list of referents (and thus, that you coded under "other referent"). The following may be coded under context:

A. Child vocal
B. Adult vocal (use this when you cannot see the referent on our own – e.g., adult points to picture in book that we cannot see on video but clearly names the picture)
C. Not listed (in list of possible referents)

REPRESENTATIONAL GESTURES

Representational gestures refer to an object, person, location, or event through hand movement, body movement, or facial movement. Representational gestures are content driven and generally echo or elaborate co-occurring speech. Representational gestures differ from Deictic gestures in that they represent specific referents and their meaning does not differ across contexts. Deictic gestures "point out" a given referent whereas Representational gestures "stand for" some referent, or a class of referents or relations. The purpose of a representational gesture is to offer clues or hint at the spoken language. Representational gestures are executed with empty hands. If an object is in the same hand in which the gesture is executed, *DO NOT CODE.*

1. **Representational gesture:** The parent uses hand, body, or facial movement as a means of demonstrating or referring to an action, object, person, location, or event.

   Example: The parent pretends to throw a ball and also says "Throw the ball to me!" or the parent rubs his/her hands together and says "I'm cold!". reaching up in the air ("so big").

   Do not code representational gestures that occur within a song (e.g. 'Itsy Bitsy Spider').

2. **Signs**: Signs are coded as representational gestures. If you are not sure whether something is a sign, you can google the words "baby sign" or "ASL" to find a glossary.

CONVENTIONAL GESTURES

Conventional gestures are those in which the meaning is culturally defined and thus their meaning is consistent across time. *Conventional gestures include, but are not limited to: waving ("hi" or "bye"), clapping("yay")*→ they must strike twice*, head shake ("no"), head nod("yes")*→ must go up and down completely*, shrugging shoulders("I don't know"), holding hand out with palm facing up and/or repeatedly opening and closing the hand ("give it to me"),wagging index finger ("no"), holding hand out with palm facing out ("stop") beckoning/leg pat ("come here"), raising hands up into the air/above midline ("woah!"), placing a palm up towards the child ("high five!"), finger to mouth ("shh"), flipping hands at or near the midline ("I don't know"), waving hand to side of body ("I'm done"), thumbs up ("good job").*

Wiping the child's nose, playing with child's hair, tickling/hugging, fixing clothing are NOT gestures.

Conventional gestures are executed with empty hands. If an object is in the same hand in which the gesture is executed, *DO NOT CODE.*

If two conventional gestures take place at the same time code the one in higher order (hand flip and shoulder shrug; code shoulder shrug)

Modifier for Conventional and Representational Gestures

1. **Gloss**: For all Conventional and Representational Gestures, the meaning of the gesture will be determined. Examples of gloss are indicated in parentheses next to the conventional or representational gesture. The gloss may be indicated by context or accompanying speech. When coding a sign, put the agreed-upon meaning of the sign. This may be indicated by the context or the caregiver.

EMPHATIC GESTURES

Emphatic gestures serve to highlight aspects of accompanying speech. They are non-representational, have no specific semantic content or precise referent, and are not linked to a specific hand shape or facial expression. Typically, Emphatic gestures are executed in a rhythmic fashion when two adults are speaking to one another and are often used to emphasize specific elements of speech. *Example: bringing a fist to an open palm to stress feeling strongly about something.*

MODIFIERS FOR ALL GESTURES

Informational relationship between gesture and speech: The contribution of the gestured portion of the utterance to the overall message conveyed in the speech. An utterance is defined as a unit of speech beginning and ending with a clear pause.

Affective/other vocalizations: Vocal sounds that directly express an affective bodily state including grunts, laughs, raspberries, cries, sighs (e.g. "ahhhh"), should not be coded as an utterance.

Before coding informational relationship, first ask yourself:

1. What is the referent (gloss)?/What is the gesture indicating?
2. What does the parent say?
3. What is the relationship between the gesture, the referent, and speech?

A. **Gesture Only:** the gesture(s) was executed with no accompanying speech. If you cannot make out what the parent is saying (i.e. whispers) and don't have enough evidence to code language, code as gesture only.

Example: The parent places their palm out without any speech

B. **Emphasizing:** the gesture was semantically equivalent and conveyed the same message as speech. An emphasizing gesture reinforces speech. All conventional gestures in which the gloss is identified as equivalent to the verbal speech should be coded as emphasizing (e.g. shrugging shoulders and saying "I don't know"). Deictic gestures in which the referent is labeled in speech and indicated with a gesture should also be coded as emphasizing (e.g. showing a ball and saying "ball"). All emphatic gestures should be coded as emphasizing.

Examples. Saying "No" while shaking the head
Holding up a banana and saying "banana"
"What does the cow say?" while showing a cow
"Put him in the car" while pointing to the car

C. **Disambiguating:** the gesture identifies the precise referent of the verbal utterance (clarifying). When an utterance includes a word such as "this", "that", "there", "here", or a personal or possessive pronoun ("yours", "ours") or an attention-directing expression (e.g. "Look!" "see", "Oh my goodness", "ta da!") ***and*** the gesture indicates the **precise** referent, it should be coded as disambiguating. Be careful with vague actions (ex. put it in there/Put it right here/Put them in here). Vague descriptors should be coded as disambiguating.

Examples. "Do you see this?" while showing the child a toy bear.
"This one" while pointing to the car.
"What do you have?" while pointing to an object in the child's hand. "It's your favorite!" while showing the child a book.
"You do it/You do this one" and handing the child a ball
"House goes right there" while pointing to the puzzle.

D. **Adding:** the gesture conveys information not provided in the accompanying utterance. The verbal portion of the speech provides more information about the referent indicated through a gesture (typically deictic). The gesture may serve to identify the referent while the verbal portion of the speech describes some attribute of the referent. Adding may also include indicating an action (verbally) that may be done with the referent which is identified through gesture.

Descriptive adjectives used in speech to describe a referent (e.g. "beautiful", "stinky", "scary") should be coded as adding.

Examples: "Do you want a drink?" while signing "milk".
Saying "moo" while pointing to a cow.
Pointing to a picture of a frown "sad".
"You can cook with it" while showing a teapot.
"Look it goes up!" while pointing to the elevator.
Pointing to a ball and saying "bouncy!"
"You can do it!" "You did." "Those are your shoes." "Good job."
"You did it." "That's right." "okay" "yes" "uh-huh" while nodding head (yes)
"Where's the car?" "Where did it go?" "What is it?" while flipping hands (I don't know)
"Can you bring it back to me?" while using conventional gesture "give it to me"
"They don't come apart." While shaking head no

E. **Contradicting:** the gestural information is unrelated to the verbal utterance. *Examples*: "Do you want a drink?" while pointing to a picture of a bunny in a book. Saying "one, two" while beckoning a child. Shaking head no while saying "I know". *"Throw the ball"* while using a conventional gesture "give it to me."

<u>Child Attention:</u> For all parent produced gestures, you will code whether the child attended to the gesture by either looking towards the appendage(s) used to perform the gesture and/or toward the referent indicated immediately after gesturing. Conventional, Representational, and Emphatic gestures require the child to attend to the gesture in order to be coded as attending. For deictic gestures, the child must attend to either the gesture being produced by the parent or the referent indicated by the gesture. The child may attend to the gesture at any point immediately before, during, or after the gesture.

A. **Attending:** Child attended to the gesture being produced by the parent by looking at/towards the appendage(s) used to perform the gesture and/or the child looks at/towards the referent indicated by the gesture at any point during or immediately following the parents gesture. If the referent is not in view on camera, DO NOT CODE.
B. **Not attending:** Child did not look at the gesture or the referent
C. **Uncodable:** Cannot determine where the child is looking (e.g. can only see the back of the child's head or child is off-screen)

<u>Opening, Saving and Naming Files in ELAN</u>

1. Open ELAN and select "file" then "new." Select the media file and add it to the right. Then select the template (etf file) and add it to the right. Select "ok" and it will bring you to the coding screen. At this point, you should IMMEDIATELY rename and save the file by selecting "file," "save as."

2. Use the following format to name TRAINING and RELIABILITY files: Child ID, PCX, Date of Sample, and coder initials (e.g., UT-0001-301 MG PCX 3-13-13 AS)
3. Make sure the two ELAN files associated with a sample (i.e., the EAF and PFSX files) are named the same.

ELAN Coding Parameters

1. Creating the annotation window (the purple area within which you will code the behaviors): It is critical that you start the annotation at the onset of the behavior (gesture), and that you stop the annotation at the offset of the gesture. Make sure the entire gesture occurs within your annotation selection. Note: The first step prior to coding any specific behavior is to get the annotation window correct. Thus, **prior to** making your first code (e.g., deictic) within an annotation, you must make sure you have the annotation window correct (i.e., that you mark the start of the annotation when the behavior is beginning and the end of the annotation at the end of the behavior).

Exporting data from ELAN to EXCEL:

1. Open the ELAN EAF file for the child. Go to file, export as, tab-delimited text.
2. Choose the following:
   - Under Select Tiers: choose Select All
   - Under Output Options (leave as the default, which is): Separate Column for Each Tier and Repeat Values of Annotations Spanning other Annotations
   - Under Include Time Column For: Choose Begin Time and End Time
   - Under Include Time Format: Choose: hh:mm:ss:ms **AND** ss.msec
3. Click OK, name the new (txt) file just like you did before (e.g., UT-0001-301 MG PCX 4-4-13 AS), and click Save.
   a. Note: Save the file in your coded files folder, in a new folder with (Your initials) Exported Data.
4. Next open a new excel file (by simply opening excel). Click on the Data tab, double-click the "from text" icon, then find and highlight the txt file you just saved to the network, click import. When a box appears, check "delimited" then Next. Under delimiters, click Tab, then Next. Under Column Data Format, click General. Click Finish. When asked "where do you want to put the data, just click okay (as long as you have a new excel file open).

Save (name) this new excel file just like you did before (e.g., UT-0001-301 MG PCX 4-4-13 AS) in the same Exported Data file you created for yourself, and click Save.

Appendix A. List of ELAN Referents

baby	Picture in book
ball	pig
black sheep	plastic container
blue car	plastic container lid
blue-shirted girl	Prickly ball
child	Puzzle - airplane
cooking pot	Puzzle - car
cooking pot lid	Puzzle - cloud
corn	Puzzle - house
cow	Puzzle - sun
cup	Puzzle - tree
dog	Puzzle - whole
egg	red bowl
farm	red repairman
farmer	red tomato
father	Shape sorter - blue star
Foam block - bridge	Shape sorter - green triangle
Foam block - cylinder	Shape sorter - orange circle
Foam block - rectangular prism	Shape sorter - pink polygon
Foam block - semi-circle	Shape sorter - whole
frying pan	Shape sorter - yellow square
frying pan lid	spatula
garage	spoon
goat	teapot
green pepper	teapot lid
green-shirted boy	Teddy bear book
horse	truck book
keys (to shape sorter)	Where's spot book
ladle	whisk
mother	white sheep
off-screen	yellow mushroom
orange onion	yellow tow truck
OTHER REFERENT	

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