Best Practice Protocols

SoundRecover for children

What is SoundRecover?

SoundRecover (non-linear frequency compression) seeks to give greater audibility of high-frequency everyday sounds by compressing sounds that a child is unable to hear to a lower frequency region where a child can hear better. SoundRecover compresses the signal above a specified cut-off frequency. The degree of compression applied to this high-frequency band is defined by the compression ratio. The spectrum below the cut-off frequency remains unchanged to avoid vowel artifacts.[1,7] When fitting SoundRecover to children using DSL v5, a different pre-calculation is used compared to adults. These default settings for SoundRecover for pediatric fittings are based on research from the University of Western Ontario and are implemented in Phonak Target™ fitting software.

Why perform verification?

As with all pediatric fittings, it is important to measure the output of hearing instruments with SoundRecover to check that prescriptive targets are met and the child has access to important speech cues. The aim of this report is to provide current best-practice guidance for verifying the electroacoustic characteristics with SoundRecover on and off.

How to verify SoundRecover?

The following clinical protocol for verifying hearing aids with frequency lowering technology such as SoundRecover is designed to assist clinicians with optimizing hearing aid settings.[3] For current best practice, both live voice and calibrated signals are acceptable. However, functionality and availability of stimuli varies among the different verification devices. Below is a step-by-step general protocol that can be used across devices to verify SoundRecover. This general protocol has been applied in several studies of SoundRecover in the pediatric population.[1,2,5,7]

1. Disable SoundRecover in the hearing aids within the fitting software.

2. Evaluate the shape and gain of the hearing aid fitting using speech stimuli with SoundRecover disabled.

   a. Ensure that the aided speech spectra meet prescriptive targets as broad a bandwidth of audibility as possible. If necessary, adjust the output response to optimize the fitting.

   b. MPO measurements are not valid in the frequency-lowered region. Therefore, always measure MPO with SoundRecover disabled.

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3. Enable SoundRecover. Choose moderate-level stimuli (i.e. live voice and/or calibrated signals) that represent /s/ and /sh/ sounds respectively.

   a. Fine-tune the hearing aid settings to optimize audibility of these sounds within the child's audible range. It is important to note that audibility of /s/ is not always possible depending upon the extent and configuration of hearing loss.

   b. Use the weakest SoundRecover setting that provides audibility when possible and check for separation of /s/ and /sh/.

4. Perform a listening check prior to completing a fitting with SoundRecover. Due to some fittings having high output levels, it may be helpful to listen to the output of the hearing aids via the test box. For example, headphones can be plugged into some test boxes allowing the ability to adjust the volume and to listen to the aided responses during verification. If you cannot detect any difference between aided /s/ and /sh/, consider the spectral overlap of these sounds, and the possibility of a weaker SoundRecover setting.

5. Perform other measurements as needed for troubleshooting or further fine tuning.

   a. If /s/ or /sh/ is not audible, repeated measurements with additional fine tuning to the hearing aid may assist in discovering a setting that provides more audibility.

   b. If subjective feedback indicates /s/ and /sh/ confusion, a setting that provides less frequency compression while maintaining audibility for high-frequency sounds may be needed.

   c. Live voice productions of /s/ and /sh/ can provide an estimate of audibility and frequency band perception. However, live voice signals do not give a calibrated method for estimating audibility. Therefore, there are different calibrated test signals which can be used to represent /s/ and /sh/ across verification systems. For system-specific background knowledge and troubleshooting, please refer to the documents: Electroacoustic verification of SoundRecover using the Audioscan Verifit® or Electroacoustic verification of SoundRecover using the GN Otometrics AURICAL located in the pediatric web tool box via the following link: https://www.phonakpro.com/us/b2b/en/pediatric/pediatric_fitting/pediatric-web-tool-box.html

6. Provide post fitting support.

   a. Provide information and guidance for caregivers, therapists or anyone else who may do a listening check on the hearing aids. It is important to recognize the sound quality will differ from conventional hearing aids. One approach is to alert caregivers or therapists that sound quality may differ from previous hearing aids, and that listening checks should focus on changes from baseline rather than on whether sound quality is similar to the child's previous hearing aids. Hearing care professionals need to incorporate feedback from therapists and family on the perception of high-frequency sounds (i.e. /s/) in the child's program to support discrimination skills, word recognition and therefore, language development. It is helpful to include the child's production of the different speech sounds (e.g. /s/, /f/, /sh/, etc) to optimize auditory discrimination skills.

Note: Some fitting cases can provide additional challenges and may include factors such as tinnitus masking, dead regions, and auditory neuropathy. Feel free to request fitting support if needed from your local Phonak representative.

Available stimuli for verifying SoundRecover

Live voice productions

Live voice is an option which is available across various verification devices. This allows for the estimation of the audibility and evaluating the true bandwidth of phonemes such as /s/ and /sh/.

Live voice has the following advantages:

   a. Some sounds such as /sh/ can be several octaves wide. Live voice is beneficial for looking at the entire frication bandwidth. This may be helpful for estimating how much of that sound is audible across a wider frequency

range. In cases of steeply sloping, severe to profound high frequency hearing loss, the audibility of /s/ or /sh/ may be limited to only the lower shoulder of the frication band. In such cases, this information can prove to be helpful for estimating audibility and whether fine tuning can provide additional benefit.

b. Because live speech sounds reflect true bandwidth, they are well suited for evaluation of frequency overlap between /s/ and /sh/. For example, if confusion between /s/ and /sh/ is a concern (i.e. feedback from the Speech and Language Pathologist or Auditory Verbal Therapist or the individual using this technology), measuring these phonemes carefully may help in evaluating if too much frequency compression has been applied.

Live voice has the following possible limitations:

a. Live voice is not presented at a calibrated level and talker gender differences will impact responses. Take caution to present speech sounds with normal vocal effort which can be monitored via a sound level meter in some verification systems and at a normal distance and azimuth to the hearing aid microphone(s). This test should be done in a quiet room.

b. Male and female talkers will produce /s/ at different frequencies. A male /s/ is typically about 5-6 kHz while female /s/ is 7 kHz or higher.[3,4]

Filtered speech with high-frequency bands of energy

Calibrated filtered speech test signals have energy surrounding the specific 1/3 octave band and have been notched out to provide better visualization of the speech band. Test stimuli with the following center frequencies can be selected by the clinician: 3150, 4000, 5000, or 6300 Hz. These speech bands have the following advantages:

a. They are presented at a calibrated level.

b. The test is repeatable both in intensity level and frequency.

c. The speech bands at 4000 Hz and 6300 Hz provide a reasonable estimate of the center frequency for /sh/ and /s/, respectively.

These signals have the following possible limitations:

a. The 1/3 octave band filtered signals are narrower than the frication band of naturally produced speech sounds (i.e. /sh/ or /s/). This may lead to a conservative estimate of audibility.

b. These signals are presented at the level of the Long Term Average Speech Spectrum (LTASS) at that test frequency. This presentation level is slightly lower than the level of /sh/ or /s/ would be in clearly articulated speech. This may lead to a conservative estimate of audibility.

c. This test allows evaluation only to 6300 Hz, while a female /s/ is typically higher in frequency.

Calibrated Ling 6 /sh/ and /s/ signals

The calibrated Ling 6 test stimuli are derived from the Ling 6 (HL) test from the University of Western Ontario, but are presented in SPL and provide the reference for the test.

These signals have the following advantages:

a. It provides a calibrated set of stimuli spoken by a female speaker. This allows for the estimation of audibility of these phonemes.
b. Similar to live voice, these calibrated speech sounds better reflect the true bandwidth of the frication bands and are well suited for evaluation of frequency overlap between /sh/ and /s/. If confusion between /sh/ and /s/ is a concern, measuring these phonemes can help evaluate the settings and determine if too much frequency compression has been applied.

These signals have the following possible limitations:

a. GN Otometrics recommends that clinicians present the Ling /s/ and /sh/ at an overall level of 65 dB SPL. Further evaluation is needed in order to determine the effectiveness of this method.

Case example A:
Illustrating the frequency lowering fitting protocol with different commercially available verification devices.

The following case illustrates a typical fitting for a child who has high-frequency thresholds in the severe range (figure 1).

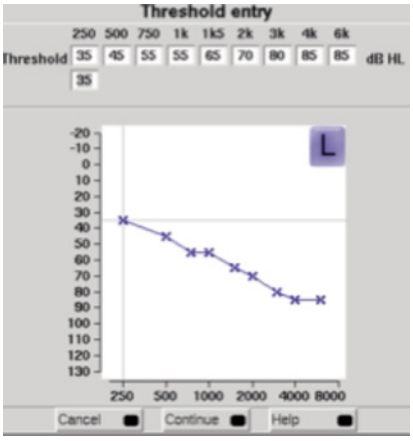

Figure 1: Audiogram

A modern hearing aid is fitted without SoundRecover. The hearing aid response begins to roll off above about 5000 to 6000 Hz. Audibility is poorer for the high-frequency energy in soft speech (green) and high-frequency sounds such as a female production of /s/ (figure 2).

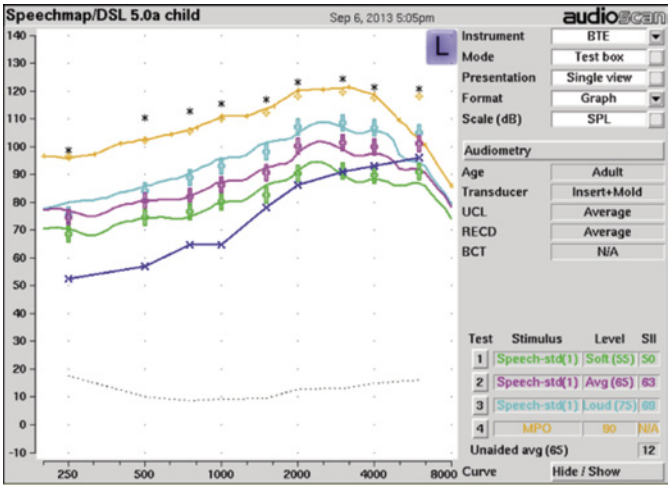

Figure 2: Hearing aid output responses with SoundRecover off

The limitations of high-frequency audibility for speech sounds can be evaluated using the live voice production of /s/ and /sh/. Without frequency lowering, the /s/ sound (green area) is not likely audible for soft speech inputs while /sh/ (purple area) is audible (figure 3).

With frequency lowering enabled (figure 4), more of the /sh/ bandwidth is audible and /s/ is now clearly audible and above threshold. The peak frequency area and lower shoulder of the

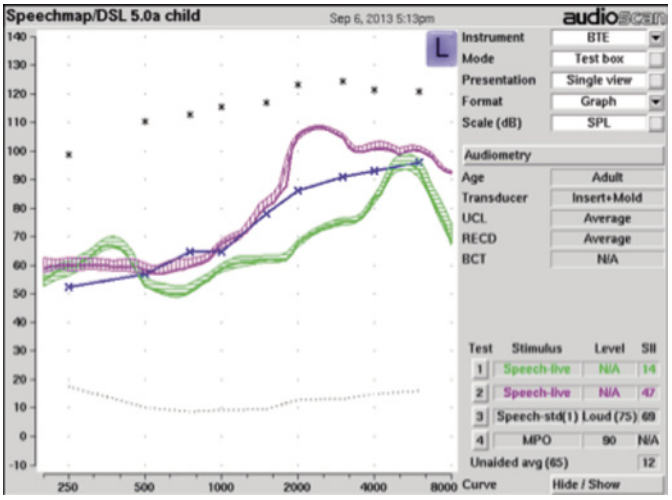

Figure 3: Live speech—SoundRecover off

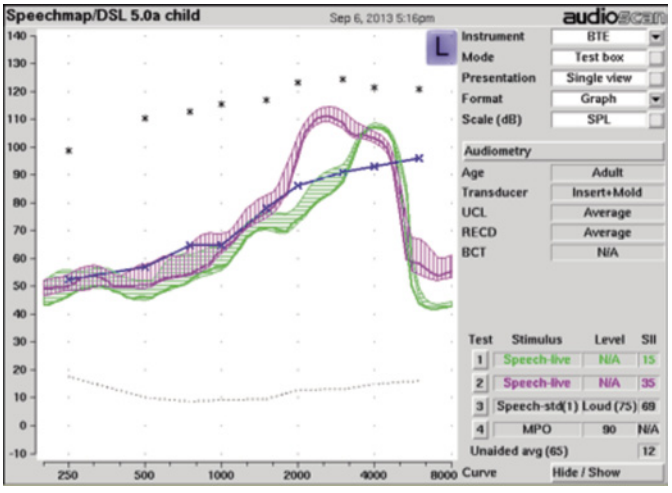

Figure 4: Live speech—SoundRecover on

frequency lowered fricatives are non-overlapping, which may support discrimination of /s/ and /sh/ sounds.

Because this fitting was done using one clinician's voice as the test signal, future follow up should monitor whether functional benefits are also obtained in real life. Another option for verifying this fitting is the use of the filtered speech bands offered by the Audioscan Verifit®. Two of the test signals, "Speech4000" (green curve) and "Speech6300" (purple curve), are shown with and without SoundRecover (figures 5 & 6 respectively). They are filtered to show a 1/3 octave band of speech centered around those frequencies. Details regarding the construction and calibration of these signals are provided in the Verifit user's manual and discussed in Glista and Scollie (2012).[1]

The limitations of high-frequency audibility for speech sounds can also be evaluated using the calibrated Ling 6 sounds available in the GN Otometrics AURICAL. They can be found under the FreeFit option. Choose "Signal Type" and then "Ling S" or "Ling SH" along with the intensity level.

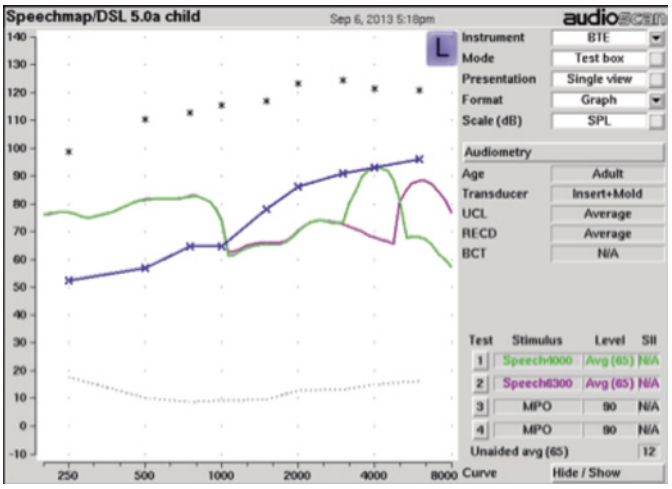

Figure 5: Filtered signals with SoundRecover off

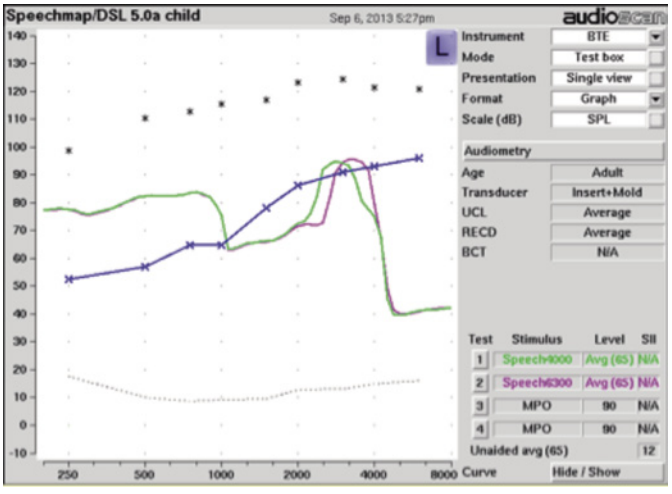

Figure 6: Filtered signals with SoundRecover on

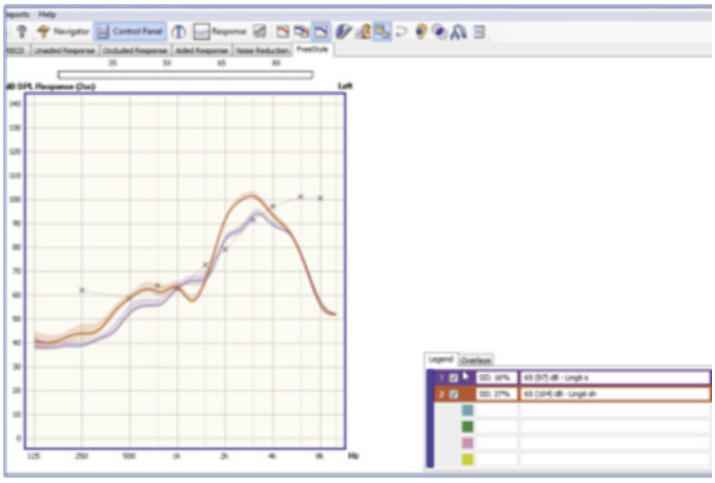

Figure 7: Ling 6 /s/ and /sh/ with SoundRecover off

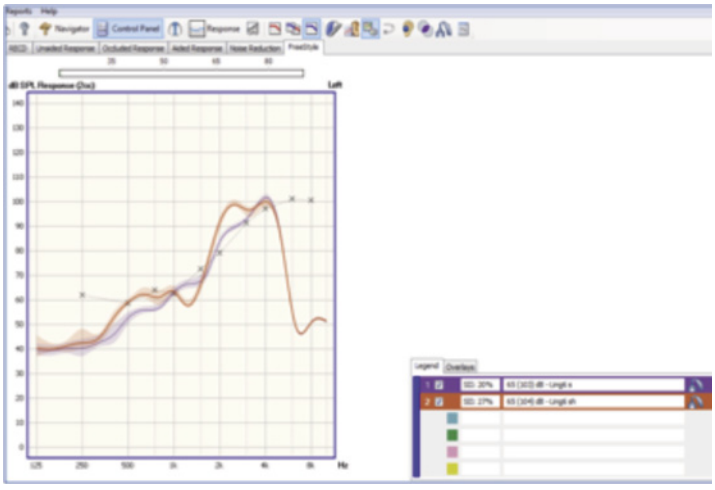

Figure 8: Ling 6 /s/ and /sh/ with SoundRecover on

The example in Figure 7 demonstrates limited audibility of /s/ and the shoulder of /sh/ without SoundRecover. However, with SoundRecover enabled (Figure 8), both /s/ and /sh/ are audible, and the fitting shown is likely acceptable for real world use. The peak frequency area and lower shoulder of the frequency lowered fricatives are non-overlapping, which may support discrimination of /s/ and /sh/ sounds.

These examples using stimuli for evaluating frequency lowering available in different verification devices illustrate the same fitting conclusions as with live speech production:

1. The use of SoundRecover is necessary to obtain better audibility for the 6300 Hz speech band representative of /s/ or a calibrated Ling 6 /s/.

2. The output responses are non-overlapping which can support discrimination of /s/ and /sh/ sounds.

These test approaches (live speech, speech bands or calibrated Ling 6 fricatives) provide similar results, as shown by this example. For this reason, clinicians can choose to select their preferred test/s. However, if there are fitting concerns related to inaudibility or spectral overlap of /s/ and /sh/, then additional testing and fine tuning is recommended. The next example will demonstrate how to potentially manage the concerns of spectral overlap or limited audibility.

Case example B: (This case has been previously published in ENT & Audiology News (2011)[5]

Illustrating the role of fine tuning using the Audioscan Verifit® This child (John) was seen for fine-tuning of the frequency compression settings in his hearing aids. He has a steeply sloping loss, with severe to profound hearing loss in the high frequencies (figure 9).

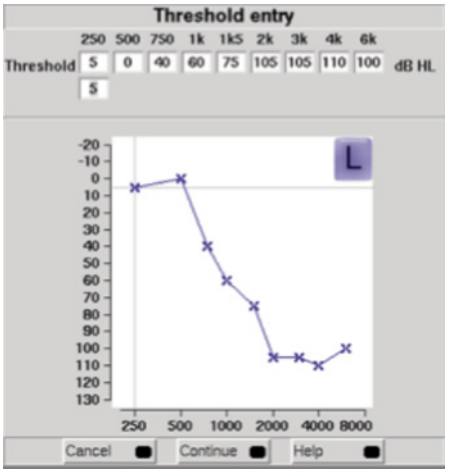

Figure 9: Audiogram*

Verification measures using the Audioscan Verifit® were completed according to the verification protocol discussed earlier in this document. Measurements suggest the default setting (2100 Hz cut-off, 4:1 compression ratio) did not provide sufficient audibility of high-frequency sounds for either speech bands (figure 10) or live speech sounds (figure 11).

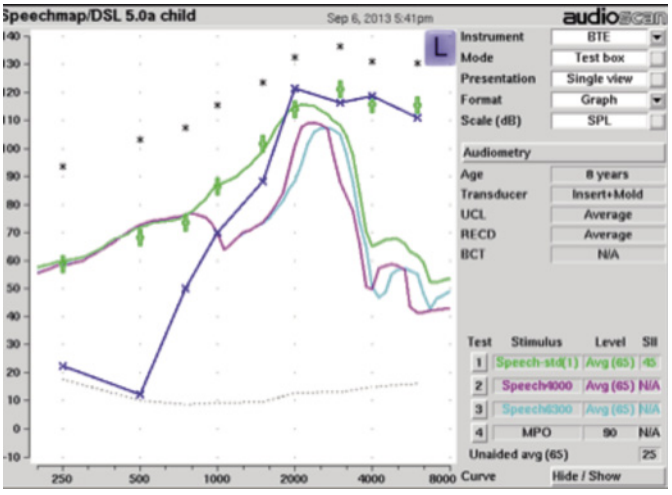

Figure 10: Filtered signals with SoundRecover with default settings*

Verification measures were completed with a revised, stronger SoundRecover setting (1600 Hz cut-off, 4:1 compression ratio). Results for the filtered speech bands test (figure 12) indicate that 6300 Hz (yellow curve) for /s/ is clearly not audible.

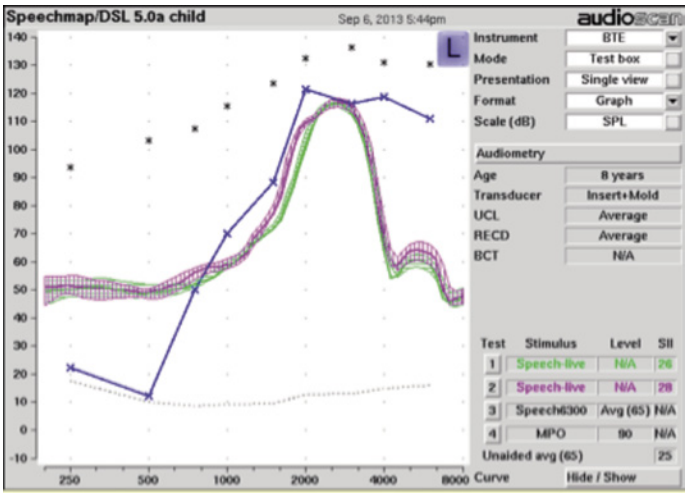

Figure 11: Live speech with SoundRecover with default settings*

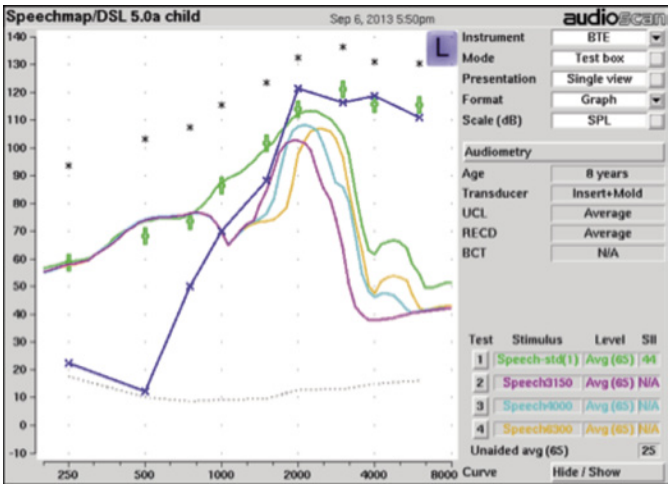

Figure 12: Filtered signals with stronger SoundRecover setting*

The borderline audibility of 3150 and 4000 Hz (purple and blue curves respectively) raises concern that the /sh/ sound might not be audible. In order to evaluate audibility for /sh/, the live speech tests were completed. Results suggest audibility of /sh/ is available across the low-frequency shoulder of the /sh/ frication band as indicated by the purple spectrum (figure 13). The live /s/ sound is clearly not audible. Due to the severity of John's hearing loss and limitations of the hearing aid, audibility of high-frequency sounds beyond 4 kHz could not be achieved, likely impacting detection and recognition of /s/ (green area).

Behavioral outcome measurements were completed with each hearing aid condition (default setting and the stronger SoundRecover setting). These results (figure 14) provide further information regarding whether fine tuning was effective in this older child. Overall, they suggest that the fine-tuned setting provided better access to speech sounds than the original setting. This case illustrates the importance of fine tuning to optimize audibility, but also that audibility of all frequencies and speech sounds may not always be possible.

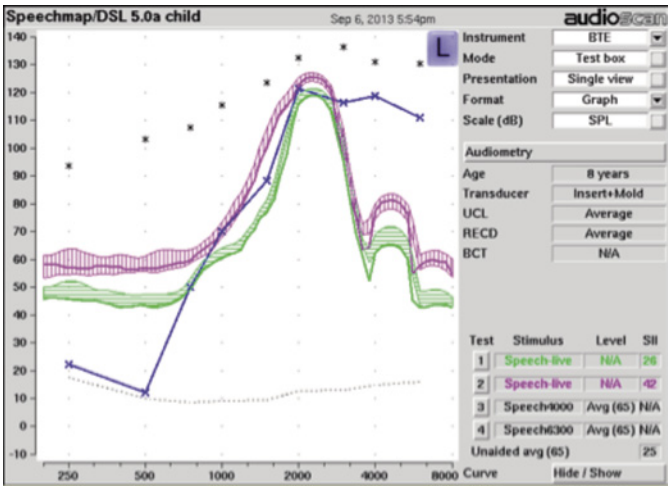

Figure 13: Live speech with stronger SoundRecover setting*

Test	Percent correct score Setting 1	Percent correct score Setting 2	Interpretation
Nonsense syllables	56%	69%	Significant improvement with the revised settings
Discrimination of s/sh	37%	65%	Significant improvement with the revised settings

Figure 14: Behavioral outcome measures for nonsense syllables and /s/ and /sh/ discrimination for different SoundRecover settings*

Clinical implications when using different stimuli for verifying SoundRecover

The 1/3 octave band high-frequency speech band tests appear to be valid electroacoustic stimuli that can quantify the degree and nature of frequency compression. The use of live voice productions of /s/ and /sh/ as a verification option is recommended.[5] In addition, calibrated Ling 6 stimuli can provide a signal that more closely represents the true frication bandwidth of live speech stimuli. The following are important to note:

1. The use of live voice productions of /s/ and /sh/ are recommended because of their face validity. However, it is important to be aware of differences in frequency between female and male productions of high frequency sounds.[2] The calibrated Ling 6 stimuli for /s/ and /sh/, reflect more closely the true bandwidth of live voice productions for high frequency phonemes and can be well suited for evaluation of frequency overlap between /s/ and /sh/.
2. The 6300 Hz speech band provides a good approximation of a naturally produced female /s/ sound.
3. None of the frequency-specific speech bands provide a good approximation of /sh/, because they are narrower in bandwidth than a /sh/ sound. However, the 4000 Hz and 6300 Hz speech band tests can be used in combination to establish audibility of /sh/.

Summary

This document illustrates how various stimuli such as live voice and filtered speech signals can be used for verifying SoundRecover by:

1. Demonstrating whether sounds such as /s/ and /sh/ are audible and the application of SoundRecover may increase audibility of /s/ and sometimes /sh/ depending upon the severity and audiometric configuration.

2. Checking the amount of overlap created from a specific SoundRecover setting. For example, as SoundRecover settings are made stronger, /s/ and /sh/ are subject to a greater amount of overlap. As these sounds become more similar in frequency, (i.e. the bandwidth of /s/ gets smaller with more SoundRecover applied) this creates the potential for sound confusion. This demonstrates procedures for further fine tuning with a weaker setting and repeating all electroacoustic measures.

3. Although overlap is an area of concern requiring detailed evaluation, further research is needed to be able to quantify "how much" overlap can occur while still maintaining the ability to discriminate between two phoneme patterns (i.e. /s/ and /sh/).

*Permission to use images in this document were granted by ENT & Audiology news as well as the authors.[5]

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