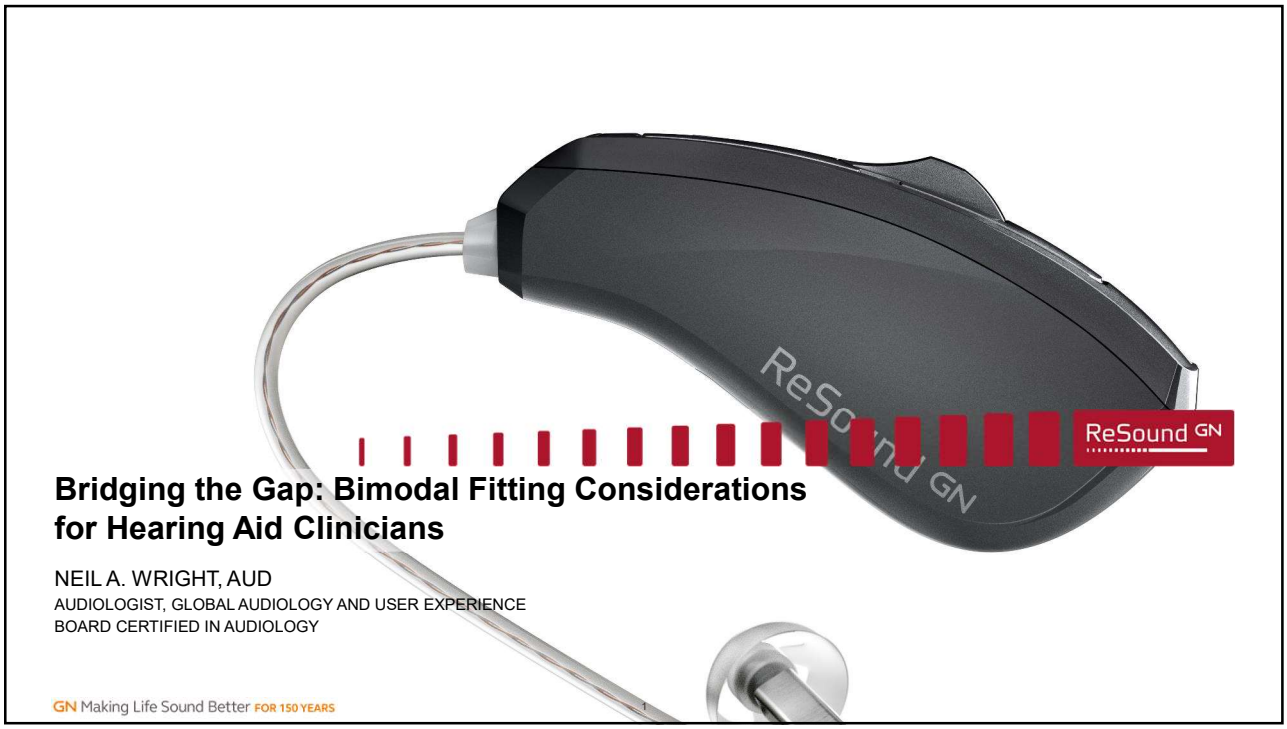

Bridging the Gap: Bimodal Fitting Considerations for Hearing Aid Clinicians

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BOARD CERTIFIED IN AUDIOLOGY

Disclosure

- I have the following financially relevant relationship 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

1. After this course, participants will be able to identify 3 benefits of bimodal fittings compared to unilateral Cochlear Implant fittings
2. After this course, participants will be able to complete an optimal bimodal fitting of a hearing aid
3. After this course, participants will be able to program an optimal streaming program and system for bimodal streaming

Outline

- Introduction
- Overview of Bimodal Fitting Flow
- Fitting Consideration #1: Hearing Aid Verification
- Fitting Consideration #2: Hearing Aid Directionality
- Fitting Consideration #3: Music Perception
- Fitting Consideration #4: Tinnitus
- Conclusions & Questions

Overview of Bimodal Fitting Flow

Setting off on the right foot

Bimodal Patients: An Introduction

- Definition: Patients who utilize electrical and acoustic stimulation for hearing
- 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
  - 10% in 2002[2]
- Expanded CI fitting range[3]
  - More CI patients have useable residual hearing that ever before
  - Increased utilization of bimodal stimulation[4,5]
  - Majority of CI centers report fitting unilateral CI patients bimodally at least 31% of the time[1]

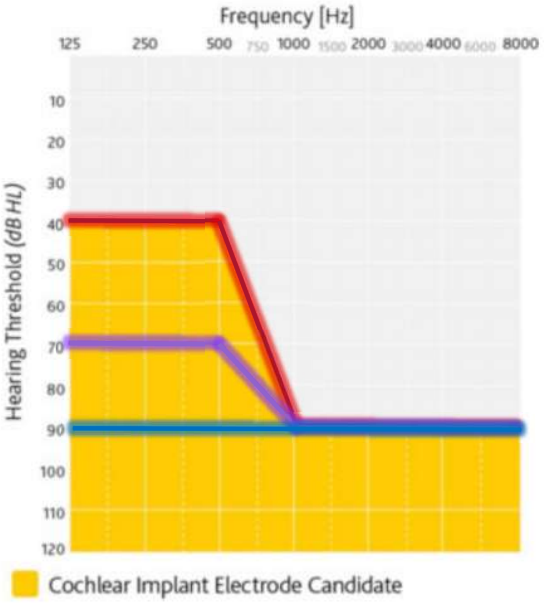
1. Siburt, H. W., & Holmes, A. E. (2015). Bimodal Programming: A Survey of Current Clinical Practice. *American journal of audiology*, *24*(2), 243-249.
2. Huart, S. A., & Sammeth, C. A. (2008). Hearing aids plus cochlear implants: Optimizing the bimodal pediatric fitting. *The Hearing Journal*, *61*(11), 54-56.
3. 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
4. Stender, T. (2016) What About the Contralateral Ear? Bimodal Programming Considerations. *Hearing Review*. 23(4):32.
5. 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.

Current Cochlear Implant Candidacy Criteria

Standard electrode array

- **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

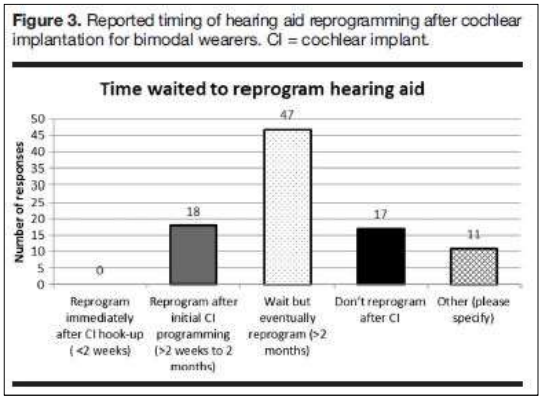
Source: http://www.cochlear.com/wps/wcm/connect/us/for-professionals/products/cochlear-implants/candidacy



Bimodal Fitting Protocol: Current Practice in the US

Bimodal Practice Survey - 2015

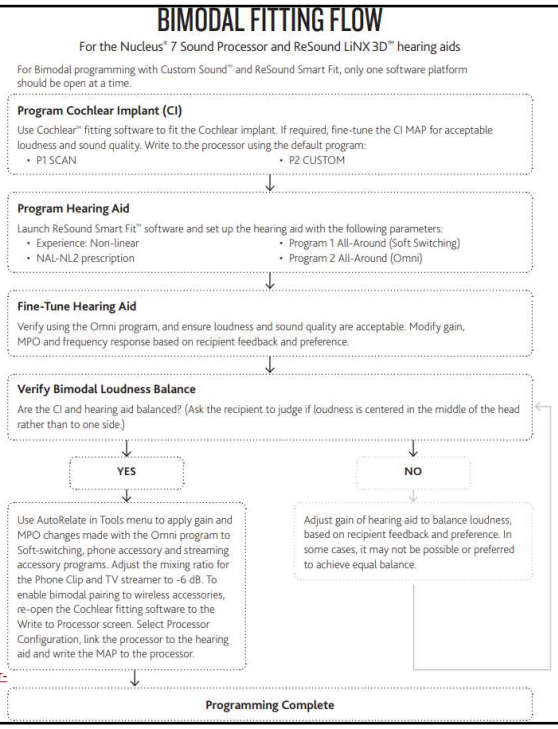
- Bimodal fitting protocol highly variable[1]
- Bimodal hearing aid fittings occur at varying times post-CI activation
  - 18% report HA is never reprogrammed post-CI activation
- Bimodal patients often treated by two separate audiologists[1]
  - At least 50% as of 2015 (US survey data)



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 Flow

- 5 Key steps
  1. Program Cochlear Implant
     - CI map needs to be stable before moving to Step #2
     - This talk will focus on hearing aid programming: Steps 2-5
  2. Program Hearing Aid
  3. Fine-Tune Hearing Aid
  4. Verify Bimodal Loudness Balance
  5. Auto-Relate/Streaming Set-up



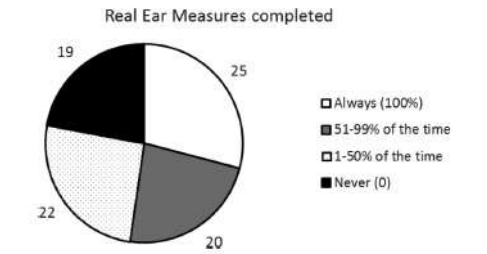
Source: https://www.cochlear.com/us/en/professionals/products/cochlear-implants/smart-bimodal-solutions

Bimodal Fitting Consideration #1: Hearing Aid Verification

Bimodal Hearing Aid Verification: Background

- Bimodal researchers utilize hearing aid verification as part of their methodology for bimodal stimulation
  - Set to commonly accepted fitting rules
  - NAL-NL2 is the recommended fitting rule in the bimodal fitting flow
  - Bimodal input improves speech-in-noise understanding over CI alone[6]
- Some discrepancy between which fitting rule to use
- Research shows that a properly fit hearing aid improves bimodal performance over unilateral CI
  - Poor hearing aid fitting can reduce bimodal performance
  - Current bimodal fitting data highlights variability in verification processes completed in practice[1]

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

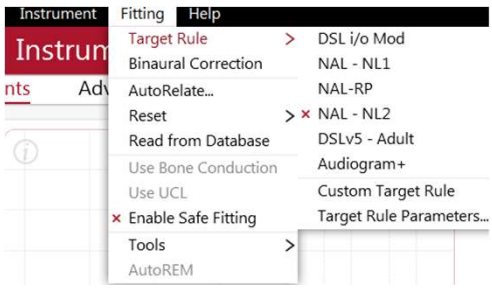


Taken from: Siburt, H. W., & Holmes, A. E. (2015). Bimodal Programming: A Survey of Current Clinical Practice. *American Journal of Audiology*, *24*(2), 243-249.

Bimodal Hearing Aid Verification: What fitting rule to use?

Bimodal benefit has been shown with multiple fitting rules:

- **DSL v5:** commonly used in the US as a pediatric fitting rule[7]
- **NAL-RP, NAL-NL1:** Older fitting rules by today's standards, but have shown benefit in past bimodal research studies[8,9,11]
- **Proprietary fitting rules:** Manufacturer developed fitting rules have shown benefit in past bimodal research studies



- *No direct comparison studies between fitting rules to suggest one fitting rule provides more benefit than another*
  - Experience with specific fitting rules can provide insight to patient preference[13]

- ***Key Takeaway:** Most critical part of the fitting is to set to fitting rule targets using REM verification!*

Bimodal Hearing Aid Verification: Restricted Bandwidth vs. Wideband

Restricted Bandwidth	Wideband Amplification
▪ Drastically reduce gains in high frequencies to restrict aided gains to lower frequencies	▪ Provide gains across all aidable frequencies set to fitting rule targets via REMs
▪ Some research shows that restricting hearing aid bandwidth, particularly above 2000 Hz, can provide improved bimodal benefit ▪ Presence of cochlear dead regions indicated need for restricted bandwidth[6] ▪ Threshold Equalizing Noise Test (TEN Test)	▪ Much more common in bimodal-focused research compared to restricted bandwidth ▪ ***Significant bimodal benefit over HA or CI alone[7,8]*** ▪ No testing for cochlear dead regions ▪ Measured in subjective questionnaires and speech understanding

➢ ***Key Takeaway: Wideband amplification provides bimodal benefit in most bimodal research. However, cochlear dead regions may indicate need for restricted bandwidth.***

Bimodal Hearing Aid Verification: Loudness Balancing

➢ Completed as part of bimodal fitting protocol after Real Ear Measurements and gain adjustments

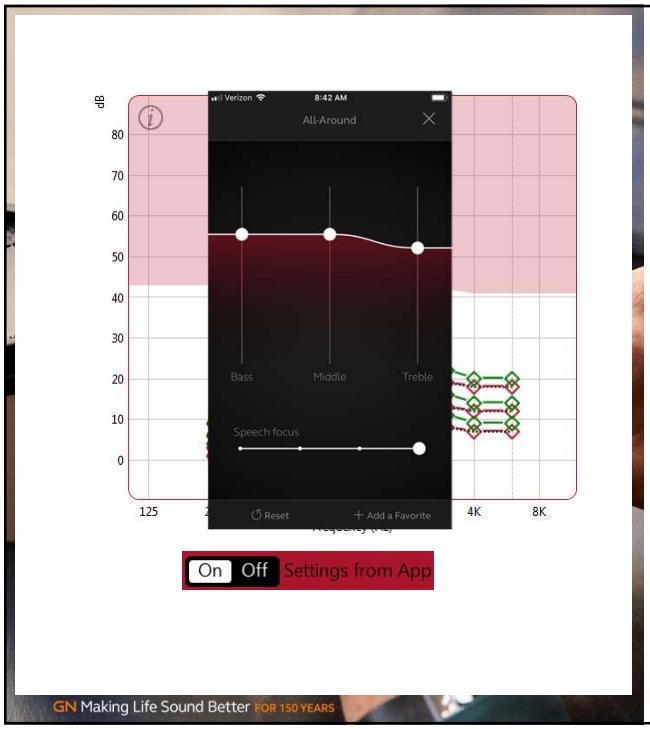
➢ Bimodal research commonly applies loudness balancing as part of bimodal fitting protocol[9,10]

➢ Limited research specifically investigating loudness balancing's impact on bimodal benefit

  ➢ Some patients prefer more/less gain than fitting rule prescribes[9,10]

➢ Loudness growth in cochlear implants and hearing aids are perceptually different due to frequency input, stimulus type

➢ ***Key Takeaway: Start from Real Ear Measurements, then adjust gains as needed***



Bimodal Hearing Aid Verification: Loudness Balancing with RFT

ReSound GN

Common for Bimodal patients to see different audiologists for CI mapping & HA programming

1. Once CI mapping is completed, utilize Sound Enhancer to balance Bass, Middle, & Treble
   - ✓ Complete RFT request with adjustments
2. In Smart Fit, changes to Sound Enhancer settings can be shown with "Show User Settings" turned **ON**
   - ❖ **Note:** Master Volume changes in HA will NOT show in Smart Fit as User Settings
3. Adjust gains to match User Settings
4. Auto Relate gain changes to other programs
5. Save & Send new settings!

Bimodal Hearing Aid Verification: Frequency Lowering

ReSound GN

- Studies have been completed investigating whether frequency lowering has a positive impact on bimodal benefit
  - Frequency Transposition[12] and Frequency Compression[14] tested
- Neither showed significant benefit or detriment over conventional amplification benefits
- ***Key Takeaway: Bimodal benefit can be achieved without frequency lowering***

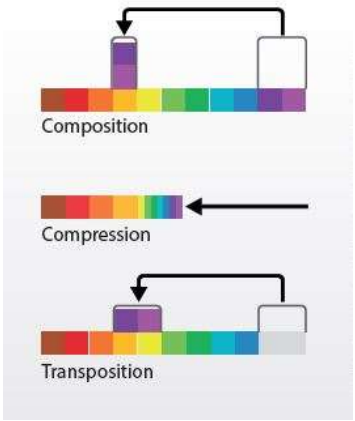


Image taken from:Speech and hearing loss / hearing aids – Hearing Loss- Hearing Aid Forum – Active Hearing Loss Community. Image retrieved Aug. 21, 2019. https://forum.hearingtracker.com/t/speech-and-hearing-loss-hearing-aids/26246

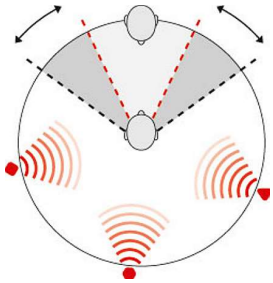
Bimodal Fitting Consideration #2: Hearing Aid Directionality

Bimodal Hearing Aid Directionality: Background

- Research shows directionality benefits for both CI and HA alone by improving SNR
  - Minimal research has focused specifically on hearing aid directionality settings for Bimodal users for speech understanding improvements
  - Binuaral cues have been shown to improve localization over CI alone
- Benefits of HA directionality can be limited due to the degree and configuration of hearing loss typical of patients with CIs
  - High degree of hearing loss in high frequencies
- Environment will be a significant factor[22]
  - High SNR is ciritical for CI/Bimodal patients' success
- Utilization of directionality to reduce noise input can be beneficial for these patients

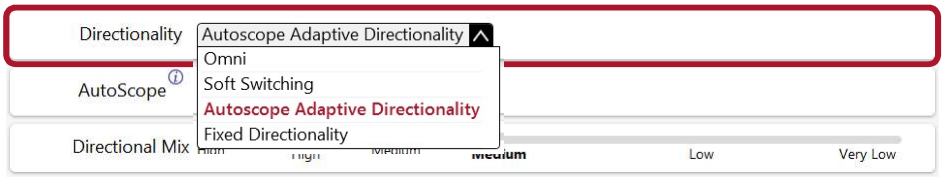
Bimodal Hearing Aid Directionality: Programming Options & Rationale

- Omnidirectional
  - Amplifies sound from all directions equally
  - **Key Benefit**: Environmental Awareness
- Fixed directional
  - Fixed hypercardioid with null located behind patient to reduce noise from behind patient
  - **Key Benefit:** SNR improvement, consistent performance across environments
- Automatic directional
  - Hypercardioid with null located behind patient that can adjust width of directional response based on environment, background noise
  - **Key benefit**: SNR improvement, adapts to varying levels of environmental noise



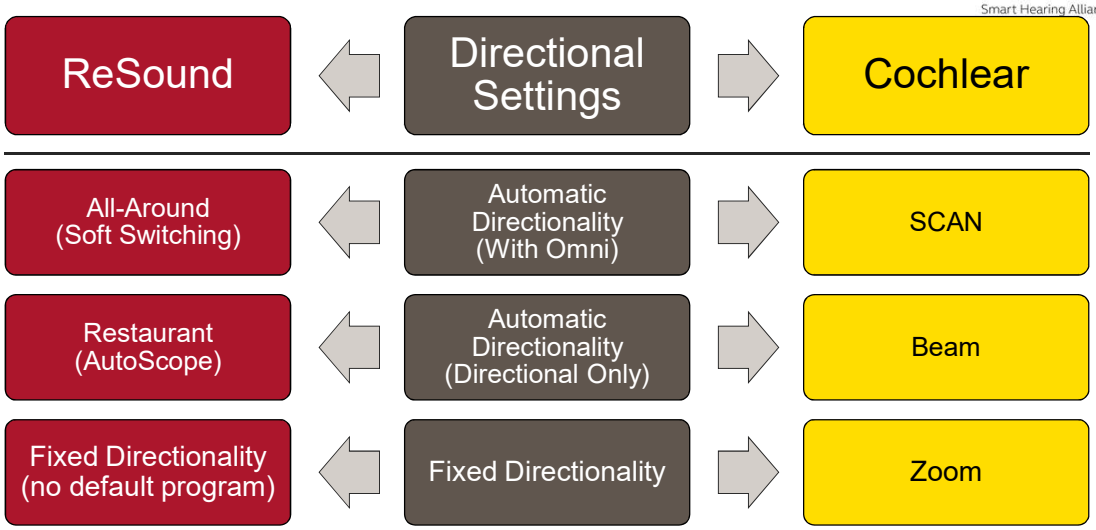
Bimodal Hearing Aid Directionality: ReSound Programming Considerations

- Environmental Programs' directionality options
  - All-Around: Soft Switching and Omni
  - Restaurant, Music, & Outdoor: Soft Switching, Autoscope Adaptive Directionality, Fixed Directionality, & Omni
- Soft Switching vs. AutoScope Adaptive
  - Soft Switching: Automatic Directionality with Omni response option
  - AutoScope Adaptive: Automatic Directionality without Omni response option
- Directional Mix
  - Sets band-split directional frequency: frequencies below remain in omni, frequencies above are set to a directional response



Smart Hearing Alliance: Comparable Directionality Settings

Smart Hearing Alliance



15. Clarke, J. (2018) What's new for the Cochlear Nucleus 7 System. Audiology Online. https://www.audiologyonline.com/articles/what-s-new-for-cochlear-23586

Note: Application of automatic settings can differ between CI and HA based on environment

Bimodal Hearing Aid Directionality: Key Takeaways

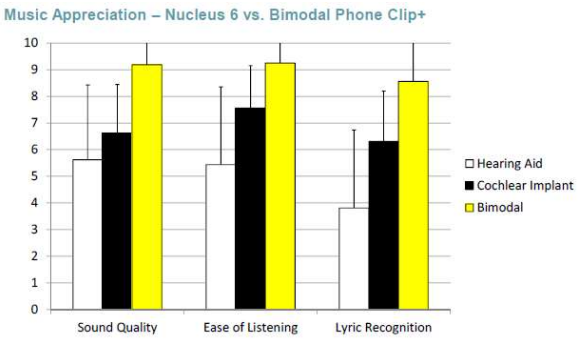
1. ***Bimodal fittings can provide bilateral cues that improve localization***
2. ***Research is limited for Directional benefit on speech understanding for bimodal users – but improved SNR does shows benefits for bimodal users***
3. ***Different environmental programs offer different directional options***
4. ***Communication between CI and HA audiologist key to providing similar directional input across ears***

Bimodal Fitting Consideration #3: Music Perception

Bimodal Hearing Aid Programming & Music Perception: Background

ReSound GN

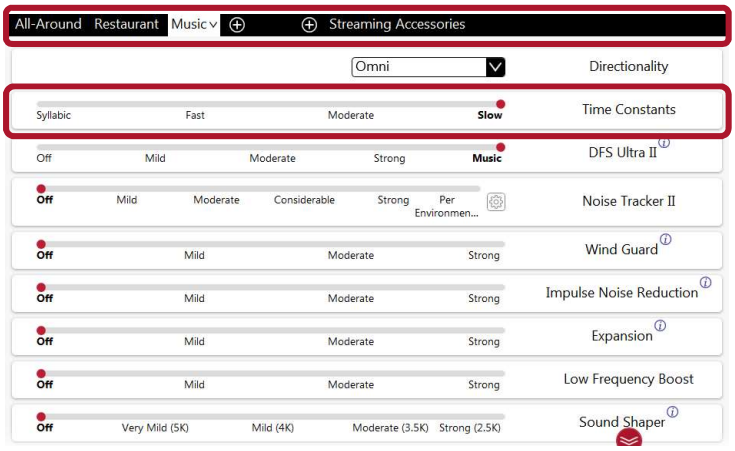
- Cochlear implants provide great timing cues, like rhythm, but limitations remain for music perception & enjoyment
  - Routinely rate music enjoyment lower than normal hearing users
- Hearing aids alone also have their limitations for this population
  - Amplification limitations & limited lyric understanding
- Bimodal stimulation can improve sound quality, ease of listening and lyric recognition beyond HA or CI alone[16]
  - Combines the best of both devices!



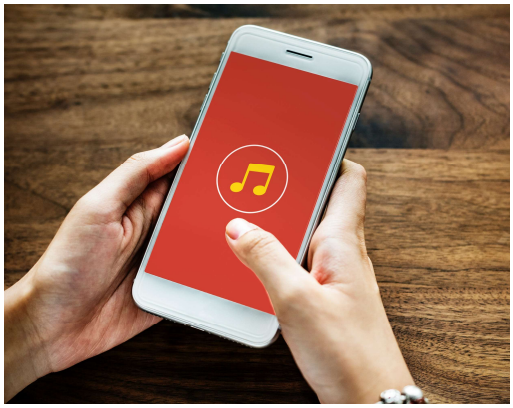
Wolfe, J. Cochlear Wireless Accessories for Bimodal Users. Presentation, San Antonio, TX, 2015

Bimodal Hearing Aid Programming & Music Perception: Smart Fit Fitting Considerations

- Music Program
  - More linear environmental gain offsets
- Compression speed
  - Defaults to Slow
- Feedback suppression
  - Music setting to prevent feedback suppression or distortion of high pitched musical instruments
- Low Frequency Boost
  - Available for UP receivers & Super Power devices



Bimodal Hearing Aid Programming & Music Perception: Streaming & Phone Programs



- Music & audio streamed through hearing aid & cochlear implant
  - Able to stream phone call audio, music, audiobooks, videos, and app audio (tinnitus stimuli)
- Research has shown access to bimodal streaming can improve Quality of Life in Social Activities for bimodal patients[17]
- Accessories vs. iPhone/Smartphone/tablet Streaming
  - Different audio routing have different defaults in Smart Fit
  - Opportunity to utilize streaming for music perception, speech perception on the phone, and auditory rehab
- Patient technology literacy a key factor for implementation
  - HA, CI, & phone tech will all dictate optimal programming

Bimodal Hearing Aid Programming & Music Perception: Accessories

Streaming Accessories

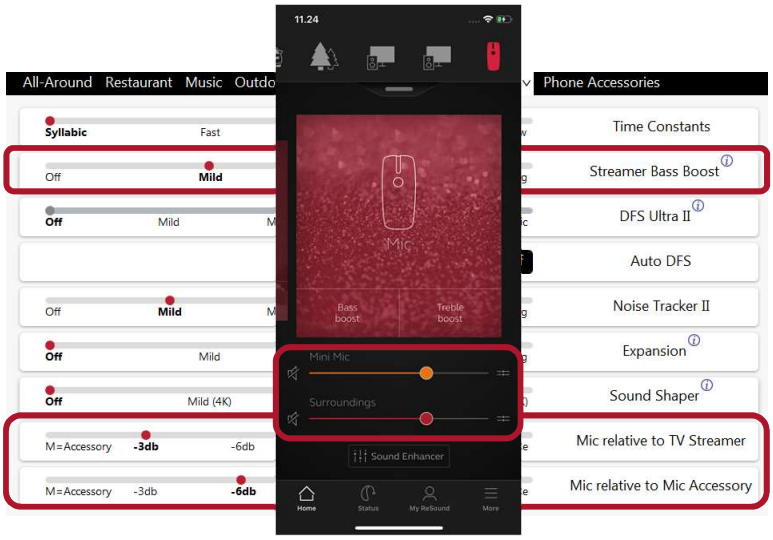
Phone Streaming Accessories

Bimodal Hearing Aid Programming & Music Perception: Accessory Program settings

Streaming Accessory Program

- Independent Gain/advanced feature settings from environmental programs
- Streamer Bass Boost defaults ON
- Music Setting for DFS available
- Accessory/HA Microphone balance

- Smart 3D app provides patient control
  - Mic Balance
  - Bass//treble boost



Bimodal Hearing Aid Programming & Music Perception: Bimodal Phone Streaming Benefits

- Providing bimodally-streamed audio improves patient performance over the phone[18]
  - Word recognition when using Phone Clip+
- Performance improved in both quiet and in noise compared to bimodal acoustic option
- Streaming provides direct audio without signal loss or struggling to find the hearing aid or cochlear implant on ear microphone

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

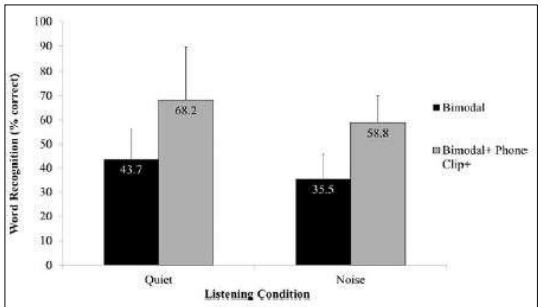
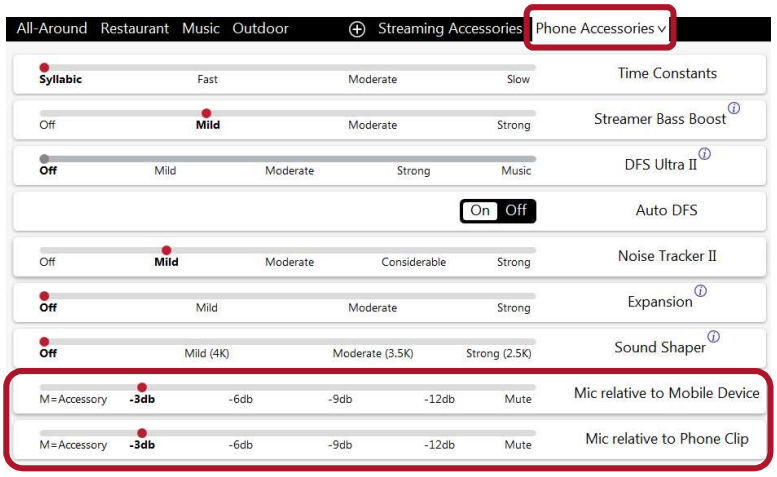


FIG. 4. Average word recognition in the quiet and noise conditions over the mobile telephone.

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.

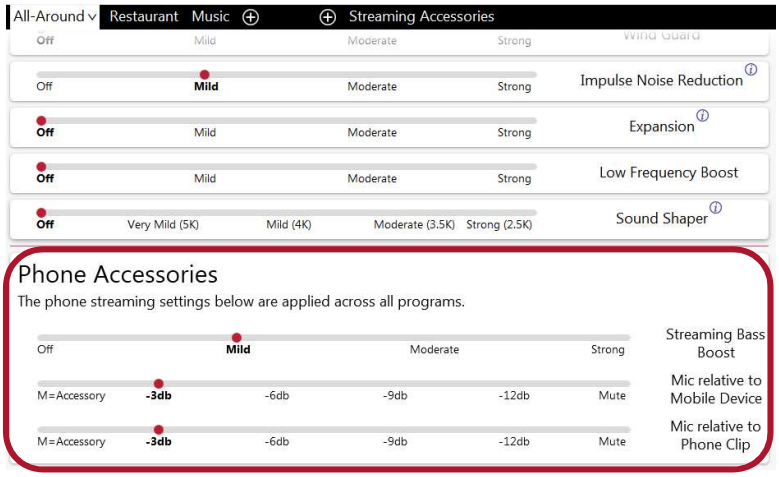
Bimodal Hearing Aid Programming & Music Perception: LiNX 3D, ENZO 3D, and legacy phone program settings

- LiNX 3D, ENZO 3D & legacy devices utilize a dedicated phone streaming program
- Default settings similar to streaming accessories program
  - Key difference is the microphone balance
- Phone call volume controlled by phone volume settings
  - Additional volume controls on Phone Clip +

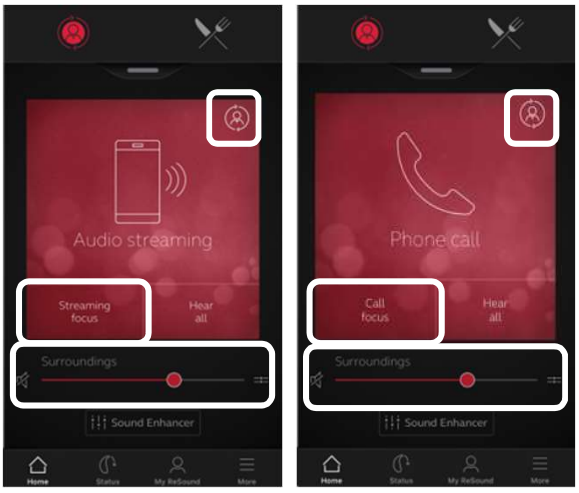


Bimodal Hearing Aid Programming & Music Perception: LiNX Quattro & Mix-In Phone Program

- LiNX Quattro devices utilize “Mix-In” phone streaming
  - Streamed audio input initiated faster
- Provides audio through current HA program’s setting
- Phone Accessory Settings apply across all environmental programs



Bimodal Hearing Aid Programming & Music Perception: LiNX Quattro & Mix-In Phone Program



- While streaming, Smart 3D app provides different options compared to environmental program options
  - Streaming/Call Focus
  - Surroundings Volume
    - Controls Hearing aid microphone volume
- Phone volume controls the audio/phone call audio

Phone Streaming Compatibility

MFi Streaming with Nucleus 7

- ✓ ReSound LiNX Quattro RHAs & RIEs
- ✓ ReSound LiNX 3D BTEs & RIEs
- ✓ ReSound ENZO 3D BTEs

Phone Clip+ Streaming with Nucleus 6

- ✓ ReSound LiNX Quattro RHAs & RIEs
- ✓ ReSound LiNX 3D full family
- ✓ ReSound ENZO 3D BTEs
- ✓ ReSound LiNX2 full family
- ✓ ReSound ENZO2 BTEs
- ✓ ReSound LiNX RIE
- ✓ ReSound ENZO BTEs
- ✓ All families back to ReSound Alera!

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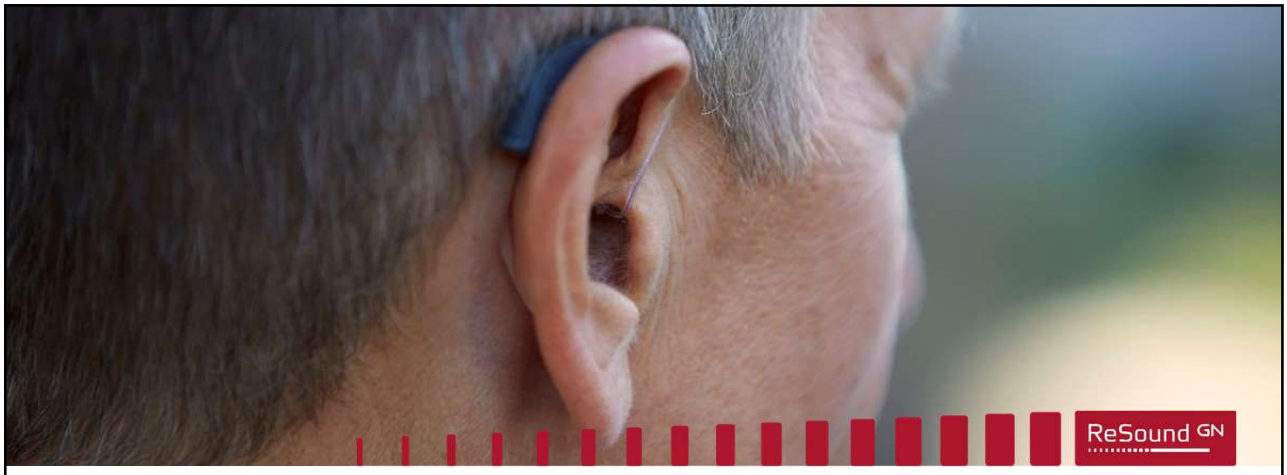

Bimodal Fitting Consideration #4: Tinnitus

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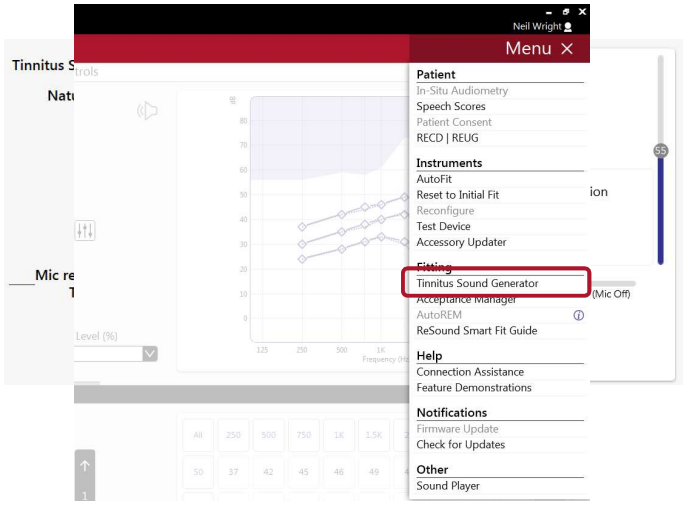
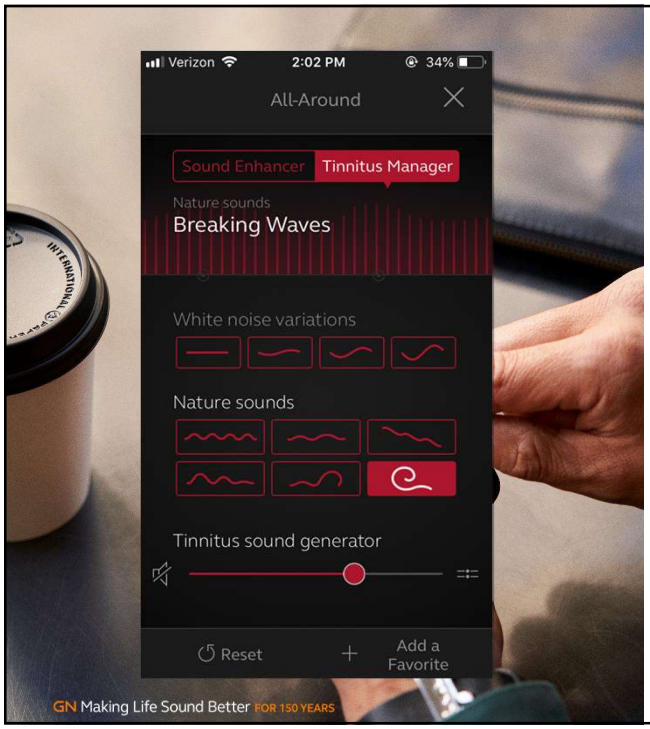
Bimodal Hearing Aid Fitting Considerations & Tinnitus: background

- Tinnitus reportedly affects ~67-86% of cochlear implant candidates[19]
- Tinnitus & Cochlear implant research shows that many implant users who report tinnitus pre-implantation report a reduction in tinnitus post-implant[19]
  - Not true in all cases
  - Some users report new/increase in tinnitus (rare)
- Perception of tinnitus can complicate CI mapping, making it more difficult for patients and audiologists[20]
- Tinnitus perception/intensity varies between patients
- Providing options for patients with tinnitus is critical

Bimodal Hearing Aid Fitting Considerations & Tinnitus: Smart Fit Options



- Tinnitus stimuli can be program specific
  - White, pink, speech, or high frequency noise options
    - Customize Hz range
    - Modulation degree/speed
  - Nature Sounds
- Volume control can control Stimulus level or Stimulus + environment
- Mic balance



Bimodal Hearing Aid Fitting Considerations & Tinnitus: Smart 3D app controls

- Programs set with TSG in Smart Fit will provide addtional "Tinnitus Manager" controls
- White Noise Variations: Ability to change frequency range, depth of modulation, and volume
- Nature Sounds provide 6 different calming naturescapes
- User can switch between White noise and nature sounds – regardless of the program's initial settings

Bimodal Hearing Aid Fitting Considerations & Tinnitus: ReSound Relief Tinnitus App

ReSound Relief app

- ReSound Relief app provides preset and customizable soundscape options for bimodal patients to stream sounds bilaterally
- Recent research has shown that use of the Relief app in CI patients can provide some tinnitus relief[21]
- Audio Streamed through Nucleus 6 processor using smartphone, tablet, or iPod and Multi Mic (Mini Mic 2+)
- Study found that all users showed a reduction in tinnitus loudness rating
- There were large differences in benefit between users
- Further research needed to confirm benefits for larger group, bimodal users

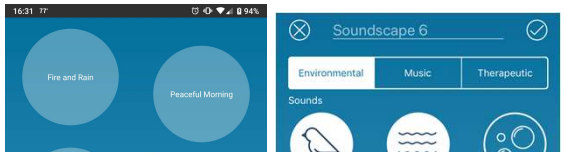
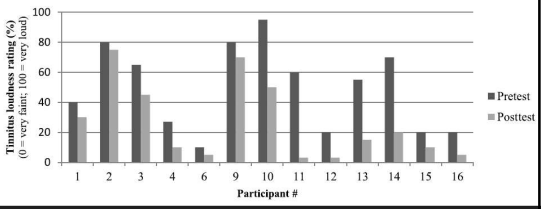
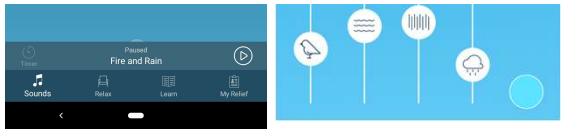


Figure 3. Shown are the pretest and posttest measures of tinnitus loudness during the laboratory trial.





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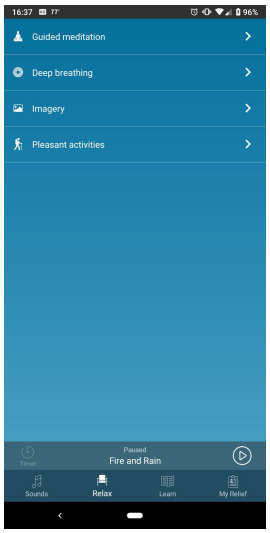
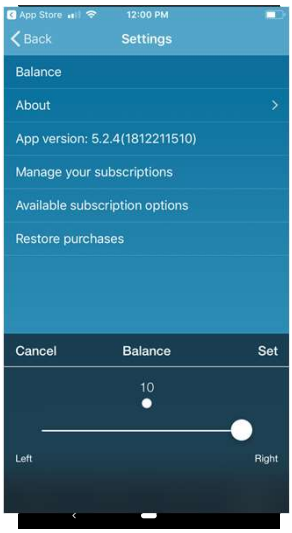
Bimodal Hearing Aid Fitting Considerations & Tinnitus: ReSound Relief Tinnitus App

ReSound Relief app





Beyond just Soundscapes…

- Relax
  - Guided Meditations, breathing exercises
- Learn
  - Sleep, tinnitus info, app introduction
- My Relief
  - Usages stats
  - Access to personalized plans
  - New download Options
  - Settings
    - Audio Balance Option

Bimodal Hearing Aid Fitting Considerations & Tinnitus: Key takeaways

1. ***Bimodal users need options for tinnitus management depending upon the location and degree of tinnitus reported***
2. ***Noise and environmental tinnitus stimuli are available via Smart Fit & provide a customizable experience in different environmental programs***
3. ***Streaming via Phone Clip+, MFi, or streaming accessories provides options for streaming tinnitus stimuli to both the CI and HA for bimodal users***
4. ***ReSound Relief app has shown promise in reducing Tinnitus loudness rating for CI users, more testing needed in Bimodal users***

Conclusions & Wrap Up

- **Bimodal stimulation can provide improved speech-in-noise perception, localization, and music perception compared to either cochlear implant or hearing aids alone**
- **Bimodal patients require unique considerations for hearing aid fittings**
- **REM verification of the hearing aid output is critical to success of bimodal patients**
- **Directional settings provide options to improve SNR in real-world environments for bimodal patients**
- **Streaming offers improved sound quality for music and phone calls for bimodal patients**
- **Bimodal users who experience tinnitus have a variety of options, including options in Smart Fit and the ReSound Relief App**

Thanks!

Questions?
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