Acoustic Measures of Linguistic Prosody in the Speech of Children with Cochlear Implants: a study in comparison with hearing peers

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Introduction

Production of prosody in speech requires complex interactions of various physiological mechanisms of articulation, phonation and respiration timed with a linguistic message (Nooteboom, 1999). The regulation and coordination of pitch, loudness and rhythm by speakers requires use of underlying physiology to create systematic patterns of change in fundamental frequency (F0), intensity and relative durations of segments across a phrase. Historical accounts of use of prosody in deaf speakers highlight use of multiple breaths, extended pauses, monotonous pitch and inconsistent loudness (Osberger & McGarr, 1982). The speech of children with cochlear implants has been documented as more intelligible (Tobey et al., 2003) with increased accuracy in production of segmental features. Little is known about the production of prosody in the speech of children with cochlear implants.

Purpose

The purpose of this study is to describe acoustic correlates of prosodic forms in the speech of children with cochlear implants and to compare the acoustic measures with those produced in the speech of typical-hearing peers.

Methodology

The data analyzed in this study consists of a subset of prior-collected speech samples from an NIH/NIDCD-funded study titled *Cochlear Implants and Education of the Deaf Child* (see *Ear & Hearing, 2003,* 24: Supplement for series of articles). Participants were provided with a written and spoken model of 47 sentences and their imitations were recorded. Prosodic analyses of duration of utterance, % pause, % schwa, % final syllable lengthening, breath groups, # of syllables, F0 range and F0 rise/fall were completed on 12 utterances varying in length (# of syllables), and type (command, statements and questions).

Participants

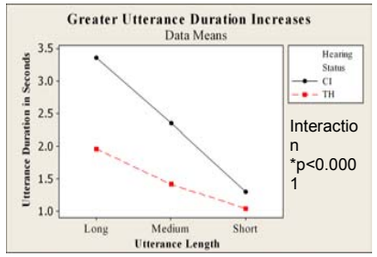
27 children with cochlear implants:
- 16 girls and 11 boys
- congenitally deaf
- implanted from ages 2.39 to 4.96
- IQ within 2 standard deviations of the mean

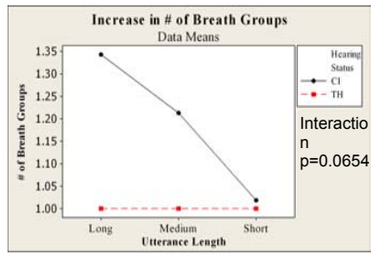
12 children with typical-hearing:
- 6 girls and 6 boys
- no language or speech impairments

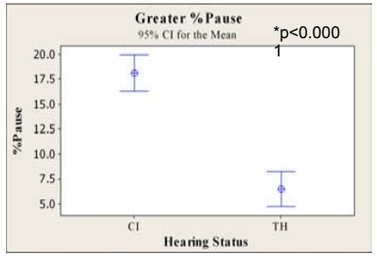
Sentences for Analysis

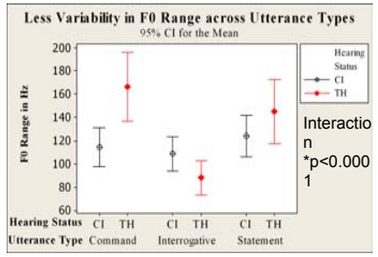
	Short **(3 syllables)**	***Medium*** **(5-6 syllables)**	***Long*** **(7-8 syllables)**
Statement	**The dog barks.**	**Mother has the car.** **Daddy took his new shoes.**	**I wish I had a pony.** **Chuck seems thirsty after the race.**
Command	**Read the book.** **Feed the dog.** **Get the cake.**		
Question		**Is that the tall one?** **Did you brush your teeth?**	**Did you like the zoo this spring?** **Can you dive in deep water?**

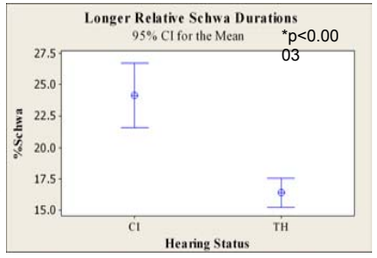
Main Findings of Differences

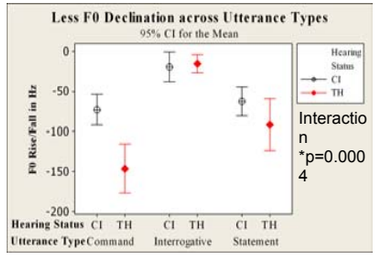












Results

In comparison with the typical-hearing group, the cochlear implant group produced:
- Utterances of longer durations as utterance length increased
- Greater % pause
- Longer durations of schwa
- Similar % final syllable lengthening
- More breath groups as utterance length increased
- Similar # of syllables
- Less variability in F0 range across utterance types
- Less F0 declination across utterance types

Conclusions

Prosodic differences exist between the speech of children of cochlear implants and their typical-hearing peers on measures of durational and pitch variation. Children with cochlear implants demonstrate tendencies to lengthen rather than shorten segments and to use less pitch variation across utterances than their typical-hearing peers.

Discussion

Based on this evidence of acoustic differences in prosody, further research as to the perception and functional use of prosody is warranted. Questions remain as to the development of coordination of respiration, articulation and phonation with the linguistic message in children with cochlear implants.

Nooteboom, S. (1999). The prosody of speech: melody and rhythm. In Hardcastle, W.J. and Laver, J. (Eds.) The Handbook of Phonetic Sciences. (pp.640-673). Oxford: Blackwell Publishers.

Osberger, M.J. & McGarr N.S. (1982). Speech production characteristics of the hearing impaired. In Lass, N.J. (Ed.) Speech and Language: Advances in Basic Research and Practice: Vol. 8. (pp. 221-283). Washington, D.C.: Academies Press, Inc.

Tobey, E.A., Geers, A.E., Brenner, C., Altuna, D. & Gabbert, G. (2003). Factors associated with development of speech production skills in children implanted by age five. *Ear & Hearing*. 24: 36S-45S.