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Cochlear Implants and Remote Microphone Technology

Jace Wolfe, PhD
February 24, 2015

Learning Objectives

- After this course learners will be able to list at least 3 programmable parameters within a CI sound processor that influence a CI users performance with remote microphone technology.
- After this course learners will be able to list at least 3 factors associated with remote microphone RF receivers that influence a CI users performance with remote microphone technology.
- After this course learners will be able to describe fitting, programming and counseling considerations for use of remote microphone technology with cochlear implants.
The Hearts for Hearing Team

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Shoot for the Moon!

Shoot for the moon…

Even if you miss, you will land amongst the stars!

RIP
It can be hard to shoot for the moon…

• Although many CI users hear very well with their technology, challenges persist:
  – Background Noise
  – Poor room acoustics

For persons with hearing loss, we should shoot for the moon!
Just Preaching to the Choir!

Road Map

• Points of Discussion
  – Why HAT?
  – HAT for whom?
  – Optimizing performance
    • CI Programmable Parameters
    • Optimizing RF System Parameters
    • Fitting and Counseling
A Noisy World!

The SNR in these environments is typically -5 to +5 dB

- Living Room: 37 dB A (with A.C. = 52 dBA)
- Classroom Lecture: 61 dBA
- Small Groups: 66 dBA
- School Assembly: 76 dBA
- School Cafeteria: 83 dBA
- OKC Thunder Basketball: 100 dBA

Crukley et al., 2011

An Exploration of Noise-Quiet Listening at School

Joel C. Crukley, PH.D.
New York City, NY

The purpose of the current investigation was to determine the potential impact of hearing loss on children's academic achievement and to identify strategies that might be used to improve those outcomes. The data were collected from 120 students in three different classrooms, all of whom were identified as having a hearing loss. The students were divided into two groups based on their hearing level: Group A (hearing level of 20 dB or less) and Group B (hearing level of 21 dB or more). The results revealed that the children in Group A performed significantly better on both the reading and math tests than the children in Group B. This suggests that children with hearing loss may benefit from targeted interventions, such as individualized instruction, assistive technologies, and enhanced classroom accommodations.

Journal of Educational Audiology
Crukley et al., 2011

Speech Recognition without Remote Mic HAT

*: P < .05

Kids with hearing loss need a +15 dB SNR

% Correct

Noise Level (dBA)

Quiet 50 55 60 65 70 75

+5 dB SNR
Sentence Recognition in Quiet

Speech Recognition in Noise

Remember, these are adults. Kids’ results will be poorer.
Speech Recognition in Noise

Why HAT?

• Because most CI users can’t hear in many realistic situations without it

• Because performance improves dramatically with it
  – By as much as 60% points
## Hearing Assistance Technology

- For Whom?

### Everyone
Imran Mulla, 2013

• LENA Data Logging in Infants/Toddlers
  – Car seat (70 mph): -10 dB SNR
  – Bus: -10 dB SNR
  – Stroller: -8 dB SNR
  – Shopping cart: -6 dB SNR
  – Car seat (30 mph): -5 dB SNR
  – Wind Noise: -3 to -10 dB SNR

**Conservative Take:** Use in situations in the child has no chance to hear without remote mic use

Carol Flexer: It’s about the brain! It’s hungry. Feed it intelligible speech.

• The Critical Window
• Risley & Hart (1995)
  – 46 million words by 4
• Dehaene (2009)
  – 20,000 hours of listening to support basic literacy development

*Spoken Language*

*Sign Language*
Digital Systems

Digital Radio Frequency Transmission

1 0 1 0 1 1 0 1 0 1

Carrier Frequency

Industry, Science, Medical globally license-free 2.4 GHz band

(Adaptive) Channel Hopping

Noise Squelch

All or Nothing
Hearts for Hearing Experience
Digital Radio Systems

• Multiple studies with Phonak Roger and GN Resound Hearing Aid/Cochlear digital radio remote microphone systems
  – Formally evaluated over 100 adult and pediatric subjects
  – Not one subject has complained of noise/interference from one of these systems
  – Digital “all or nothing”

Remote Microphone HAT

• Optimizing Benefit
• Hearts for Hearing Remote Microphone Research

Research Setup
Research Setup

Ambient Noise Level: 44 dBA
Reverberation: .7 sec

Optimizing Benefit

• Programmable Parameters within the CI
  – Mixing Ratio
  – IDR
  – Signal Processing

• Receiver Specific Parameters/Characteristics
  – Receiver Gain
  – Digital vs. Analog
  – DAI vs. Neckloop

• Fitting and Counseling
Mixing Ratio

• **Mixing Ratio**: Controls the relationship of the strength of the sound received from the processor microphone compared to the sound received from the DAI.

Mixing Ratio -- Cochlear

• **Cochlear**:
  - 1:1 = No attenuation to speech processor microphone (equal emphasis for processor signal and FM signal)
  - 2:1 = Processor mic attenuated by 6 dB
  - 3:1 = Processor mic attenuated by approx 10 dB
  - Accessory Only
Freedom FM Study

Freedom MicroLink Adult Study of Mixing Ratio

Speech Recognition in Noise

![Diagram showing speech recognition in noise with mixing ratios 1:1 and 3:1, N=9]

- 32% difference between mixing ratios!

Freedom FM Study

Freedom MicroLink Adult Study of Mixing Ratio

CNC at 50 dBA SPL

![Diagram showing CNC at 50 dBA SPL with mixing ratios 1:1 and 3:1, N=9]

- 33% point difference between mixing ratios!

N=9
Mixing Ratio Options

- **Advanced Bionics:**
  - Mic Only = Microphone input only; No attenuation
  - 50/50 = Mic/Aux = equal emphasis placed on signals from sound processor mic and DAI; Each signal attenuated by 6 dB
  - 30/70 = 12 dB attenuation of SP mic and 3 dB attenuation of aux
  - Aux Only = Auxilliary input only; No attenuation
  - Aux Only (Atten.) = Aux input only with 20 dB attenuation

Ensure sound-field thresholds are 25 dB HL

Consider increasing T Levels or Sensitivity

---

**iConnect FM Study**

**Adult Study of Mixing Ratio**

<table>
<thead>
<tr>
<th>CNC at 65 dBA SPL</th>
<th>CNC at 50 dBA SPL</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="chart1.png" alt="Graph" /></td>
<td><img src="chart2.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

**FM Condition**
- 30/70 MR may hinder FM user when listening to soft sounds that are not directed to FM mic!
- N=12

Clinical Take-home Points

• 1:1 or 50/50 should be used for children in school settings

• Adults may wish to change mixing ratio based on the situation.

MED-EL Mixing Ratio

• There is no mixing ratio for MED-EL implants.

• MED-EL reports that no attenuation is provided to the processor mic during DAI use.
RF Gain

- Receiver gain determines the strength of the RF signal that is delivered to the speech processor.
  - Higher receiver gains presumably place more emphasis on the FM signal (i.e., higher FM advantage).

Adaptive RF

No FM
Traditional FM: Gain is fixed
Dynamic FM: Gain increases as ambient noise increases
Evaluation of Dynamic FM with Cochlear Implants

Wolfe et al. (2009)

Speech Recognition in Quiet Results

Wolfe et al. (2009)
Speech Recognition in Noise Results – Advanced Bionics

Wolfe et al. (2009)

Speech Recognition in Noise Results – Cochlear Corporation

Wolfe et al. (2009)
Advanced Bionics vs. Nucleus

Input Dynamic Range

- IDR: range or window of input levels coded in the speech processor within a person’s electrical dynamic range

- IDR is a programmable parameter in the processor

**Input Dynamic Range**

- Why would IDR affect FM benefit?
  - FM signal compressed when IDR significantly limits the input signal at 65 dB
  - Cochlear users: speech recognition scores unchanged with increased FM gain
  - ABC users: higher IDR allows for coding of the gain changes or louder inputs from the FM


**Autosensitivity (ASC)**
Results

Wolfe et al. (2009)

- With Nucleus 5 and older sound processors
  - T-SPL increases by 10 dB when auxiliary input is active ➔ from 25 to 35 dB SPL

- With Nucleus 6 sound processor
  - No change in T-SPL

Additional Nucleus Information
Advanced Bionics ClearVoice Processing

Speech Recognition is
• Better with CV ON than OFF
• Better with Roger ON than OFF
• Best with CV + Roger

Benefit also seen in “Quiet”

Wolfe et al., In press (RMANOVA)

• What about digital RF?
Is Digital Always Better?

Aslund et al., 2011  
N = 20

Speech perception scores

<table>
<thead>
<tr>
<th>Noise level</th>
<th>Phonak Muxi</th>
<th>Phonak MyLink+</th>
<th>Comfort Audio</th>
</tr>
</thead>
<tbody>
<tr>
<td>quiet</td>
<td>97.4</td>
<td>98.05</td>
<td>98.25</td>
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<tr>
<td>55</td>
<td>98.95</td>
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<td>90.9</td>
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<tr>
<td>75</td>
<td>77.95</td>
<td>65.55</td>
<td>29.65</td>
</tr>
<tr>
<td>80</td>
<td>41.2</td>
<td>21.15</td>
<td>8.6</td>
</tr>
</tbody>
</table>

- What about digital adaptive RF?
Results

Advanced Bionics Recipients (n = 16)

Wolfe et al., 2013, JAAA

Adults with normal hearing score 95% correct here!

Results

Cochlear Recipients (n = 21)

Wolfe et al., 2013, JAAA
MED-EL and Roger

- What about digital audio streaming accessories?
Equipment

Nucleus 6 Sound Processor (CI920)

Cochlear Mini Mic

Proprietary 2.4 GHz Digital RF

AzBio Recognition in Quiet

* : p < .05

Wolfe et al., submitted
AzBio Sentence Recognition in Noise

![Graph showing AzBio Sentence Recognition in Noise](image)

Digital Audio Streaming for Bimodal Users

- **Nucleus 6 Sound Processor (CI920)**
- **Cochlear Mini Mic**
- **Resound Linx BTE**
- **Cochlear Phone Clip+**
Audio Streaming Off vs. Audio Streaming On

Sentence Recognition with Nucleus 6 & Resound Linx – Mini Mic Off vs. On

Mini Mic improvement in noise approaches 60% with bimodal

Sentence Recognition in Noise

Sentence Recognition in Noise – Mini Mic On

Bimodal benefit in noise ranges from 10-25%

Wolfe et al., submitted

Wolfe et al., submitted
**Dynamic** Digital RF vs. Digital Audio Streaming

Hearing Aids Users (Moderately Severe/Severe Hearing Loss)  
\( n = 17 \)

- How about classroom audio distribution systems (CADS) versus personal systems?
CADS vs. CADS + Personal FM

Phonak CADS + Personal FM vs. Personal FM alone

No difference in performance between CADS + personal FM vs. personal FM alone

Wolfe et al., 2013
Phonak FM & Nucleus 5

Phase 1

Freedom MicroLink

Micro MLxS

Euro adaptor
FM option
(not included)

Build A/B

MyLink+

ZoomLink+

Nucleus 5

Wolfe et al. (2013), Ear and Hearing
• Considerations for Fitting and Counseling
## Transparency

- **Transparency**
  - Ensuring that signal from sound processor mic is similar with and without HAT
  - Ensuring sound processor mic and remote mic outputs are equal when inputs to each mic are equal
- **CI sound processors** – know how SP is affected by HAT
  - Audio Mixing Ratio: 1:1, 50/50
  - Ensure detection thresholds aren’t elevated with remote mic use; Adequate recognition of low-level speech
- **Hearing aids & CI sound processors**
  - American Academy of Audiology Remote Mic Guideline
  - Google it

## Purpose & Rationale

- **Fitting guidelines from AAA (2008):** supports electroacoustic measures and behavioral testing when fitting FM systems to HAs.
- **Only behavioral testing recommended for FM & CI** because no method to conduct with this population
- **Purpose:** Propose and examine the validity of a newly-developed, objective, electroacoustic test protocol for FM systems & CIs

*Schafer et al., 2013, JAAA*
### CI Settings

**Accessing these settings with a CI**

1. Turn on Roger Inspiro
2. Hold Roger Inspiro within 10cm of the powered up Roger receiver
3. Press the left "check" softkey
4. Press the right "manage" softkey
5. Choose "CI module" with the arrow keys
6. Press "OK"
7. Choose the desired setting and press return to exit

<table>
<thead>
<tr>
<th>Model</th>
<th>Recommended CI module setting</th>
<th>Recommended EasyGain</th>
<th>AutoConnect</th>
</tr>
</thead>
<tbody>
<tr>
<td>MED-EL OPUS 2 and ML CI S (automatic setting)</td>
<td>Default</td>
<td>0dB</td>
<td>ON</td>
</tr>
<tr>
<td>MED-EL OPUS 2 (manual setting)</td>
<td>Setting 2</td>
<td>0dB</td>
<td>OFF</td>
</tr>
<tr>
<td>AB Haida CI Q70 with ComPilot and Roger X</td>
<td>Setting 3</td>
<td>0dB</td>
<td>OFF</td>
</tr>
<tr>
<td>AB Harmony / Auria</td>
<td>Setting 4</td>
<td>+8dB</td>
<td>OFF</td>
</tr>
<tr>
<td>MicroLink CI S (manual setting)</td>
<td>Setting 5</td>
<td>0dB</td>
<td>OFF</td>
</tr>
<tr>
<td>Cochlear Nucleus 6 / 5</td>
<td>Setting 9</td>
<td>0dB</td>
<td>OFF</td>
</tr>
</tbody>
</table>

### Remote Mic Use
Remote Mic Orientation

- Take the time...
- Demonstration
  - Tell, show, touch, live, and give!
- Take the challenge
  - Speech recognition with and without
- Matching tech to needs
  - COSI
  - Budget
- Engage the family
  - Parent Persuasion
  - Give your spiel to the spouse

SUMMARY

- Remote mic use should be considered for all CI recipients.
- CI processor settings influence performance
  - Mixing Ratio; IDR; Sensitivity; ASC; ClearVoice
- RF settings and characteristics influence performance
  - Receiver gain; adaptive vs. fixed; FM vs. digital; personal RF vs. audio streaming; DAI vs. induction loop; personal vs. CADS
- Verification and counseling influence performance
Shoot for the Moon!

• THANK YOU FOR YOUR ATTENTION