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Hearing Parents' Use of Auditory, Visual, and Tactile Cues as a Function of Child Hearing Status

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Parent/child dyads, in which the child is deaf but the parent is hearing, present a unique opportunity to examine parents' use of non-auditory cues, particularly vision and touch, to establish communicative intent. This study examines the multimodal communication patterns of hearing parents during a free play task with their hearing (n = 9) or deaf (n = 9) children. Specifically, we coded parents' use of multimodal cues in the service of establishing joint attention with their children, and the relationship between multimodal behaviors on the part of the parents were tracked for whether they resulted in successful or failed initiation of joint attention. Dyad types were compared for overall use of multimodal – auditory, visual, and tactile – attention-establishing cues and for the overall number of successful and failed bids by a parent for a child's attention. We focus our interpretation of the results on how hearing parents differentially accommodate their hearing and deaf children to engage them in joint attention by using multiple modalities in various combinations. Our findings are relevant to the development of recommendations for hearing parents of deaf children who are candidates for cochlear implantation regarding communication strategies to use prior to a child's implantation. Moreover, these findings expand our understanding of how joint attention is established between parents and their preverbal children, regardless of child hearing status.

Keywords: joint attention, deaf children, touch, multimodal communication

Much of social engagement in humans occurs in the form of joint attention, which consists of two people simultaneously focusing on an object or event while still maintaining social awareness of one other (Markus, Mundy, Morales, Delgado, & Yale, 2000). A crucial part of joint attention is the awareness that one is sharing one's stream of attention with another person, a phenomenon that has been referred to as "shared intentionality" (Tomasello, 1995; Tomasello & Carpenter, 2007). Humans are not born able to participate in joint attention, but a typically developing infant will begin to acquire the ability to engage in spontaneous joint attention by the end of his or her first year of life (Carpenter, Nagell, & Tomasello, 1998). One of the precursors of joint attention, being able to follow another person's eye gaze, emerges fairly early in development and becomes more proficient over time. For example, 3- to 6-month-olds correctly follow an adult's gaze towards a puppet 73% of the time (D'Entremont, Hains, & Muir, 1997). Additionally, and in support of the trajectory of increased proficiency across development, Scaife and Bruner (1975) found that 11- to 14-month-old infants followed another person's eye gaze significantly more often than did 2- to 4-month olds. The amount of gaze following and gaze switching in joint attention appears to increase linearly between 9 and 18 months of age (Mundy et al., 2007), and infants with better gaze-following skills have been shown to have higher vocabularies as young children than infants with less robust skills (Morales, Mundy, & Rojas, 1998).

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Joint attention can be divided into two subtypes: initiation of joint attention, in which one participant tries to get the attention of the other regarding an object of mutual interest, and response to joint attention, in which one participant responds to the other's bid for attention by following a point or gaze, verbalizing, or changing an affective response towards the object of mutual interest (Mundy & Newell, 2007; Mundy et al., 2007). Some have argued that the initiation of joint attention on the part of a child marks the beginning of formalized intentional communication in humans; as such, this may be considered a more appropriate developmental milestone to track than responding to joint attention (Brinck, 2001). Nonetheless, both forms are critical to the development of mature communication abilities. Thus, an important early component of communication is when infants learn to respond to others' attempts to establish joint attention with them.

In recent years, a child's failure to engage in joint attention has emerged as an important indicator of possible developmental delay. One notable population in which joint attention and mature communication abilities can be delayed or absent is children with autism spectrum disorder (ASD) (Bean & Eigsti, 2012). At 24 months, children with ASD were found to engage in less joint attention than typically developing 24-month-olds (Naber et al., 2008). Given that the visual modality plays a crucial role in joint attention, subtle gaze-following differences are important to track (but see Akhtar & Gernsbacher, 2008, for a critique of focusing solely on gaze as an indicator of joint attention). Consequently, early joint attention deficits as an indicator of ASD risk has becoming an active area of research.

Another population in which joint attention may be compromised, but about which relatively little is known, is deaf and hard-of-hearing children of hearing parents (Depowski, Abaya, Oghalai, & Bortfeld, 2015; Bortfeld & Oghalai, in press). While causes of early deafness include genetic origins, and deafness at birth occurs in 1 to 2 of every 1,000 infants (Nikolopoulos & Vlastarakos, 2010), hearing loss can also be due to exposure as a neonate to ototoxic medications such as aminoglycoside antibiotics or loop diuretics, noise exposure, hyperbilirubinemia, cytomegalovirus exposure, and hypoxia (Cristobal & Oghalai, 2008). In the United States, the current estimate of neonatal deafness rates is 2 to 3 of every 1,000 infants (National Institute of Health, 2010). Importantly, 9 out of every 10 deaf infants born in the US are born to hearing families (National Institute of Health, 2010). In deaf-child/hearing-parent dyads, the child has limited-to-no access to the auditory modality, despite spoken language serving as the parents' primary modality for communication. The majority of deaf infants and young children find themselves in this situation.

Of course, hearing parents of deaf children can attempt to learn and to communicate with their children using sign language, and many do. But many more opt for their children to receive assistive technology, such as a cochlear implant, a device that bypasses the hair cells of the inner ear to directly stimulate the auditory nerve and thus provide the sensation of hearing (Yawn, Hunter, Sweeney, & Bennett, 2015). In normal hearing, auditory neurons are distributed along the tonotopic gradient of the cochlea and sounds of different frequencies stimulate different auditory nerve fibers via approximately 4,000 inner hair cells that exist to convert sound pressure waves into electrical signals. Due to these differences, hearing through a cochlear implant is different from normal hearing and it takes time for children to learn language from this somewhat degraded signal (Sevy et al., 2010 and references therein). Because post-implantation langauge learning outcomes remain quite variable, the consensus from the research community is that the earlier in age that deaf children are implanted, the more robust their language abilities will be (Bruijnzeel et al., 2016).

However, differences in the time to the child's diagnosis, the length of the parental decision-making process, and the logistics of qualifying for the procedure itself all factor into the amount of time that passes before the deaf child has access to spoken language (Sevy et al., 2010). Thus, these factors also contribute to differences in the length of time during which hearing parents and their deaf child remain mismatched in their dominant mode of communication. Moreover, there is limited information available to parents regarding how to communicate with their child during the preimplant period, an issue that is relevant even if parents opt to begin to learn sign language. Finally, because research on pediatric cochlear implantation is relatively new, there are very few data on what parents actually do during their child's implant candidacy period (bee Depowski et al., 2015; Bortfeld & Oghalai, in press). The goal of the current study is to document the ways in which hearing parents accommodate their deaf child's lack of hearing during the preimplantation period while attempting to gain the child's attention.

Development of Attentional Allocation in Deaf Children

While there is little research focused on communication in hearing-parent/deaf-child dyads, more is known about deaf-parent/deaf-child dyads. Generally, deaf-parent/deaf-child dyads communicate using sign language. In this case, because parent and child share a dominant mode of communication (i.e., visual language), this dyad type is actually more comparable to hearing-parent/hearing-child dyads than to hearing-parent/deaf-child dyads. Nonetheless, the experience of deaf-parent/deaf-child dyads is informative to the question we pose here. As observed in a longitudinal study (Spencer, 2000), the children in deaf-parent/deaf-child dyads develop joint attention at rates similar to their hearing peers, although the nature of the episodes of joint attention may be quite different. For example, Lieberman and colleagues examined joint attention abilities and gaze-shift patterns in deaf children while they took part in a joint-book reading activity with their deaf mothers (Lieberman, Hatrack, & Mayberry, 2014). These researchers found that deaf children of deaf parents exhibited unique and specific gaze shifts relative to those observed in hearing children of hearing parents during communicative events. It was evident that these children knew that the activity required multiple gaze shifts in order for them to attend to both the visual stimulus of the book and the visual language input. The parents elicited these gaze shifts by using a modality-specific prompt – physical touch or a gaze shift of their own. In another study, deaf parents were observed to scaffold their child's receptiveness to language by performing sign within the child's visual field (Nowakowski, Tasker, & Schmidt, 2009). These findings provide evidence that a matched communicative modality, be it spoken or visual, affords the support necessary for typical development of joint attention in children.

Another line of research that is relevant to understanding hearing-parent/deaf-child communication employs a procedure called the Still-Face paradigm. In the Still-Face paradigm, the mother initially interacts with her infant normally. Then, at specific time intervals indicated by the researcher, the mother maintains a stoic, unemotive face regardless of the child's behavior (Cohn & Tronick, 1983). Although originally developed as a tool to mimic the decreased affect displayed by mothers with depression, researchers have begun using this paradigm to probe other aspects of early development (Mesman, van IJzendoorn, & Barkermans-Kranenburg, 2009). In the case of deaf and hard-of-hearing children, it is used to observe what the mother does at the end of the still-face period to re-engage the child. Mesman and colleagues (2009) found that hearing mothers used the auditory modality (that is, spoken language) to engage their deaf infants at the completion of the Still-Face paradigm and did so significantly more often than the deaf mothers in the deaf/deaf dyads (Koester, Karkowski, & Traci, 1998). Although this is not particularly surprising, what is surprising is that no differences emerged between deaf and hearing mothers in relative use of the tactile modality to re-engage their infants. Similar findings emerged in research demonstrating that, across a nine-month age range (testing children from 9 to 18 months of age), deaf mothers tended to use the visual modality more than hearing mothers to engage their children after the Still-Face paradigm and hearing mothers tended to use the auditory modality more than deaf mothers (Koester, 2001). Again, no differences emerged between the dyad types in their use of the tactile modality.

Despite this lack of difference in mothers' use of the tactile modality in the Still-Face paradigm, in free play sessions involving 9-month-olds, differences did emerge. Specifically, deaf mothers were found to use short, active touches (e.g., tapping) to get their hearing or deaf infants' attention, while hearing mothers use long, passive touches (e.g., resting a hand on the infant's back) (Koester, Brooks, & Traci, 2000). These findings suggest that, despite superficial similarities, differences go beyond the auditory/vocal modality in how hearing mothers and deaf mothers communicate with their deaf children, particularly with regard to touch.

There is also some evidence that hearing mothers change how they interact with their deaf children in an effort to accommodate their lack of access to sound. For example, during free-interaction sessions (mothers and children interacting as they normally would without toys), hearing mothers used vocal games with extreme/exaggerated gestures (e.g., while singing "The Itsy Bitsy Spider" to their deaf children) (Koester, Brooks, & Karkowski, 1998). Other research has revealed that during free-play sessions (mothers and children interacting with toys), hearing mothers of deaf children are more likely than hearing mothers of hearing children to position objects in the child's line of sight (or visual field), as well as to tap on, touch, or point to the objects. In short, hearing mothers used both tactile and visual modalities to communicate with their deaf children and they did so more than mothers in hearing-parent/hearing-child dyads (Waxman & Spencer, 1997). Such findings suggest that hearing mothers do work to engage their deaf children by accommodating the children's unique communicative needs. The present study aims to extend examination of how hearing parents accommodate their deaf children to the realm of how they establish joint attention.

Joint Attention in Hearing Parent-Deaf Child Dyads

While the research we have reviewed details specific aspects of how hearing parents and deaf children interact, few studies have examined parent-child interactions aimed at establishing mutual focus of attention, or joint attention. One, however, did specifically examine the differences between hearing-parent/deaf-child dyads and hearing-parent/hearing-child dyads in success rates of both child- and adult-initiated bids for joint attention (Nowakowski et al., 2009). Results indicated that there were lower success rates for hearing-parent/deaf-child dyads than for hearing-parent/hearing-child dyads in maternal-initiated bids for joint attention. However, no differences emerged between hearing-parent/hearing-child and hearing-parent/deaf-child joint attention episodes when the child was the one doing the initiating, suggesting that hearing mothers are as sensitive to their deaf children's signals for attention as deaf mothers are (Nowakowski et al., 2009). Critical to the present research, researchers observed that hearing-parent/hearing-child dyads and hearing-parent/deaf-child-with-cochlear implant dyads both engaged in more instances of joint attention overall than did hearing-parent/deaf-child dyads (Tasker, Nowakowski, & Schmidt, 2010).

Finally, a study on maternal sensitivity provides insight into the question of whether and how hearing parents accommodate their deaf children's attentional demands. In this work, the researchers followed four types of parent/child dyads (i.e., hearing/hearing, hearing/deaf, deaf/hearing, and deaf/deaf) longitudinally. Testing took place when the children were 9, 12, and 18 months of age (Meadow-Orlans & Spencer, 1996). At each time point, the researchers recorded parent-child play with a standard set of toys and rated maternal sensitivity based on a coder's interpretation of mothers' sensitivity, participation, flexibility, positivity, and consistency. Hearing mothers of deaf children were rated significantly less positively for sensitivity and were judged to exhibit less positive interaction quality compared to hearing-parent/hearing-child and deaf-parent/deaf-child dyads. Spencer (2000) used the same longitudinal videos to code attentional episodes using Bakeman and Adamson's (1984) original joint attention coding scheme. Results demonstrated that children's hearing status alone was not predictive of the development of joint attention abilities, but that the parent's hearing status was also relevant. Critically, Spencer (2000) observed that hearing-parent/deaf-child dyads communicated less in general when compared to dyads in which parent and child were matched on hearing status and thus shared a dominant sensory modality for communication.

The Current Study

As more deaf children receive cochlear implants, researchers have begun to examine how parental interactions prior to implantation may affect children's language development once they do receive their implant. In a study by Depowski and colleagues (2015), interactions in hearing-parent/hearing-child dyads were compared to those in hearing-parent/deaf-child dyads in which the child was a candidate for cochlear implantation. The researchers predicted that hearing parents of deaf children would work to engage their children using modalities (e.g., touch, vision) beyond the auditory domain (Depowski et al., 2015). Overall, results from this study showed that there was considerable variability in the type and amount of such "multimodal communication" observed in hearing-parent/deaf-child dyads, but that, in general, hearing parents of deaf children worked to accommodate their children's unique communicative needs by using multiple sensory modalities to gain their attention.

The goal of the present study was to build on this previous work by systematically examining patterns of modality use during joint attention episodes between hearing parents and their deaf children, all of whom were candidates for cochlear implantation, and to compare these to patterns observed in hearing-parent/hearing-child dyads. In particular, we focused on documenting instances of parent-initiated joint attention during a free-play interaction. Joint attention episodes were classified as either successful or failed and then were coded for the range of modalities used by parents during those episodes. We predicted that hearing-parent/deaf-child dyads would engage in fewer instances of joint attention relative to hearing-parent/hearing-child dyads. Moreover, we expected to see hearing parents use a wider range of sensory modalities when attempting to engage in joint attention with their deaf children than hearing parents of hearing children.

Method

Subjects

Participants were nine severely- to profoundly-deaf children (females, *n* = 3) aged 22 months (*M* = 22.2, *SD* = 9.4) and their hearing parents (females, *n* = 9) and nine typically-developing children (females, *n* = 5) aged 24 months (*M* = 24.2, *SD* = 11.3) and their hearing parents (females, *n* = 5). The hearing children were matched as closely as possible based on age to each of the deaf children. Self-identified ethnicities of the parents of deaf children were Hispanic (*n* = 6), Asian (*n* = 1), and White (*n* = 2); for parents of hearing children, Hispanic (*n* = 1), White (*n* = 8). Each family was recruited using the National Institute of Health website or via local recruitment at the respective research sites (i.e., at Stanford University or at the University of Connecticut). All deaf children included in this study were bilaterally prelingually deafened and were candidates for cochlear implantation who had not yet been implanted. All were receiving at least one hour of speech therapy each week at the time of testing, as well as some basic instruction in American Sign Language (ASL), yet none produced any spoken or sign language during their play session. Parents occasionally produced simple signs (e.g., indicating an item or description), and these were coded. This study was carried out in accordance with recommendations from the Stanford University School of Medicine Institutional Review Board (IRB) and the University of Connecticut IRB with written informed consent from all participants in accordance with the Declaration of Helsinki. For young children, parents provided written informed consent.

Materials

Each parent/child dyad was invited to participate in a free-play session during a visit with the speech language pathologist at the Stanford University Hearing Clinic or during a visit to the Husky Pup Language Lab at the University of Connecticut. Matching sets of appropriate toys for the child's age were made available during free-play sessions (a ball, a set of large blocks, a set of stacking cups, tableware, a tower of stacking rings, and toy cars). Parents were instructed to play with their children as they would at home. Each play session was video recorded and lasted for approximately five minutes (M = 464.23 s, SD = 154.35 s). Videos of the hearing-parent/deaf-child dyads were then transmitted from collaborators at Stanford University to researchers at University of Connecticut using REDCap electronic data capture tools hosted at Stanford University (Harris et al., 2009). For the current study, REDCap was used solely as a means of secure video transfer between collaborators and was not used for any analytical/coding purposes.

Procedure

The videos were coded for initial instances of parent-initiated joint attention using ELAN (Wittenburg, Brugman, Russel, Klassman, & Sloetjes, 2006), language annotation software created by the Max Planck Institute for Psycholinguistics (The Language Archive, Nijmegen, The Netherlands). ELAN allows for multimodal analyses of language and other behaviors (http://tla.mpi.nl/tools/tla-tools/elan/), and is available free of charge. We used modified coding criteria for joint attention based on the work of Tomasello and Farrer (1986). Coded variables were analyzed using ELAN, Microsoft Excel, and VassarStats.

Video processing. Videos were reviewed for visual clarity, and Adobe Premiere Pro (CS6) was used to edit videos for the start and end time of each play session. The start time of the play session was defined as the first frame in which the testing room door was closed, leaving the parent and child alone. The end of each play session was defined as the first frame in which the experimenter opened the door to end the play session. These two values were subtracted to give a baseline length of time for the play session.

Joint attention coding. In the present study, parent-initiated bids for joint attention – both successful and failed – were coded and quantified. A successful joint attention episode consisted of an adult bid for the child's attention, gaze switching between the object and the child, and any combination of tapping or touching the child, deliberate waving within the child's visual field, changing affect, and language to engage the child's attention This parental bid was then responded to by the child using pointing, gaze following, tapping or touching the parent, touching the object of interest, deliberate waving within the parent's visual field, changing affect, and/or language. This type of initiation could also occur if the parent shifted the child's attention from one object or another using one of the mentioned techniques. The child was required to engage in one or more of the mentioned activities for three seconds or more (Bakeman & Adamson, 1984) for the bid to be considered successful. If the parent attempted to initiate interaction with the child and he or she did not respond or did not engage for more than three seconds, then the instance was coded as a failed bid. Additionally, if the parent did not engage in gaze-switching behavior between the object and the child, then the instance was not coded at all.

To identify initiation of joint attention in ELAN, the parent's initiation of the behavior (e.g., reaching, showing) marked the onset of the initiation in the joint attention instance. The code for each attempt ended when the parent completed one gaze shift between the child and the object. Our criteria for initiating joint attention were conservative: The parent had to demonstrate a look to the toy and a look back to ensure the child was engaging. Additionally, a 5-s rule of engagement was used (i.e., after the parent began interacting with an object, the child had 5 s to begin engaging with the object/parent). If the child disengaged and re-engaged within a 5-s window, then the episode continued and no new initiation was coded. Similarly, there was a 5-s rule of disengagement (i.e., a joint attention episode was terminated after the child was no longer engaged with the object/parent for five or more seconds).

Modality coding. All parent-initiated joint-attention instances were coded separately for parent use of the following modality or modality combinations: auditory, visual, tactile, auditory-visual, auditory-tactile, visual-tactile, and auditory-visual-tactile. Only instances of initiation of joint attention were coded for modality. More specifically, actions that occurred within joint attention were not captured, as we are interested in the behaviors that establish joint attention.

Auditory. The auditory modality included using sound to gain a child's attention. This included language, humming, other vocal sounds (e.g., "psst!"), making noise with a toy, and clapping outside of a child's visual field.

Visual. The visual modality involved the parent moving a hand or an object into a child's visual field to get the child's attention. This included behaviors such as waving, gesturing, reaching, pointing, offering a toy, holding an object in the child's visual field, or changing visual affect in the child's line of sight (visual field).

Tactile. The tactile modality involved interactions initiated via touch, direct or indirect. This included tapping or touching the child, tickling, hugging, touching with a toy, or physically moving the child to direct their attention.

Auditory-visual. The auditory-tactile modality constituted a multimodal act that involved the parent mixing an auditory and a tactile cue. This included touching a child with a toy while describing it or making an accompanying noise or speech sound (e.g., touching the child with a toy and stating a feature of the toy).

Visual-tactile. The visual-tactile modality was a multimodal cue that involved the parent using both a visual and a tactile cue simultaneously. This included directing a child's attention to a toy not currently within the child's visual field by physically moving the child (e.g., while the child was sitting in the parent's lap, the parent might turn the child to guide him or her to look at new toys).

Auditory-visual-tactile. The auditory-visual-tactile modality was a multimodal cue that included the use of sounds, visual information, and touch all at the same time in an effort to gain a child's attention (e.g., the parent showed the child the toy, while labeling the toy, and tickling the child).

Overall tactile coding. For comparative purposes, touch was coded throughout each interaction episode, including outside of episodes of joint attention. This coding included any type of touch initiated by the parent, directly of the child or indirectly with a toy, regardless of the attentional states of either the parent or child.

Data analysis. Rates of successful and failed biding for joint initiation were calculated and compared as a function of children's hearing status. Seven modality metrics were computed for both successful and failed bids at initiating joint attention. This was done by extracting the raw number of occurrences for each modality type used during attempts to gain the child's attention, whether successful or failed. Finally, overall tactile contact between a parent and child was coded for its duration for the entirety of each free-play session. Mann-Whitney U-tests were used to assess differences in modality use between dyad types because measures were not normally distributed. In contrast to a t-test, this non-parametric test compares median rather than mean scores of two samples. Thus, it is more robust against outliers and heavy tail distributions (i.e., non-normal distributions), as in these data.

Results

The overall number of occurrences of successful bids for joint attention across dyad types was as follows: 47 successful bids for hearing/hearing dyads; 39 successful bids for hearing/deaf dyads. Despite differing in the expected direction, a Mann-Whitney test indicated that there was no significant difference in the raw number of successful attempts to establish joint attention by parents by dyad type ($U = 50.0$, $p = 0.43$). The overall number of occurrences of failed bids for joint attention across dyad types was as follows: 16 successful bids for hearing/hearing dyads; 21 successful bids for hearing/deaf dyads. Again, despite differing in the expected direction, a Mann-Whitney test indicated that there was no significant difference in the raw number of failed attempts to establish joint attention by parents by dyad type ($U = 30.5$, $p = 0.40$).

Table 1 shows the raw number of successful and failed bids for joint attention that employed either a single modality or combination of modalities. There were no instances of tactile-only modality use in either the successful or failed instances on joint attention, and there were no instances of auditory-tactile or visual-tactile combinations in failed instances. Therefore, these modalities were excluded from further analysis.

Table 2

Number of Occurrences for Each Modality by Joint Attention Bid Type and Dyad Hearing Status. Hearing status of dyads is indicated with HH (for hearing parent/hearing child) and HD (for hearing parent/deaf child).

Modality	Auditory		Visual		Tactile		Auditory-Visual		Auditory-Tactile		Visual-Tactile		Auditory-Visual-Tactile	
Hearing Status / Bid Type	HH	HD	HH	HD	HH	HD	HH	HD	HH	HD	HH	HD	HH	HD
Successful	9	3	7	8	0	0	28	23	1	0	0	1	2	4
Failed	2	3	4	2	0	0	10	12	0	0	0	0	0	4

Note. Bid type includes both successful and failed bids. Modality or modality combinations are indicated as auditory, visual, and tactile, or some combination of these.

Successful Parent-Initiated Joint Attention

There were no significant differences by dyad type in the raw number of occurrences of parents successfully initiating joint attention using either unimodal auditory (U = 49.5, p = 0.45) or unimodal visual cues (U = 39.0, p = 0.92). Additionally, there were no significant differences by dyad type in the number of successful joint attention episodes initiated via auditory-visual (U = 48.5, p = 0.51), auditory-tactile (U = 45.0, p = 0.73), visual-tactile (U = 45.0, p = 0.73), or auditory-visual-tactile multimodal combinations (U = 35.0, p = 0.66).

Failed Parent-Initiated Joint Attention

There were no significant differences by dyad type in the raw number of failed attempts to initiate joint attention using either unimodal auditory (U = 31.5, p = 0.45) or unimodal visual (U = 41.5, p = 0.97) cues. Additionally, there were no significant differences by dyad type in failed attempts to initiate joint attention using auditory-visual (U = 37.5, p = 0.83) or multimodal auditory-visual-tactile multimodal combinations (U = 27.0, p = 0.25).

Unimodal and Multimodal Bids

A Mann-Whitney test comparing the number of joint attention attempts using unimodal cues (auditory, visual, and tactile), regardless of success or failure, by dyad type showed no significant difference (U = 44.0, p = 0.80). Similarly, there was no difference in the number of joint attention attempts made using multimodal cues (auditory-visual, auditory-tactile, visual-tactile, and auditory-visual-tactile) by dyad type (U = 35.0, p = 0.66).

Proportions of Bids

An analysis comparing proportions of parental bids for attention as a function of dyad type also indicated no significant difference (U = 43.0, p = 0.86), nor were there significant differences by dyad type in proportion of successful bids for joint attention (U = 51.5, p = 0.35), or failed bids for joint attention (U = 29.5, p = 0.35).

Tactile Use Overall

A Mann-Whitney test did, however, demonstrate that overall use of the tactile modality was greater for hearing-parent/deaf-child dyads (*Mdn* = 3) than for hearing-parent/hearing-child dyads (*Mdn* = 0.5; $U = 17.5$, $p = 0.05$). Indeed, hearing parents of deaf children touched their children 12.1 times on average during the interaction period versus 6.9 times for the hearing parents of hearing children.

Discussion

In comparing hearing-parent/deaf-child to hearing-parent/hearing-child dyads, we found no differences with regard to overall attempts to establish joint attention or in the modality or modalities used in those attempts. While limited research has been conducted regarding the role of the parent in successful joint attention between hearing parents and their deaf children, the research that has been conducted to date has demonstrated that hearing parents can accommodate their children's hearing status in this domain (Lieberman, Hatrak, & Mayberry, 2011; Lieberman et al., 2014). The findings of the present study are consistent with our earlier work showing wide variability in the ways that hearing parents work to engage their children in joint attention, and this holds regardless of the child's hearing status. The alignment between our current and previous results suggests that more work is needed to establish when, how, and how often hearing parents successfully initiate joint attention with their deaf children, as well as when, how, and how often they fail to do so. For example, our current findings indicate that hearing parents use the auditory modality quite a lot with their deaf children despite the children having limited-to-no access to the auditory modality. Further research is needed to understand the role of different modalities and combinations of modalities in the establishment of joint attention in hearing-parent/deaf-child dyads. Indeed, other work has found that hearing mothers tend to use the auditory modality to engage their children regardless of the child's hearing status (Koester & Lahti-Harper, 2010), and our findings are consistent with this. If a deaf child does not experience the communicative modality being used (i.e., spoken language), the parent may very well be doing something else (i.e., in another modality) to engage that child's attention that has not been systematically documented to date. Our own data demonstrate that parents of deaf children rarely use the auditory modality in isolation, instead opting to combine it with other modalities either together or alone (i.e., visual, tactile, visual plus tactile) that are more accessible to their children.

There is a growing body of research focusing on the adjustments that hearing mothers of deaf children make to accommodate their children's hearing status (Koester, 2001; Koester, Karkowski & Traci, 1998; Traci & Koester, 2003) and findings from the present study add to this. Here, hearing parents of deaf children were more likely to attempt engagement with their child via trimodal (e.g., auditory-visual-tactile) cues compared to hearing parents of hearing children. Although not statistically significant, the pattern of these data supports the idea that hearing parents of deaf children make adjustments to their engagement style, likely as a means of enhancing interactions. The lack of significant differences here is likely due to our small sample size and corresponding low power. This is exacerbated by the relatively wide range of ages tested and the variability inherent in the behavior of parent/child dyads, regardless of a child's hearing status. Future research will be needed to determine whether overall success or failure of bids for joint attention, as well as modality-specific differences in the nature of those bids, exist, yet that our small sample size failed to uncover.

The present findings are consistent with those demonstrating that hearing mothers of deaf children tended to move objects into the child's line of sight or touch/point to objects (i.e., used the tactile and visual modalities) during free-play sessions with their 9-, 12-, or 18-month-old infants and did so significalty more often than mothers in the hearing-parent/hearing-child dyads (Waxman & Spencer, 1997). One might expect to see similar, or perhaps even greater, levels of joint attention in those hearing-parent/deaf-child dyads in which parents use such multimodal accommodating techniques to gain their deaf children's attention.

Although our results are difficult to interpret at present, our approach establishes a means by which specific behaviors related to joint attention produced by participants in a dyad can be tracked over time in microdetail. In particular, given increased evidence of the association between joint attention and successful language development in children from various backgrounds and varying levels of so-called typical development (see Morales et al., 1998), understanding the influence of parent accommodation of children's unique communication needs clearly is important.

Finally, the significantly greater overall use of touch by parents in the hearing-parent/deaf-child dyads relative to the hearing-parent/hearing-child dyads is intriguing. Recent work (i.e., Botero, 2016) has argued that a bias in joint attention research towards the visual modality ignores an important potential source of influence: the use of touch in parent-child interaction around the world and across species. In a thorough review of the literature, Botero (2016) makes a compelling argument for touch as the fundamental or primary sense that guides communication. The fact that the only significant difference between the two dyad types in our data was in overall tactile use adds tentative support to this argument. Although we did not find that the use of touch within bids for joint attention was different across dyad types, the overall use of touch during the free-play period was substantially different, in that parents in the hearing-parent/deaf-child dyads touched their children almost twice as often as parents in the hearing-parent/hearing-child dyads. Perhaps hearing parents of deaf children use touch as a way to "check in" with their children more generally and in a way that hearing parents of hearing children do not. This merits further investigation.

Given unequal access to information in the auditory modality in hearing-parent/deaf-child dyads, therapeutic approaches that emphasize the establishment and maintenance of joint attention between parents and their deaf children may help facilitate language development, whether while the parents are learning a signed language, while their children are awaiting a cochlear implant, or both. A greater focus on documenting how parents of all types use touch with their children can inform the nature that such therapeutic approaches should take. Likewise, given the possibility of establishing joint attention via nonauditory means (e.g., in the visual or haptic modalities) (Akhtar & Gernsbacher, 2008), there are clearly many ways in which meaningful communication does take place between parents and their children, regardless of either's hearing status. Although ours is an exploratory study, the observations reported here highlight the utility of moving beyond standardized (i.e., gaze-based) measures of joint attention to obtain rich, ecologically valid data on the details of parent-child interactions. The present study lends support for tracking the use of multisensory input by parents and particularly their use of touch during their interactions with children, as such input likely has long served in the establishment of communicative success.

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