



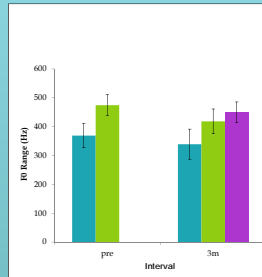
3aSC3. Prosodic characteristics of speech directed to adults and to infants with and without hearing impairment

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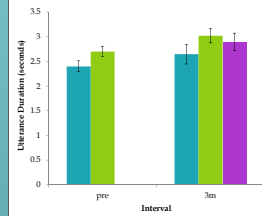
Introduction

- The prosody (i.e., rhythm and pitch) of maternal speech differs between infant-directed speech (IDS) and adult-directed speech (ADS) (Burnham et al., 2002; Fernald et al. 1989; Fernald & Mazzei 1991).
- Prior research suggests prosodic characteristics of IDS may facilitate word learning and language development (Bryant & Barret 2007; Fernald 1989; Fernald & Kuhl 1987; Thiessen et al. 2005; Trainor & Desjardins 2002).
- Children with hearing impairments (HI) tend to have language delays (e.g., Svirsky et al. 2000), which could be exacerbated if the prosody of input they receive is of lesser quality. Little research examined prosody of speech directed to infants with cochlear implants (CI) as compared to normal-hearing (NH) infants. Kondaurova and Bergeson (2011) did not control linguistic content. Differences do exist in linguistic content directed to children with HI as compared to children with NH (Henggeler & Cooper, 1983), and prosody depends on lexical content and syntactic structure (Shattuck-Hufnagel & Turk, 1996).
- A categorical difference may exist in the distribution of linguistic-prosodic constructs associated with meaning differences (i.e., prominences and phrasal boundaries) or in acoustic-prosodic characteristics (i.e., fundamental frequency (F0) and timing), or both. A more detailed understanding of prosodic input to children with HI may help develop better interventions to maximize HI children's overall language development.
- Research Question:** Is there a difference in acoustic-prosodic and/or linguistic-prosodic characteristics of speech to infants with cochlear implants compared to infants with normal hearing, when syntactic structure and lexical content are controlled?



Acoustic-Prosodic Differences

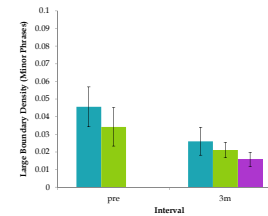
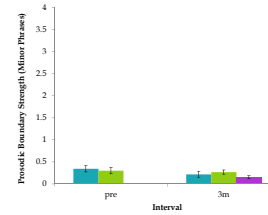
- ### Fundamental Frequency (F0)
- Mean F0 across groups was not significantly different ($p > .33$).
 - F0 range was significantly smaller in the CI group compared to the CAM group ($p < .05$), and trended toward a smaller F0 range in the CI group than the HEM group ($p = .096$).
 - This difference in range may be driven by a significantly higher F0 minimum in speech to children with CI's compared to speech to the CAM group ($p = .011$) or the HEM group ($p = .001$).



Duration

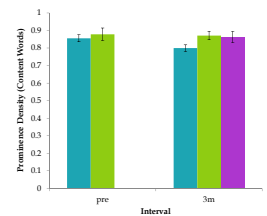
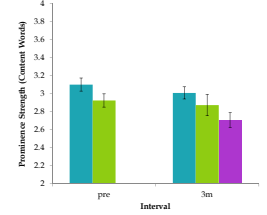
- Utterance duration was significantly shorter in the CI group compared to the CAM group ($p = .021$).
- However, utterance duration was not significantly different between the CI and HEM groups ($p = .363$).
- *In general, there was no effect of the time interval on the vast majority of dependent measures.

Results



Linguistic-Prosodic Differences

- ### Boundaries
- No significant difference in prosodic boundary strength was found at minor syntactic junctures in the CI group compared to the CAM group ($p = .199$).
 - A trend toward weaker prosodic boundaries at these locations was found in the CI group compared to the HEM group ($p = .076$).
 - No significant difference was found in prosodic boundary density at minor syntactic junctures in the CI group compared to the CAM ($p = .228$) or HEM group ($p = .474$).
 - This pattern held for a variety of syntactic locations and prosodic boundary sizes.
- ### Prominences
- Prominences were significantly stronger on content words in the CI group compared with the HEM group ($p = .01$), and a trend in the same direction was found relative to the CAM group ($p = .073$).
 - A trend towards a lower density of prominences was found in the CI group compared to the CAM group ($p = .073$) or the HEM group ($p = .096$).



Methods

- ### Study Design
- #### Hearing Status:
- CI Group:** Each mother read to her hearing-impaired infant who was scheduled to receive a cochlear implant (CI) or had recently received a CI approximately 3 months earlier.
 - Chronological Age Match (CAM) Group:** Each mother read to her NH infant matched to an infant in the CI group whose chronological age was equivalent.
 - Hearing Experience Match (HEM) Group:** Each mother read to her NH infant matched to an infant in the CI group whose amount of post-implantation hearing experience was equivalent.
- #### Participants
- ##### CI Group versus CAM Group
- Pre interval:**
 - CI Group: 12 mothers of hearing-impaired infants prior to cochlear implantation (CI) aged from 8.2 to 22.9 months ($M = 15.2$, $SD = 4.7$)
 - CAM Group: 12 mothers of normal-hearing infants aged from 8.8 to 23.5 months ($M = 15.2$, $SD = 4.6$)
 - 3m interval:**
 - CI Group: 11 mothers of infants post-CI with 2.5 to 4.0 months ($M = 3.2$, $SD = 0.4$) of hearing experience, aged from 14.3 to 24.8 months ($M = 19.2$, $SD = 2.5$)
 - CAM Group: 11 mothers of normal-hearing infants aged from 14.8 to 23.5 months ($M = 19.2$, $SD = 2.1$)
- ##### CI Group versus HEM Group
- CI Group: 11 mothers of infants post-CI with 2.5 to 4.0 months ($M = 3.2$, $SD = 0.4$) of hearing experience, aged from 14.3 to 24.8 months ($M = 19.2$, $SD = 2.5$)
 - HEM Group: 11 mothers of normal-hearing infants aged from 2.5 to 4.1 months ($M = 3.1$, $SD = 0.4$)

- ### Materials
- Storybook recordings of English-speaking mothers reading to their infants during one or more sessions at the DeVault Otologic Lab at Indiana University School of Medicine.
- ### Analysis
- #### Prosody Labeling:
- Speech files were annotated for linguistic-prosodic characteristics using the Rhythm and Pitch (RaP) prosody labeling system (Dilley & Brown 2005).
 - Two analysts coded each file separately, and their labels were combined to create a consensus transcription of prosodic attributes.
 - The following characteristics were coded:
 - Phrase boundaries**, i.e., word boundaries perceived as points of disjuncture in speech. Levels of boundary strength ranged from 1 (weakest) to 4 (strongest).
 - Prominences**, i.e., syllables perceived as salient in context. Levels of prominence strength ranged from 1 (weakest) to 4 (strongest).
 - The following characteristics were analyzed:
 - Boundary strength** = (sum of prosodic boundary strengths) / (count of syntactic boundaries)
 - Boundary density** = (count of prosodic boundaries) / (count of syntactic boundaries)
 - Prominence strength** = (sum of prominence strengths) / (count of words)
 - Prominence density** = (count of prominences) / (count of words)
- #### Speech Quality:
- Timing duration: measurements were taken across all utterances and pauses (silence > 250 ms).
 - Acoustic frequency: Measures of fundamental frequency (F0) characteristics (i.e., mean, min, max, range, and standard deviation) were taken across each soundfile.

Conclusions

- When looking at acoustic-prosodic differences, mothers produced less variable F0 in speech to CI children than in speech to NH children of the same chronological age. Also, the temporal characteristics of mothers' utterances in speech to children with CI's were more similar in speech to children matched on chronologically age than amount of hearing experience.
- When looking at linguistic-prosodic differences, mothers produced a comparable strength and density of prosodic phrase boundaries in speech to children with CI's and in speech to matched control groups. However, mothers tended to produce fewer, but stronger, prominences in their speech to children with CI's as compared to speech to both matched control groups.
- Mothers of any group did not tend to differentiate their linguistic-prosodic or acoustic-prosodic characteristics at the pre-implantation or 3-month intervals studied.
- Given findings that prosodic phrase boundaries and prominences assist with word segmentation and word learning in typically-developing infants (Christophe et al. 2004), our results suggest possible benefits of developing therapies aimed at increasing the density of prosodic prominences on words, and increasing the density and/or strengths of prosodic phrase boundaries between words in speech directed to infants with hearing loss. These issues should be examined in future research to determine the exact clinical applications and benefits.

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