Sensitivity of Deaf Infants to Spectral and Temporal Acoustic Changes During the First Year of Cochlear Implant Activation

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Susan Norton
Jay Rubinstein
Lynne Werner
Disclosures

• JR:
  – Consultant for AB, Cochlear, Nurotron, Shanghai Lishengte
  – Previous recipient of research funding from AB/Cochlear
  – Recently licensed technology to Shanghai Lishengte
Auditory Language With a Degraded Signal

Niparko 2010
Spectral and Temporal Patterns in Speech
Spectral and **Temporal** Patterns in Speech

"Ba"

"Pa"

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Time</th>
<th>Intensity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
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Spectral and Temporal Patterns in Speech

- Speech perception develops gradually
- Spectral and temporal resolution matures early
- Non-linguistic psychoacoustic measure of efficacy?
Longitudinal Study Design

**Outcome Measures**
- CI infants activated < 2yo
- Post-lingually deaf adults
- Long-term users (>5y)
- Oral communicators

**Auditory Tests**
- Tested Once
- Hearing-age NH infants
- Age-matched NH adults

- CI Infants: 3m Post, 6m Post
- CI Adults: Tested Once
- NH Infants: Birth, 3m Old, 6m Old
- NH Adults: Tested Once
Study Progress

• Enrolled: 12 CI infants, 4 CI adults
  – Cross-sectional data on 10 CI infants
  – Longitudinal data on 4 CI infants
<table>
<thead>
<tr>
<th>ID</th>
<th>Gender</th>
<th>Ethnicity</th>
<th>Race</th>
<th>Device</th>
<th>Etiology</th>
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CI Results – Spectral Test

Individual Data (20dB)

- **Better Performance**

![Graph showing individual data with markers and lines representing different thresholds.](image-url)
CI Results – Spectral Test

**Individual Data (10dB)**

- Better Performance
- Ripples Per Octave
- Hearing Age (months)

Graph shows:
- +/- 1 SD
- Mean Adult Threshold
- Chance

**Group Data**

- Better Performance
- Ripples Per Octave
- Ripple Depth (dB)

Graph shows:
- Infant
- Adult
- Chance

Legend:
- More Difficult
# CI Results – Temporal Test

<table>
<thead>
<tr>
<th>Modulation Frequency (Hz)</th>
<th>Infant</th>
<th>Adult</th>
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<tr>
<td>1000</td>
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</table>

**Modulation Depth (dB):**

-30, -25, -20, -15, -10, -5, 0

**Mean Modulation Depth (dB):**

- More Difficult

- Better Performance
Correlations – Spectral Test

Receptive Language

Expressive Language

Ripples Per Octave
Better Performance

Population Mean

+/- 1 SD
Correlations – Temporal Test

Receptive Language

Expressive Language

Modulation Depth (dB)

Better Performance

Population Mean

+/- 1 SD

PLS Standard Score

Ripples Per Octave

Auditory Language Score and AMD Threshold

Correlations – Temporal Test

Receptive Language

Expressive Language

Modulation Depth (dB)

Better Performance

Population Mean

+/- 1 SD

PLS Standard Score

Ripples Per Octave

Auditory Language Score and SRD Threshold
Conclusions

Reliable spectral and temporal thresholds can be obtained from most CI infants.

Spectral resolution appear adult-like in CI infants.
Limitations

Too early to tell if early auditory capacity is correlated with spoken language outcome

Difficult to separate effects of stimulus processing, neural substrate, and central processing

Possible non-spectral, non-temporal factors in performance
Limitations

Unclear test-test reliability

Measures of capacity may not reflect which cues listeners actually use for speech discrimination
Opportunities

Auditory Rehabilitation:
Emphasize deficient auditory capacity in training?
De-emphasize deficiency, focus on other cues?

Behavioral Testing

Niparko 2010
Opportunities

Behavioral Testing

Good Spectral Resolution

Poor Spectral Resolution

Programming:

Personalized maps to maximize spectral/temporal acuity?

Niparko 2010
Opportunities

Behavioral Testing

Good Spectral Resolution

Poor Spectral Resolution

Alternative Habilitation:
Earlier routing toward ASL-based education?

Niparko 2010
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  – Jay Rubinstein

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  – Meg Meredith
  – Robin Dembeck

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  – Ward Drennen
  – KC Lee

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  – Gift from the estate of Verne J. Wilkens
Thank You
Results – Spectral Test

**Individual Data (10dB)**

- Better Performance
- Ripples Per Octave
- Hearing Age (months)
- +/- 1 SD
- Mean Adult Threshold
- Chance

**Group Data**

- Better Performance
- Ripples Per Octave
- Ripple Depth (dB)
- Infant
- Adult
- Chance
- More Difficult

**CI Results**
<table>
<thead>
<tr>
<th>ID</th>
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NH Results

**Spectral Test**

- Better Performance:
  - More Difficult

- Ripples Per Octave vs. Ripple Depth (dB)
- Infant vs. Adult
- Chance

**Temporal Test**

- Better Performance:
  - More Difficult

- Modulation Depth (dB) vs. Modulation Frequency (Hz)
- Infant vs. Adult

Horn et al. ARO 2013, CI 2014. Manuscript in preparation