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Development of Joint Engagement in Young Deaf and Hearing Children: Effects of Chronological Age and Language Skills

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Abstract

Purpose—To evaluate joint engagement (JE) in age-matched children with and without hearing and its relationship to oral language skills.

Method—Participants were 180 children with severe-to-profound hearing loss prior to cochlear implant surgery, and 96 age-matched children with normal hearing; all parents were hearing. JE was evaluated in a 10-minute videotaped free play task with parents. Engagement states ranged from the lowest (unengaged) to the highest level (symbol-infused coordinated). Standardized language measures were administered.

Results—Multivariate analyses were conducted between the groups, stratified by chronological and language age. Children who were deaf (Deaf) spent less time in total symbol-infused JE than children with normal hearing (NH) across all ages. The majority of the Deaf group (83%) fell in the lowest language age group, in comparison to 35% of the NH group, and spent significantly less time in symbol-infused JE than hearing children. These delays were also observed in the Deaf group, who fell into the 18-36 month language age. No children in the Deaf group had achieved a language age of >36 months.

Conclusions—Young children with and without hearing had different developmental trajectories of JE, which were related to oral language skills.

Introduction

A considerable body of literature suggests that joint engagement between a parent and child develops in the first three years of life (Adamson, Bakeman, & Deckner, 2004). This developmental process lays the foundation for regulating attention and affect during interpersonal interactions, facilitating acquisition of new words, and subsequently scaffolding representational skills and use of symbols in play (Beuker, Rommelse, Donders, & Buitelaar, 2013; Smith, Adamson, & Bakeman, 1988). Thus, joint engagement is strongly linked to language development and is one mechanism by which children map language onto their environment (Tomasello & Farrar, 1986).

In the first year of life, infants learn to focus their attention from their caregiver to objects in the environment and master joint engagement skills, such as responding to and initiating object-directed gaze and affective social referencing (Klinnert, Campos, Sorce, Emde, &

Svejda, 1983; Adamson et al., 2004). As joint attention skills develop in the latter half of the first year, children begin to sustain these episodes of joint engagement, which facilitates the sharing of objects and events with a social partner, such as the parent (Bakeman & Adamson, 1984; Adamson et al., 2004). Finally, by 18 to 30 months of age, as children begin to master language, there is a major transition to the use of symbols in play, which allows the child and parent to communicate about topics that are not present in the here and now (Adamson & Bakeman, 2006; Piaget, 1962; Werner & Kaplan, 1963). These representational skills enable longer episodes of coordinated joint engagement, increase the frequency of dyadic social interactions, and lead to the formation of theory of mind and narrative skills at ages 3 to 4 (Bruner & Feldman, 1993; Firth & Firth, 2001; Perner, 1991; Tomasello, 2003; Tomasello & Farrar, 1986).

Several definitions of joint engagement have been used in the literature over the past 30 years (see Tasker & Schmidt, 2008), however, these definitions generally include the use of communicative acts to engage a social partner's attention to an object or event with the intent to communicate and share the experience (e.g., eye contact, gestures, affective expression) (Mundy & Neal, 2001; Tomasello, 1995). Most importantly, joint engagement has been conceptualized as a precursor to early communicative and linguistic development (Wetherby & Prizant, 2002), is dyadic and interactional, and relies on coordinated exchanges between both partners (e.g., affective social referencing, signaling between dyads) (Girolametto, Verby, & Tannock, 1994; Tomasello & Farrar, 1986). Several joint engagement states have been identified, ranging from “disengaged” to “symbol-infused coordinated” joint engagement. If the dyad is actively involved with the same object or event, the engagement state is characterized as “joint” with a further evaluation of whether the child is using some form of symbolism (“symbol-infused”), and a determination of the extent of coordination between the child's attention to the partner and shared object (“symbol-infused coordinated joint engagement”) (Adamson et al., 2004).

A growing body of literature has demonstrated that children with atypical development (e.g., autism spectrum disorder, hearing loss) evidence delays in joint engagement (Adamson, Bakeman, Deckner & Nelson, 2012; Mundy, Sigman & Kasari, 1990; Prezbindowski, Adamson, & Lederberg, 1998; Tasker, Nowakowski, & Schmidt, 2010). Given that children with hearing loss have significant delays in oral language and difficulties with parent-child communication (Bergeson, 2011; Cruz, Quittner, DesJardin, & Marker, 2013; Quittner, Cruz, Barker, Tobey, Eisenberg, & Niparko, 2013), the development of symbol-infused joint engagement is likely to be disrupted. Later, as language develops, it facilitates engagement between parents and children, making it easier to initiate and sustain episodes of joint engagement. However, one previous study found that joint engagement developed similarly in deaf and hearing children until 18 months of age (Spencer & Waxman, 1995). Note that the deaf children in this study, ages 9 to 18 months, had significant delays in language compared to the hearing children, and symbol-infused states were not coded.

In contrast, Prezbindowski and colleagues (1998) found significant differences in joint attention between deaf and hearing children. They evaluated 24 hearing and 24 deaf toddlers, ages 20 to 24 months, in a videotaped free play task and found that fewer deaf children spent any time in symbol-infused joint engagement (2% deaf vs. 30% hearing) and,

on average, 10% less time in joint engagement states overall. Unfortunately, there is limited work that directly addresses the relationship between joint engagement and language skills in young deaf children. Neither of these studies directly tied joint engagement to language ability.

In a more recent study of two-year olds (Gale & Schick, 2009), symbol-infused joint engagement was measured in a total of 15 dyads categorized into three groups according to hearing status (hearing-hearing, deaf-deaf, deaf-hearing). Results showed that hearing-hearing dyads spent more time in symbol-infused joint attention than deaf-deaf dyads (i.e., 360.80 seconds vs. 175.60 seconds). Hearing dyads also spent more time in symbol-infused states than the deaf-hearing dyads (360.80 seconds vs. 279.20 seconds), although it was not statistically significant. Note that the sample size ($n = 5$ per group) was too small to reach statistical significance. This is one of the few studies to measure language and its relationship to engagement states. Despite finding moderate correlations between symbol-infused joint engagement and a standardized language measure, the study was not powered adequately.

In sum, although developmental theory would suggest that delays in both joint engagement and language are linked, this relationship has not been directly tested. Prior studies have been limited by small samples and narrow age ranges, which have precluded our understanding of the timing and trajectory of the development of joint engagement states, including those which are symbol-infused.

The primary aim of this study was to evaluate joint engagement in a wide range of deaf and hearing children, ages 5 months to 5 years. We utilized the largest, most nationally representative sample of young cochlear implant candidates at six implant centers, along with age and gender matched hearing controls. It was hypothesized that deaf children would exhibit delays in the attainment of symbolic, joint engagement states in comparison to their age-matched, hearing peers. Younger children were expected to spend less time in symbol-infused states than older children. A second aim was to examine how language influenced the development of joint engagement. We hypothesized that higher levels of language would be related to more time spent in symbol-infused engagement states in both the deaf and hearing groups. Thus, we expected that deaf children would show similar rates of joint-engagement as hearing children with similar language abilities. To test these hypotheses, we examined the emergence and development of joint engagement using both chronological and language age.

Method

The CDaCI study is a multicenter, national cohort investigation of the effectiveness of pediatric cochlear implants. Participants were recruited from six clinical implant centers and two preschools that enrolled normal hearing children (Fink, Wang, Niparko, Quittner, Eisenberg, & Tobey, 2007). Inclusion criteria for children in the CDaCI study were: 1) age under 5 years, 2) severe to profound sensorineural hearing loss (implant candidates only), and 3) parents committed to educating the child in spoken English. Exclusion criteria included significant cognitive impairment (i.e., a Bayley Mental or Motor score of less than

70 or Leiter International Performance Scale – Revised (Leiter-R) score of less than 66). Children with minor cognitive deficits were included to increase the generalizability of the findings to a broader population of children receiving cochlear implants (Cruz, Vicaria, Wang, Niparko, & Quittner, 2012).

Normal hearing (NH) children were selected to be similar to the deaf children in terms of age and gender. All participants were assessed at Baseline (prior to implantation) and every six months post-implantation for three years, and then annually after that. This study uses the cross-sectional data from the Baseline visit. Institutional review boards at all centers and preschools approved the study protocol.

Participants—The CDaCI cohort consisted of 188 deaf and 97 hearing children, and their hearing parents. Nine children were removed from the analytic dataset because they were too young to evidence the emergence of joint engagement (8 from the Deaf group and 1 from the NH group). Demographic information is presented in Table 1. Deaf children had a mean age of 2.3 years, $SD = 1.2$, and hearing children had a mean age of 2.3, $SD = 1.1$. Among the deaf children, age of onset of hearing loss varied between birth and 3.6 years, $M = 0.2$ years, $SD = 0.6$, and the mean Pure Tone Average (PTA-4) for the better ear was 105.97, $SD = 17.3$. Hearing loss was diagnosed at a mean age of 0.9 years, $SD = 0.9$, however, for a majority of these children (54%) the onset of hearing loss was at birth. Average length of hearing aid use prior to implantation was 1.1 years, $SD = 0.9$. Although 19% noted that their children exclusively used sign language, our observations of dyadic interactions indicated that no families used American Sign Language and approximately 17% use sign-supported English.

Comparisons of the demographic data between the Deaf and NH cohorts indicated similar child age, gender, and racial composition. However, the Deaf sample had a higher proportion of Hispanic children, lower parental education, and lower income, likely due to the geographical locations of the sites from which Deaf vs. NH children were recruited (see Table 1). This was likely due to different recruitment procedures for the deaf and hearing samples. The hearing samples were recruited from preschool programs that were affiliated with universities (University of Texas at Dallas and Johns Hopkins University); thus, these parents tended to be in the higher education and socioeconomic strata.

Procedures—After an initial medical screening for children in the Deaf group, a Baseline assessment was performed by a speech and language pathologist two to four weeks prior to cochlear implant surgery. The assessment was conducted during two half-day appointments to lessen fatigue for the child and family. During the first day, parents completed demographic and self-report measures of communication and behavior, and children were assessed with language measures, cognitive tests, and an audiological exam.

On the second day, children participated in videotaped structured play and problem-solving tasks with and without parents (93% mothers, 1 grandmother, 6% fathers), and parents completed psychosocial measures about their children. These tasks were completed in a separate “playroom” that was part of the cochlear implant clinic. Thus, children and parents were familiar with the setting and the staff. All measures and play tasks, including those

assessing language, were conducted in spoken English. Parents in the deaf group received a \$100 honorarium annually, travel stipends if required, and extended warranties for the implants as reimbursement for their time and effort; parents in the hearing group received the same honorarium. All written and videotaped materials were de-identified to ensure confidentiality.

Measures

Joint Engagement—Joint engagement was evaluated in the 10-minute, videotaped Free Play task using Adamson's codes (Adamson et al., 2004). The Free Play task was similar to prior developmental studies and provided age-appropriate toys for parents and children to play together (Belsky & Most, 1981, NICHD, 1999). In our study, we used one set of toys for children 24 months and younger and a different set for children ages 24 to 60 months. The parent and child were directed to “play as you would at home,” and their interactions were videotaped and then coded using Observer Video-Pro Version 5.0 software (Noldus, Trienes, Hendriksen, Jansen, & Jansen, 2000).

First, Coders watched each tape and identified the engagement state using eight possible codes (see Table 2). We calculated the number, total duration, and percentage of time spent in each state during the 10-minute Free Play. The analyses were conducted on the percentage of time spent in each of the attentional states. Percentages were used to facilitate interpretation of the parent-child interactional states.

Joint engagement was coded on the basis of where or with whom the child focused attention (person, object, or both) and if symbols (e.g. words, sign) were being used or understood. Total engagement with a caregiver included both symbolic and non-symbolic interactions which formed the Total Joint Engagement Composite. We also calculated a Total Symbol-Infused Joint Engagement Composite which included any use of symbols (i.e., symbol-infused supported and symbol-infused coordinated) (see Table 2). Each bout of joint engagement was watched until it was evident that the child's engagement state had shifted. A total of 12 coders were trained to code the joint engagement videotapes; both graduate students and paid research assistants comprised the coding group. Coders worked in pairs and were involved in weekly consensus coding to minimize rater drift. Interrater reliability was assessed for 20% of the tapes using Cohen's kappa and percent agreement. Both statistics were calculated on a second by second basis, a more stringent method for calculating agreement on summary measures (Bakeman & Gottman, 1997). The average average kappa coefficient was .72, with 86.8% agreement, indicating good interrater reliability.

Language Measures

Reynell Developmental Language Scales: The Reynell Developmental Language Scales (RDLS; Reynell & Gruber, 1990) are commonly used, well-validated language scales for children ages one to seven. The test consists of two scales: the Verbal Comprehension and Expressive Language scales. Both scales have acceptable split-half reliability coefficients across age groups (.74 to .93). They have been used with deaf and hearing children (DesJardin, Ambrose, & Eisenberg, 2009; Horn, Fagan, Dillon, Pisoni, & Miyamoto, 2007;

Laing, Law, Levin, & Logan, 2002). Children's scores can be compared to normative data to produce either standard scores or language age. In the current sample, 88% of the CI and 100% of the NH cohorts completed the RDLS, 53% of CI and 5% of NH cohorts scored at the floor of the both the RDLS scales and 0% of CI and 2% of NH cohorts scored at the ceiling of both scales.

MacArthur-Bates Communicative Development Inventories: In order to supplement the RDLS by extending the floor of the measure, parents reported on children's language using the MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 1993). The CDI is a widely used parent report measure of children's language for ages 8 to 30 months. Words and Gestures (CDI-WG) were used for children ages 8 to 16 months and Words and Sentences (CDI-WS) were used for children 16 to 30 months. Good internal consistency has been reported for both of these scales, .88 and .95, respectively. Scores from the CDI were translated into language age categories based on normative data, which was reported by gender in one-month age strata. Language age categories were defined by the means of each gender/age strata, CDI scores falling above the mean of one strata and below the mean of the subsequent strata were assigned the age of the lower block. In the current sample, 97% of the CI and 92% of the NH cohort completed the CDI-WG; 52% of the CI and 6% of the NH cohort reported scores at the floor of the scale and 23% and 70% reported scores at the ceiling of the scale. For the CDI-WS 72% of the CI and 92% of the NH cohorts completed the measure; 49% of the CI and 18% of the NH cohort reported scores at the floor, and 1% and 31% reported scores at the ceiling of the scale.

Language Age: The age-equivalent scores for each of the language measures provided a common metric that facilitated combining information across these instruments, which helped to expand the floor of the RDLS Consistent with previously published data from the CDaCI cohort (Quittner et al., 2013), only scores within the valid range were used in these analyses. Scores at the floor or ceiling of each measure, as documented in their respective manuals, were excluded. Language age was calculated by averaging across the age-equivalent scores from the language measures completed by each participant at Baseline (i.e., two RDLS scales and two CDI scales). At baseline 51% of the CI and 3% of the NH cohorts scored at floor on all of the scales, and 0% and 2% scored at the ceiling of all scales. Those who scored at the floor of all scales were given a language age score of 8 months, the lowest valid range of the CDI.

Analytic Approach—Multivariate analyses of variance (MANOVA) were used to test for differences between Deaf and NH samples among the *individual attention states*. Analyses of variance (ANOVA) were used to test for differences in *composite attention states* (i.e., Total Supported Joint Engagement, Total Coordinated Joint Engagement, Total Symbol Infused Joint Engagement, and Total Joint Engagement). Separate analyses were run for chronological and language age. Consistent with data presented in previous studies using the CDaCI cohort (Niparko et al., 2010) and to address non-linear relationships between the attention states and chronological and language age, analyses were stratified by age category (< 18 months, 18-36 months, >36 months). Effect sizes were estimated using eta-squared (η^2). Demographic differences between the CI and NH cohorts were accounted for by

including a propensity score as a covariate in all analyses (D'Agostino, 1998). The propensity score included parental education and household income, as well as child gender, age, race, ethnicity, and IQ. Locally weighted scatterplot smoothing was used to graphically depict the relationships among joint engagement, chronological age, and age-equivalent language scores (Cleveland & Devlin, 1988). Locally weighted smoothing allows for visual depiction of non-linear relationships. All analyses were performed using SPSS 22 (IBM Corp, 2013).

Results

Chronological Age

The overall aim of this study was to evaluate joint engagement in age-matched deaf and hearing children. We hypothesized that deaf children would exhibit delays in the attainment of symbol-infused joint engagement states when compared to hearing peers. This hypothesis received was strongly supported. Using the composite of total symbol-infused joint engagement, deaf children spent less time in this state than hearing children across all age groups (see Table 3 and Figure 1).

Child age: 18 months—For children 18 months or younger, the omnibus test for group differences suggested a significant difference between cohorts across the eight attention states (Wilk's $\lambda = 0.82$, $F(8,80)=2.20$, $p=.04$; see Table 2). Univariate tests revealed significant group differences for unengaged ($F(1,87)=9.85$, $p<.01$; $\eta^2=.10$; see Table 3), however, it is important to note that there was a great deal of variability in the deaf group for this state. There was also a difference for the composite attentional state of total symbol-infused joint-engagement ($F(1,87)=4.05$, $p=.05$; $\eta^2=.04$).

Child age: 18-36 months—For children between the ages of 18 and 36 months, the omnibus test was significant (Wilk's $\lambda = 0.27$, $F(8,97)=32.65$, $p<.01$). Univariate tests indicated significant group differences for: object ($F(1,104)=27.22$, $p<.01$; $\eta^2=.21$), supported joint engagement ($F(1,104)=12.64$, $p<.01$; $\eta^2=.11$), coordinated joint engagement ($F(1,104)=28.62$, $p<.01$; $\eta^2=.22$), symbol-infused supported joint engagement ($F(1,104)=25.54$, $p<.01$; $\eta^2=.20$), and symbol-infused coordinated joint engagement ($F(1,104)=48.81$, $p<.01$; $\eta^2=.32$). There were also group differences among the composite attention states including, total coordinated joint engagement ($F(1,104)=11.29$, $p<.01$; $\eta^2=.10$), total symbol-infused joint-engagement ($F(1,104)=147.92$, $p<.01$; $\eta^2=.59$), and total joint-engagement ($F(1,104)=23.94$, $p<.01$; $\eta^2=.19$). Again, there was a great deal of variability in time spent in the total symbol-infused JE state in the deaf versus hearing groups, reflecting individual differences in how quickly deaf children are able to use symbols in a dyadic interaction.

Child age: >36 months—For children who were older than 36 months, the omnibus test was significant (Wilk's $\lambda = 0.59$, $F(8,62)=5.44$, $p<.01$). Univariate tests indicated significant group differences for object ($F(1,69)=12.00$, $p<.01$; $\eta^2=.15$), supported joint engagement ($F(1,69)=10.27$, $p<.01$; $\eta^2=.13$), coordinated joint engagement ($F(1,69)=11.91$, $p<.01$; $\eta^2=.15$), and symbol-infused coordinated joint engagement (F

(1,69)=42.04, $p < .01$; $\eta^2=.38$). There were also group differences among the composite attention states including, total supported joint engagement ($F(1,69)=11.43$, $p < .01$; $\eta^2=.14$), total coordinated joint engagement ($F(1,69)=29.49$, $p < .01$; $\eta^2=.30$), total symbol-infused joint-engagement ($F(1,69)=42.41$, $p < .01$; $\eta^2=.38$), and total joint-engagement ($F(1,69)=16.08$, $p < .01$; $\eta^2=.19$).

Language Age

Our second aim was to examine the relationship between language and joint engagement. We hypothesized that higher levels of language, measured as language age on standardized instruments, would be related to more time spent in higher-level engagement states. This hypothesis was strongly supported, however, 83.2% of deaf children fell into the *lowest* language age group in comparison to 27.1% of the hearing children. Further, none of the deaf children had a language age above 36 months, in comparison to 21.9% of the hearing children (see Table 4).

For children in the youngest language age group, the omnibus test for group differences revealed a significant difference between cohorts across attention states (Wilk's $\lambda = 0.89$, $F(8,160)=2.47$, $p=.02$), with univariate tests indicating significant group differences for onlooking ($F(1,167)=4.50$, $p=.04$; $\eta^2=.03$) (see Table 4). For children with language ages between 18 and 36 months, the omnibus test was significant (Wilk's $\lambda = 0.78$, $F(8,68)=2.44$, $p=.02$), with univariate tests indicating significant group differences for coordinated joint engagement ($F(1,75)=10.96$, $p < .01$; $\eta^2=.13$) and symbol-infused supported-joint engagement ($F(1,75)=5.18$, $p=.03$; $\eta^2=.07$). There was also a significant difference for the symbol-infused composite ($F(1,75)=5.08$, $p=.03$; $\eta^2=.06$).

Predictors of Joint-Engagement in the Deaf Cohort—Step-wise linear regression was used to explore how features of early childhood deafness explain variability in the joint-engagement composites (total supported JE, total coordinated JE, total symbol-infused JE, and total JE). The first step included three parameters that modeled the non-linear relationship between chronological age and the composite attentional states. These parameters tested a linear relationship between each composite and chronological age across the three age categories used in the previous analyses (< 18, 18-36, and >36 months). The second step included age of onset, age at first amplification, and the best pure-tone average in either ear. The features of early childhood-deafness did not significantly add to the predictive power of chronological age for any of the composite scales.

Discussion

The overarching purpose of this study was to evaluate joint engagement in age-matched deaf and hearing children and examine its relationship to oral language skills. Our results showed that young deaf children of hearing parents, compared to hearing dyads, have deficits in joint engagement, which are related to oral language. As expected, deaf children exhibited delays in joint engagement when compared to their hearing peers. In the youngest age groups, deaf children spent more time in unengaged states and less time in symbol-infused states (e.g., parent and child are taking turns pretending to feed a doll) than the youngest hearing children. Our results contrast with those of Spencer and Waxman (1995), who

reported no differences in engagement states between deaf and hearing children ages 9 to 18 months. In the prior study, episodes involving symbol-infused joint engagement were coded as coordinated joint engagement, with no clear distinction between episodes that involved symbols or language versus those that did not. Thus, they could not detect the emergence of symbol-infused engagement in the deaf or hearing groups and these behaviors were collapsed into the coordinated engagement results, inflating the amount of time spent in that state.

In the current study, by age 18 months and older, hearing children were rapidly increasing the amount of time spent in total symbol-infused states and by 36 months of age and older, most of their time was spent in this engagement state (93%). In contrast, deaf children in both of the older groups (i.e., 18-36 months, 36 months and older) spent relatively little time in this state. At 18-36 months, they averaged only 8% of their time in this state, which increased to 34% in the oldest age group. These results parallel those of Prezbindowski and colleagues (1998) and Gale & Schick (2009) in which they found that deaf children spent less time than hearing children in symbol-infused engagement states.

Our second aim investigated how these engagement states were related to language age. Comparisons of time spent in symbol-infused states indicated strong support for the hypothesis that children with better language would spend more time in these states. This directly contrasts with the results using chronological age. At the youngest language age (18 months), deaf (4.6%) and hearing children (5.3%) spent similar amounts of time in symbol-infused states. As more language emerged, between 18 and 36 months using language age, both groups spent more time in total symbol-infused states, however, deaf children spent less time in these states (53.5%) than hearing children (67.9%). Importantly, no deaf children achieved a language age greater than 36 months and thus, we could not make comparisons with the hearing group. However, of the 21 hearing children who were in this highest language age group, 93.6% of their time was spent in the total symbol-infused state. Thus, language age was strongly associated with the emergence of higher-level engagement states.

This is the first study to directly test associations between language skills and dyadic engagement states in deaf and hearing children. Further, this is the only study that measured joint engagement in a large sample with a wide range of ages, which enabled us to identify the emergence of higher level engagement states in the youngest age groups and its establishment at the older age level. The delays in joint engagement we have identified in the deaf group have important implications for how children regulate their attention and affect, engage in social interactions, and acquire and map new words onto their environment. In a recent study with parents of children with autism, a 24-session intervention over 8 weeks to promote joint engagement was shown to decrease object-focused play and increase joint engagement in the dyads (Kasari, Gulsrud, Wong, Kwon, & Locke, 2010). These types of parent-mediated interventions are urgently needed for families seeking cochlear implants for young deaf children.

Interventions that promote a richer language environment and foster positive, dyadic interactions may be helpful in increasing the use of symbols in play and thus, indirectly

affect the growth of oral language. For example, we recently showed in a longitudinal study that parents' use of higher-level facilitative language techniques (e.g., expanding the child's utterance) was associated with better receptive and expressive language both before and three years following implantation (Cruz et al., 2013). Further, measures of maternal sensitivity (e.g., warmth, respect for autonomy, positive regard), which reflect the quality of parent-child interactions, were significantly related to growth in oral language over four years of implantation (Quittner et al., 2013). Examples of sensitive parenting would include providing adequate scaffolding and assistance in solving a difficult puzzle, while praising the child for his/her effort. The effect size for maternal sensitivity was substantial and similar to the effects of age at implantation (Niparko et al., 2010).

Limitations and Future Directions

This study had several limitations. Our hearing parents, who were recruited from two preschool programs that also enroll hearing-impaired children, had significantly more education and a higher family income than our parents in the deaf group. Although we controlled for these variables in the analyses, we acknowledge these differences. In addition, we did not code the parental initiation of joint engagement and thus, cannot address the question of whether mothers of deaf children initiate JE less often than parents of hearing children (Nowakowski, Tasker, & Schmidt, 2009). Finally, despite using videotaped behavioral coding and a well-established coding system, a 10-minute dyadic interaction has limitations in terms of generalizing to joint engagement behaviors in other contexts.

Our future research directions include following the CDaCI cohort from pre to three years post-implantation to evaluate the developmental trajectory of joint engagement and changes post-implantation. This will allow us to identify how an implant facilitates the emergence of joint engagement and its combined effects with language. We also plan to examine relationships between joint engagement and parents' use of both facilitative language techniques and sensitive parenting. Developmental studies have consistently shown that joint engagement is fundamental to important social-cognitive skills, such affective social referencing, the fostering of parent-child and later peer interactions, development of theory of mind, and behavioral regulation (Adamson et al., 2004). Thus, interventions to promote joint engagement in young deaf children prior to and after cochlear implantation may have beneficial effects. A recent, small study (Tasker et al., 2010) found that children using cochlear implants exhibited more joint engagement than deaf children not using implants; these children were also rated by their mothers as having fewer externalizing behavior problems.

Given universal newborn hearing screening and the established efficacy of cochlear implants (Geers, Nicholas, & Sedey, 2003, Niparko et al., 2010; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000), future studies should identify early intervention strategies that maximize the benefits of an implant for "catch-up" growth across many aspects of development. Promising strategies, such as the use of higher-level language techniques and more sensitive parenting, have been identified but not yet tested in randomized, controlled trials. Future studies should focus on evaluation of these types of strategies which may have benefits for both oral language and social and behavioral development. To date, cochlear implant teams

have focused primarily on auditory and language training, with little attention to broader developmental processes, such as sustained attention, behavioral regulation and improved social interactions.

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Figure 1.

Compares joint engagement states by hearing status. The top panel illustrates joint engagement states as a function of chronological age during free play. The bottom panel illustrates joint engagement states as a function of language age during free play.

Table 1
Baseline Characteristics of the CDaCI Cohort

Characteristic	Deaf (n = 180) Mean (SD) or % (N)	NH (n = 96) Mean(SD) or % (N)	Group Differences
Age (years) Mean age (SD)	2.3 (1.2); 0.78-5.09	2.3 (1.1); 0.75-4.99	$F(1,274)=.002, p=.96$
Age of onset of hearing loss (years)	0.2 (0.6)	--	
Pure-tone average (PTA4; better ear)	105.97 (17.3)	--	
Age at diagnosis (years)	0.9 (0.9)	--	
Age at first hearing aid use (years)	1.1 (0.9)	--	
Length of hearing aid use (years)	1.4 (1.0)	--	
Onset of hearing loss			
Sudden	6% (10)	--	
Progressive	36% (64)	--	
Congenital	54% (98)	--	
Cause of hearing loss			
Genetic	28% (51)	--	
Other	14% (26)	--	
Unknown	57% (103)	--	
Gender % Female (n)	53% (96)	62% (59)	$\chi^2(1)=1.68; p = .20$
Race			
White	73% (127)	79% (75)	$\chi^2(3)=4.37; p = .22$
African-American	11% (19)	14% (13)	
Asian	6% (10)	2% (2)	
Other/No response	10% (18)	5% (5)	
Ethnicity: Hispanic	21% (36)	10% (9)	$\chi^2(1)=5.31; p = .02$
IQ	96.24 (21.19); 45.82-162.22	106.89 (15.18); 66.41-142.53	$F(1,271)=18.65, p<.01$
Average and above	72% (112)	86% (80)	$\chi^2(2)=7.97; p = .02$
Low Average	16% (25)	11% (10)	
Borderline	12% (19)	3% (3)	
<70	8% (22)	1% (1)	
Communication Mode ^a			
Speech	28% (33)	--	
Sign	19% (34)	--	
Simultaneous/Speech Emphasis	19% (34)	--	
Simultaneous/Sign Emphasis	7% (12)	--	
Other / Undecided	37% (67)	--	
Parents' education			
< High school	7% (12)	5% (5)	$\chi^2(2)=9.15; p = .01$
High school grad	13% (23)	2% (2)	
College	80% (144)	93% (88)	
Parents' Income			
< \$15,000	9% (15)	6% (5)	$\chi^2(5)=39.85; p < .01$

Characteristic	Deaf (n = 180) Mean (SD) or % (N)	NH (n = 96) Mean(SD) or % (N)	Group Differences
\$15 – 29,999	12% (19)	4% (4)	
\$30 – 49,999	26% (42)	7% (6)	
\$50 – 74,999	18% (29)	16% (14)	
\$75 – 100,000	16% (26)	13% (12)	
\$100,000 +	19% (30)	54% (49)	
RDLS Receptive	6.01 (9.97); 0-45	30.38 (18.20); 3-66	$F(1,252)=189.78, p<.01$
RDLS Expressive	9.76 (10.07); 0-45	27.81 (15.04); 4-65	$F(1,252)=131.17, p<.01$
CDI Words and Gestures	48.63 (96.42); 0-385	225.44 (155.28); 0-393	$F(1,261)=128.60, p<.01$
CDI Words and Sentences	93.82 (158.01); 0-574	376.52 (256.24); 0-677	$F(1,216)=101.41, p<.01$

^a children in this study were cochlear implant candidates and all parents committed to teach their children spoken English. These categories, therefore, represent the primary communication mode used prior to enrolment in this study per parent report.

Table 2
Definitions of Attention States

Engagement State	Definition	Example
Unengaged	There is no evidence that the child is actively involved with a person, object or symbol.	Staring into space, staring at the floor, having a tantrum
Onlooking	Child is watching another person, observing his/her activity, or the objects the person is manipulating, however, child is not engaged or involved with the activity.	Child watches while parent stacks the blocks to make a tower
Object	Child is engaged with one or more objects, exploring or playing with objects him or herself.	Toddler playing with his/her foot, playing with a car or truck
Person	Child is actively engaged solely with a person (no objects are involved).	Parent tickles child and child reacts to the activity
Supported Joint Engagement	Child is actively involved with an object or event with which the other person is also engaged, but the child does not acknowledge this involvement.	Parent and child take turns rolling a ball and child is only focused on the movement of the ball
Coordinated Joint Engagement	Child coordinates his/her attention between person and objects. Child acknowledges the person's involvement.	Child holds up a toy plane, shows it to mother and then moves it through the air, while parent acknowledges their shared focus by laughing and saying "zoom"
Symbol-Infused Supported Joint Engagement	Child and parent are both focused on the same object or event and there is evidence that the child is actively attending to symbols (e.g., oral and sign language, symbolic gestures, symbolic play), but the child is not explicitly attending to the parent.	Parent assists the child as he/she focuses on pretending a block is a train.
Symbol-Infused Coordinated Joint Engagement	Child is coordinating his/her attention between the parent and a shared object or event, and the child is actively attending to symbols.	Parent and child are discussing a toy of mutual interest or they are taking turns feeding a doll

Table 3
Percent of Freeplay spent in each attention state by chronological age

	<=18 months Mean (SD)				18-36 months Mean (SD)				>36 months Mean (SD)			
	Deaf <i>n</i> =64	NH <i>n</i> =27	<i>p-value</i>		Deaf <i>n</i> =59	NH <i>n</i> =48	<i>p-value</i>		Deaf <i>n</i> =51	NH <i>n</i> =21	<i>p-value</i>	
Unengaged	6.28 (8.46)	0.92 (0.92)	<.01		3.96 (10.98)	0.55 (0.97)	.23		0.79 (1.80)	0.23 (0.51)	.11	
Onlooking	5.15 (5.93)	6.08 (6.08)	.96		2.23 (3.39)	1.01 (2.29)	.10		0.81 (1.39)	0.15 (0.69)	.14	
Object	52.29 (24.89)	53.39 (25.82)	.30		41.48 (29.01)	12.98 (16.08)	<.01		24.83 (24.14)	3.32 (5.80)	<.01	
Person	0.97 (2.07)	0.66 (1.05)	.46		0.74 (1.70)	0.16 (0.52)	.16		0.14 (0.48)	0.08 (0.35)	.73	
Supported JE	22.20 (17.58)	23.37 (18.33)	.91		20.90 (19.44)	5.13 (10.34)	<.01		17.74 (17.61)	2.12 (7.20)	<.01	
Coordinated JE	9.55 (12.95)	10.61 (14.11)	.71		19.31 (22.03)	1.98 (5.32)	<.01		16.45 (17.90)	0.27 (0.97)	<.01	
SI Supported JE	0.07 (0.41)	3.88 (8.50)	.08		1.01 (4.02)	21.51 (23.65)	<.01		5.87 (13.21)	2.46 (7.95)	0.19	
SI Coordinated JE	0.13 (0.93)	0.51 (1.74)	.35		7.21 (18.94)	50.45 (37.85)	<.01		29.63 (35.57)	90.54 (18.73)	<.01	
Total Supported JE	22.28 (17.70)	27.25 (21.05)	.60		21.91 (20.80)	26.64 (26.96)	.30		23.61 (20.90)	4.58 (4.58)	<.01	
Total Coordinated JE	9.69 (13.34)	11.12 (14.64)	.79		26.52 (28.81)	50.44 (36.76)	<.01		44.17 (32.62)	90.81 (18.23)	<.01	
Total SI JE	0.21 (1.00)	4.39 (8.57)	.05		8.22 (19.01)	69.97 (27.54)	<.01		33.59 (35.48)	92.99 (11.86)	<.01	
Total JE	31.96 (23.69)	38.36 (24.63)	.80		48.43 (29.86)	77.08 (24.30)	<.01		67.78 (27.41)	95.39 (6.03)	<.01	

Note: *p-values* are based on results from multivariate and univariate analyses of variance reported in text.

Table 4
Percent of Freeplay spent in each attention state by language age

	<=18 months Mean (SD)		18-36 months Mean (SD)		>36 months Mean (SD)	
	Deaf n=144	NH n=26	Deaf n=29	NH n=49	Deaf n=0	NH n=21
Unengaged	4.53 (9.17)	0.88 (1.63)	0.61 (1.33)	0.51 (0.90)	--	0.38 (0.83)
Onlooking	3.37 (4.79)	6.13 (5.62)	0.42 (0.97)	1.09 (2.31)	--	0.15 (0.69)
Object	45.82 (27.35)	53.52 (25.61)	14.15 (15.25)	13.50 (15.82)	--	2.59 (5.61)
Person	0.77 (1.78)	0.60 (1.08)	0.06 (0.20)	0.20 (0.54)	--	0.08 (0.35)
Supported JE	22.46 (18.33)	21.25 (17.40)	10.44 (14.17)	6.65 (13.14)	--	2.06 (7.22)
Coordinated JE	15.14 (18.33)	10.60 (14.29)	13.80 (20.03)	2.16 (5.55)	--	0.27 (0.97)
SI Supported JE	1.19 (4.81)	3.63 (8.04)	6.63 (15.47)	20.82 (23.75)	--	3.53 (9.05)
SI Coordinated JE	3.39 (10.03)	1.63 (5.77)	50.23 (39.07)	49.27 (38.83)	--	90.02 (19.18)
Total Supported JE	23.65 (19.04)	24.89 (18.53)	17.06 (21.98)	27.47 (27.99)	--	5.59 (13.62)
Total Coordinated JE	18.53 (22.73)	12.22 (15.54)	60.67 (32.30)	49.27 (37.44)	--	90.29 (18.69)
Total SI JE	4.58 (12.27)	5.26 (12.24)	53.49 (36.82)	67.92 (28.98)	--	93.55 (11.89)
Total JE	42.18 (28.35)	37.11 (24.23)	77.73 (23.00)	76.74 (23.89)	--	95.88 (5.92)

Note: p-values are based on results from multivariate and univariate analyses of variance reported in text.