

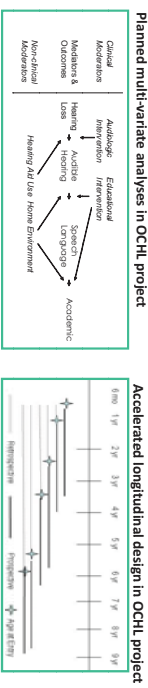
Mark Vandam¹, Mary Pat Moeller¹, Bruce Tomblin²

¹Center for Childhood Deafness, Boys Town National Research Hospital
²Department of Communication Sciences and Disorder, University of Iowa
mark.vandam@boysstown.org www.VandamMark.com

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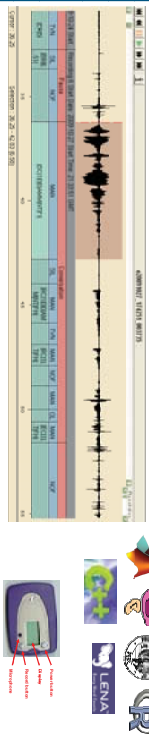
Outcomes of Children with Hearing Loss

Outcomes of children with hearing loss (OCHL) is a large, multi-center, NIH-funded longitudinal study currently following 230 children with mild to moderately-severe hearing loss. Acoustic analyses were conducted on a sub-sample of 28 families who contributed monthly, full-day audio recordings for a period of one year. Software automatically analyzes the collected acoustic waveform as live human voices (e.g., woman, target child, man, etc) or features of the acoustic environment (e.g., silence, TV/radio, noise, etc).



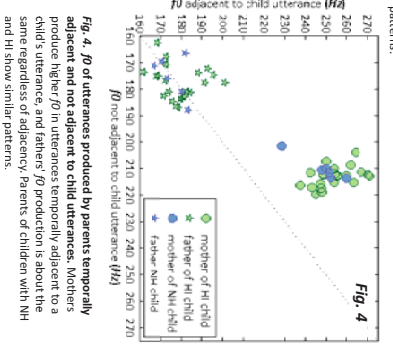
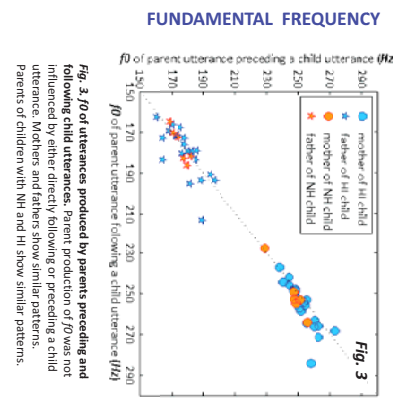
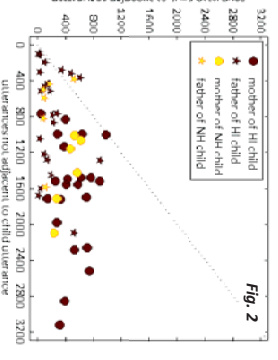
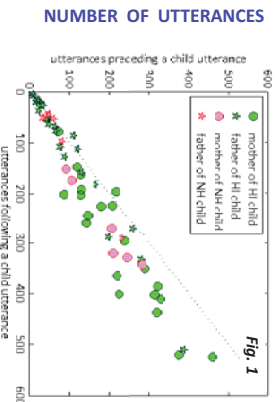
Method, study details

Children: 22 children with hearing loss (HL), 6 children with normal hearing (NH); 54% male; $M = 1.2$ siblings
HL: Mild to moderately-severe; PTA: $M = 48$ dB HL ($SD = 10.1$, range = 28-68); Age at ID of hearing loss: $M = 1.8$ mos; Age at amplification: $M = 7.0$ mos
Disabilities: No major secondary disabilities (eg, Down Syndrome, Autism Spectrum Disorders)
Age: $M_{HL} = 29.9$ mos ($SD = 2.4$); $M_{NH} = 29.4$ mos ($SD = 1.9$); $M_{NH} = 31.5$ mos ($SD = 2.4$)
Sites: Boys Town National Research Hospital (Omaha, NE), University of Iowa (Iowa City, IA), University of North Carolina (Chapel Hill, NC)
Raw data: Unprocessed whole day recordings (mono, 16k, 16-bit, PCM) from wearable recorder (total = 398,72 hrs)
Coding: Raw acoustic signal ($M = 14.2$ hrs/child) is coded by LENA Foundation software using unsupervised Gaussian mixture model, outputting a transparent (i.e., XML-coded) record of onset and offset times of (a) vocalizations by live human talkers (target-child, adult-female, adult-male, other-child) and (b) other acoustic environments (electronic-TV-radio, overlapping-words, noise, silence, jazz). Talker labels are evaluated in serial position and interpreted into blocks of conversations. Codes and logs collected on the day of recordings support interpretation of adult-female and adult-male categories as mother and father.
Analyses: Child, mother, and father utterances were identified in the whole-day acoustic recordings. Serial order, usage-frequency, and fundamental frequency were collected by custom scripts prepared in MATLAB, PRAAT, Perl, R, C++.



Research questions

1. Do children use different f_0 when talking to mothers versus fathers?
2. Do children with HI and NH produce f_0 differently as a function of how conversations are structured?
3. Do children with HI use f_0 in the same way as children with NH?
4. How often do children and their parents talk in a day?
5. Do parents vary f_0 production in conversations with their children?



Conclusions

1. Acoustic-phonetic characteristics of speech production from whole day recordings can be obtained. Ecological validity is improved. This work is proof-of-concept.
2. Children do not change f_0 to address mothers versus fathers or depending on who initiates a conversation (Fig. 5).
3. Neither number of utterances nor f_0 of parents' productions depends on the hearing status of the child (Figs. 1-4).
4. Parents tend to produce slightly more utterances following a production by the child (Fig. 1), but f_0 of parent production tends not to vary as a function of position to child utterance (Fig. 3).
5. Mothers produce more utterances than fathers not temporally adjacent to child utterances; fathers produce a higher proportion of utterances adjacent to child utterances (Fig. 2).
6. Mothers produce higher f_0 in utterances adjacent to child utterances, but fathers do not show this pattern (Fig. 4).
7. Some basic groundwork laid for automatic detection of child directed speech.

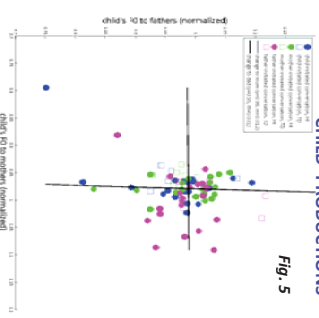


Fig. 5. Child f_0 production in conversation with parents. Children's f_0 was stable when talking with parents regardless of hearing status, who initiated a conversation, or whether child talked uniquely adjacent to either mother or father.