Suprasegmental Abilities of Children with Cochlear Implants

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Thank You

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Agenda

• Background
• Methods
• Results
• Interpretation
• Directions for Future Research
Background
Background

- Historically children with severe-to-profound hearing loss have fallen well behind their peers with normal hearing in the areas of speech and language development;
- Limited spoken language development in turn restricts academic, vocational and social opportunities;
Background

- Cochlear implant technology has provided unprecedented access to the speech signal to children with severe-to-profound hearing loss;
- If we expect these children to perform linguistically at a level of their peers with normal hearing, they should be able to extract critical acoustic cues from the spoken language signal.
History of Pediatric Cochlear Implantation in the United States

- **First American child received a cochlear implant in 1980;**
- **During first pediatric clinical trial average age of implantation was 8 years;**
- **Most children used sign language as primary mode of communication;**
- **Single channel electrode.**
History of Pediatric Cochlear Implantation in the United States

• What did we learn re: spoken language development?
  – Multichannel stimulation is better;
  – Earlier is better;
  – Auditory deprivation is bad.
Do Cochlear Implants Work?
Factors That Influence Auditory Development

- Age of the Child
- Age at Onset of Deafness
- Age at Diagnosis
- Duration of Deafness
- Use of Amplification
- Degree of Hearing Loss
- Etiology of the Hearing Loss
- Availability of Support Services
- Skills of Therapist
- Skills of Parent
- Expectations for Success
- Cognitive Ability/Learning Style of the Child
- Parent Support and Commitment
- Emotional Status of the Family
How Have Our Questions Changed?

• “Theory-driven research moves from simple description and device “efficacy” studies to issues, which may allow for explanation of and prediction for future success.”

How Have Our Questions Changed?

- Shift from efficacy measures to influencing cognitive factors and level of linguistic benefit that can be derived by children with prelinguistic deafness who have received a cochlear implant.

How Have our Questions Changed?

- Pisoni (2000) suggested that future research should take on a new direction, to assume an “information-processing” approach, which looks at cognitive factors, such as perception, learning, and memory, in a child’s ability to utilize the cochlear implant to develop spoken language.
Suprasegmental Development of Children with Normal Hearing Thresholds and Children with Cochlear Implants
Definitions

Segmental Features of Speech

• structural aspects
• meaningful combinations of phonemes and morphemes that form words, phrase units, and sentences
Definitions

Suprasegmental Features of Speech

• nonsegmental / prosodic aspects

• represented by three primary acoustic parameters: intensity/loudness; frequency/pitch; duration/time

• often considered secondarily to segmental aspects in terms of representation of meaning
Five main functions of prosody (Crystal, 1979)

**Grammatical**

- *Distinctions between sentences and statements*
  You’re going, aren’t you.
  You’re going, aren’t you?

- *Distinctions between nouns and verbs otherwise identical*
  CON-vict
  con-VICT
Functional Use of Suprasegmentals

Five main functions of prosody (Crystal, 1979)

Semantic

- conveys the relative importance of one element of a message to overall meaning, often by emphasizing one lexical unit.
Functional Use of Suprasegmentals

Five main functions of prosody (Crystal, 1979)

Attitudinal

• expression of personal emotion in relation to context of utterance
Functional Use of Suprasegmentals

Five main functions of prosody (Crystal, 1979)

Psychological

- ability of prosody to support the workings of short-term memory and other executive functioning
Functional Use of Suprasegmentals

Five main functions of prosody (Crystal, 1979)

Social

- Conveys social linguistic characteristics of the speaker, such as sex, class, race, professional status, etc.
Speech Perception Abilities in Typically Hearing Children

• 9 months of age:
  – Increasing ability to discriminate native vs. non-native suprasegmental patterns;
  – Prosodic patterns seem to be more salient to infants than segmental patterns;
  – Begin to recognize segmental sequences as early as 7 months.

Speech Perception Abilities in Typically Hearing Children

- Changes in expected stress patterns of native language affects word recognition in infants from English-speaking families.

Speech Perception Abilities in Typically Hearing Children

- Longitudinal study of infants before 12 months of age and later at 4-6 years of age showed that infants who exhibited earlier or more accurate ability to segment language had higher language scores.

Speech Perception Abilities in Typically Hearing Children

• *Early multi-word combinations require “rich-interpretation”, that is, the interpretation of the meaning beyond the words;*

• *Prosodic cues are needed to interpret syntactic and semantic relations;*

• *Forms like “mommy sock” can mean several things based on intonation pattern in which they are produced.*

*Bloom, L. (1970)*
What are Suprasegmentals?

- Speech consists of individual sound units (segmental) and prosodic features (suprasegmental);
- Meaning, however, is conveyed not only by combinations of sound units but also by modulating prosody.
What are Suprasegmentals?

- Acoustic parameters associated with prosody include:
  - fundamental frequency (F0)
  - intensity
  - duration

...which are perceived as pitch, loudness, and length, respectively.
What are Suprasegmentals?

• Linguistically, prosodic information serves many functions, including
  
  – marking contrasts such as signaling questions versus statements
  – placing contrastive stress within a word or a phrase.
Research Question

• Do children who use cochlear implants exhibit the same ability to discriminate suprasegmental features of spoken language as their peers with normal hearing?
Cochlear Implant Insertion
Findings of Past Literature

• *Children who use cochlear implants do not show the same level of mastery of suprasegmental perception as children with normal hearing* (Chatterjee & Peng, 2008; Most & Peled, 2007; Peng, Tomblin, Turner, 2008).

• *According to Most and Peled (2007), “present cochlear implants are not sufficient in providing acoustic information on the suprasegmental features of speech”*. 
Motivation for the Dissertation Study

- Clinical experience and anecdotal evidence contradict the findings of these studies.

- Published studies that claim age-appropriate speech perception (segmental) and language skills of these children.
Methods
Methods

• Design: Exploratory
  Non-experimental / Posttest only

• Participants:
  Forty children (ages 6-14) assigned to two groups:
  – Children who use cochlear implants (CI)
  – Children with normal hearing (TH)

• Controls

• Administration Procedures
Participants

• 7-11 years of age;
• Prelingual sensorineural hearing loss;
• Identified between birth and 3 years of age;
• MAPping within last 6 months and at least 4 years of use;
• Hearing, English-speaking parents;
• Communicate orally through spoken language;
Participants

- Fully mainstreamed;
- No additional identified handicaps;
- Received speech and language intervention since identification;
- Language age within one year of chronological age.
Administration Procedures

• Investigator followed a script for administration;

• Children were asked to listen to prerecorded stimuli presented auditory-only and then select from a closed set of options by circling their choice on an answer sheet.
Speech Perception

- Early Speech Perception Test - Standard Version
Speech Perception

• Results from independently developed lists that assess various additional aspects of suprasegmental speech perception development;

• Includes word pattern, intonation, syllable stress, and word emphasis.
Early Speech Perception Test

Assesses Syllable Pattern, Spondee and Monosyllable Identification
Early Speech Perception Test
# Early Speech Perception Test

## Early Speech Perception (ESP) Test

**Standard Version**

Developed by Jean S. Moog and Ann E. Geers  
Central Institute for the Deaf

<table>
<thead>
<tr>
<th>Name</th>
<th>Speech Perception Category:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>1—No Pattern Perception</td>
</tr>
<tr>
<td>DOB</td>
<td>2—Pattern Perception</td>
</tr>
<tr>
<td>Age</td>
<td>3—Some Word Identification</td>
</tr>
<tr>
<td>Examiner</td>
<td>4—Consistent Word Identification</td>
</tr>
<tr>
<td>Listening Device</td>
<td></td>
</tr>
</tbody>
</table>

## Pattern Perception

<table>
<thead>
<tr>
<th>RESPONSE</th>
<th>shoe</th>
<th>ball</th>
<th>fish</th>
<th>cookie</th>
<th>baby</th>
<th>apple</th>
<th>airplane</th>
<th>toothbrush</th>
<th>hotdog</th>
<th>hamburger</th>
<th>birthday cake</th>
<th>ice cream cone</th>
</tr>
</thead>
<tbody>
<tr>
<td>stimulus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Correct**

Speech Perception Category:  
Category 1: 0 - 16  
Category 2: 17 - 24
Sentence Lists
Areas of Investigation

- Syllable Number
- Intonation
- Syllable Stress
- Word Emphasis
Definition:

- In **linguistics**, **intonation** is variation of **pitch** while speaking which is not used to distinguish words. (Compare **tone**.) Intonation and **stress** are two main elements of **linguistic prosody**.

- All languages use pitch **semantically**, that is, as intonation, for instance for emphasis, to convey surprise or **irony**, or to pose a question. **Tonal languages** such as **Chinese** and **Hausa** use pitch to distinguish words in addition to intonation.

- **Rising intonation** means the pitch of the voice increases over time; **falling intonation** means that the pitch decreases with time. A **dipping intonation** falls and then rises, whereas a **peaking intonation** rises and then falls.
Sentence Lists: Intonation

Examples:

Mom is going to the grocery store.
Mom is going to the grocery store?

The brown dog is hungry.
The brown dog is hungry?
Definition:

In *linguistics*, stress is the relative emphasis that may be given to certain *syllables* in a word. The term is also used for similar patterns of phonetic prominence inside syllables. The word *accent* is sometimes also used with this sense.
Address vs. Address

The address on the envelope was missing.
The girl will address the letter.

Convict vs. Convict

The convict spent three years in jail.
The judge will convict the guilty man.
Sentence Lists: Word Emphasis

Examples:

GIVE mommy the sweater.
Give MOMMY the sweater.
Give mommy the SWEATER.
Results
# Means, Standard Deviations (SD) and Variance (VAR)

<table>
<thead>
<tr>
<th>Task</th>
<th>CI (N=20)</th>
<th>TH (N=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Syllable Number</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Intonation</td>
<td>18.05</td>
<td>1.82</td>
</tr>
<tr>
<td>Syllable Stress</td>
<td>13.15</td>
<td>1.53</td>
</tr>
<tr>
<td>Word Emphasis</td>
<td>21.85</td>
<td>4.09</td>
</tr>
</tbody>
</table>
Data Screening

• All variables examined separately for both groups;

• One possible univariate outlier was identified:
  – Data reexamined
  – Statistical analysis in two conditions: retaining the outlier and removing the outlier.
Data Screening

- Examination of Normality for CI Group:
  - Removal of Syllable Number variable;
  - All other variables (Intonation, Syllable Stress, Word Stress) were within normal limits for skewness and kurtosis.
Data Screening

- Examination of Normality for TH Group:
  - Intonation:
    - negatively skewed and highly kurtotic
  - Syllable Stress:
    - within normal limits for skewness and kurtosis
  - Word Emphasis:
    - negatively skewed and highly kurtotic
Frequency Distribution for CI Group: Intonation
Frequency Distribution for TH Group: Intonation
Frequency Distribution for CI Group: Syllable Stress
Frequency Distribution for TH Group: Syllable Stress
Frequency Distribution for CI Group: Word Emphasis
Frequency Distribution for TH Group: Word Emphasis
Multivariate Analysis of Variance

• Results of the analysis indicate that there is a statistically significant difference between groups on a combination of the three dependent variables ($p = .05$):

  Multivariate $F (3, 36) = 3.470$, $p = .026$

  Effect size = .224
Post Hoc Testing

- Independent samples t-tests were conducted to determine which of the three dependent variables affected the MANOVA result ($p = .05/3$):

  - Intonation: $t(38) = -2.013$, $p = .051$
  - Syllable Stress: $t(38) = 1.467$, $p = .151$
  - Word Emphasis: $t(38) = -2.642$, $p = .012$
Interpretation
Interpretation

• Results were interpreted as indicative of a developmental gap versus true insufficiency of the cochlear implant device.

• Current FDA regulations for cochlear implantation induce at least a 12 month delay in access to language for children who require cochlear implant technology for full access to sound.
Interpretation

- Research on children with normal hearing shows a large age continuum exists for mastery of prosodic perception: from five to twelve years of age.
Interpretation

- **Histories support this theory:**
  - **CI group exhibits a normal distribution of total scores that indicate an expected pattern development in progress;**
  - **TH group exhibits a negatively-skewed and highly kurtotic distribution for the Intonation and Word Emphasis subtests, indicating an overall mastery of these areas by most participants. Syllable Number was still normally distributed for this group.**
Directions for Future Research
Directions for Future Research

• **Question 1:** Why was the mean for the CI group higher than the TH group in the Syllable Stress subtest?

• **Question 2:** Significance of the acoustic correlates in the Word Emphasis subtest?

• **Question 3:** What would the distribution look like if the children were matched for hearing age not chronological age?
Directions for Future Research

• A longitudinal design that investigates the development of these skills to determine if mastery is the ultimate outcome;
Directions for Future Research

• Increase sample size to develop a more representative sample of all children who use cochlear implants;
Directions for Future Research

• Expand from pure discrimination ability into interpretation for investigation into complex language comprehension.
Directions for Future Research

• Other child-intrinsic and external variables:
  – Effects of etiology
  – CI Manufacturer / age of technology
  – Specialized therapeutic intervention
  – Parental interaction as well as quantity and quantity of language experience
Questions and Comments
References


References

