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Research Article

Gesture Use in 14-Month-Old Toddlers With Hearing Loss and Their Mothers' Responses

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Purpose: This study examined the gesture use of 14-month-old toddlers with hearing loss (HL) and mothers' responses to children's early gesture use. Comparisons were made to symbolic language and to dyads in which the toddler had normal hearing (NH).
Method: Participants were 25 mother–toddler dyads in which the child had HL and a socioeconomic-status matched group of 23 mother–toddler dyads in which the child had NH. Thirty-minute mother–child interactions were video-recorded, transcribed for spoken language, sign, and gesture use, and coded for maternal responses to children's gestures. Mothers also reported on children's gestural and spoken language abilities.
Results: Toddlers with HL used gesture similarly to their peers with NH, but demonstrated delays in spoken language. Spoken language and gesture were not significantly related for either group. Hearing levels were related to spoken language, but not gesture for the HL group. Maternal and child gesture were only related for signing mothers. Mothers of children with HL were more likely than their counterparts to provide no response to children's gestures.
Conclusion: Although toddlers' gesture abilities remain intact in the presence of HL, mothers were not maximally responsive to those gestures and thus should be coached to increase their provision of contingent feedback.

Over the past decade, the implementation of universal newborn hearing screening programs has resulted in children with hearing loss (HL) being identified and enrolled in early intervention (EI) at increasingly younger ages (Halpin, Smith, Widen, & Chertoff, 2010; Sininger, Grimes, & Christensen, 2010). To support these children in developing age-appropriate language skills, a better understanding of their communication skills during the first 2 years of life is necessary. Relying on past literature on communication development for this population is not feasible, as the advantages of early identification and intervention, coupled with recent advances in hearing assistive technologies (i.e., cochlear implants [CIs], hearing aids, and FM systems), has resulted in today's generation of deaf and hard of hearing children differing substantially from previous generations of children with HL. This article explores the early communication abilities of 14-month-old toddlers with HL, with a focus on gestural development, which is one of the earliest forms of intentional communication. This work also explores how mothers of toddlers with HL respond to their children's communicative gestures and includes comparisons to dyads in which the toddler has normal hearing (NH).

Gestural Development of Children With NH

Gestural development is a relatively robust phenomenon for typically developing (TD) children, with communicative gestures emerging around 10 months of age and following a fairly predictable developmental sequence throughout the first 2 years of life (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979). The age at which children reach gestural milestones during this period conveys important information about their communicative and cognitive abilities (Iverson & Goldin-Meadow, 2005). For example, children's use of deictic gestures (e.g., points) indicates that they are able to reference objects, and their use of iconic gestures demonstrates their capacity for utilizing symbolic representations. In a similar manner, their use of gesture–speech combinations in which the gesture provides information to supplement the speech (e.g., pointing to a cookie while saying "more") signifies that they are capable of conveying sentence-like

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ideas. Delays in reaching these gestural milestones may be indicative of delays in cognitive and communicative abilities that will also affect development in the spoken modality (Iverson, 2010). Evidence of the tight connection between gesture and spoken language has been reported in multiple studies of toddlers who are TD, both when examining the relationship concurrently (e.g., Bates, Thal, Whitesell, Oakes, & Fenson, 1989; Caselli, Rinaldi, Stefanini, & Volterra, 2012) and longitudinally (e.g., Capirci, Iverson, Pizzuto, & Volterra, 1996; Iverson & Goldin-Meadow, 2005; Rowe, Ozçalişkan, & Goldin-Meadow, 2008). For example, Rowe and Goldin-Meadow (2009b) found that the number of meanings conveyed in gesture by toddlers at 18 months was predictive of vocabulary knowledge 2 years later. The authors also found that the number of gesture–speech combinations utilized by toddlers at the earlier time point was predictive of the complexity of their sentence productions at the later time point.

The connection between gesture and speech also extends to caregivers' use of gestures; the frequency with which caregivers use gesture is positively related to language abilities for children with NH, both when examined concurrently (e.g., Iverson, Capirci, Longobardi, & Caselli, 1999; Zammit & Schafer, 2011) and longitudinally (e.g., Goodwyn, Acredolo, & Brown, 2000; Iverson et al., 1999; Pan, Rowe, Singer, & Snow, 2005; Rowe & Goldin-Meadow, 2009a). The relationships between parent gesture and child speech are likely attributable to two different roles of parental gesture use. First, when a parent couples a gesture with a spoken message, the gesture increases the likelihood that the child will process the parent's spoken message; the gesture helps the child attend to the object being referenced in speech, assists the child in discerning the parent's intent to label an object, and provides the child with information about the object of reference (e.g., the shape or function; McGregor, 2008). Second, parent gesture use encourages child gesture use—that is, parents who gesture frequently are likely to have children who gesture frequently (Iverson et al., 1999; Rowe & Goldin-Meadow, 2009a).

This latter point is important because when children gesture, they are giving their communicative partners the opportunity to provide the child with responsive feedback about a topic of interest to the child. Olson and Masur (2012) noted that mothers provide verbal responses to approximately 75% of toddlers' gestures in mother–child interactions. These verbal responses frequently serve the purpose of translating the information conveyed in children's gestures into spoken language (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007). For example, a child's point to a dog may elicit a maternal utterance of "That's the dog." Children are particularly likely to process spoken information provided by mothers in these responses, because they relate to the focus of the child's attention and interest. Evidence supporting the importance of these responses is found in studies indicating that provision of contingent responses to children's gestures promotes increased infant gesture use (J. L. Miller & Lossia, 2013) and is positively correlated with later language outcomes for children who are TD (Goldin-Meadow et al., 2007; Masur, 1982; Wu & Gros-Louis, 2014).

Gesture and Children With HL

Although much is known about the gestural development of children with NH, including the relationships between gesture and speech development, we know little about the development of gesture for the current population of infants and toddlers with HL. This is, in part, because the majority of research on the gesture use of children with HL has involved children who were deaf and who did not have access to newborn hearing screenings, EI, or advanced assistive hearing technologies (e.g., Goldin-Meadow, 2003; Volterra & Erting, 1998). Better understanding this domain for the current population of toddlers with HL has implications for ensuring that we are maximizing our ability to identify infants with HL who are most at risk for delays in spoken language development and for making decisions regarding EI approaches. As a first step toward these goals, it is necessary to better understand the gesture use of toddlers with HL and whether their gesture use differs from that of their peers with NH. In addition, it is crucial that we understand how mothers respond to the gesture use of toddlers with HL and whether this differs from how mothers respond to the gesture use of toddlers with NH. Both of these topics are explored within this article.

To date, studies seeking to identify early indicators of risk for children with HL have primarily focused on early vocal and speech development (e.g., Castellanos et al., 2014; Ching et al., 2013; Hay-McCutcheon, Kirk, Henning, Gao, & Qi, 2008). However, as previously noted, research from children with NH indicates that gestural abilities serve as one of the earliest and most reliable predictors of eventual linguistic achievement for those toddlers (Sauer, Levine, & Goldin-Meadow, 2010). Whether gestural abilities can also be utilized to identify toddlers with HL who are most at risk for spoken language delays is unclear, as research examining gestural development and the relationships between gesture and spoken language for this new generation of children with HL has been limited. The pressing need for such work was recognized in the recommendations developed during the National Institute on Deafness and Other Communication Disorders (NIDCD) workshop on Outcomes Research in Children with Hearing Loss (Eisenberg et al., 2007). To be specific, it was noted that communicative gestures should be examined as one of the many outcome domains for this population and that assessments of the gesture to symbol continuum were needed to facilitate future research on language development.

Although a handful of studies have described the gestural abilities of children with HL since the workshop's recommendations were published, these studies have been limited in scope and have presented conflicting findings with regard to the relationships between gesture and spoken language. For example, one study reported a potential disconnect between concurrent development in the gestural and spoken modalities for toddlers with HL, with children's auditory deficits negatively affecting spoken language development while leaving gestural development intact (Zaidman-Zait & Dromi, 2007). In contrast, work by Vohr and colleagues (Vohr et al., 2008; Vohr et al., 2011) indicates a close coupling of gesture and spoken language for children with HL. The authors reported that toddlers with moderate-to-profound HL demonstrated delays in gesture and spoken language development, and that delays in gestural development at 12 to 16 months were predictive of spoken language delays at 18 to 24 months.

Another implication of better understanding the relationships between gesture and speech for toddlers with HL relates to identifying approaches for promoting spoken language development for this population. As previously discussed, the frequency with which parents use gesture and translate their children's gestures into spoken language are both positively correlated with language outcomes for toddlers with NH (Goldin-Meadow et al., 2007; Goodwyn et al., 2000; Iverson et al., 1999; Masur, 1982; Pan et al., 2005; Zammit & Schafer, 2011). In addition, training parents to utilize gestures when communicating with their children and to be responsive to their children's gestures and other communicative attempts has been shown to improve the linguistic outcomes of NH toddlers with and without language delays (Fey, Warren, Fairchild, Sokol, & Yoder, 2006; Goodwyn et al., 2000; Yoder & Warren, 2002). If these findings are also applicable to children with HL, an argument could be made for promoting EI approaches that coach parents to maximize their use of gesture and their responsiveness to the gestures of their toddlers with HL. However, concerns have been expressed regarding the potential for input in the gestural (visual) modality to compete with input in the spoken modality, thus resulting in gestural input impeding spoken language development (Acredolo & Goodwyn, 1988), especially for children with HL for whom visual input may be easier to process (Power & Hyde, 1997). Developing a better understanding of how parents of children with HL use gestures and respond to their children's gestures is a first step toward understanding whether these behaviors contribute to the spoken language outcomes of this population. This line of research is important as findings could inform how parents of toddlers with HL are guided to promote their children's linguistic development.

Objectives

The current study seeks to better understand the gesture use of toddlers with HL and how their mothers respond to children's early gesture use. This work had four primary objectives:

1. To examine how 14-month-old toddlers with HL use gesture as compared to symbolic forms (spoken words, signs) and to investigate whether their use differs from that of toddlers with NH.

It was hypothesized that there would be no differences between groups for gestural abilities, but that differences would be identified between groups in symbolic forms, with the NH group using more spoken words than the toddlers with HL and the toddlers with HL using more signs then their NH peers.

2. To determine whether gesture and symbolic forms are interrelated for toddlers with HL and how that compares to the relationships between gesture and symbolic forms for toddlers with NH.

It was hypothesized that spoken words and gesture would be interrelated for both groups of children, given the similar cognitive mechanisms underlying both communication modalities. However, the relationship between gesture and spoken language was hypothesized to be weaker for children with HL than for their peers with NH, given that hearing status may affect development of spoken language, while leaving gestural abilities intact.

3. To determine which factors related to maternal communication style (maternal gesture, sign, and spoken language use) and child HL (better-ear pure tone average [BEPTA] and device type) predict individual variability in the gesture and symbol use of toddlers with HL and whether the relationships between maternal communication style and child gesture and symbol use for children with HL differ from those of children with NH.

It was hypothesized that maternal communication style would be related to children's gestural and symbolic communication. However, it was hypothesized that factors related to children's HL would not be related to their gestural abilities, and instead would only be related to their spoken language abilities.

4. To explore how mothers of 14-month-old toddlers with HL respond to children's communicative gestures and whether this differs from that of mothers of children with NH.

No predictions were made for this objective because of the limited background literature to support making predictions.

Method

Participants

Participants included 25 mother–toddler dyads in which the child had a HL and 23 mother–toddler dyads in which the child had NH. Eighteen dyads in the HL group and all 23 dyads in the NH group were initially recruited as part of an NIDCD-funded longitudinal study (R01DC006681) on the factors influencing word learning of infants with HL and were reconsented for use of their data in the current study. The remaining seven dyads in the HL group were recruited for the current study on gesture use of infants and toddlers with HL (NIDCD R03DC012647) to increase the number of participants in the HL group. The study was longitudinal, with all children entering by 14 months of age and continuing through at least 3 years of age. This article reports on data collected from children's 14-month visits (see Table 1 for age of both groups).

Four inclusion criteria were applied to toddlers in the HL group: (a) bilateral, permanent conductive or sensorineural HL, (b) a family goal of developing the child's spoken language abilities, (c) a home where English was the primary language, and (d) no significant cognitive delays or neurological diagnoses. The latter two inclusion criteria for the HL group were also applied to toddlers in the NH group, who were matched for maternal education, $\chi^2(3, n = 48) = 3.20$, $p = .362$, $\phi = .258$ (see Table 1 for demographic information, including maternal education).

All toddlers with HL had a history of a failed newborn hearing screening and/or HL confirmed by 6 months of age. In addition, all toddlers with HL were fit with hearing aids prior to collection of data for this project. However, at the time of data collection, three children in the HL group utilized a unilateral CI and four children utilized bilateral CIs (*M* months since initial stimulation of first CI = 1.11, *SD* = 1.04, range = 0.00–3.26). Of the seven children who utilized CIs, one child had a BEPTA in the severe range prior to implantation, and the others all had BEPTAs in the profound range prior to implantation.

Table 1. Demographic and audiologic characteristics for the toddlers in both groups.

Characteristics	HL group (*n* = 25)	NH group (*n* = 23)
Age (months)		
M	13.83	13.52
SD	0.47	0.16
Range	13.00–15.24	13.2–13.97
Maternal education		
High school or less	8%	0%
Some college	21%	13%
College graduate	38%	43%
Graduate education	33%	43%
Sex		
Male	44%	48%
Female	56%	52%
Age HL confirmed (months)		
M	3.91	
SD	3.31	
Range	0.63–13.74	
Age hearing aid fitted (months)		
M	4.96	
SD	3.23	
Range	1.50–13.77	
BEPTA		
M	72.77	
SD	13.87	
Range	33.33–123.33	
Degree HL in better ear		
Mild (25–40 dB HL)	16%	
Moderate (41–70 dB HL)	32%	
Severe (71–90 dB HL)	20%	
Profound (91+ dB HL)	32%	

Note. HL = hearing loss; NH = normal hearing; BEPTA = better-ear pure tone average.

At the time of the current study, all children were enrolled in home-based EI services that were provided by or contracted through their local school district. The frequency of services for each child was determined by the school district based in part upon the needs of the child and family (e.g., degree of HL) and ranged in frequency from one to eight visits per month. In a similar manner, the focus of the intervention programs differed on the basis of the established needs of each family, with the focus shifting based upon the child's changing needs (e.g., upon receipt of a CI). Three children also received supplemental services from a center-based speech-language pathologist, and one child received supplemental services from a private auditory–verbal therapist.

Procedures

Audiologic Information

Hearing status for the NH group was confirmed via distortion product otoacoustic emission measures. Audiologic information for the toddlers with HL was collected via records from the child's audiologist. Four-frequency (500, 1000, 2000, 4000 Hz) BEPTAs were calculated using the child's most recent audiogram where both good reliability and normal tympanograms were noted, when possible. When this information was unavailable, three-frequency audiograms or auditory brainstem response results were utilized to calculate BEPTA. When no response was obtained at one or more frequencies, mean thresholds were calculated by adding 5 dB to the threshold for the relevant frequencies. Audiologic information is displayed in Table 1.

Parent-Report Questionnaire

Mothers completed the Words and Gestures form of the MacArthur–Bates Communicative Development Inventories (MBCDI; Fenson et al., 2007) at the 14-month visit. This questionnaire queries parents regarding a variety of early communicative skills. Of relevance for this study were the vocabulary checklist, which was filled out regarding children's spoken language abilities, and the first communicative gestures section. The vocabulary checklist queries parents regarding their children's understanding and production of 396 words. The first communicative gestures section queries parents regarding whether their child uses 12 common gestures, including showing, giving, pointing, waving, and blowing kisses.

Language Samples

Naturalistic mother–child interactions were video-recorded in a controlled play setting for 30 min. During the sessions, mothers were asked to play with their child in a typical manner using a standard set of age-appropriate toys in a laboratory playroom. Children wore a vest that held a wireless lavalier microphone on the chest approximately 2 in. from the child's mouth. Audio and video recordings of mother–child interactions were captured using two mounted cameras with pan-tilt capability that were controlled from an observation room, allowing the researchers to unobtrusively follow the movements of the child and mother around the room.

Transcription and Coding

Spoken Language and Sign

Each mother–child interaction was assigned to a team of two listeners for transcription by consensus (Shriberg, Kwiatkowski, & Hoffmann, 1984), with one listener doing the initial transcription and the transcription checked by the second listener. In addition, further checks of the transcript occurred with each additional layer of coding (i.e., gesture coding, maternal-response coding). This consensus transcription procedure was implemented in an attempt to reduce measurement error by using at least two judges. When disagreements occurred, transcribers worked together to come to an agreement or conferred with the project director. The transcription team included undergraduate and graduate students, as well as certified speech-language pathologists.

All interactions in which the mother or child used sign language were assigned to research assistants fluent in Signing Exact English or American Sign Language. To differentiate signs from gestures, signs were defined as being hand movements that can be found in a sign language dictionary and that are not typically utilized by adults who have not been exposed to sign language. Formal signs that might be used by adults who were not exposed to sign language, such as pretending to lick an ice cream cone for "ice cream," were coded as gestures.

Transcription of the interactions was completed using either Systematic Analysis of Language Transcripts (SALT; J. F. Miller & Chapman, 1998) or Computerized Language Analysis software (CLAN; MacWhinney, 2000). All SALT files were converted to CLAN files after transcription was complete. CLAN software was used to calculate the number of spoken words (spoken word tokens), number of different spoken root words (spoken word types), the number of signs (sign tokens), and the number of different signs (sign types) used by children and mothers.

Gesture

In accordance with the criteria outlined by Rowe et al. (2008), *gestures* were defined as communicative hand movements that do not involve direct manipulation of an object (e.g., pushing a toy car) or a ritualized game (e.g., Itsy Bitsy Spider). Emphatic hand movements were not considered gestures, as these are not generally observed in children of this age. Each identified gesture was categorized as being deictic, conventional, or iconic and assigned a meaning. *Deictic* gestures are gestures that call attention to or indicate an object or event in the immediate environment. These include pointing, showing, giving (only coded for the child), and requesting (e.g., open-handed reach). For all deictic gestures, the meaning was transcribed as the referent of the gesture (e.g., pointing to a bird was transcribed as "bird"). On occasion, the meaning could not be determined because the referent was not clearly visible (e.g., pointing in a book when the book was held at an angle, rendering the pages not visible via the two cameras). For maternal gestures, the mother's speech was used to clarify the referent when feasible. However, for the child gestures, speech was not utilized to clarify the referent, so as not to inflate gesture types for children with stronger speech skills as compared with children with more limited use of spoken language. When the meaning could not be determined, the meaning was coded as "unknown," and the gestures were excluded from counts of gesture meanings (child M = 22.2%, mother M = 2.5%). *Conventional* gestures are social gestures whose form and meaning are culturally defined, such as a nod of the head to indicate "yes" or a finger to the lips to indicate "quiet." *Iconic* gestures convey semantic information about a concrete or abstract referent and do not change appreciably with context (e.g., opening and closing thumb and finger or flapping arms for a meaning of "bird" or pretending to drop an object for a meaning of "drop").

Gesture transcription and coding was completed within the CLAN files containing transcription of spoken and signed utterances. CLAN software was utilized to calculate the number of gestures used (gesture tokens) and the number of meanings conveyed via gesture (gesture type) for children and mothers. Gesture token and type were also calculated separately for each gesture category (deictic, conventional, and iconic). Interjudge reliability was assessed by having a second research assistant independently code gesture presence, meaning, and category for 20% of the transcripts for each group. Reliability for gesture presence was calculated using the formula two times the number of agreements divided by the total number of observations made by Coder 1, plus the total number of observations made by Coder 2 (Iverson et al., 1999; Kratochwill & Wetzel, 1977). Agreement for gesture presence was 91.8% (range = 84.0–96.3) for children and 91.1% (range = 87.0–95.7) for mothers. Point-by-point agreement was calculated for meaning and category. For children, agreement for meaning was 91.3% (range = 72.7–100.0) and agreement for category was 100%. For mothers, agreement for meaning was 94.6% (range = 85.3–100.0) and agreement for category was 99.7% (range = 97.1–100.0).

Maternal Responses

Following each child utterance that contained a communicative gesture, the maternal response (or lack thereof) to the child's gesture was coded. The initial code was Uncodable, Not Contingent, or Contingent. Uncodable responses were those that followed a child's gesture for which the meaning was transcribed as "unknown" or responses in which the mother's speech was unintelligible. Not Contingent responses were divided into No Response (no spoken response within 2 s) and Unrelated (e.g., child points to a ball and mother says, "Come look at my car"). Contingent responses were divided into Translated and Not Translated and could only be applied when the mother had a spoken response within 2 s of the child's gesture. Translated responses were those in which the meaning of the gesture was translated into spoken language (e.g., child points at a ball and mother says, "Yes, a ball"). Not Translated responses were those in which the mother contingently responded with spoken words, but without translating the gestures (e.g., child points to a ball and mother says, "You want to play with that"). Interjudge reliability was assessed by having a second research assistant independently use the five-level coding system for 20% of the transcripts for each group. Point-by-point agreement calculations yielded an agreement of 99.7% (range: 96.7–100).

Data Analysis

Data analyses were conducted using SPSS (Version 22). The analyses primarily comprised making between-groups comparisons and calculating the strength and direction of relationships between variables. For between-groups comparisons, when data met the assumptions for normality, independent samples *t* tests were conducted and Cohen's *d* was calculated to report on effect size. When the assumptions for normality were not met, typically due to floor effects, Mann–Whitney *U*-tests were instead utilized to test for between-groups differences. To report on effect size for these comparisons, *r* values were calculated by dividing the *z* value in the SPSS output by the square root of the number of observations in the comparison. The test utilized for each comparison is noted in Tables 2, 3, and 4. To determine whether a linear relationship existed between variables and the magnitude and direction of any relationships, Pearson product–moment correlation coefficients were calculated. For all analyses, the alpha level for significance was set at .05.

Results

Between-Groups Comparison of Children's Gesture and Symbol Use

The first study objective addressed whether the gesture and symbolic communication use of 14-month-old toddlers with HL differed from those of their age-matched peers with NH. Data were analyzed from both the MBCDI and the language sample and are presented in Table 2.

MacArthur–Bates Communicative Development Inventories

For five of the 25 HL dyads, data from the first communicative gestures section on the MBCDI was unavailable, although data were available for words understood and words produced on the vocabulary checklist. For one additional child, no MBCDI form was available at 14 months. However, for that child, forms were available from 12 and 16 months and, given that limited progress was documented in two of the three MBCDI scores for that child, an average of the 12 and 16 month scores were used in analyses of the MBCDI. All data were complete for the NH group. Data from between-groups comparisons indicated that the groups' gesture scores were similar. However, differences were identified for words understood and words produced, with the children in the NH group understanding and producing more spoken words than children in the HL group.

Language Sample

Between-groups comparisons were made for the numbers of gestures, signs, and spoken words children used (tokens) in the language samples, as well as the number of meanings they conveyed in each modality (types). Gesture use was similar between the groups, as can be seen in Table 3. All but two children with NH and one child with HL used at least one gesture to communicate. Analyses of gesture category (meanings conveyed via each category of gesture) indicated that both groups used deictic gestures to convey the most meanings, with conventional and iconic gestures being relatively rare. No significant differences were identified between groups for gesture categories, as can be seen in Table 4. Given that gesture types and tokens are naturally highly correlated, further analyses focus on gesture types.

With regard to use of signs, as can be seen in Table 3, neither group used signs frequently. Only one child in the NH group and four children in the HL group used any signs. One child in the HL group served as an outlier, using 17 sign tokens. Of the three other children in the HL group who used any signs, none of those children used more than three sign tokens. Given the limited sign use of both groups, children's sign use is not further examined in this article.

Significant differences between groups were identified in the spoken modality; children with NH used significantly more spoken words and conveyed more meanings via spoken language than did children with HL. Whereas 83% of the children with NH used at least one spoken word, only 48% of the children with HL did so.

Table 2. Between-groups comparison of parent-reported gesture and spoken language use on the MacArthur-Bates Communicative Development Inventories (Fenson et al., 2007).

	NH group			HL group			Between-groups comparison	
Communicative skill	*n*	*M* (*SD*)	Range	*n*	*M* (*SD*)	Range	Test statistic	Effect size
Gesture score	23	8.39 (1.44)	6–11	20	8.43 (1.84)	5–11	*t* = –0.67	*d* = –0.02
Words understood	23	99.78 (71.93)	11–284	25	48.02 (49.50)	0–154	*t* = 2.92**	*d* = 0.84
Words produced	23	11.70 (9.62)	0–34	25	6.52 (13.44)	0–64	*U* = 148.50**	*r* = –.42

Note. NH = normal hearing; HL = hearing loss.
**$p < .01$

Table 3. Between-groups comparison of toddlers' gesture, sign, and spoken language use in the 30-min language samples.

	NH group (n = 23)		HL group (n = 25)		Between-groups comparison	
	M (SD)	Range	M (SD)	Range	Test statistic	Effect size
Gesture						
Tokens	17.57 (19.94)	0–91	17.52 (18.39)	0–78	t = 0.01	d < −0.01
Types	7.00 (6.11)	0–21	6.20 (4.33)	0–17	t = 0.52	d = 0.15
Signs						
Tokens	0.17 (.83)	0–4	0.92 (3.43)	0–17	U = 255.00	r = −.18
Types	0.09 (.42)	0–2	0.36 (1.08)	0–5	U = 254.50	r = −.19
Spoken word						
Tokens	10.70 (16.17)	0–58	2.68 (6.18)	0–28	U = 148.00**	r = −0.42
Types	3.83 (3.63)	0–13	1.00 (1.73)	0–8	U = 136.00**	r = −0.47

Note. NH = normal hearing; HL = hearing loss.
**p < .01

These findings, along with those from the MBCDI, generally fit with the hypothesis that there would be no differences between groups for gestural abilities, but that differences would exist between groups for symbolic forms. However, the one caveat is that no significant difference was identified between groups for use of signs, which likely was due to few children being exposed to signs by their mothers and even fewer children having begun to use signs expressively.

Relationships of Gesture Use With Symbolic Communication Use

The second study objective addressed how gesture use was related to use of symbolic forms for children with HL as compared to children with NH. Due to floor effects in the HL group for observed spoken word types (52% of the children used no spoken words in the language samples), a composite score for spoken language was derived on the basis of the number of spoken word types children produced in the language sample and the number of words they were reported to understand and produce on the MBCDI vocabulary checklist. For spoken word types from the language sample, children in the HL group and the NH group were divided into two subgroups representing performance below the median and performance above the median and assigned corresponding scores (low = 0, high = 1). For both words understood and words produced on the MBCDI, which had more variance, children in the HL group and the NH group were divided into three subgroups representing performance in the lowest third, middle third, and highest third of their respective group and assigned corresponding scores (0, 1, and 2, respectively). The three scores were then summed for each child, yielding a composite score with a value of 0 to 5. This procedure was supported by a Cronbach's alpha of .75 for the HL group and .71 for the NH group, indicating that the three scores represented similar skills. The relationships between gesture use in the language sample (tokens and types) and speech composite scores for each group were investigated using Pearson product–moment correlation coefficients. Speech composite scores were not significantly correlated with gesture tokens (NH $r = -.29$, $p = .185$; HL $r = -.23$, $p = .275$) or gesture types (NH $r = -.27$, $p = .209$; HL $r = -.18$, $p = .395$) for either group. Thus, the data did not support the hypotheses outlined for Objective 2.

Table 4. Between-groups comparison of toddlers' deictic, conventional, and iconic gesture use in language samples.

	NH group (n = 23)		HL group (n = 25)		Between-groups comparison	
	M (SD)	Range	M (SD)	Range	U	r
Deictic						
Tokens	16.43 (19.74)	0–91	15.52 (17.39)	0–74	272.50	−.04
Types	7.83 (7.13)	0–23	5.96 (4.88)	0–20	257.00	−.09
Conventional						
Tokens	1.00 (1.95)	0–7	1.04 (1.49)	0–6	246.50	−.14
Types	0.57 (1.04)	0–4	0.84 (0.99)	0–3	232.00	−.18
Iconic						
Tokens	0.13 (0.63)	0–3	0.88 (2.51)	0–9	254.00	−.19
Types	0.09 (0.42)	0–2	0.48 (1.36)	0–6	253.50	−.19

Note. NH = normal hearing; HL = hearing loss.

Contributions of Maternal Communication and Child HL Factors

The third study objective addressed whether factors related to maternal communication style or the child's HL were related to children's gesture or symbol use (with child symbol analyses again focusing only on spoken language, due to minimal sign use for both groups). The variables explored for maternal communication style were maternal gesture types, maternal sign use, and maternal spoken word types. Maternal sign use was only explored for the HL group, given the minimal sign use by mothers in the NH group. For the HL group, maternal sign use was represented by a dichotomous variable in which mothers were divided into those who used more than four sign types in the language sample (signing $n = 7$, M sign types = 32.1, $SD = 15.7$, range = 20–66) and mothers who used fewer than three sign types in the language samples (nonsigning $n = 18$). Pearson product–moment correlation coefficients were calculated separately for the NH and HL groups and are displayed in Table 5.

For the NH group, no significant relationships were identified between the child and maternal variables. For the HL group, maternal gesture types and child gesture types were significantly correlated ($p = .023$), as were maternal sign and child gesture types ($p = .012$). This latter relationship appeared to be driven by the strong correlation between maternal gesture types and maternal sign—that is, the signing mothers of children with HL used significantly more gesture types than the nonsigning mothers of children with HL (Signing $M = 42.43$, $SD = 7.66$; Nonsigning $M = 22.39$, $SD = 10.24$; $t = -4.67$, $p < .001$, $d = -2.21$). The relationship between maternal gesture types and child gesture types was no longer significant after removing the seven signing dyads from the HL group ($r = .09$, $p = .736$).

As a follow-up analysis, to ensure that a different pattern of relationships would not have emerged with examination of gesture tokens instead of gesture types, correlations were calculated between the following variables: child gesture tokens, child speech composite scores, maternal gesture tokens, maternal sign (signing, nonsigning), and maternal spoken word tokens. The same pattern emerged when using the token variables as was identified for the type variables. For the NH group, no significant relationships were identified between the child and maternal variables. For the HL group, maternal gesture tokens and child gesture tokens were significantly correlated ($r = .74$, $p < .001$), as were maternal sign and child gesture tokens ($r = .60$, $p = .002$). However, again, this latter relationship appeared to be driven by the strong correlation between maternal gesture token and maternal sign ($r = .782$, $p < .001$). The relationship between maternal gesture token and child gesture token was no longer significant after removing the seven signing dyads from the HL group ($r = .31$, $p = .201$). However, it is worth noting that the magnitude of this relationship was stronger for the gesture token variables than the gesture type variables. Thus, the hypothesis that maternal communication style would be related to children's gestural and symbolic communication was only supported for children whose mothers used sign language.

The child HL factors were BEPTA and device type (hearing aid $n = 18$, CI $n = 7$). A Pearson product–moment correlation coefficient revealed no significant correlation between BEPTA and gesture types ($r = .31$, $p = .127$). However, a strong significant correlation was identified between BEPTA and speech composite scores ($r = -.68$, $p < .001$). Given that the relationship between pre-CI BEPTA and speech may change after a child receives a CI, the correlation was also calculated separately for the 18 children who used hearing aids ($r = -.81$, $p < .001$). Device type was not significantly correlated with either gesture types ($r = -.01$, $p = .968$) or speech composite score ($r = -.25$, $p = .238$). The findings related to BEPTA provide support for the hypothesis that factors related to children's HL would not be related to their gestural abilities, and instead would only be related to their spoken language abilities.

Maternal Response to Children's Gestures

For the final study objective, we were interested in how mothers of toddlers with HL respond to their children's communicative gestures and whether their response profile differs from that of mothers of children with NH. The analysis of maternal response to gesture was completed for children who had five or more gesture tokens for which a maternal response could be coded, resulting in 18 children in the HL group and 19 children in the NH group. Maternal

Table 5. Correlation matrix for relationship of maternal communication variables with child gesture and spoken language (normal hearing [NH] group above the diagonal line and HL [hearing loss] group below the diagonal line).

	Child gesture (types)	Child speech (composite score)	Maternal gesture (types)	Maternal sign (signing, nonsigning)	Maternal spoken words (types)
Child gesture (types)	—	–.27	–.20	n/a	.27
Child speech (composite score)	–.18	—	.25	n/a	.21
Maternal gesture (types)	.45*	–.06	—	n/a	.15
Maternal sign (signing, nonsigning)	.50*	–.34	.70**	—	n/a
Maternal spoken words (types)	–.15	.31	.36	–.09	—

Note. n/a = not applicable.

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

response data were represented as the percent of all maternal responses that were assigned to each category (Not Contingent–No Response, Not Contingent–Unrelated, Contingent–Not Translated, and Contingent–Translated), excluding those identified as Uncodable. Data are provided in Table 6. For both groups, Contingent–Not Translated responses were most frequent, followed by Contingent–Translated. A significant difference was identified between groups for Not Contingent–No Response ($p = .042$), with the mothers of children with HL being significantly more likely to not respond to their child's gestures within 2 s than were the mothers of children with NH. No other significant differences were identified.

Given the differences between signing and nonsigning mothers identified in earlier analyses, a between-groups comparison between nonsigning and signing mothers was completed to determine whether one of these groups might be independently responsible for the observed difference between mothers of children with NH and HL for Not Contingent–No Response. No differences were observed between nonsigning ($n = 11$, $M = 25.87$, $SD = 19.71$) and signing ($n = 7$, $M = 25.97$, $SD = 20.50$) mothers in the HL group ($t = 0.01$, $p = .993$, $d = -0.01$).

Discussion

This study examined the gesture use of toddlers with HL, with comparisons made to their use of symbolic forms of communication and an exploration of how their mothers responded to the toddlers' use of communicative gestures. At 14 months of age, toddlers with HL were found to predominately communicate via gestures, with fewer than half the group using any spoken words and even fewer using formal signs. This same profile of gestural dominance was also found for toddlers with NH, and the two groups were observed to use gesture at remarkably similar rates to convey similar numbers of meanings. In addition, both groups primarily used deictic gestures for communication, with conventional and iconic gestures being relatively rare. Despite similar communication profiles and gesture use, the groups differed in their spoken language abilities, with the NH group using significantly more words in the language samples and being reported by parents to understand and produce more words than their peers with HL. This fits with the finding that BEPTA was related to speech composite scores but not gesture use—that is, limitations in children's ability to access auditory information negatively affected their ability to communicate via spoken language, while leaving their gestural abilities intact.

The findings of this study fit with those reported by Zaidman-Zait and Dromi (2007), who found that 11- to 20-month-old toddlers with HL demonstrated similar gestures skills to their NH peers, but with relatively lower spontaneous use of words. However, the findings of both the current work and the Zaidman-Zait and Dromi study differ from those of Vohr et al. (2008), who reported that 12- to 16-month-old toddlers with moderate-to-profound HL had significantly lower scores on the MBCDI gestures section as compared to their peers with mild/minimal HL or NH. This discrepancy may be related to differences in the populations of these studies. Whereas the inclusion criteria for the current work and the Zaidman-Zait and Dromi study included typical cognitive development, the Vohr et al. (2008) study had no such inclusion criteria. In addition, their sample included a high proportion of infants from the neonatal intensive care unit (NICU), with 83% of the infants with moderate-to-profound HL having spent time in a NICU, as compared to 33% and 55% of their mild/minimal HL and NH control groups, respectively.

This difference in recruitment may also be responsible for differences between the studies with regard to the relationships between gesture and spoken language for children with HL. Although predictions for the current work were that gesture and spoken language would be interrelated for toddlers with HL, neither findings from the current work nor from Zaidman-Zait and Dromi (2007) included a significant relationship between skills in these two modalities. However, these skills were interrelated in the study by Vohr et al. (2008). In their model exploring predictors of language scores for the children with HL, the degree of HL did not contribute independently to any of the language outcomes, including gesture, whereas NICU care either contributed significantly or trended toward association for each of the communication measures. This indicated that the high-risk

Table 6. Between-groups differences for percent of maternal responses to children's gestures that were assigned to each maternal response category.

	NH group ($n = 19$)		HL group ($n = 18$)		Between-groups comparison	
	M (SD)	Range	M (SD)	Range	Test statistic	Effect size
Not Contingent						
No response	14.29 (17.71)	0–66.7	25.91 (19.41)	0–60.0	$U = 104.5$*	$r = -.30$
Unrelated	7.51 (14.54)	0–62.5	6.26 (9.78)	0–40.0	$U = 166.0$	$r = -.02$
Contingent						
Not translated	43.83 (23.07)	0–83.3	41.52 (22.05)	0–80.0	$t = 0.31$	$d = 0.10$
Translated	37.36 (26.26)	0–100	26.31 (19.42)	0–63.2	$t = 1.06$	$d = 0.48$

Note. NH = normal hearing; HL = hearing loss.

*$p < .05$

status associated with care in the NICU had a greater impact on language outcomes for toddlers with HL than did the degree of HL. Thus, assessment of gestural abilities during the first half of the second year of life may be valuable in identifying children with HL who have general developmental delays or cognitive deficits, but serve less value when children have already been determined to be TD with the exception of their HL.

However, it is also worth noting that the current work did not identify a relationship between the gesture and spoken language skills of the toddlers with NH, which is in contrast to other studies reporting relationships between gesture and spoken language for toddlers who are TD. This includes one study by Rowe and Goldin-Meadow (2009a) of children the same age as children in the current work. The authors reported a correlation of .61 for the relationship between gesture types and spoken word types for toddlers with NH who were 14 months of age. They also reported a correlation of .44 for the relationship between meanings conveyed via maternal gesture and child gesture. Although predictions for the current work included finding a similar relationship for both the NH and HL dyads, maternal and child gesture use were only found to be related for the children of signing mothers in the HL group. It is unclear why these discrepancies occurred. It is possible that the discrepancies are related to a methodological issue, such as differences in the ranges of socioeconomic status (SES) in the two studies. The Rowe and Goldin-Meadow (2009a) study included a wide range of SES, which was related to both child and maternal gesture use. In contrast, the current study had a more restricted range of SES, with all mothers in the NH group having completed at least some college education, which may have further limited variability in gesture use. However, another hypothesis is that an uncoupling of gesture and spoken language may have occurred for children who were in the process of developing a new skill or experiencing rapid growth of an established skill (e.g., a vocabulary growth spurt). This hypothesis is supported by the dynamic systems theory which proposes that developmental systems are interconnected, but that these connections can be disrupted as new skills emerge or undergo significant growth (Gershkoff-Stowe & Thelen, 2004; Iverson & Thelen, 1999; Parladé & Iverson, 2011). It is also possible that the relationship did not exist because of the limited variability in spoken language development demonstrated by the groups in this study or the fact that there is limited stability in expressive language abilities at this young age (Fenson et al., 1994; Thal & Bates, 1997)—that is, children's relative standing within the group (i.e., as being more or less advanced in spoken language development) may have differed if language abilities had instead been assessed at 12 or 16 months. This supports the need for longitudinal work that can examine concurrent gestural and spoken language abilities at multiple time points, as well as the longitudinal relationships between development in the two modalities.

Had a relationship existed between gesture and spoken language for children with NH, but not for children with HL, it would have been reasonable to conclude that the differential effect of HL on gesture and spoken language resulted in a decoupling of development between the two domains. However, given that evidence of a coupling between these two domains was not evident for children with NH either, it is possible that there are other developmental or methodological issues contributing to the lack of a relationship between gesture and spoken language for children with HL.

A novel finding of the current work is that children of signing mothers used gestures to communicate about a wider variety of topics than children of nonsigning mothers. This has significant clinical implications if future work identifies a relationship between early gesture use and later spoken language outcomes for children with HL. Another novel finding of the current work, with potentially significant clinical implications, was the difference in how mothers of children with HL and NH responded to their children's gestures—that is, mothers of children with HL were less likely than mothers of children with NH to provide a spoken response to their child's communicative gesture within a 2-s window. It is unclear what led to this difference between groups. Although one might hypothesize that the mothers of children with HL were less likely to recognize gestures as a form of communication or that they were singularly focused on their children's spoken language development, the evidence that signing and nonsigning mothers were similarly unresponsive to the gestures of their toddlers with HL runs contrary to these hypotheses. Regardless of the reason, it appears problematic that mothers of children with HL are not fully capitalizing on the potential to provide their children with responsive feedback, given the literature documenting the positive contributions of maternal responsiveness and prelinguistic communication to the subsequent language outcomes of children with NH (Brady, Marquis, Fleming, & McLean, 2004; Goldin-Meadow et al., 2007; Masur, 1982; Wu & Gros-Louis, 2014; Yoder & Warren, 1999). Providing responsive feedback to the gestures produced by toddlers with HL may be especially important, given that their more limited use of spoken words results in caregivers having fewer opportunities to provide children with HL with contingent feedback. Intervention approaches that teach caregivers to provide rich feedback in response to all communication attempts by their children, including translating children's gestures into words, have the potential to positively affect the language outcomes of children with HL.

Limitations and Future Directions

One limitation of the current work is that substantial floor effects were evident in the spoken language measures for children in the HL group. In addition, minor floor effects were present for both groups on the measure of gesture use. Longer mother–child interactions could have been beneficial for reducing these floor effects and increasing variance within each group. However, the floor effect for spoken language development of the HL group was at least partially unavoidable. Thus, questions regarding the relationships between gesture and spoken language may be better explored at later ages, when variance may naturally increase. Additional limitations include the small sample size for subgroup analyses relating to maternal use of sign and the collected data not being sufficient for analyzing relationships between the focus of each child's intervention and the dyad's use of gesture.

Variance in the current study, as well as generalizability to the full population of toddlers with HL, may also have been reduced by attempts to limit the heterogeneity of the HL group—that is, inclusion criteria resulted in all children being from English-speaking homes, having parents who were committed to their children developing spoken language, being TD other than their HL, and enrolled in the study by 14 months of age. This latter criterion also meant that they were identified and enrolled in intervention relatively early. In addition, given that the families were willing to commit to participation in a longitudinal study, one could speculate that family involvement may have been fairly high for this group. These inclusion criteria and the use of a longitudinal study may have further reduced variance as most families meeting these criteria were from somewhat advantaged socioeconomic backgrounds. Inclusion of children with more heterogeneous backgrounds and development, including children with additional disabilities and more limited family resources, may have yielded more variability in early communication development.

This article only presented a snapshot of gesture use at one discrete point in time. However, this work is part of a longitudinal study, thus future work on this project will examine the trajectory of gestural development for this group through 36 months of age. In addition, standardized measures of language and cognition will be collected at the final visit. This longitudinal work will allow for examination of the contributions of early gesture use to later spoken language outcomes and exploration of the relationships between gesture and cognition. This work will also examine how maternal use of gesture and maternal responsiveness to gesture is related to the spoken language development of children with HL as compared to their peers with NH. This examination should shed light on whether the concern that input in the gestural modality may compete with input in the spoken modality is warranted. In addition, the longitudinal work should allow for more conclusive findings regarding whether gestural abilities can be utilized to identify infants with HL who are most at risk for limited linguistic achievement, despite having no additional disabilities.

Summary

At 14 months of age, toddlers with HL were observed to use gesture at similar rates as their hearing peers, despite delays in spoken language development. No significant relationships were identified between gesture and spoken language use at this early time point for children with HL or their peers with NH. Spoken language use, but not gesture use, was related to children's hearing levels, indicating that HL may negatively affect children's spoken language development, while leaving their gestural development intact. Children who were exposed to sign language used more gestures than children with nonsigning mothers, thus these children provided their mothers with more opportunities to provide contingent feedback to gesture use. Mothers of children with HL were observed to be less responsive to their children's gesture use than were mothers of children with NH. Caregivers of toddlers with HL should be taught to identify and be responsive to all of their children's early communication attempts, regardless of the modality. This is especially critical given that caregivers of children with HL may have fewer opportunities than parents of children with NH to provide responsive feedback to children's productions of spoken words.

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