Long-term development of overall consonant accuracy and consonant place, manner and voicing features in pediatric cochlear implant recipients

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Speech Production

- Speech Production is the most complex act performed by the human body
  - Multisystem
    - Motor
    - Linguistic
    - Sensory
    - Cognitive system
  - Long developmental course in typically developing children
  - Major goal of cochlear implantation
  - Very few studies on speech production accuracy
Purpose of this Study

- To develop a model growth of segmental speech production of consonants over time
- Investigate the impact of age of implant on
  - Initial status
  - Acceleration or initial year of growth
  - Deceleration or dampening of growth over time
- This study also incorporates a number of different speech production outcomes
  - Overall Consonant Production
  - Consonant Manner of Articulation
  - Consonant Place of Articulation
  - Consonant Voicing Feature
Acceleration and Deceleration

Milano

Verona

Venice
Acceleration and Deceleration

Younger CI Recipients

Older CI Recipients

100% Speech Accuracy

Younger CI Recipients
Acceleration and Deceleration

Segmental Production Accuracy

100% Speech Accuracy

Older CI Recipients

Younger CI Recipients

Time post implant
Hypotheses

- Younger CI recipients would have a steeper initial growth rates.
- Younger CI recipients would surpass their older CI peers at some point.
  - Older children would initially start with higher accuracy rates due to their age, hearing aid use, and years in therapy.
- Younger CI recipients would have higher endpoints of production accuracy.
  - Mastery is defined as exceeding 90% accuracy.
- Younger CI recipients would have a faster deceleration rates.
Participants

- 63 children
- 61 received Cochlear Nucleus 22 or 24 device
- 2 received Advanced Bionics devices
- Initial processing was the most current available at the time of implant
- Mean age of implant was 60 months
  - Range 10 –170 months
- Various etiologies (48% unknown)
- Mainstreamed within local schools
- Simultaneous communicators but communication modality evolved overtime as speech and listening skills improved
- Diverse treatment intensities and programs in local public schools
Data Collection

- Annual visits over a 11-year time span beginning at pre-implant
- Videotaped recordings
- Connected “spontaneous” speech
  - Story re-tell task
  - Play task with standard set of toys
- Broad phonetic transcription
  - 30% of samples were transcribed for inter-rater reliability
- Entered into Logical International Phonetics Programs or LIPP
  - LIPP calculates accuracy based on the child’s production compared to a target production. This is reported in percent correct.
Data Analysis: Statistical Models

- Multi-level or Hierarchical Linear & Nonlinear Modeling (HLM6) Raudenbush, Bryk, Cheong & Congdon
  - Large data set
  - Accounts for missing data
- Repeated measures of speech production
  - A minimum of 10 attempts of a specific phoneme were required to be included in the statistical analysis
- Unconditional Model—determines if a linear or quadratic model best fits the data and overall averages of production
- Conditional Model—determines if age of implant impacts initial status, acceleration & deceleration
Results—Conditional Model—Overall Consonants

- Average initial status of all the participants—15.74%
  - Age of implant was a **significant** predictor of initial status
    - Older children were more accurate pre-implant
      - Initial status differed by 0.32% per month based on mean implant age

- Acceleration or initial “instant” growth of 9.97% per year for the first year.
  - Age of implant was a **significant** predictor of the first year of growth
    - Younger children had steeper rates of growth
    - Initial year of growth differed by 0.10% per month based on the mean implant age

- Deceleration rate -0.39% per year
  - Age of implant was **non-significant** and did not predict the rate of deceleration

- For consonants overall there was not mastery of production
- By 4 years post implant the younger children began to surpass the older children in production
Consonants—2 D graph
Results—Conditional Model—Manner

- Average pre implant accuracy across the 63 children was 20.90%
  - Age of implant is a **significant** predictor of pre-implant status
    - Older children were more accurate pre-implant
      - Initial status differed by .29% per month based on mean implant age.

- Average acceleration or growth was 10.46% per year
  - Age of implant was a **significant** predictor of the rate of acceleration
    - Younger children had steeper growth rates
    - Older children have more constant growth rates
      - Rate of change was -.11% per month based on the mean implant age.

- Average deceleration rate was -.49% per year
  - Age of implant was a **non significant** in predicting rate of deceleration

- For manner of articulation there was not mastery of production
- By 3.5 years post implant the younger children began to surpass the older children in manner accuracy
Overall Manner—2D Graph
Results—Conditional Model—Place

- Average pre implant accuracy across the 63 children was 19.87%
  - Age of implant is a significant predictor of pre-implant status
    - Older children were more accurate pre-implant
      - Initial status differed by .35% per month based on mean implant age.

- Average acceleration or growth was 10.41% per year
  - Age of implant was a significant predictor of the rate of acceleration
    - Younger children had steeper growth rates
    - Older children have more constant growth rates
      - Rate of change was -.11% per month based on the mean implant age.

- Average deceleration rate was -.47% per year
  - Age of implant was not significant in predicting rate of deceleration.

- For place of articulation there was not mastery of production
- By 4 years post implant the younger children began to surpass the older children in production
Place—2D Graph
Results—Conditional Model—Voicing

- **Average pre implant accuracy across the 63 children was 23.31%**
  - Age of implant is a **significant** predictor of pre-implant status
    - Older children were more accurate pre-implant
      - Initial status differed by .30% per month based on mean implant age.

- **Average acceleration or growth was 10.39% per year**
  - Age of implant was a **significant** predictor of the rate of acceleration
    - Younger children had steeper growth rates
    - Older children have more constant growth rates
      - Rate of change was -.11% per month based on the mean implant age.

- **Average deceleration rate was -.48% per year**
  - Age of implant was **not significant** in predicting rate of deceleration.

- For the voicing feature there was **not mastery of production**
- By 3.5 years post implant the younger children began to surpass the older children in production
Voicing

The graph shows the progression of voicing over time. The x-axis represents time, while the y-axis represents the voicing level. Each line represents a different time point:

- voicingAT12m
- voicingAT18m
- voicingAT24m
- voicingAT48m
- voicingAT72m
- voicingAT96m

As time progresses, the voicing level increases for all the time points indicated.
Summary

- These results support our clinical observations that consonant accuracy is a challenge for most children with cochlear implants.
- Age of implant impacted initial status of production at pre-implant and initial growth rate but did not reach significance for deceleration which would indicate mastery of consonants and consonant features.
- Speech production accuracy occurs over a long time course.
- Younger children surpassed their older implanted peers resulting in higher endpoints of accuracy.
- These results provide a clinical benchmark or guide for expected growth over time.
Questions?

- Please email me at mooreja2@unk.edu if you would like a copy of this presentation or a table explaining the impact of the various growth rates.