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## Early pragmatics in deaf or hard-of-hearing infants

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**Abbreviations:** DHH: Deaf or Hard-of-Hearing; BSL: British Sign Language; SSE: Sign Supported English; HAs: Hearing Aids

### Table of Contents Summary

This study tested early pragmatic predictors of language development in deaf or hard-of-hearing (DHH) infants typically at risk of reduced access to communicative interaction.

### What's Known on This Subject

How often typically-hearing infants engage in pragmatic behaviors (like pointing, showing, and vocalizing with eye contact) predicts language development. These early skills are thought to develop through interaction but evidence is mixed regarding whether DHH infants show early pragmatic delay.

### What This Study Adds

DHH infants aged 12-18 months engage less frequently than closely-matched, typically-hearing peers in early gestural and vocal communicative behaviors that predict later spoken language. Caregivers need support from infancy to nurture pragmatic development.

## **Contributors' Statement Page**

Dr. Kelly designed the study, reviewed the literature, collected the data, adapted the coding scheme, led coding, and co-wrote and revised the initial manuscript.

Dr. Bannard carried out the statistical analyses, and critically reviewed and revised the manuscript.

Prof. Morgan critically reviewed and revised the manuscript.

Dr. Matthews conceptualized and designed the study, supervised data collection and analysis, acquired funding, and co-wrote and revised the initial manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

## **Abstract**

### **Background and Objectives**

A set of important pragmatic skills emerge during infancy and pave the way for later language learning. It is thought these early social communication skills develop through infant-caregiver interaction. In a micro-analysis, we tested whether deaf or hard-of-hearing (DHH) infants - typically at high risk of reduced access to rich communicative interaction in infancy - are less likely to engage in gestural and vocal pragmatic behaviors.

### **Methods**

We coded the naturalistic communication of 8 DHH infants who had no additional needs, were not preterm or low birth weight, whose parents were hearing, monolingual English speakers, and who had spoken English as their primary target language. Frequency of use of five types of infant communication known to positively predict later language development (*show gestures*, *give gestures*, *index-finger pointing*, *communicative vocalizations*, and *early word use*) was compared to that of 8 typically-hearing infants matched for age, gender, and socio-economic status.

### **Results**

Hearing loss had a significant negative effect on the frequency with which infants engaged in all types of early communication that predict later language development.

### **Conclusions**

DHH infants are at high risk of delay in the gestural and vocal communicative skills that lay the foundations for later language. Delay in the gestural domain suggests this is not simply a consequence of difficulties in imitating auditory stimuli. There is significant potential to lift DHH infants onto a positive developmental trajectory by supporting caregivers to nurture interaction from the first year.

## Introduction

The development of early pragmatic (i.e., social communicative) skills during infancy paves the way for later language.<sup>1,2</sup> These skills are thought to emerge in the context of infant-caregiver interaction, during which caregivers intuitively scaffold communicative development.<sup>3</sup> For example, hearing parents intuitively respond to their infants using speech and vocal cues (e.g., gasps and exclamations to indicate interest) and, by 5 months, typically-hearing infants come to expect a vocal response to their babble.<sup>4</sup> Furthermore, fluent signing deaf parents intuitively use visual-tactile strategies during interaction to indicate interest and support visual perception of language and, by 24 months, DHH infants of fluent signing deaf parents have learned to look to their caregivers' faces more often than hearing dyads do.<sup>5,6</sup> However, around 95% of DHH children are born to hearing parents<sup>7</sup> who typically are not fluent sign language users, have little to no experience communicating with a DHH infant and, for the majority of families, have spoken language as the goal for their child (typically providing an oral, sign-supported or sign-spoken bilingual environment<sup>8</sup>).

Hearing parents with a DHH infant often find scaffolding communicative development challenging, whether targeting a spoken language, a signed language or both. When learning a signed language, hearing parents can struggle with fluency and with the adaptations necessary to support their DHH infant's visual perception of language.<sup>9-12</sup> When supporting development of a spoken language (with or without signed support), ensuring access to communication is often not immediately intuitive.<sup>9,13</sup> Professional support for families to meet these challenges is highly variable,<sup>14</sup> as is social support,<sup>15,16</sup> and parents' belief in their ability to support their child's communicative development (i.e., feelings of self-efficacy).<sup>17,18</sup> Due to reduced access to language, as well as the impact hearing loss can have on the quality of communicative interactions, delays in communicative development and later language learning are found in the majority of DHH infants.<sup>8,19,20</sup> To date, however,

it is unclear whether delays emerge in social communication during infancy; current evidence regarding delays in the key early communicative behaviors that pave the way for language development is sparse and equivocal.<sup>21,22</sup>

### *The Relationship Between Early Pragmatic Skills and Later Language Development*

Recent research with typically-developing, typically-hearing infants has identified specific early communicative behaviors as being theoretically important indicators of readiness for language learning and good empirical predictors of later language development.<sup>2,23-27</sup> Positive predictors include the frequency with which infants produce *give* gestures, *show* gestures, *index-finger pointing*, and *communicative vocalizations* (operationalized as vocalizations made within one second of looking to the caregiver's face). Alongside first words, these behaviors are thought to be positive predictors because they indicate social-cognitive readiness for language development, and because they elicit timely and informative caregiver responses which are known to scaffold further development.<sup>28-32</sup> The positive predictive value of these early communicative acts seems to be specific to these behaviors. Indeed, the frequency with which infants rely on some other gestures (e.g., open-hand pointing) is a *negative* predictor of language development.<sup>25,27</sup> Thus, when assessing early pragmatic development in DHH infants, it has become apparent that investigating precise frequencies of specific infant naturalistic behaviors is important.

### *The Communication of Deaf or Hard-of-Hearing Infants: Current Knowledge*

Relatively little is known about how hearing loss affects social communication in the first two years of life. There is evidence that DHH 22-month-olds have difficulty in maintaining joint attention (a state arising when caregiver and infant are mutually aware of sharing attention to the same thing).<sup>19,33-35</sup> However, research with younger infants to date suggests that DHH infants communicate with their hearing parents at a broadly similar rate to their typically-hearing peers,<sup>21,36,37</sup> albeit with some evidence of reduced frequency of gesture

use.<sup>22</sup> A limitation of these studies is that they have collapsed across a broad range of behaviors (likely including both *positive* and *negative* predictors of spoken language in one count), or have employed binary measures of whether a behavior is in repertoire, rather than measuring the *frequency* with which that behavior is used for communication. It is the latter that is known to predict outcomes.<sup>27</sup> Moreover, although DHH infants' vocalizations have been explored in terms of their phonology (with evidence of delay<sup>38,39</sup>), there has been little study of the communicative use of vocalizations (regardless of phonological properties). It has recently been found that one of the most valuable predictors of typically-hearing infants' transition to speech is the frequency with which they produce communicative vocalizations that are then responded to by the caregiver with language that is relevant to the infant's focus of attention. An infant who benefits from such interactions with a frequency one standard deviation above the mean at 12 months, is predicted to produce approximately 28 more words than the average infant by 19 months.<sup>27</sup>

### *The Present Study*

Motivated by the evidence for the predictive value of specific early pragmatic indicators for later language development, and the gap in knowledge about the development of these skills in DHH infants, we used a fine-grained coding scheme to measure the early naturalistic communication of DHH infants. We hypothesized that DHH infants who are at risk of reduced access to communicative interaction (in this case, those with hearing parents whose target primary language was spoken English) would engage less frequently than closely-matched, typically-hearing infants in the communicative behaviors that are positive predictors of spoken language development. If such differences are observed, this would: 1) provide healthcare professionals with a more complete picture of the developmental trajectory of DHH infants' early pragmatic skills; and 2) suggest a need to start targeted support of pragmatic development during the first year of life.



## Method

### *Participants*

Participants were 8 DHH infants, 8 typically-hearing infants, and their primary caregivers. The DHH infants were recruited across England and Scotland through the United Kingdom's National Deaf Children's Society database of families with DHH children. The typically-hearing infants were participants in the control condition of a longitudinal randomized controlled trial<sup>40</sup> which collected data using the same procedure as the present study. All caregivers gave informed consent for their data to be used for further research. Participation was subject to the following inclusion criteria: infants were full-term (born no more than 3 weeks before due date), with a birth weight over 2.5 kilograms, and no other known disabilities or developmental delays. All caregivers had no known physical, mental or learning disabilities. Written informed consent was obtained from each caregiver. The Psychology Ethics Committee at the University of Sheffield approved this study.

*[Insert Table 1 here]*

### *Procedure*

Infant-caregiver dyads were video-recorded in free play together for 25 minutes in their home, from two different camera angles, and without the researcher present.

### *Coding*

Following the coding scheme reported in Donnellan et al.,<sup>27</sup> video recordings were coded for infant gestures, vocalizations, gaze to caregiver's face, and recognizable British Sign Language (BSL) signs using ELAN software<sup>41</sup> by the first author. Gestures were categorized as either *give*, *show*, or *index-finger point*. All non-vegetative vocalizations (i.e., vocalizations containing speech sounds as opposed to coughs, sneezes, hiccups, etc.<sup>42,43</sup>) were categorized as either *infant vocalization* (i.e., vocalizations with or without a consonant that were *not* recognizable words) or *word* (i.e., a recognizable word). *Gaze-coordinated*

*vocalizations* were automatically identified as any infant vocalization occurring within one second of a gaze to the caregiver. Words were orthographically transcribed. BSL signs were translated to English and orthographically transcribed. Since only two infants produced signs (2 and 35 signs respectively), these were not included in statistical analyses. A new coding pass of each video was made for each behavior type (i.e., each video was coded four times, once each for gestures, vocalizations, gaze, and signs. See Figure 1). Any periods of time where the infant was not within view of the cameras were identified and not coded.

Observable coding time was under 25 minutes (but no less than 21 minutes 11 seconds) for 4 DHH infants and 6 typically-hearing infants. On-screen time was controlled for in analyses.

*[Insert Figure 1 here]*

### *Reliabilities*

Twenty-five percent of video recordings (8 play sessions) were coded for reliability by a second coder. Counts of gestures, infant vocalizations, gaze to caregiver's face, and words were highly correlated ( $r = .99$ ,  $r = 1.00$ ,  $r = .99$ ,  $r = .98$  respectively). Cohen's Kappa revealed that coders categorised gestures as either gives, shows, or index-finger points with high reliability ( $k = .97$ ,  $p < .001$ ).

### *Statistical Analysis*

To assess whether the DHH infants raised with spoken English as their primary target language differed from typically-hearing infants in their production of communicative acts known to predict later spoken language development, we fitted two multi-level negative binomial regression models to the data (using *lme4* version 1.1-23). This model type was chosen because the outcome variable is a count measure but does not meet the assumption for a Poisson regression (equality of variance and mean). A set of counts for each of the communicative acts (give and show gestures, index-finger pointing, gaze-coordinated vocalizations, and early word use) was entered as the dependent variable, hearing status as a

fixed effect (DHH or typical-hearing), participant and age as random effects on the intercept, and communication type as random effects on the intercept and slope. In model 1, we included all pre-linguistic acts alongside early word use, as this provided the best overall picture of infants' readiness for spoken language. In model 2, given that DHH infants have been observed to show a delay in the onset of spoken word use at 18 months,<sup>21,44</sup> we then restricted the analysis by removing word production from the set of communicative behaviors, thereby focusing on pre-linguistic communicative acts. In both models, we included a scaled and centered on-screen time variable as a control, since infants varied in how much on-screen coding time they had (4 DHH & 6 typically-hearing infants < 25 minutes). Whether we included on-screen time in this way or as an exposure offset with a coefficient of 1 did not affect outcomes.

## **Results**

The demographic characteristics of the 8 DHH infants are shown in Table 1. All were born with bilateral permanent hearing loss identified within 3 weeks of birth through newborn hearing screening and received bilateral hearing aids by 15 weeks. All were continuing to use bilateral hearing aids at the time of testing. Hearing loss ranged from moderate (41-70 dB) to profound (> 95 dB). Information on specific hearing thresholds (aided or unaided) was not available. Four infants were aged between 12 and 13 months (2 boys) and 4 were aged between 18 and 19 months (all boys). The 8 typically-hearing infants were closely matched to the DHH infants for age, gender, and socio-economic status (determined using the English and Scottish Indices of Multiple Deprivation; a government measure based on neighborhood income, employment, health provision, and housing). All caregivers were female, typically-hearing, and monolingual English-speaking. Four parents were learning BSL to provide sign support for spoken English.

Table 2 presents descriptive statistics by group for the specific communicative acts

under study. Relative to the typically-hearing group, the DHH group produced all communicative acts with a lower median frequency.

*[Insert Table 2 here]*

Hearing loss had a significant negative effect on the frequency of infant communication (model 1:  $b = -0.853$ , 95% CI  $[-1.515, -0.192]$ ,  $p = .01$ ). According to model estimates, DHH infants produced 5 fewer communicative behaviors in 25 minutes of play than their matched typically-hearing peers. This effect held when the dataset was restricted to pre-linguistic communicative acts only (model 2 [removing words]:  $b = -0.770$ , 95% CI  $[-1.516, -0.024]$ ,  $p = .04$ ). According to model estimates, DHH infants produced 4 fewer pre-linguistic communicative behaviors in 25 minutes of play than their matched typically-hearing peers.

## **Discussion**

We analyzed the early communicative behaviors of infants with moderate-to-profound hearing loss who had no additional needs, were not preterm or low birth weight, whose parents were hearing, monolingual English speakers, and who had spoken English as their primary target language. These infants were closely matched demographically with typically-hearing infants. Fine-grained, naturalistic observation of the specific communicative behaviors that positively predict later spoken language development suggested that hearing loss puts infants at significant risk of delay. Analyses restricted only to pre-linguistic communication suggested that the risk extends to those early gestural and vocal communicative developments that pave the way for language. By producing fewer communicative behaviors during interaction, DHH infants are likely to experience fewer learning opportunities, which cumulatively would affect later language learning.

Where do these early gestural and vocal communicative skills come from? Their development is thought to depend on frequent, finely-timed interactions between caregiver and infant during earlier stages of development<sup>45-47</sup> (see Mood, Szarkowski & Brice, this

volume). Since both vocal *and* gestural pre-linguistic communication was affected, we assume that reduced communication was not simply the product of reduced imitation of verbal stimuli – this would not explain gestural delay. Rather, communicative tools including pointing gestures are likely not being used as frequently by DHH infants due to: 1) reduced access to timely caregiver reinforcement of their early communication; and 2) reduced access to cues that support joint attention and thereby provide insights into how people use gestures and vocalizations to communicate.<sup>48</sup> Hearing parents typically use non-linguistic vocal cues (e.g., gasps and exclamations) to regulate interaction, alert the infant to a topic of interest, initiate joint attention with their infant, and respond to them. These non-linguistic vocal cues are used alongside gestures. By using sound and gesture in predictable, *synchronous* ways,<sup>49-51</sup> hearing parents intuitively make it easier for infants to understand how communicative acts can direct others' attention. However, DHH infants are more likely to miss some of these cues and so early joint attentional episodes are more likely to break down before learning occurs.<sup>33,52,53</sup> Furthermore, hearing parents tend not to use visual cues as frequently or as proficiently in comparison to deaf fluent signing parents, which again places joint attention at risk.<sup>10,34,54</sup> The critical point here is that this study strongly suggests that access to sound is important not just for learning spoken language through imitation, but for the non-linguistic uses of sound that hearing parents intuitively use in synchrony with other cues to regulate the back-and-forth of the very earliest interactions.

The implications of these findings are that families need support to nurture specific pragmatic developments during the first two years of life (namely the appropriate communicative interaction around infant *give* gestures, *show* gestures, *index-finger pointing*, *communicative vocalizations*, and eventually *words/signs*). A major challenge in this work will be engaging sensitively with parents at what, for many, is an emotionally turbulent time<sup>55-57</sup> when not all families are ready to participate in interventions or research.

In this study, we took the approach of exploring a fine-grained set of behaviors in a hard-to-reach group of infants that was as homogenous as possible (e.g., no known language development risk factors other than hearing loss). While this allowed us to control for potential confounding variables, this had the effect of limiting the sample size and generalizability beyond infants with these characteristics. A complementary approach would be to include a broader range of infants (including those with cochlear implants and those primarily learning to sign) and then to control for additional characteristics. Further research will allow us to fully understand the source of the current observed differences with: 1) longitudinal studies that predict DHH child outcomes from both early infant communication and caregiver practice; and 2) trials of early intensive intervention to assess how support programs change parenting behaviors and child outcomes. These interventions would need to support all aspects of early communication, including pragmatic aspects of language development.<sup>58</sup>

In sum, the current study used a fine-grained analysis of infant pragmatic development and found DHH infants are at significant risk of delay in precisely the types of early gestural and vocal communication that are important for future language development. The implications for healthcare providers and allied health professionals are clear. By responding to the call to action (Szarkowski, Young, Matthews & Meinzen-Derr, this volume) *from the first year* of a DHH child's life (i.e., screening for risks to infant-caregiver interaction and supporting caregivers to nurture early social communication), there is real potential to lift children onto a positive learning trajectory and open the way to the cumulative learning experiences that build from these early moments.

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**Figure 1.** Example of video coding in ELAN.

**Table 1.** Characteristics of the Deaf or Hard-of-Hearing Infants

Participant	Gender	Age (Months; Days)	Left Ear	Right Ear	Age HAs <sup>a</sup> Received	Family Mode of Communication	IMD <sup>c</sup> Decile
1	M	12; 21	Moderate- Severe	Moderate	5 weeks	Spoken English	6
3	M	13; 07	Moderate- Severe	Profound	8 weeks	Mostly SSE <sup>b</sup>	5
6	F	12; 25	Profound	Severe	12 weeks	Spoken English, occasionally SSE <sup>b</sup>	6
9	F	12; 30	Severe- Profound	Moderate- Severe	9 weeks	Spoken English & SSE <sup>b</sup>	7
4	M	19; 09	Moderate	Moderate	6 weeks	Spoken English, rarely SSE <sup>b</sup>	6
5	M	18; 17	Severe	Severe	12 weeks	Spoken English	4
7	M	18; 12	Moderate	Moderate	15 weeks	Spoken English	2
8	M	18; 20	Moderate	Severe	8 weeks	Spoken English	7

<sup>a</sup>HAs = hearing aids. <sup>b</sup>SSE = Sign Supported English. <sup>c</sup>IMD Decile = Indices of Multiple Deprivation Decile (where areas considered to be within the most deprived 10% of England and Scotland = 1, and areas considered to be within the least deprived 10% of England and Scotland = 10).

<b>Table 2.</b> Descriptive Statistics for Infant Production of Communicative Acts as a Function of Hearing Status <sup>a</sup>										
<b>Variable</b>	<b>Deaf/Hard-of-Hearing Group (<i>N</i> = 8)</b>					<b>Typically-Hearing Group (<i>N</i> = 8)</b>				
	<b>Mean</b>	<b>SD</b>	<b>Median</b>	<b>Min- Max</b>	<b>% scoring &gt; 0</b>	<b>Mean</b>	<b>SD</b>	<b>Median</b>	<b>Min- Max</b>	<b>% scoring &gt; 0</b>
Give gestures	3.88	4.05	2.50	0-12	75 ( <i>N</i> = 6)	9.75	9.59	8.50	0-26	88 ( <i>N</i> = 7)
Show gestures	1.13	2.10	0.00	0-6	38 ( <i>N</i> = 3)	4.75	5.39	3.50	0-16	75 ( <i>N</i> = 6)
Index-finger points	3.00	5.81	0.50	0-17	50 ( <i>N</i> = 4)	6.50	8.07	2.00	0-19	63 ( <i>N</i> = 5)
Gaze-coordinated vocalizations	15.75	11.31	15.00	6-42	100 ( <i>N</i> = 8)	25.00	20.56	19.50	5-61	100 ( <i>N</i> = 8)
Word production	6.63	11.56	0.50	0-29	50 ( <i>N</i> = 4)	22.00	30.92	1.50	0-74	63 ( <i>N</i> = 5)

<sup>a</sup>Descriptive statistics were pro-rated for amount of on-screen coding time from a 25 minutes recording.