4pSC11. **Analyses of fundamental frequency in infants and preschoolers with hearing loss.**

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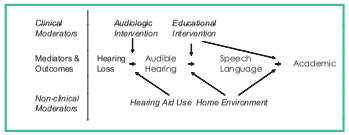
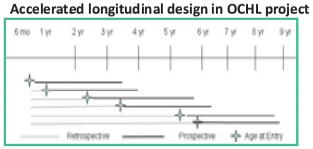
Outcomes of Children with Hearing Loss

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).

Planned multi-variate analyses in OCHL project



Accelerated longitudinal design in OCHL project



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)

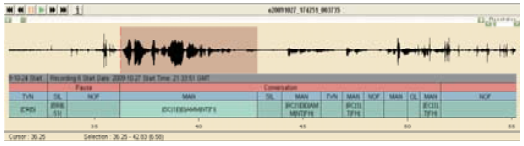
Age: M_{all} = 29.9 mos (*SD* = 2.4); M_{HI} = 29.4 mos (*SD* = 1.9); M_{NH} = 31.5 mos (*SD* = 2.4)

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-vocals*, *noise*, *silence*, *fuzz*). 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 *f0* when talking to mothers versus fathers?**
2. **Do children with HI and NH produce *f0* differently as a function of how conversations are structured?**
3. **Do children with HL use *f0* in the same way as children with NH?**
4. **How often do children and their parents talk in a day?**
5. **Do parents vary *f0* production in conversations with their children?**

SERIAL POSITION | **TEMPORAL ADJACENCY**

NUMBER OF UTTERANCES

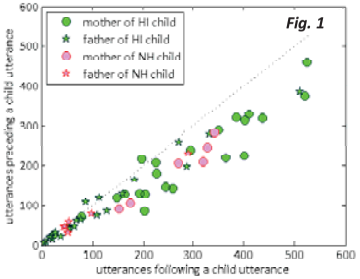


***Fig. 1.* Number of utterances produced by parents preceding and following child utterances.** Number of parent utterances tends to increase when directly following a child utterance. Mothers and fathers show similar patterns. Parents of children with NH and HI show similar patterns.

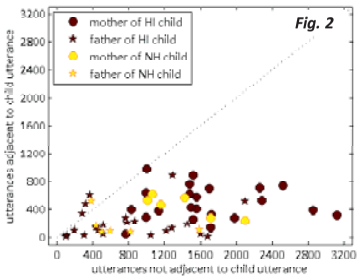


***Fig. 2.* Number of utterances produced by parents temporally adjacent and not adjacent to child utterances.** Parents produced more utterances not adjacent to child utterances. Although mothers produced more total utterances, fathers produced a higher proportion of their utterances immediately adjacent to child utterances. Parents of children with NH and HI show similar patterns.

FUNDAMENTAL FREQUENCY

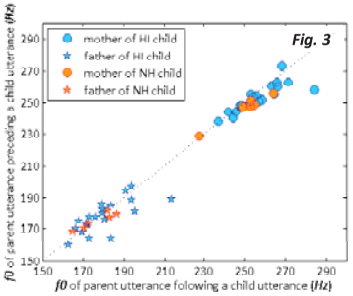


***Fig. 3.* f0 of utterances produced by parents preceding and following child utterances.** Parent production of *f0* was not influenced by either directly following or preceding a child utterance. Mothers and fathers show similar patterns. Parents of children with NH and HI show similar patterns.

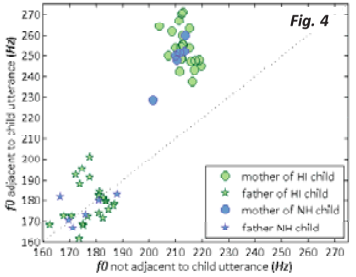


***Fig. 4.* f0 of utterances produced by parents temporally adjacent and not adjacent to child utterances.** Mothers produce higher *f0* in utterances temporally adjacent to a child's utterance, and fathers' *f0* production is about the same regardless of adjacency. Parents of children with NH and HI show similar patterns.

CHILD PRODUCTIONS

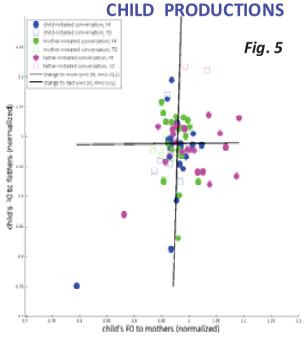


***Fig. 5.* Child *f0* production in conversation with parents.** Children's *f0* was stable when talking with parents regardless of hearing status, who initiated a conversation, or whether child talked uniquely adjacent to either mother or father.

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 *f0* to address mothers versus fathers or depending on who initiates a conversation (*Fig. 5*).**
3. **Neither number of utterances nor *f0* 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 *f0* 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 *f0* 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.**