The Use of an Integrated Electric-Acoustic Sound Processor in Children with Low-Frequency Residual Hearing

Sara Neumann, AuD
Jace Wolfe, PhD
Disclosures

This research was partially funded by a grant from Cochlear Americas
The Hearts for Hearing Team

Audiologists
- Jace Wolfe, Ph.D., CCC-A
- Krystal Hudgens, AuD
- Megan Marsh, AuD
- Sara Neumann, AuD
- Mila Duke, AuD
- Elizabeth Musgrave, AuD
- Rachel Magann-Faivre, AuD
- Johnna Wallace, AuD
- Sarah Cain, AuD
- Emily Mills, B.S., AuD Student

Speech-Language Pathologists
- Joanna T. Smith, M.S., CCC-SLP, LSLS Cert. AVT
- Tamara Elder, M.S. CCC-SLP, LSLS Cert. AVT
- Darcy Stowe, M.S. CCC-SLP, LSLS Cert. AVT
- Lindsay Hanna, M.S., CCC-SLP, LSLS Cert. AVT
- Carly Graham, M.S., CCC-SLP, LSLS Cert. AVT
- Casey Banks, M.S., CCC-SLP
- Jenn Bryngelson, CCC-SLP, LSLS Cert. AVT
- Tessa Hixon, M.S., CCC-SLP
- Parker Wilson, M.S., CCC-SLP

Additional Team Members
- Kris Hopper
- Sherry Edwards
- Reyna Romero
- Dianne Ward
- Jackie Keathly
- Rachel Magann-Faivre, AuD

- Kerri Brumley
- Susan LaFleur
- Kristi Murphy
- Kelsey Kuehn
- Sabrina Calise
- Verneda Osborne
- Pati Burns
- Rocio Portillo
- Christian Boone
- Rachel Odor

The Hearts for Hearing Team
EAS in Children
Hearts for Hearing

• 12 Children with electric-acoustic stimulation

• A variety of
  – electrode arrays
    • Nucleus Hybrid (L24)
    • Nucleus CI422 (Slim Straight)
    • Nucleus Freedom Contour Advance
  – acoustic amplification devices
    • Phonak BTE Hearing Aids
    • Nucleus 6 Acoustic Component

• A variety of stimulation modes between ears
  – Bilateral EAS
  – EAS one ear with electric on opposite ear
  – EAS one ear with acoustic on opposite ear
Reporting on...

- 7 children fitted with the Nucleus 6 electric-acoustic processor
Reporting on...

- 5 adults for whom EAS allocation settings were adjusted within their Nucleus 6 electric-acoustic processor
Pediatric Recipients

- Age range: 7 yrs, 6 mo to 16 yrs, 7 mo
- Length of CI use: 5 months to 7 years
- 2 males, 5 females
Recipients’ Technology

<table>
<thead>
<tr>
<th>Recipient</th>
<th>Left Ear</th>
<th>Right Ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP</td>
<td>Nucleus CI 512</td>
<td>Nucleus CI 512</td>
</tr>
<tr>
<td>AA</td>
<td>Phonak Naida SP V</td>
<td>CI24RE Contour Advance</td>
</tr>
<tr>
<td>JM</td>
<td>CI24RE Contour Advance</td>
<td>Phonak Naida SP V</td>
</tr>
<tr>
<td>AP</td>
<td>Nucleus CI 422</td>
<td>Nucleus CI 422</td>
</tr>
<tr>
<td>JF</td>
<td>Phonak Naida Q70-RIC</td>
<td>Nucleus Hybrid (L24)</td>
</tr>
<tr>
<td>BJ</td>
<td>Nucleus CI 422</td>
<td>Nucleus CI 422</td>
</tr>
<tr>
<td>HA</td>
<td>Nucleus CI 422</td>
<td>CI24RE Contour Advance</td>
</tr>
</tbody>
</table>

All seven of these recipients used the Nucleus 6 EAS processor for their implanted ear(s)
Mean Pre-CI Audiogram
Pre- and Post-op Audiometric Results

![Graph showing pre- and post-operative audiometric results for different frequencies. The y-axis represents dB HL (decibels hearing level) and the x-axis represents frequency in Hz (Hertz). The graph compares pre-CI and post-CI outcomes, with error bars indicating variability.](image-url)
Assessment

- BabyBio Sentences (Spahr et al., 2014)
  - Quiet at 60 dBA
  - Noise
    - +10 dB SNR
    - +5 dB SNR
    - 0 dB SNR
  - Different conditions
    - Electric only
    - Acoustic Only
    - Bimodal
    - EAS
Bimodal vs. Combined

- **Acoustic**
- **Electric**

### %Correct

- Quiet
- +10 dB SNR
- +5 dB SNR
- 0 dB SNR

<table>
<thead>
<tr>
<th>Condition</th>
<th>Bimodal</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiet</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>+10 dB SNR</td>
<td>90</td>
<td>85</td>
</tr>
<tr>
<td>+5 dB SNR</td>
<td>80</td>
<td>75</td>
</tr>
<tr>
<td>0 dB SNR</td>
<td>65</td>
<td>60</td>
</tr>
</tbody>
</table>

**n=3**
Best EAS

![](chart.png)

1. Best Acoustic
2. Best Electric
3. Best EAS

n=7
Preliminary Report

• Evaluation of EAS Performance with Different Acoustic/Frequency Allocations
EAS Fitting

Acoustic and electric allocation based on the “meet protocol”

Acoustic component fitted to NAL-NL2 Target
Programming EAS

The “Meet” Approach

The “Wideband Overlap” Approach

The “F1 – 438 Hz” Approach

The “Cochlear Default (> 70 dB HL)” Approach

The “Gap” Approach
Programming EAS

• Acoustic component output set to NAL-NL2 target for 65 dB SPL speech
• Electric allocation set to:
  – **Wideband**: 188 Hz
  – **Cochlear Default**: The lowest frequency at which the participant’s air conduction threshold exceeded 70 dB HL
  – **F1**: 438 Hz (comprehensive inclusion of F1)
  – **Meet Approach**: The highest air conduction frequency at which sufficient audibility was provided by the acoustic component (defined as the highest frequency at which the NAL-NL2 target was met or the highest frequency without a cochlear dead region)
  – **Gap Approach**: One octave above the highest air conduction frequency at which sufficient audibility was provided by the acoustic component
Study Design

• Participants used each of the acoustic/frequency allocations for at least 2-4 weeks
  – Phase 1: Two programs with different acoustic/frequency allocations – Switch between the two
  – Phase 2: Two programs with different acoustic/frequency allocations – Switch between the two
  – Phase 3: One program with different acoustic/frequency allocations

• After each phase, assessment was completed
  – CNC Word Recognition (50 dBA) (Peterson & Lehiste, 1962)
  – AzBio Sentence Recognition (0, +5, and +10 dB SNR) (Spahr et al., 2012)
  – Speech Intelligibility Rating Index (SIRI) (Cox & McDaniel, 1989)
  – Abbreviated Profile of Hearing Aid Benefit (APHAB) (Cox & Alexander, 1995)
  – Speech, Spatial, Qualities of Hearing Scale (SSQ) (Gatehouse, 2004)

• Data collection is ongoing with 15 adults and 10 children with EAS
CNC Word Recognition

Adults

![Bar chart showing CNC Word Recognition results for different settings: Wideband, Default 70 dB+, 438 Hz, Meet, Gap. The y-axis represents the percentage of correct responses, ranging from 0 to 100, with error bars indicating variability. The chart shows varying performance across settings, with 'Gap' having the lowest percentage. The sample size is n = 5.](chart.png)
AzBio Sentence Recognition

Adults

![Graph showing AzBio Sentence Recognition results for Adults. The graph compares different conditions (Wideband, Default 70 dB+, 438 Hz, Meet, Gap) across different signal-to-noise ratios (+10 dB SNR, +5 dB SNR, 0 dB SNR). The data is presented for n = 5 participants.]
Speech Intelligibility Rating Index

Adults

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wideband</td>
<td>Default 70 dB+</td>
<td>438 Hz</td>
<td>Meet</td>
<td>Gap</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>8</td>
</tr>
</tbody>
</table>

n = 5
• Similar group scores were obtained across conditions except for the “Gap” approach, which was perceived to provide significantly poorer hearing performance
Summary

• EAS with the Nucleus 6 sound processor allows for better word recognition and sentence recognition in noise for children with residual acoustic hearing preservation after cochlear implantation.

• These children reported better sound quality and subjective hearing performance with the use of EAS over acoustic- and electric-only hearing.

• The Cochlear Hybrid default strategy for acoustic/electric allocation appears to be effective for the selection of EAS crossover parameters.

• The “Gap” allocation approach results in poorer speech recognition and subjective hearing performance/sound quality.
Summary

• EAS with the Nucleus 6 sound processor provided better word recognition and sentence recognition in noise for children with residual acoustic hearing preservation.

• Children using EAS reported better sound quality and subjective hearing performance compared to performance with acoustic- and electric-only hearing.

• The Cochlear Hybrid default strategy for acoustic/electric allocation appears to be effective for the selection of EAS crossover parameters.

• The “Gap” allocation approach results in poorer speech recognition and subjective hearing performance/sound quality.
Thank you for your attention