Comparing Speech Perception Abilities of Children with Cochlear Implants and Digital Hearing Aids

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Cochlear Implants and Digital Hearing Aids

• Both designed to restore the audibility of the speech signal
• Do so in fundamentally different ways
• Cochlear implants require surgical intervention
Technology for CI and DSP HA

- Increased audibility for a wide range of input levels including soft sounds

- High input levels delivered at comfortable listening levels
Technology

- **Hearing Aids**
- Advanced Compression Circuitry (WDRC)
- Feedback Control
- Directional Microphones
- Digital Signal Processing

- **Cochlear Implants**
- Speech Coding Strategies
- Processor Designs
- Electrode Array
- Digital Signal Processing
Comparing Cochlear Implants and Hearing Aids for Children

- Determine device that will provide optimal speech perception performance

- Provide child with opportunity to develop age appropriate speech and language skills
Determining Device Candidacy for Children

- Newborn Hearing Screening
- FDA Guidelines- Minimum Age for Implantation 12 months
- FDA Guidelines- Recommendation that children with severe to profound loss and open set word recognition scores of < 30 % be considered for cochlear implants
Determining Device Candidacy for Children

- In the absence of formal speech perception testing
- Using unaided puretone thresholds as a guide
- Using limited aided information as a guide
- Using survey/parent-clinician reports
Past Comparisons as Guidelines for Candidacy

- Children using analog linear hearing aids and older cochlear implant processing strategies
- Speech testing conducted at 70 dB SPL (raised to loud level of conversational speech)
Aim of Study

- The aim of this study was to determine the unaided PTA above which a child will exhibit significantly better speech recognition with a cochlear implant than a DSP hearing aid.
Sample Characteristics

- Total 52 Subjects, 30 Female, 22 Male
- Age 5-16 years
- Etiology 37 unknown, 10 genetic, 3 CMV, 2 Wardenburg’s
- Placed in oral education or mainstreamed with oral education background
- 26 Children with Cochlear Implants
- 26 Children with DSP Hearing Aids
DSP Hearing Aid Group

- Mean Age at Test 10 years 3 months (6-16 years)
- Mean Age at Identification 2 years (6 months – 4 years 6 months)
- Fit with Amplification within 2-3 months
- Mean Better Ear Unaided PTA 79.4 dB HL
• Mean Length of DSP Use - 1 year 2 months (3 months – 4 years 5 months)
• 23 out of 26 wore two hearing aids
• 3 DSP Hearing Aid Makes- 11 Widex Senso C18 or P38, 8 Oticon DigiFocus, 7 Phonak Claro
• Hearing Test within 12 months of test date
• Earmolds within 6 months
• Verified Using AudioScan Speech Maps
Age at Identification for DSP Hearing Aid Group

![Bar chart showing the number of children identified with hearing loss at different ages. The x-axis represents the age at which hearing loss is identified (in years), ranging from 0 to 6. The y-axis represents the number of children, ranging from 0 to 10. The chart shows a peak at age 2 with 6 children, and another peak at age 3 with 4 children. There are fewer children identified at older ages.]
DSP HA Group Poorer Ear Mean Thresholds

Mean Earphone Threshold (dB HL)

Mean w/1sd

Min

Max

Frequency in Hertz

Mean Earphone Threshold (dB HL)
Sample Characteristics of Implant Group

- 26 Subjects
- Mean Age at Test 8.5 years (5-15 years)
- Mean Age at Identification 1 year 3 months (6 months – 3 years)
- Mean Age at Implantation 5 years (1 year 6 months- 13.4 years)
- Mean Length of Implant Use 3.5 years (15 months-6 years)
- 10 Clarion, 16 Nucleus
Age at Identification for the CI Group

![Bar Chart]

- **X-axis**: Age Hearing Loss Identified (years)
- **Y-axis**: Number of Children

The chart shows the distribution of the age at which hearing loss was identified for children in the CI group. The majority of children (8) were identified at the age of 1 year.
Method

- Lexical Neighborhood Test (Kirk et al., 1995) at 70 and 50 dB SPL
- VIDSPAC (Boothroyd, 1997) at 70 and 50 dB SPL
- SRT in Noise
- Aided Thresholds
- Each Test Administered Twice 1 Month Apart
Test-Retest Reliability LNT 70 dB SPL

$r = 0.90, p < .0001$
Test-Retest Reliability LNT 50 dB SPL

$r = 0.83, p<.0001$
Data Analysis

• Repeated Measures Multiple Regression Analysis
• Device (CI and DSP HA) and Unaided PTA as Between-Subject Predictors
• Level (50&70 dB SPL) and Time (Test Time 1 and 2) as repeated measures
Three Stage Data Analysis

Stage 1- Device entered as predictor

Stage 2- Unaided PTA dB HL entered as predictor

Stage 3- Interaction between Device and Unaided PTA dB HL entered
Mean LNT Word Score by Device and Level

Mean LNT Percent Correct

50 dB SPL 70 dB SPL 50 dB SPL 70 dB SPL

DSP HA CI

Mean LNT Percent Correct Word Score
Mean LNT Word Score by Device and Time

![Bar graph showing mean LNT word score by device and time.]
Predicting LNT from Unaided PTA for Raised/Loud Speech for DSP HA Group

![Graph showing the relationship between LNT (% Correct) at 70 dB SPL and Unaided PTA (dB HL).](image)
Predicting LNT from Unaided PTA for Soft Speech for DSP HA Group
Predicting LNT from Unaided PTA for Raised/Loud Speech for CI Group
Predicting LNT from Unaided PTA for Soft Speech for CI Group
Aim of Study

• The aim of this study was to determine the unaided PTA above which a child will exhibit significantly better speech recognition with a cochlear implant than a DSP hearing aid.
Predicting LNT Score at a Raised/Loud Level Time 1

LNT (% Correct) at 70 dB SPL Time 1 vs. Unaided PTA (dB HL)

- CI
- HA
DSP HA and CI Group Performance

The intersection of the regression lines for these two device groups represents the unaided PTA value where performance is, on average, equal.
DSP HA and CI Group Performance

Determine the unaided PTA value at which the DSP HA group and the CI group were different at the .05 significance level.
Predicting LNT Score at a Raised/Loud Level Time 1

**CI = HA (91dB HL)**

CI > HA (113dB HL)
Predicting LNT at a Soft Level Time 2

CI = HA (68 dB HL)

CI > HA (88 dB HL)
### CI = DSP HA Performance

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<thead>
<tr>
<th></th>
<th>Time 1</th>
<th>Time 2</th>
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<tbody>
<tr>
<td>Level 70 dB SPL</td>
<td>91 dB HL</td>
<td>82 dB HL</td>
</tr>
<tr>
<td>Level 50 dB SPL</td>
<td>85 dB HL</td>
<td>68 dB HL</td>
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<td>Time 1</td>
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<tr>
<td>Level 70 dB SPL</td>
<td>113 dB HL</td>
<td>97 dB HL</td>
</tr>
<tr>
<td>Level 50 dB SPL</td>
<td>96 dB HL</td>
<td>88 dB HL</td>
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</table>
Conclusions
Results obtained on the LNT revealed that the Unaided PTA at which the CI group would score significantly higher than the DSP HA group was dependent on the test level (50 vs. 70 dB SPL) and the time the test was conducted (Time 1 vs. Time 2).
Differences in Level (50 vs 70 dB SPL)

- PTA dB HL increases the amount of gain for DSP HA must increase
- The amount of gain will be greater for 50 dB SPL level signal
- Providing audibility for soft sounds for greater degree of loss may exceed limitations of hearing aid
CI Group Average Aided Soundfield Thresholds

Average Soundfield Threshold (dB HL) vs Frequency in Hertz
HA Group Average Aided Soundfield Thresholds

Average Soundfield Threshold (dB HL)

Frequency in Hertz

HA means
Difference in Time 1 vs. Time 2

- DSP HA Group had a decrease in performance from Time 1 to Time 2
- CI Group performance remained the same or slightly improved
- Consistency of signal may be a factor
• The Unaided PTA is lowest at Time 2 and when the signal is reduced from 70 dB SPL to 50 dB SPL

• Unaided PTA- 88 dB HL for Time 2 at 50 dB SPL
Implications
Candidacy Considerations

- Soft speech for incidental language cues
- Consistent audibility of all speech sounds
- Ease of communication in everyday listening conditions
- Self monitoring of speech
Candidacy Guidelines

- Most conservative- Time 1 at 50 dB SPL represents the optimal performance of the DSP HA Group,
- The Unaided PTA cut-off for this group of children would be 96 dB HL
Candidacy Guidelines

- Assume that 50 dB SPL at Time 2 represents “real world” listening conditions and fitting issues
- The Unaided PTA of 88 dB HL would be the cut-off
Factors Related to Device Group Comparisons

• Configuration of Hearing Loss
• Age of Identification
• Age at Implantation
• Duration of DSP Hearing Aid Use
• Optimization of DSP HA
Configuration of Hearing Loss

DSP HA Group Better Ear Mean Thresholds

- Mean w/1sd
- Min
- Max

Frequency in Hertz

Mean Earphone Threshold (dB HL)
Mean Age at Identification

- CI Group: 1.3 years
- DSP HA Group: 2 years
Mean Age at Implantation

- CI Group: 5 Years
- Younger age at implantation may result in higher performance for CI Group
Duration of Device Use

- DSP HA Group mean: 1.2 years
- CI Group mean: 3.6 years
Optimization of Fitting and Signal Processing of DSP HA Group

- Optimization of DSP for soft speech
- Differences in signal processing of DSP Hearing Aids
Future Research

• 1. Conducting this study on a larger sample size that includes children that were identified and received DSP hearing aids by 6 months of age and cochlear implants by 12-18 months of age.

• 2. Device fitting that is optimized for both soft and conversational speech levels.

• 3. Development of speech measures for pre-verbal children at both soft and conversational levels.
Thank You
Questions?
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