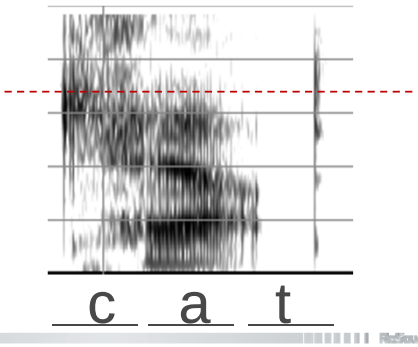
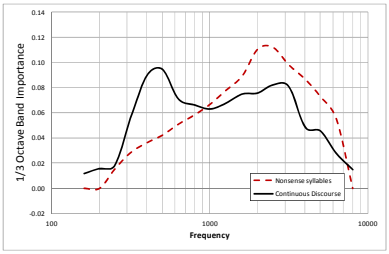
INTRODUCING RESOUND SOUND SHAPER: A UNIQUE IMPLEMENTATION OF FREQUENCY COMPRESSION

Tammara Stender, Au.D.
Principal Audiologist
GN ReSound

The man was wearing a __at on his head.



Effect of linguistic redundancy on band importance



Knowledge about the language helps you "guess" what is being said and changes the relative importance of different frequency areas.

Possible Reasons for Trouble with Traditional Amplification

- Amplification-related limitations
  - Feedback from high gain requirements in the high frequencies
  - Receiver limitations
- Physiological "dead region"
  - Providing high frequency amplification for severe hearing losses may not be beneficial, as the inner hair cells may not be functional

Amplification

/s/ /ʃ/ /f/



Why frequency lowering?

What is frequency lowering?

- Frequency lowering = moving sound from higher-frequency areas to lower-frequency areas
- Audibility at "misplaced" frequencies is better than no audibility
- Most common frequency-lowering strategy = frequency compression

Frequency compression is an alternative tool

3 Types of Frequency Lowering

No FL

- Frequency Transposition
  - Superimposes the unreachable high frequencies to low frequency range

- Frequency Compression
  - Compresses the entire frequency spectrum into the range of the patient's residual hearing
  - Reduces the bandwidth
  - Compression ratio can be constant (proportional FC) or variable (non-proportional FC)

- Frequency Translation
  - Signal-dependent frequency transposition
  - Tries to target speech

Recent Research on Frequency Compression

- Arehart et al., 2013
  - **Working Memory, Age, and Hearing Loss: Susceptibility to Hearing Aid Distortion**
    - Older listeners with hearing loss and poor working memory are more susceptible to distortions caused by at least some types of hearing aid signal-processing algorithms and by noise, and that this increased susceptibility should be considered in the hearing aid fitting process.

Arehart KH, Souza P, Baca R, Kates JM. Working Memory, Age, and Hearing Loss: Susceptibility to Hearing Aid Distortion. Ear Hear. *2013:34(3);251-60.*

Recent Research on Frequency Compression

- Ching et al., 2013
  - **A randomized controlled trial of nonlinear frequency compression versus conventional processing in hearing aids: Speech and language of children at three years of age**
    - Kids fitted with NLFC had higher receptive and expressive language, *however…*
    - Receptive vocabulary and consonant articulation scores were lower for children who use NLFC
    - Increased substitution of affricates by fricatives by kids fitted with NLFC
    - Insufficient evidence to indicate a difference in global language ability

Ching TYC, Day J, Zhang V, Dillon H, Van Buynder P, Seeto M, Hou S, Marnane V, Thomson J, Street L, Wong A, Burns L, Flynn C. A randomized controlled trial of nonlinear frequency compression versus conventional processing in hearing aids: Speech and language of children at three years of age. Int J Audiol. *2013:52(S2);S46–S54.*

What about Dead Regions?

- Baer et al., 2002; Vickers et al., 2001
  - For listeners with severe-profound high-frequency hearing loss and extensive high-frequency dead regions, amplification is useful for frequencies up to about 1.7 times the lower edge frequency (*Fe*) of the dead region.

Baer T, Moore BCJ, Kluk K. (2002). Effects of low pass filtering on the intelligibility of speech in noise for people with and without dead regions at high frequencies. J Acoust Soc Am., 112:1133–1144.

Vickers DA, Moore BCJ, Baer T. (2001). Effects of low-pass filtering on the intelligibility of speech in quiet for people with and without dead regions at high frequencies. J Acoust Soc Am., 110:1164–1175.

What about Dead Regions?

- Cox et al., 2012
  - **Implications of High-Frequency Cochlear Dead Regions for Fitting Hearing Aids to Adults with Mild to Moderately Severe Hearing Loss**
    - Overall, adult hearing aid wearers with mild to moderately severe hearing loss benefitted from high-frequency gain, whether or not they had dead regions.
    - Provision of NAL-NL1 high-frequency gain never resulted in poorer performance in groups with our without dead regions, as compared to a low-pass target rule with NAL-NL1 targets provided up to 1KHz.
      - *NOTE: Some users reported preference for the low-pass target rule as they thought NAL-NL1 was "too loud." However, today's more widely used NAL-NL2 rule incorporates lower prescriptive levels due to this complaint about NAL-NL1, so results with NAL-NL2 might alleviate this complaint.

Cox, R.M., Johnson, J.A., Alexander, G.C. (2012). Implications of High-Frequency Cochlear Dead Regions for Fitting Hearing Aids to Adults With Mild to Moderately Severe Hearing Loss. Ear and Hearing,33(5), 573–587.

What about Dead Regions?

- Moore et al., 2011; Ricketts et al., 2008
  - **Steeply sloping hearing losses** tend to prefer a **narrower** bandwidth, while people with a shallower slope with hearing loss, regardless of the magnitude of hearing loss, tend to prefer a broader bandwidth.

Moore, B. C. J., Fullgrabe, C., Stone, M. A. (2011). Determination of preferred parameters for multichannel compression using individually fitted simulated hearing aids and paired comparisons. Ear and Hearing, 32(5), 556-568.

Ricketts, T. A., Dittberner, A. B., Johnson, E. E. (2008). High-frequency amplification and sound quality in listeners with normal through moderate hearing loss. Journal of Speech, Language, and Hearing Research, 51(1), 160-172.

However…

- In general, a review of the current literature on listeners with dead regions suggests that providing high frequency amplification for the dead region (up to 1.7 times the Fe) yields better or equivalent results as compared to not providing it/rolling it off.

Ricketts TA. Hearing Aid Features Across Manufacturers: What Really Works and Clinical Implications. Illinois Academy of Audiology Convention, Chicago, Jan. 29, 2014.

The Research Continues On

- Hopkins et al., 2014
  - **Benefit from non-linear frequency compression hearing aids in a clinical setting: The effects of duration of experience and severity of high-frequency hearing loss**
    - NLFC was beneficial for consonant recognition (especially /t/ and /s/), but not for speech recognition in noise.
      - Best for /t/ and /s/
    - No evidence to support that a long period of acclimatization is needed to gain full benefit.
    - Questioned the audibility of the compressed signal for patients with more severe hearing losses, using manufacturer default settings
      - Milder losses showed more benefit from NLFC, but that could have been due to measured inaudibility of compressed signals

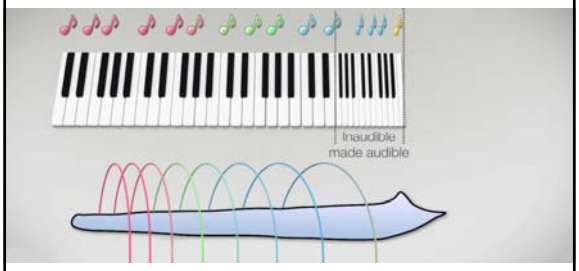
Hopkins K, Khanom M, Dickinson A, Munro KJ. Benefits from non-linear frequency compression hearing aids in a clinical setting: The effects of duration of experience and severity of high-frequency hearing loss. Int J Audiol. *2014:53;219-228.*

What is ReSound Sound Shaper™

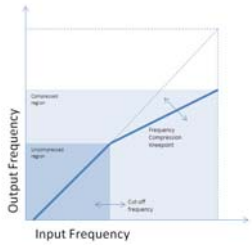
ReSound Sound Shaper:

- Improves audibility of speech cues
- Maintains the best sound quality possible

What is ReSound Sound Shaper™

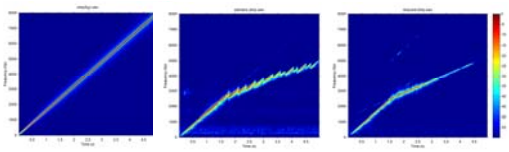


ReSound Sound Shaper™ Details



- Move high frequency sounds that may not be audible due to high frequency losses or dead zones and move these down in the frequency spectrum where audibility might be better
- This is implemented via controls for two key parameters in Aventa: Frequency Compression Kneepoint and Ratio

Proportional vs. non-proportional

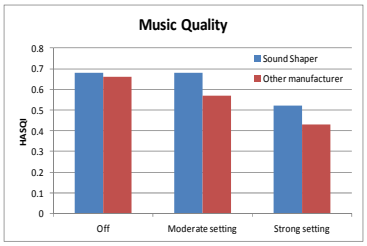


Unprocessed
Pure tone sweep

Non-proportional
Approach – more
distortion

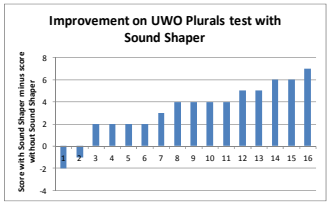
Proportional
Approach – less
distortion

Comparison to Other Approaches



Results in agreement with preferences of normal hearing listeners, and those with hearing loss

Clinical results



Applying Sound Shaper™

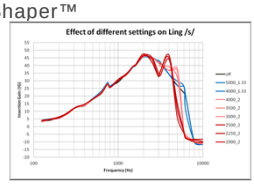
- It is difficult to determine who might be a candidate for frequency lowering thus, Aventa will always default for Sound Shaper to be **off**
  - In most cases, you will be able to provide good audibility without activating Sound Shaper
  - Conventional amplification can be expected to provide good audibility for a wide bandwidth for most hearing losses
- If the fitting professional decides to activate Sound Shaper, Aventa will recommend a setting when the hearing loss may also be appropriate for it

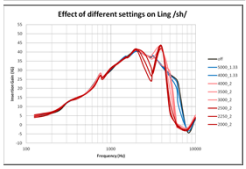
Development of Sound Shaper

- 3 Objectives:
  - Provide distinct settings that could provide user audibility benefits
  - Preserve sound quality to the extent possible
  - Simplify fitting of the feature

Development of Sound Shaper™

Setting ID	Cut-off [Hz]	CR
"Off"	n/a	n/a
1 (weakest)	5000	1.33
2	4000	1.33
3	4000	2
4	3500	2
5	3000	2
6	2500	2
7	2250	2
8 (strongest)	2000	2





Development of Sound Shaper

- Default setting is off
- Other settings:

Sound Shaper setting	Cut-off frequency and Compression Ratio
Mild	4000Hz, CR 1.33:1
Moderate	3500Hz, CR 2.0:1
Strong	2500Hz, CR 2.0:1

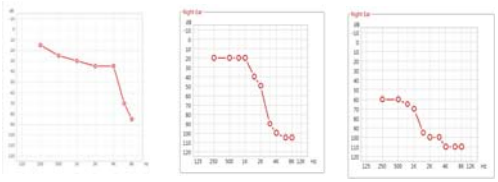
Guide to Sound Shaper Setting Criteria

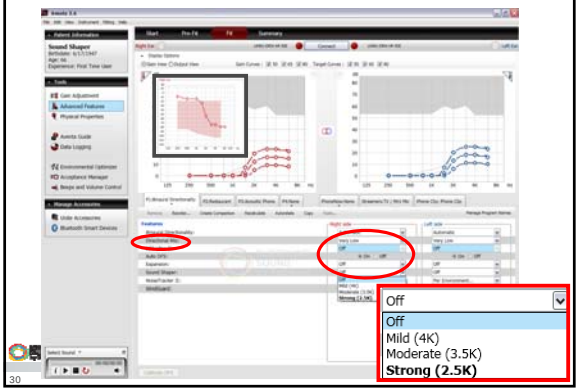
- "Off" – Default setting for all hearing losses
- "Mild"
  - Recommended if the audiogram has a slope ≥ 10 dB per octave frequency, and the slope begins ≥ 4000 Hz
- "Moderate"
  - Recommended if the audiogram has a slope ≥ 10 dB per octave frequency, and the slope begins at 2000 Hz
- "Strong"
  - Recommended if the audiogram has a slope ≥ 10 dB per octave frequency, and the slope ends ≥ 2000 Hz

Applying Sound Shaper™

Recommended setting considers configuration and severity of hearing loss per ear

Mild | Moderate | Strong





Shading Indicates Frequencies Affected by Sound Shaper when it is Activated

How Do You Ensure Audibility? General Principles:

1. Verify/fine-tune frequency response without frequency lowering
2. Evaluate whether there could be benefit (also considering factors other than the real ear results like cognition, previous experience, etc.)
3. Turn on frequency lowering to manufacturer-recommended setting and measure.
   - If audibility is still not achieved, it could be that the hearing aid is not powerful enough for the hearing loss

Objective is to find the least aggressive setting that increases audibility.

Verifying Sound Shaper

What Happens in an Open Fitting?

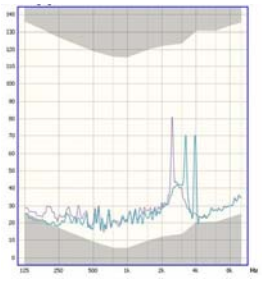
- To answer this question:
  - ReSound LiNX, open fitting
    - Low gain setting
    - Turned on Sound Shaper
      - Note the cut-off frequency (4000 Hz, 3500 Hz, or 2500 Hz)
  - Run a pure tone at a high frequency above the cut-off frequency for the setting (using an output view).
  - Run a pure tone at a lower frequency than the cut-off frequency

What Happens in an Open Fitting?

- Pure tone above cut-off frequency:
  - Two peaks:
    - Original unprocessed tone that enters the ear canal directly via the open fit AND
    - The same tone compressed, that is coming from the hearing aid
- Pure tone below cut-off frequency:
  - One peak at original pure tone frequency (not compressed).

What Happens in an Open Fitting?

- **Example:** Moderate Sound Shaper setting (3.5KHz cut-off frequency)
- **Blue:** 4KHz tone, 2 peaks due to lowered output and unprocessed signal via the open fit
- **Purple:** 2.5KHz tone, not lowered



Recommendations

- Do not turn Sound Shaper on if
  - The recommended (bolded) setting is “off”
  - Patient has known cognitive issues
- Consider using Sound Shaper if
  - The recommended setting is not “off” and
    - Low frequency thresholds are worse than 20 dB HL
    - Patient does not have known cognitive issues
    - Patient has confirmed cochlear dead region in the high frequencies (e.g. via TEN test)
    - It is not possible to reach high frequency targets
    - Patient reports that high frequencies sound distorted

Final Notes on Sound Shaper

- Sound Shaper settings may be different for each ear, based on each ear’s hearing thresholds
- Sound Shaper may be activated in one or more program, for one or both ears

Review

Thank You!

- tstender@gnresound.com