Bringing it All Together: Maximizing Benefits and Hearing Aid Fitting Strategies for Bimodal Patients

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GN GROUP / RESOUND

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Disclosure

- **I have the following financially relevant relationships in the service and/or product communicated, compared, evaluated and/or reviewed in this presentation.**
  - *Employee – GN ReSound*
- **I have no non-financial relationships to disclose**

Learning Outcomes

- **After this talk, the participant will be able to name 3 benefits of bimodal processing**
- **After this talk, the participant will be a to perform a standard bimodal hearing aid fitting**
- **After this talk, the participant will be able to identify the benefits of bimodal streaming (Assistive Listening Devices for Bimodal patients)**

Outline

- **Introductions**
- **History and Current Practice of Bimodal Fitting**
- **The Benefits of Bimodal Fitting**
- **Bimodal Fitting Protocol and Programming Considerations**
- **Benefits of Assistive Listening Devices (ALDs) and bimodal streaming**
- **Bimodal pairing and programming recommendations**
- **Conclusions & Wrap Up**
- **Q & A**

Past and Present of Bimodal Fittings

Where we've been and where we are

Bimodal Patients: An Introduction

- **Definition: Patients who utilize electrical and acoustic stimulation for hearing between ears**
- **History of cochlear implant candidacy**
  - 1985: 1st candidates had no residual hearing
  - No benefit from conventional amplification
- **Bimodal fitting initially uncommon[1]**
  - First reported early 90s[2]
  - 10% in 2002[3]
- **Expanded CI fitting range[4]**
  - More CI patients have useable residual hearing that ever before
  - Increased utilization of bimodal stimulation
  - Majority of CI centers report fitting unilateral CI patients bimodally at least 31% of the time[1]

1. Siburt, H. W., & Holmes, A. E. (2015). Bimodal Programming: A Survey of Current Clinical Practice. *American journal of audiology*, *24*(2), 243-249.
2. Shallop, J. K., Arndt, P. L., & Turnacliff, K. A. (1992). Expanded indications for cochlear implantation: Perceptual results in seven adults with residual hearing. *Journal of Speech-Language Pathology and Audiology*, *16*(2), 141-148.
3. Huart, S. A., & Sammeth, C. A. (2008). Hearing aids plus cochlear implants: Optimizing the bimodal pediatric fitting. *The Hearing Journal*, *61*(11), 54-56.
4. U.S. Food and Drug Administration. (2014). Press Announcements > FDA approves first implantable hearing device for adults with certain kind of hearing loss. Accessed on 7/10/2016. http://www.fda.gov/newsevents/newsroom/pressannouncements/ucm389860.htm

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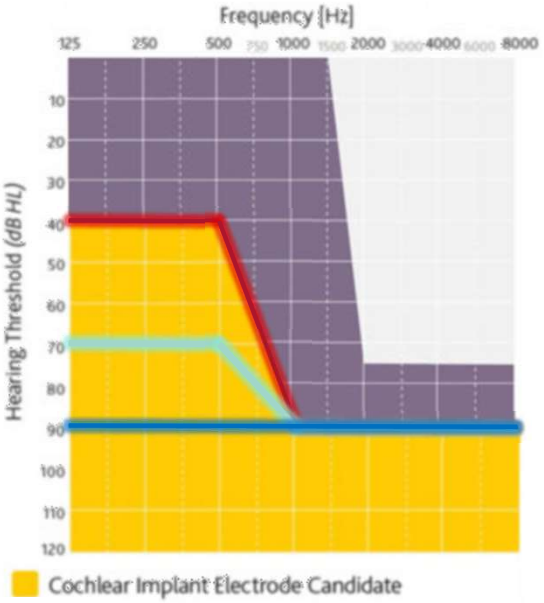
Current Cochlear Implant Candidacy Criteria

- **Adults (18 + years)**
  - Moderate to profound bilateral sensorineural hearing loss
  - Limited amplification benefit: ≤ 50% sentence recognition in ear to be implanted & ≤ 60% in opposite ear or binaurally
- **Children (2-17 years)**
  - Severe-to-profound sensorineural hearing loss
  - Limited benefit from binaural amplification
  - Multisyllabic Lexical Neighborhood Test (MLNT) or Lexical Neighborhood Test (LNT) scores ≤ 30%
- **Infants (12-24 months)**
  - Profound sensorineural hearing loss
  - Limited benefit from binaural amplification
- **Hybrid (18 + years)**
  - Severe/Profound mid-to-high frequency SNHL
  - CNC word recognition score between 10% and 60% aided
  - Contra ear's CNC score criteria are equal to or better than that of the ear to be implanted, ≤ 80% correct.
  - Moderately severe to profound mid-to-high frequency HL in contra ear.



Source: http://www.cochlear.com/wps/wcm/connect/us/for-professionals/products/cochlear-implants/candidacy

Bimodal Fitting Protocol: Current Practice in the US

Bimodal Practice Survey - 2015[1]

- **Bimodal fitting protocol highly variable**
- **Bimodal hearing aid fittings occur at varying times post-CI activation**
  - 18% report HA is never reprogrammed post-CI activation
- **Bimodal patients often treated by two separate audiologists[1]**
  - At least 50% in US survey

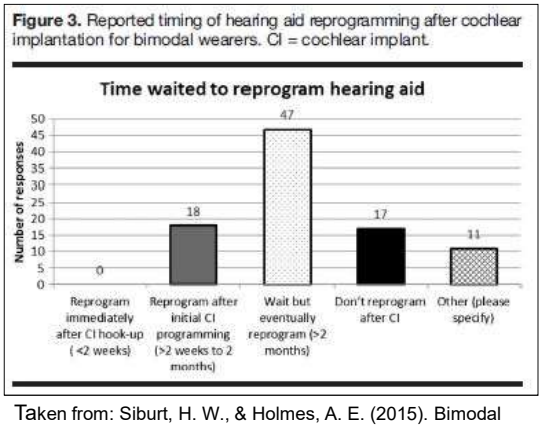
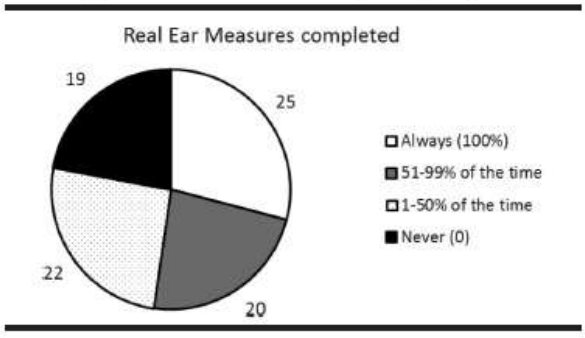


Figure 3. Reported timing of hearing aid reprogramming after cochlear implantation for bimodal wearers. CI = cochlear implant.

Taken from: Siburt, H. W., & Holmes, A. E. (2015). Bimodal Programming: A Survey of Current Clinical Practice. *American Journal of Audiology*, *24*(2), 243-249.

Bimodal Fitting Protocol: Current Practice in the US

Figure 6. Percentage of time real-ear measures are completed with the hearing aid in the bimodal condition by the reporting centers.



Taken from: Siburt, H. W., & Holmes, A. E. (2015). Bimodal Programming: A Survey of Current Clinical Practice. *American Journal of Audiology*, *24*(2), 243-249.

- **23% of bimodal fitting HA audiologists DID NOT use Real Ear Measures to confirm settings[1]**
  - 29% always performed REMs
  - Over half of all centers surveyed (53%) performed REM more that 50% of the time
- **Variability in prescription fitting formula**
  - 28% NAL only
  - 16% DSL only
  - 18% Proprietary only

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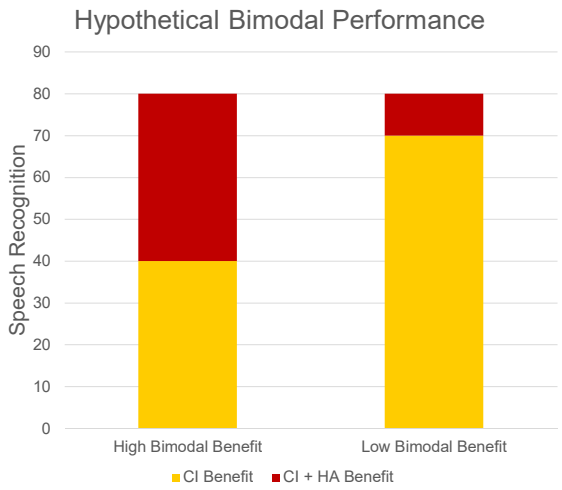
Benefits of Bimodal Fitting

Defining Bimodal Benefit

- **<u>Bimodal benefit:</u> increase in patient performance using CI and HA compared to CI alone**
  - **{ (CI + HA) – CI Alone }**
- **Bimodal Performance vs. Bimodal Benefit**
- **Measures of Benefit**
  - Weighing the benefits
- **Bimodal benefits highlight importance of binaural stimulation[4]**



Bimodal Stimulation Benefits: What does the research say?

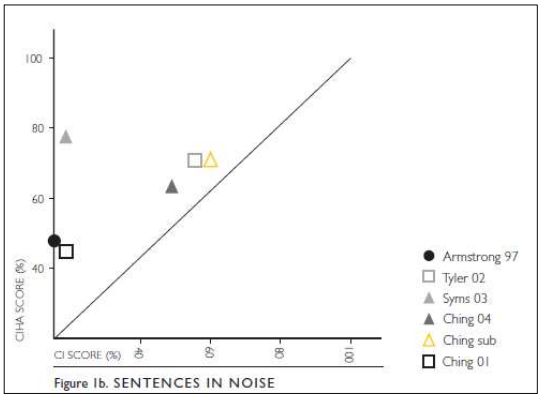


Figure 1b. SENTENCES IN NOISE

- **Speech Recognition in Noise[5-7]**
  - Binaural Redundancy
  - Head Diffraction
  - Binaural Squelch
- **Recent research continues to highlight benefit in noise**
  - Fundamental frequency cues may aid in differentiating voices in noise

5. Schafer, E. C., Amlani, A. M., Seibold, A., & Shattuck, P. L. (2007). A meta-analytic comparison of binaural benefits between bilateral cochlear implants and bimodal stimulation. *Journal of the American Academy of Audiology*,*18*(9), 760-776.
6. Ching, T. Y., Incerti, P., & Hill, M. (2004). Binaural benefits for adults who use hearing aids and cochlear implants in opposite ears. *Ear and hearing*,*25*(1), 9-21.
7. Gifford, R. H., Dorman, M. F., McKarns, S. A., & Spahr, A. J. (2007). Combined electric and contralateral acoustic hearing: word and sentence recognition with bimodal hearing. *Journal of Speech, Language, and Hearing Research*, *50*(4), 835-843.

Bimodal stimulation benefits: What does the research say?

- **Sound Localization**[8]
  - Bimodal stimulation provides better localization capabilities compared to CI alone
  - Low frequencies improve perception of inter-aural level difference (ILD)
  - Speech perception in diffuse speaker array improves with bimodal stimulation over CI alone[9]
- **Speech Prosody**[10]
  - Improved ability to tell the difference between questions and statements

8. Heo, J. H., Lee, J. H., & Lee, W. S. (2013). Bimodal benefits on objective and subjective outcomes for adult cochlear implant users. *Korean Journal of Audiology*, *17*(2), 65-73.
9. Potts, L. G., Skinner, M. W., Litovsky, R. A., Strube, M. J., & Kuk, F. (2009). Recognition and localization of speech by adult cochlear implant recipients wearing a digital hearing aid in the nonimplanted ear (bimodal hearing). *Journal of the American Academy of Audiology*, *20*(6), 353-373.
10. Straatman, L. V., Rietveld, A. C. M., Beijen, J., Mylanus, E. A. M., & Mens, L. H. M. (2010). Advantage of bimodal fitting in prosody perception for children using a cochlear implant and a hearing aid. *The Journal of the Acoustical Society of America*, *128*(4), 1884-1895.

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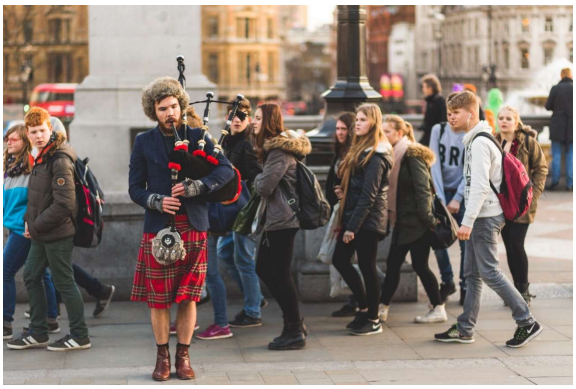
Bimodal stimulation benefits: What does the research say?

- **Prevention of auditory deprivation**[11]
- **Improved sound quality**[12,13]
  - Subjective comparison to CI alone
- **Enhanced music perception**[12,13]
  - Bimodal patients report greater music appreciation compared to either HA or CI alone
  - Improved melody recognition



11. Gifford, R. H., Driscoll, C. L., Davis, T. J., Fiebig, P., Micco, A., & Dorman, M. F. (2015). A within-subject comparison of bimodal hearing, bilateral cochlear implantation, and bilateral cochlear implantation with bilateral hearing preservation: High-performing patients. *Otology & Neurotology*, *36*(8), 1331-1337.
12. Sucher, C. M., & Mcdermott, H. J. (2009). Bimodal stimulation: benefits for music perception and sound quality. *Cochlear Implants International*, *10*(S1), 96-99.
13. Wolfe, J. (2015) Cochlear Wireless Accessories for Bimodal Users. Presentation, San Antonio, TX.

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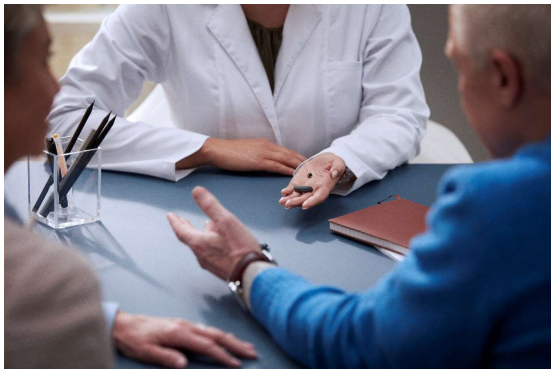
Bimodal Fitting Protocol and Considerations

Bimodal Patient Hearing Aid Considerations

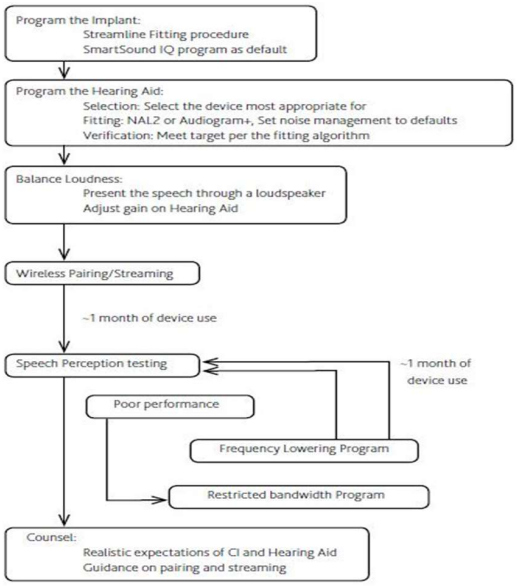
- **Aidable hearing loss in contralateral ear**
  - Some research shows relationship between residual hearing aid bimodal performance
    - low-frequency PTA (125, 250 & 500 Hz) < 60 dB HL[14]
    - Thresholds below 500 Hz < 80 dB HL[15]
  - Not all research shows relationship between residual hearing and bimodal performance[6]
- **Variability in CI, HA performance**
  - Lower performance in CI-only allows for greater possible bimodal benefit[14]
- **Managing expectations for HA performance**



14. Dorman, M. F., Cook, S., Spahr, A., Zhang, T., Loiselle, L., Schramm, D., ... & Gifford, R. (2015). Factors constraining the benefit to speech understanding of combining information from low-frequency hearing and a cochlear implant. *Hearing research*, *322*, 107-111.
15. Illg, A., Bojanowicz, M., Lesinski-Schiedat, A., Lenarz, T., & Büchner, A. (2014). Evaluation of the bimodal benefit in a large cohort of cochlear implant subjects using a contralateral hearing aid. *Otology & Neurotology*, *35*(9), e240-e244.

Optimizing Hearing Aid Programming for Bimodal Patients

1. **CI map needs to be stable[2]**
   - Typically 3-6 months post-activation
2. **Setting gains to meet prescriptive targets utilizing Real Ear Measures**
   - Fit hearing aid for **ALL** aidable frequencies[16]
   - Recommended Targets: NAL-NL2
3. **If HA not optimized, patient may lose out on some or all bimodal benefit[17]**
   - 23% of bimodal fitting HA audiologists **DID NOT** use Real Ear Measures to confirm settings[1]



16. Neuman, A. C., & Svirsky, M. A. (2013). The effect of hearing aid bandwidth on speech recognition performance of listeners using a cochlear implant and contralateral hearing aid (bimodal hearing). *Ear and hearing*, *34*(5), 553.

17. Ching, T. Y., Hill, M., Dillion, H., & van Wanrooy, E. (2004). Fitting and evaluating a hearing aid for recipients of a unilateral cochlear implant: The NAL approach. *Hearing Review*, *11*, 14-23.

Importance of Validation: Benefits of setting to target

Sentence Perception	Functional Performance	Localization Errors
• BKB sentences in quiet and in noise • **Significantly better percent correct** using verified HA settings in bimodal fitting	• Functional questionnaire given to subjects' parents • **Significantly better functional performance** with verified HA settings in bimodal fitting	• Localization tested in 180º horizontal arch around subject • **Significantly lower error rate** with verified HA settings in bimodal fitting

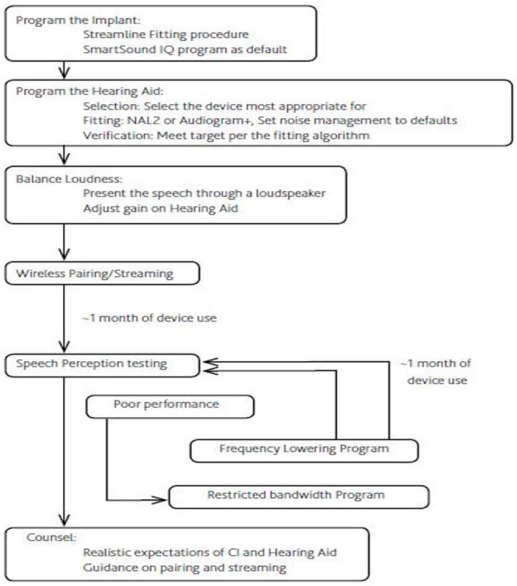
Ching *et al* 2001[18]

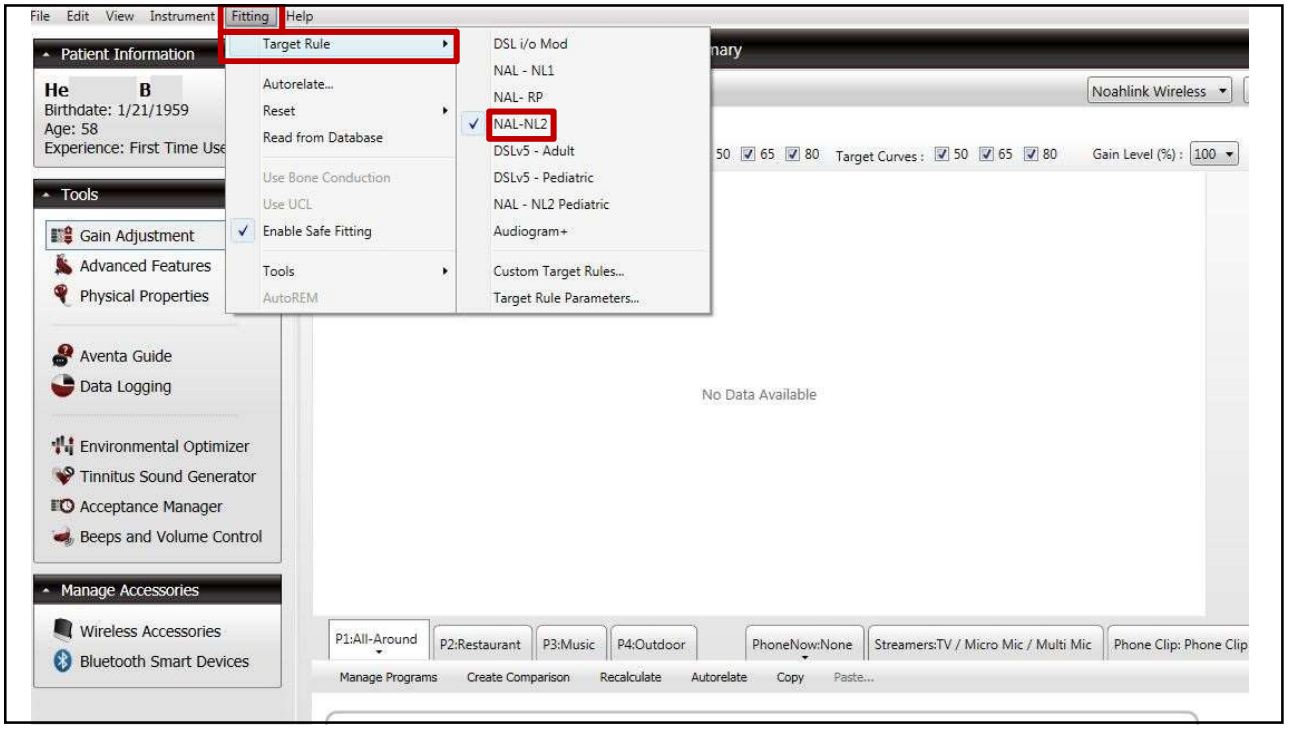
- **Compared bimodal stimulation with current HA settings to verified settings in children**
- **Verified to NAL-RP (subjects wore linear hearing aids) and loudness balanced with CI**
- **Compared performance on sentence perception, functional performance, and localization**

18. Ching, T. Y., Psarros, C., Hill, M., Dillon, H., & Incerti, P. (2001). Should children who use cochlear implants wear hearing aids in the opposite ear?. *Ear and hearing*, *22*(5), 365-380.

Optimizing Hearing Aid Programming for Bimodal Patients

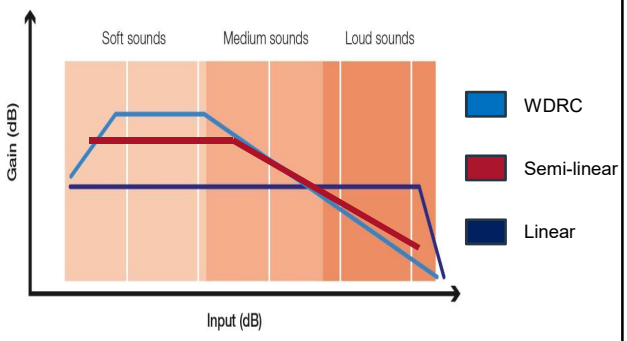
4. **Loudness match hearing aid to CI[2,6]**
   - Research has found most bimodal benefit when hearing aid loudness equal or just below CI
5. **Add wireless / assistive listening technology – as needed**
6. **Speech testing to ensure benefit**
7. **If Poor Bimodal Performance:**
   - Frequency Lowering
   - Restricted Bandwidth





Hearing Aid Fitting Algorithm: NAL-RP vs. NAL-NL2

- **NAL-RP (Revised Profound) provides gain linearly**
  - Designed for linear hearing aids
- **NAL-NL2 provides less gain to louder sounds, preventing distortion from peak clipping**
  - Provides more gain to soft sounds: Compression!
  - **NAL-NL2 is Recommended fitting algorithm**
- **Both have shown bimodal benefit in prior research**
  - Subjects had familiarity with each for given research trials
  - NAL-RP research done when linear HAs still common
- **Aventa provides both options**
  - WDRC, semi-linear, and linear programming options for Super Power devices



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Aventa Gain Programming Considerations

- Experience matters! Changes NAL-NL2 targets & gain
- Autorelate: incorporate REMs into environmental programs
- Aid what can be aided: Gain settings in high frequencies may need to be decreased based on patient audiogram
- Expansion an option for patients with moderate low-frequency thresholds

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Super Power Product Comparison

ReSound ENZO² 98	ReSound ENZO² 88	ReSound LiNX² 61/62 UP
FOG: 83	FOG: 73	FOG: 75
Greater Fitting Range	Flexibility in low frequencies	Flexibility in low frequencies
Poor Dexterity	Poor Dexterity	Cosmetics
Push Button & Volume Rocker	Push Button & Volume rocker	61 – Push button 62 – Volume Rocker
Battery Life - 675	Battery Life (Size 13): > size 312	LiNX2 61 – 312 LiNX2 62 - 13

Super Power

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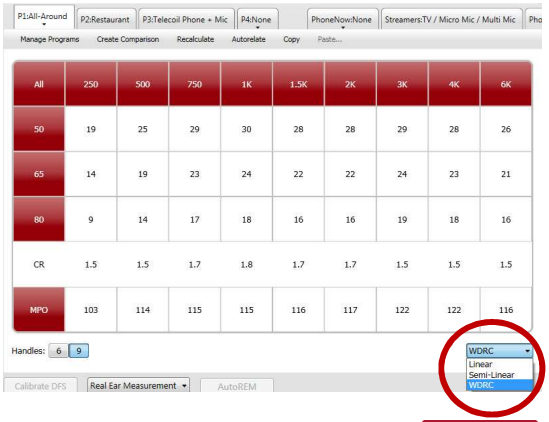
ReSound Super Power Comparisons

ENZO² (98s & 88s) / Linx² UP receiver

Key Super Power Features:

- **Amplification Mode**
  - WDRC
  - Linear
  - Semi-Linear
- **Bimodal streaming compatible at all technology levels**
- **DAI & loop compatible**
  - LiNX² 61 does not have Tcoil
- **Low Frequency Boost**



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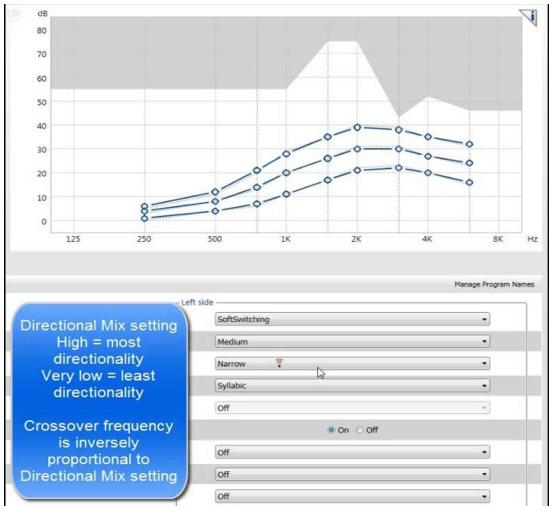
Hearing Aid Programming Considerations: Band-Split Directionality

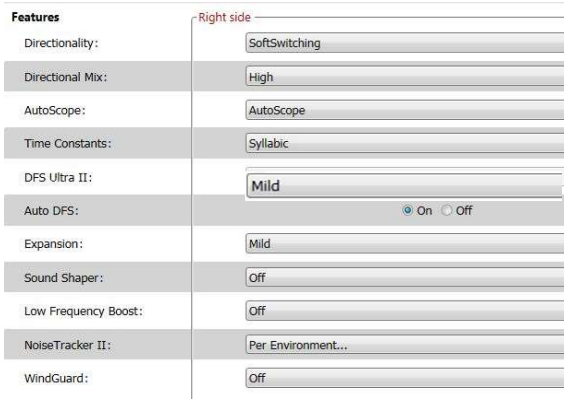


- **Directionality options for monaural hearing aid fitting[19]**
  - Omni, fixed directional, adaptive directional, SoftSwitching
  - Directional options are program dependent
- **ReSound utilizes Band-Split Directionality**
  - Omni directional below the crossover frequency
  - Directional above the crossover frequency
  - Avoids distortion & need for artificial bass boost; Improves wind noise control; Helps maintain ITDs in low-frequencies
- **Crossover frequency is adjustable**
- **May need crossover frequency adjustment based on patient performance, expectations**
  - Limited published data on Pros/Cons of adjustment in bimodal patients

19. Stender, T. (2016) What About the Contralateral Ear? Bimodal Programming Considerations. *Hearing Review*. 23(4):32.

Additional hearing aid programming considerations

- **Patient's preferred CI program settings**
  - Have unique directionality/advanced features
- **Feedback control**
  - Occlusion/mostly low frequency hearing remains
- **Noise Reduction and Scene Classifiers**
  - Severely hearing-impaired patients can perceive benefit from activating advanced features
- **Limited research on advanced features in bimodal patient populations[17]**



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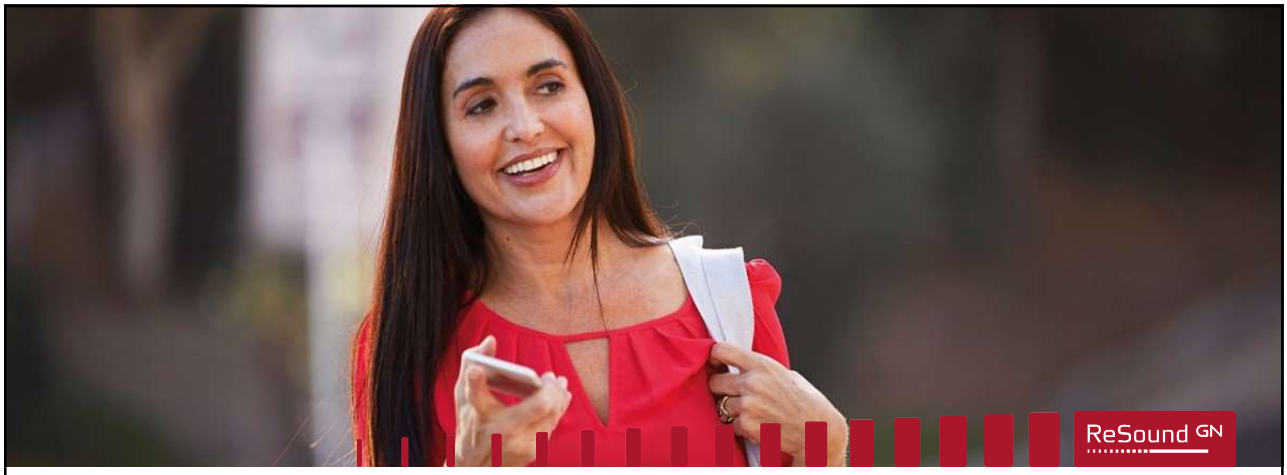

Bimodal Stimulation and Assistive Listening Devices (ALDs)

Utilization of Assistive Listening Device (ALDs) for Bimodal Patients

- **Bimodal patients still struggle in difficult listening situations**
- **ALDs provide bilateral, bimodal direct audio input that can increase benefit beyond on ear mics**
- **Remote microphones**
  - Improve speech recognition in noise
  - Improve SNR
  - Improve speech understanding at a distance
- **Phone call streaming**
  - Improve speech understanding on the phone
  - No need to find the “Sweet Spot”

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Streaming Map – Multi Mic/TV streamer/Phone Clip to CI/HA

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Wireless Pairing & Streaming – Cochlear™ Nucleus® 6 and ReSound

Maximize your hearing with both ears[1]

Microphones

Note: When bimodal pairing, first ensure hearing devices are programmed to opposite ears.

1. Turn off ReSound hearing aid and Cochlear Nucleus 6 Processor
2. Turn on microphone
   Note: Ensure microphone is charged.
   Switch on
3. Locate and press the pairing button on back by the clip
   20 seconds
   Note: The LED will flash yellow while device is in pairing mode for 20 seconds.
4. Turn on ReSound hearing aid, pause 2 seconds, then turn on Nucleus 6 Processor
   Note: The LED will flash blue to show pairing was successful.

TV Streamers

1. Plug power and audio cables into TV Streamer and connect to audio source
2. Turn off ReSound hearing aid and Nucleus 6
3. Press pairing button
   20 seconds
   Note: The LED will flash yellow while device is in pairing mode for 20 seconds.
4. Turn on ReSound hearing aid, pause 2 seconds, then turn on Nucleus 6 Processor
   Note: The LED will flash blue to show pairing was successful.

Microphones and TV Streamers

1. Turn on ReSound hearing aid then Nucleus 6 Processor
2. Turn on microphone or turn on TV

Streaming to one or both hearing devices

Note: Streaming must be started and stopped on each device individually.

OPTION A. Nucleus 6 Processor
Long-press the upper button on your sound processor once.

OPTION B. CR210 Remote Control
Long-press the Telecoil button. Audio will start streaming through the microphone.

OPTION C. Using CR230 Remote Assistant
Long-press the Telecoil button.

OPTION A. Press and hold the push button on your ReSound Hearing Aid for 3 seconds.

OPTION B. Using ReSound Unite Remote
If you have a ReSound Unite™ Remote Control (optional), simply press the streaming button on this Remote Control.

Streaming button

[1] Wolfe, Jace. "Why Two Are Better Than One." Presented at ACIA 2014, Nashville, TN.

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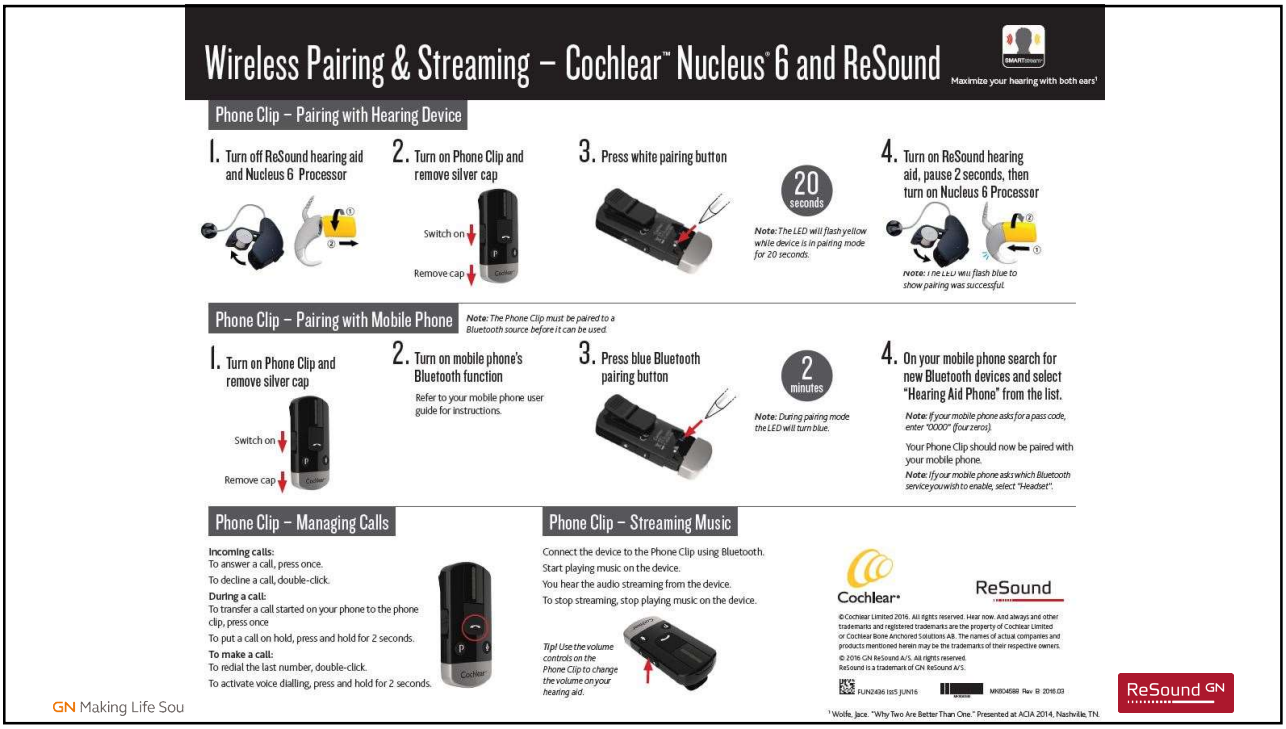
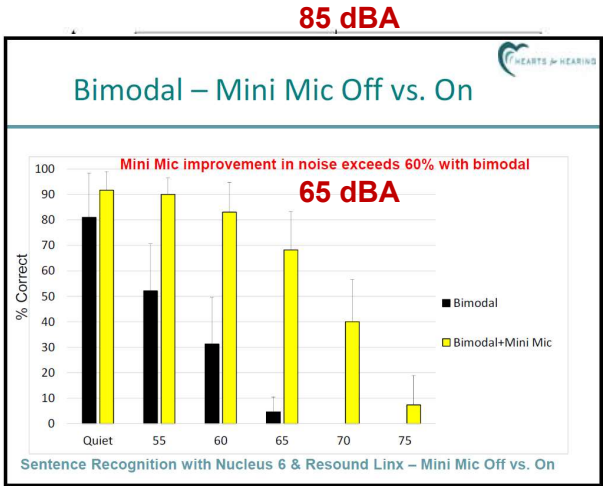


Developing a Hearing System: Incorporating Bimodal Streaming

- **Research shows bimodal patients benefit from bilateral remote microphone audio input**
  - 1st studies used FM[17]
  - Proprietary connections proven effective
- **Benefits from Remote Microphones in noise[12]**
  - Bimodal streaming testing sentence recognition in noise
    - AzBio sentence test
  - Significant improvements in sentence recognition in noise using remote microphone



Wolfe, J. Cochlear Wireless Accessories for Bimodal Users. Presentation, San Antonio, TX, 2015

20. Schafer, E. C., & Thibodeau, L. M. (2006). Speech recognition in noise in children with cochlear implants while listening in bilateral, bimodal, and FM-system arrangements. *American Journal of Audiology, 15*(2), 114-126.

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ReSound Multi Mic / Cochlear Mini Mic 2+ Advantages

2.4 GHz Streaming benefits

- No intermediary device
- True bimodal streaming
- Robust & reliable connection
- Long range of transmission
- Flexible volume and mic balance controls
- Backwards compatible for previous ReSound 2.4 GHz devices

Multi Mic Features

- Directional mic
- Omni/table mic mode
- Line-in
- DAI compatible
  - Streams DAI bimodally
- **Built-in Telecoil**
- Wireless range >80 feet
- (clear line of sight)
- Drop Detection

- Preliminary data suggests that bimodal streaming via the Multi Mic/Mini Mic 2+ provides improved SNR benefit over previous Mini Mic data particularly at lower SNR ratios

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Bimodal Streaming Benefits on the Telephone

- **Study designed to test bimodal phone calls over open air vs through bimodal phone streaming accessory[21]**
  - Tested in quiet and in noise
- **Benefits from bimodal phone call streaming**
  - Significant benefit in word recognition when using Phone Clip + for Bimodal streaming over Bimodal acoustic option
- **Non-proprietary bimodal streaming options**
  - FM, T-coil programs & Tcoil/loop streamers

Word recognition on the Phone with & without Phone Clip+ Phone streamer

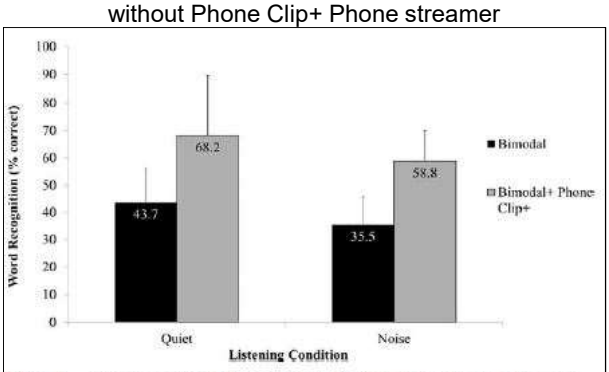

FIG. 4. Average word recognition in the quiet and noise conditions over the mobile telephone.

From: Wolfe, J., Morais, M., & Schafer, E. (2016). Speech Recognition of Bimodal Cochlear Implant Recipients Using a Wireless Audio Streaming Accessory for the Telephone. *Otology & Neurotology*, *37*(2), e20-e25.

21. Wolfe, J., Morais, M., & Schafer, E. (2016) Speech Recognition of Bimodal Cochlear Implant Recipients Using a Wireless Audio Streaming Accessory for the Telephone. *Otology & Neurology*. 37:e20-e25.

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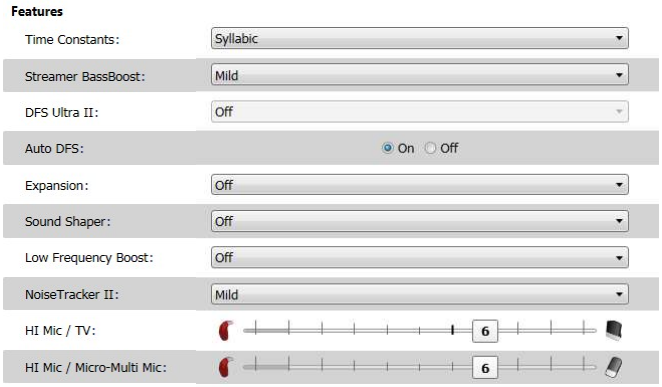
Bimodal ALD programming considerations

- **Microphone Balance**
  - Mic balance to achieve 2:1 ratio of mic to HA
- **Phone Accessory**
  - Mic balance to achieve 2:1 ratio of mic to HA
- **Directionality**
  - Hearing aid microphones will be in Omni
- **Streamer BassBoost**
- **Gain Settings**
  - Independent of other HA programs
  - Phone & remote mic streaming are separate programs
  - Autorelate to All-Around (after REM)



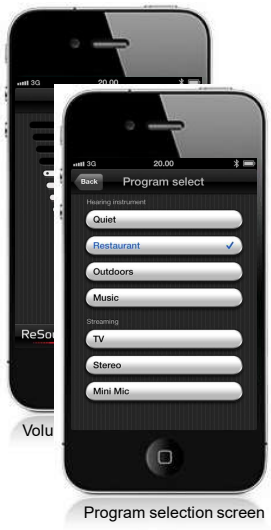
GN Making Life Sound Better

ReSound GN

Further Considerations

Apps and the future of bimodal stimulation

ReSound Apps for Added Control



Program selection screen

- **Bimodal Fittings require Phone Clip +**
- **Still compatible with Smart App for ReSound Linx2 & ENZO2 devices**
  - Requires Apple iPhone 5 and beyond or Samsung Galaxy S4, Note 4 and beyond
  - Bass/Treble controls, Geotag, Find My Hearing Aid functions
- **ReSound Control App will work with all other smartphones**
  - Control volume, change program, change HA/streaming volume independently

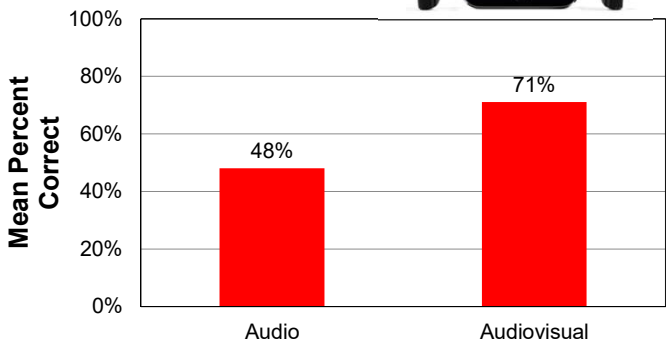
Bimodal AR Perceptual Training: iAngel App

- **App based version of Angel Sounds – based on CAST**
- **Several Module choices based on patient skill level & focus area**
- **Various different modules:**
  - Consonants, vowels, environmental sounds, food names, animal names
- **Choose level of difficulty, number of trials, number of choices**
  - Change the listening condition: quiet, phone or café
  - Change speaking rate

Advancements in Video Chat Apps

- **Video Chat apps (FaceTime) studies showing growing role for wireless technology in speech perception**
- **Jespersen & Kirkwood[23] tested bilateral, severely hearing-impaired HA users speech perception during phone calls in audio & audiovisual conditions**

- **Results showed significantly higher performance in audiovisual conditions**
- **Even higher when bilaterally streamed (vs unilateral)**
- **Needs investigation in bimodal population – may lead to increased phone benefit**



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Conclusions and Future Considerations

- **Bimodal stimulation has significant patient benefits**
- **Hearing aid must be fit correctly to ensure bimodal benefit!**
- **Bimodal wireless streaming has proven benefits in difficult listening situations**
- **If no bimodal benefit perceived, consider second implant**
- **Future research is needed to further investigate:**
  - HA fitting strategies beyond NAL-NL2
  - Benefits of advanced sound processing & ear-to-ear communication between CI and HA
  - Further research into the role of residual hearing in bimodal performance

Questions?

Thank You!
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