Disclosure

- I have a relevant financial relationship with LinguiSystems, Inc. as author of *The Source for Children with Cochlear Implants*. 
Speech Intervention for Young Cochlear Implant Recipients

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Part 1. Technological Advancement:
Multichannel Cochlear Implants

- Cochlear implants: Surgically implanted electronic devices that bypass damaged hearing hair-cells to stimulate the auditory nerve directly
- Three main manufacturers in the US
  - Advanced Bionics
  - Cochlear Americas
  - MED-EL
- Approved for children of 1;0 or older
- Approximately 30,000 deaf or severely hard of hearing children have received CIs in US
- Bilateral CIs are becoming more common
Example of CI Components

MED-EL cochlear implant
How a Cochlear Implant Works

Source: http://www.cochlearamericas.com/Products/2136.asp
How CIs provide phonetic information

- **Frequency**: represented by the location of electrodes along the basilar membrane
  - High frequencies by electrodes near the base of cochlea
  - Lower frequencies represented by those further inserted

- **Intensity**: represented by the voltage of the electrical signal

- **Timing**: represented by the activation and deactivation of electrodes
How does speech sound like?

(courtesy of Xin Luo)

1ch  2ch  4ch  8ch  16ch
In sum, CIs provide ...

- **increased access** to conversational-intensity speech and auditory feedback, thereby increasing opportunities to develop phonological abilities through **incidental learning**.

- access to a **wide range of spectral information** to support the development of a complete inventory of phonemes.

- **BUT** speech intervention usually needed because ...
  - …of a relatively **late start** in auditory-guided speech development
  - …CI thresholds **not within normal hearing sensitivity limits**.
  - …speech is represented **electronically, not naturally**
Second Technological Advancement: Newborn Hearing Screening

- 2-3 children per 1,000 are born deaf or hard of hearing
- 43 states have mandated Newborn Hearing Screening (NHS)
- Common interventions:
  - Hearing Aids
  - Cochlear Implants if HA trial indicates limited audition
  - Family-centered intervention
- Best spoken language results
  - identified before 6 months of age (Yoshinaga-Itano, 1998)
  - Intervention started by 11 months of age (Moeller, 2000)
Part 2

Prelinguistic and Phonological Achievements and Interventions
Prelinguistic Speech

• Vocal Development:
  A process by which infants and toddlers begin to produce phonetically diverse, structurally complex, and speech-like vocalizations prior to saying words on a regular basis.
1. Precanonical Vocalizations...

(Range of emergence 0 – 6 months in NH children)

- ...lack true vowels and true consonants in combination with a rapid transition between them (Oller, 2000)

- Types
  - Quasi- and fully-resonant nuclei (Oller & Lynch, 1992)
  - Squeals
  - Vowels / vocants in isolation or in series (Kent & Bauer, 1985)
  - Consonants / Closants in isolation or in series (Stark, 1980)
Examples of Precanonical Vocalizations

- Quasi and Fully resonant nuclei
- Squeals
- Vocants and vowels
- Closants
Child at Precanonical level
Precanonical Video Examples

- [http://www.youtube.com/watch?v=4oNhmWbn67c](http://www.youtube.com/watch?v=4oNhmWbn67c)
- [http://www.youtube.com/watch?v=lKLQOYMgf1A](http://www.youtube.com/watch?v=lKLQOYMgf1A)
2. Basic Canonical Syllables

(Range of emergence 6 – 10 months in TD children)

- characterized by…
  - Normal phonation
  - Full vocalic resonance
  - At least one consonant
  - Rapid CV transitions
    (Oller & Lynch, 1992)

- Types
  - CV syllables and disyllables (CVCV)
  - Reduplicated and nonreduplicated babbling
  - Whispered vocalizations
Basic Canonical Syllables

- CV
- CVCV
- Babbling
  - String of 3 or more CV syllables
- Whispered vocalizations
Child at Basic Canonical Syllable level
Basic Canonical Syllables

- http://www.youtube.com/watch?v=37JxkDNJ0Aw
- http://www.youtube.com/watch?v=WRKEElUjetg
- http://www.youtube.com/watch?v=bt077TOugdA&feature=related
- http://www.youtube.com/watch?v=_JmA2ClUvUY&feature=related
AGE OF ONSET OF CANONICAL BABBLING IN DEAF AND HEARING INFANTS

○ Hearing infant
■ Deaf infant from present work
△ Deaf infant from previous work
△ Kent, et al., 1967
● Oller, et al., 1985

Fig 1 — Frequency distribution for ages of onset of canonical babbling in deaf and hearing infants
3. Advanced Forms
(Range of emergence in NH children: 10 - 18 months)

- … have canonical attributes but are phonetically or prosodically more complex than BCS (Nathani, Ertmer, & Stark, 2002)
- Types
  - Complex syllables (e.g. CCV or CVC)
  - Jargon
    - combinations of different consonants and vowels with changes in stress or intonation
  - Diphthongs
Examples of Advanced Forms

- Complex Syllables
  - CVC, VCV, CCV…

- Diphthongs

- Jargon
Child at Advanced Forms level
Advanced Forms

- http://www.youtube.com/watch?v=drMaxN5ohA0
- http://www.youtube.com/watch?v=WdoZ8WkfoAE
- http://www.youtube.com/watch?v=wbrkkyA0F7k
Emergence of Speech-Like Utterances (BCS + AF) after Cochlear Implantation (Ertmer, Jung, & Kloiber, in press)

* $p<.05$, and ** $p<.005$

Vocal Development Expectations
(Ertmer, Jung, Kloiber, in press)

- **Precanonicals** - gradually decrease in quantity during the years 1 and 2 of CI use

- **Basic Canonical Syllables** – increase to about 30 - 40% of child utterances by 1 year of CI use and remain stable.

- **Advanced Forms** – Increase to 25% by 1 year and 50% by 2 years of CI use.

- **Speech-like utterances (BCS + AF)** - account for at least 60% of utterances by 18 months.
Possible Reasons why Expectations for Vocal Development are Not Met

- 35 – 40% of children with hearing loss have additional disabilities
- Relatively high CI-aided thresholds may slow development
- Difficulty in perceiving speech features
- Limited access to specialized intervention
- Presence of a speech/phonological impairment
- Limited follow-up in wearing CIs and mapping
- Others
Intervention: Short Periods of Prelinguistic Input (SPPI) (Ertmer et al, 2002; Ertmer, 2005; Ertmer & Iyer, 2010)

- **Goal** – to provide focused stimulation for developmentally appropriate vocalizations and to increase consonant and vowel diversity

- **Models**: vocalizations from the child’s current and next level of vocal development
  - PC – variety of vowels
  - BCS – assorted CV, CVCV, and babbled syllables
  - AF – CVC, diphthongs, jargon

- **Models presented** every 5 seconds for 1 minute, 5 times per day by parents

- [vocal development.com](http://vocaldevelopment.com) for more information and video examples
Consonant Production Accuracy after 2 Years of CI Use; Comparisons with age- and gender-matched TD peers

Ertmer, Kloiber, Jung, Kirleis, & Bradford (2012)
Initial Consonants Produced by Children with 2 years CI experience and age-matched TD Peers
Final Consonants Produced by Children with 2 years CI experience and age-matched TD Peers
### Mean Consonant Production Accuracy After 2 years of CI Use

<table>
<thead>
<tr>
<th></th>
<th>Initial Consonants</th>
<th>Final Consonants</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age- and Gender-Matched TD Children</td>
<td>85%</td>
<td>77%</td>
<td>81%</td>
</tr>
<tr>
<td>CI Users</td>
<td>58%</td>
<td>44%</td>
<td>51%</td>
</tr>
</tbody>
</table>
Strategies for Optimizing Speech Production Abilities in School-age CI recipients
(adapted from Ertmer, 2005; Ertmer, Leonard, & Pachuilo, 2002)

- **Maximize reliance on audition** - Introduce and practice new targets in the auditory-only condition using an acoustic screen (acoustic screen).

- **Encourage self-evaluation** – “Was that the old way or the new way?”

- **Use encouragement more than praise** – “You brought your lip up to your teeth that time.” instead of “good job”

- **Emphasize all word positions** for consonant targets – initial, medial, and final.

- **Trade roles** – Let the child be the teacher and judge of your productions.

- **Continuously incorporate meaningful words and sentences** – Use classmates names, spelling words, practice oral reports, memorize and tell jokes and riddles.

- **Focus on intelligibility and expression** – connected speech sounds “normal”

- **Keep parents and teachers informed of speech targets** – consistent expectations at home and in school.
Overview of Auditory Training

Acoustic screen.
Levels of Auditory Speech Perception
(Erber, 1982)

- **Detection** – recognizing the presence or absence of sound
- **Discrimination** - determining whether two sounds are the same or different
- **Identification / recognition** – being able to identify segments, syllables, words, sentences – demonstrated through imitation
- **Comprehension** – understanding the meaning of a spoken message - demonstrated by answering questions, participating in conversations
Approaches to Auditory Training
Blamey & Alcantara (1994)

- **Analytical** - (“Bottom up” approach)
  - Focus on identification of a full range of speech features and phonemes (“Parts” of speech signal).
    - Minimal Pair contrasts.

- **Synthetic** - (“Top down” approach)
  - Focus on understanding the message using available cues and linguistic constraints
    - Following directions conversations, story retelling, answering questions

- **Pragmatic** -
  - Focus on techniques to avoid and repair communication breakdowns in everyday situations
    - Reveal hearing difficulty to influence communication partners
    - Influence environment and talkers by being assertive - ”Could you say that again?”

- **Eclectic** -
  - Using all three approaches together
Suggested Lesson Organization

1. Ling Six Sound Test
   /m/, /a/, /u/, /i/, “sh”, and /s/ in random order 3 times each (tally data on accuracy each time)

2. Analytic training
   5 – 7 minutes of minimal pair contrasts (integrating speech production practice)

3. Synthetic training
   Listening to relevant, motivating, functional speech…
   Developing speech and listening through conversations and language intervention activities

4. Pragmatic training
   Ongoing within context of all activities
   Encourage transfer of assertiveness to home and classroom
References