Bimodal Hearing with Cochlear Implants

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Disclaimers

- Single sided deafness (SSD) research is helping us learn about how the auditory system works relative to hearing aids and cochlear implants

- No implant company has FDA approval for single sided deafness as an indication for cochlear implants
Increase in Bimodal Users Over Time


Buchner, A. 2016. CI2016 presentation. Data from Hannover Clinic.

Increase in Bimodal Users Over Time

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Evidence of Bimodal Advantages

- Several studies have shown the benefits of bimodal, including improvement in the following:
  - speech perception in noise
  - speech in quiet
  - music appreciation
  - Less listening difficulty in noise

- Several studies have also supported the balancing of the loudness and audibility

1. Sheffield and Gifford, 2015; Zhang et al., 2013, 2014
2. Blamey et al., 2015; Dorman et al., 2015; Gifford et al., 2007, 2014
3. Gfeller et al., 2007; Prentiss et al., 2015
4. Gifford et al., 2017

What are the Advantages of Binaural Hearing?

- Bilateral summation
- Head shadow effect
- Squelch effect
- Patient feeling more “balanced”
- Interaural timing and level differences

Pyschny et al., 2014; Kokkinakis and Pak, 2014; Schafer et al., 2007
Interaural Level Difference (ILD)

- Sound energy is absorbed / blocked by denser material, e.g. head
- Diffraction occurs for low frequency sounds
  • ability for waves to "bend around" obstacles
- For sounds off the midline, there will be a difference in level at both ears
  • particularly for high frequencies

Interaural Time Difference (ITD)

- For a sound off the midline, there is a difference in distance the sound has to travel
- This translates into a difference in time taken
  • time = (distance / velocity)
- For an ongoing sinusoid, this represents a phase difference
  • At high frequencies the phase difference becomes ambiguous
ITDs and ILDs

- Interaural level difference (ILD) is best for high frequency sounds because low frequency sounds are not attenuated much by the head.

- Interaural timing differences (ITD) occur throughout the frequency range
  - At high frequencies the phase difference becomes ambiguous

Main Questions Asked About Bimodal…

- How to get Bimodal with MED-EL?

- Why has MED-EL not paired with a hearing aid company?
How to get Bimodal with MED-EL?

Integrations of the Two Signals: CI and HA

- **Complementary integration**
  - when the brain combines the high-frequency sounds from the cochlear implant and the low-frequency sounds from the hearing aid.

Yoon et al., 2011, 2014

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Integrations of the Two Signals: CI and HA

- **Redundant integration**
  - when the brain receives high and low frequency information from the CI and low frequency information from the hearing aid.

Yoon et al., 2011, 2014

Integration of the Two Signals: CI and HA

- Several studies demonstrate that place-pitch mismatch introduced by CIs can change/reduce over time\(^1\).

- However, some studies also demonstrate that for some individuals mismatch does not reduce and in fact can lead to greater misalignment\(^2\)

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1. Reiss et al., 2007, 2008, 2011
2. Reiss et al., 2014a, 2014b
Triformance: 3 unique characteristics leading to superior performance

Potential for place-pitch match

- With ~20mm insertion, lowest filter output ends up as stimulation at ~7-800Hz place
- ~30mm insertion greatly reduces this mismatch

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Electric pitch perception often shifts in frequency, sometimes by as much as two octaves, during the first few years of implant use.

“Early pitch sensations more closely reflect peripheral innervation patterns, while later pitch sensations may reflect higher-level, experience-dependent changes.”

Reiss et al., 2014

Frequency to Place Matching

- N=5 SSD patients
  - Matching to NORMAL hearing

- Pitch matching on 8 electrodes
  - 1, 2, 3, 4, 6, 8, 10, 12

- Testing at
  - First fitting

Vermeire et al., 2015
Frequency to Place Matching

- **N=5 SSD patients**
  - Matching to NORMAL hearing

- **Pitch matching on 8 electrodes**
  - 1, 2, 3, 4, 6, 8, 10, 12

- **Testing at**
  - First fitting
  - 6 months

Vermeire et al., 2015

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Frequency to Place Matching

- **Rader et al. (2016)**
  - 11 SSD CI users
  - Pitch closer to Greenwood with place-adapted stimulation rates
    - As with fine structure coding strategy

Insertion angle and calculated rate corresponding to Equations (1)–(5) determined for six electrodes E1 to E6. Top: Subjects’ ID. Last two lines: medians and MED-EL strategy PS4 default electrode to center filter frequency mapping.

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* Default center frequency of PS4 speech coding strategy filter bands.
Frequency to Place Matching

- Triformance provides access to true or 'natural' low pitch with no/minimal need for acclimatization.

- Likely to promote better or quicker perceptual fusion across ears.
Front-end processing

“Back-end compression”

stage 1: adjustment of microphone gain

stage 2: compression of speech into electrical dynamic range
Only MED-EL incorporates timing information that mimics the traveling wave

Zirn et al., 2015

Loudness Growth with MED-EL CIs

- Our AGC has similar compression characteristics as a hearing aid. This is a coincidence as both our CI and HA parameters are designed to mimic natural hearing

- Our filter structure is implemented in a way to mimic the “timing properties” of the traveling wave in the cochlea compared to the competition which does not consider this

- Our AGC is designed with loudness growth and timing information that mimic what is used in “Natural Hearing”
Bimodal Streaming

Roger™ 21

- Allows for bimodal streaming
- Access to Roger Portfolio

Take Aways – How to get Bimodal with MED-EL?

- The CI whose performance is most like natural hearing
  - Frequency range
  - Timing

- Loudness growth (compression) in MED-EL CI is similar to hearing aid loudness growth

- There is bimodal streaming with any hearing aid
### Why MED-EL can be paired with any Hearing Aid Company

- No restrictions on what a hearing aid user can use!
- No restrictions on what a hearing professional can fit!

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Why MED-EL can be paired with any hearing aid company:

- Hearing aid software and units are developed and released much faster than CI software and units
  - HAs are Class II
  - CIs are Class III

- Audiologist chooses the best hearing aid for the patient – even the latest and greatest technology with the most advanced features

- MED-EL technology is backwards compatible

- Choosing the best technology is **EASY**
What fitting formula should be used?

- You choose!
- NAL-NL2
- DSLi/o
- Other?

MED-EL and Bimodal – Fitting Procedure

1. Fit CI as normally would
2. Fit the HA
3. Balance the CI and HA together to check for overall loudness.
4. Connect devices for streaming
Roger™ 21

- Perfect fit for SONNET
- Access to Roger Portfolio
- Allows for bimodal streaming
Streaming Options

SONNET
• Roger 21 & Roger Pen
• T-coil (Roger MyLink, Quattro or another looped system)
• Direct connect to iPhone, etc.

Any Hearing Aid
• T-coil
• Roger X

Streaming Options
Resources

- Don’t forget about the ALD database!

Why MED-EL can be paired with any Hearing Aid Company

- You are free to choose the **best CI** and **best hearing aid** for your patients

  - Hearing Professional knows what is the best hearing aid for an individual. They should not be limited by what cochlear implant they will have **for the next 20+ years**

- All MED-EL processors are backwards compatible to older implants
MED-EL – This is Why

• MED-EL has advantages for bimodal hearing using Triformance technology
  • Frequency and timing = redundant integration
• The hearing aid audiologist can fit what hearing aid they find best for their patient
• Loudness growth can be matched between devices
• Bimodal streaming is easy with Roger21
• Best CI + best hearing aid for an individual = Best performance

hearLIFE Unlimited
Bimodal with MED-EL