Field Study News

July 2016

SoundRecover2

More audibility of high-frequency sounds for adults with severe to profound hearing loss

This study was conducted at Phonak headquarters, Stäfa Switzerland, and used aided thresholds and the Phoneme Perception Test to compare SoundRecover and SoundRecover2. Twenty seven adults with severe to profound hearing loss participated in the study. While many adults with severe to profound hearing loss obtain improved audibility of high frequencies from SoundRecover, those with insufficient hearing near the lowest cut-off frequency (1.5 kHz), require remapping of frequencies to an even lower frequency, in order to extend the perceptual auditory bandwidth of hearing. The results of this study indicate that SoundRecover2 in Naída V BTEs improves the detection and recognition of voiceless high-frequency phonemes for adults with severe to profound hearing loss. In particular, those with insufficient hearing to benefit from SoundRecover, can now enjoy the benefit of frequency compression with SoundRecover2.

Objective

The objective of this study was to compare the benefit of the new SoundRecover2 with the original SoundRecover algorithm in Naída Venture Behind-The-Ear hearing aids (BTEs) for adults with severe to profound high-frequency hearing loss.

Introduction

Frequency lowering techniques which remap frequencies to extend the perceptual auditory bandwidth of hearing aid users have been commercially available for approximately 10 years now. Phonak introduced SoundRecover non-linear frequency compression, with the first Naída in 2007, offering a solution for restoring audibility of conventionally unaidable high-frequency sounds. The benefits of the SoundRecover frequency lowering were described by McDermott (2010). Subsequent extensive worldwide studies with adults and children have found increased detection, distinction and recognition of high-frequency sounds. (Uys et al 2015, Hopkins et al 2015, Wolfe et al 2010 and 2011, Glista and Scollie 2009, McCreery et al 2014, Scollie et al 2016).

While many adults with severe to profound hearing loss obtain improved audibility of high-frequencies from SoundRecover, those with insufficient hearing near the lowest SoundRecover cut-off frequency of 1.5 kHz, require remapping of frequencies to an even lower cut-off frequency in order to extend their perceptual auditory bandwidth of hearing. Lowering the cut-off frequency below 1.5 kHz, risks placing the compressed sound into a frequency region where vowel information is present. The new SoundRecover2 algorithm aims to restore the audibility of high-frequency sounds while leaving intact the low-frequency structures important for good sound quality. SoundRecover2 retains the essence of SoundRecover, and additionally introduces an adaptive algorithm and a lower cutoff frequency in order to successfully extend these benefits to those with more severe to profound hearing loss.

This study investigates whether SoundRecover2 in Naída V BTEs can improve the detection and recognition of voiceless high-frequency phonemes for adults with severe to profound high-frequency hearing loss. Adults who require a lower cut-off frequency than possible with the original SoundRecover were expected to receive greater benefit from SoundRecover2.

Study design

The study design included single blinded, objective testing of aided thresholds (ATs) and the Phoneme Perception Test (PPT). In addition participants wore the Naída V hearing aids at home during the whole of the test period and between test sessions. The results were analyzed using an analysis of variance (ANOVA) with repeated measures.

Participants

Twenty seven adults participated in the study. All have severe to profound hearing loss. The average audiograms for all participants indicate moderate sloping-to-profound hearing loss which is essentially symmetrical (Figure 1).

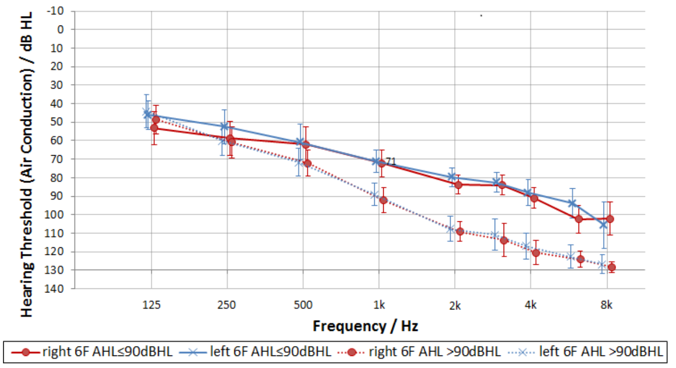

Figure1: PTA grouped by the 6F AHL: 250 to 8000 Hz for 16 participants with 6F AHL≤90 dBHL and 11 participants with 6F AHL >90dBHL.

When the average air conduction thresholds for the frequencies 250, 500, 1000, 2000, 4000 and 8000Hz were calculated, two groups of participants could be identified. 16 participants had a 6 frequency pure tone average of 90 dBHL or less (6F AHL ≤90dBHL) and better high-frequency thresholds than the remaining 11 participants with a more profound hearing loss in the high frequencies and a 6 frequency pure tone average greater than 90 dBHL (6F AHL >90 dBHL). The average Pure Tone Audiogram (PTA) falling into two groups can be seen in Figure 1.

Aided thresholds

Aided thresholds were measured using warble tones in the free field. The frequency range 250 Hz to 8 kHz was measured. Stimuli were presented from a loudspeaker at 0° azimuth at a distance of one meter. An ascending technique was used for threshold searching. 10 of the 11 participants with 6F AHL >90 dBHL and 14 of the 16 participants with 6F AHL≤90dBHL completed the aided thresholds. The remaining participants were unavailable.

Detection and recognition of high-frequency consonants

The Phoneme Perception Test is a language independent speech test developed specifically to evaluate high-frequency hearing (Boretzki et al 2011, Schmitt et al. 2016). The PPT includes three subtests, Detection, Distinction and Recognition. In this study the Detection and Recognition subtests were used to evaluate the high-frequency detection and recognition thresholds.

The Detection Test is a threshold seeking technique similar to free field audiometry. The Recognition Test measures the participants' ability to identify different high frequency speech sounds like /sh/ or /s/ from a closed set of phonemes. For both subtests the stimuli included /sh/ centered on 3 kHz (sh3 or Ascha3) and 5 kHz (sh5 or Ascha5), /s/centered on 6 kHz (s6 or Asa6) and 9kHz (s9 or Asa9). All sounds were presented from 0° azimuth and from a distance of 0.8 meters. From those with 6F AHL >90 dBHL, 8 of the participants completed the PPT and for those with a 6F AHL ≤90 dBHL, 12 completed the PPT.

Hearing aids

Each participant was fitted binaurally with Phonak Naída V90-SP/UP and Q90-SP/UP hearing aids coupled to their individual earmolds via an ear hook and standard tubing. SuperPower (SP) or UltraPower (UP) BTEs were selected based on each individuals' audiogram. The hearing aids were programmed using Phonak Target 4.3 fitting software, and the manufacturer's proprietary fitting strategy Adaptive Phonak Digital (APD) was applied. All default features and settings were activated. Frequency compression was activated per default.

Results

Aided thresholds

The results of the aided threshold (AT) measurements are shown in Figure 2 and Figure 3. Figure 2 shows the aided thresholds for 14 of the participants with 6F AHL<90 dBHL. ATs were measured for both algorithms in the Naída V. This was to ensure that the only difference between test conditions was the frequency compression algorithm. Comparing the ATs for the two frequency compression algorithms (red and green lines in Figure 2) shows identical thresholds, except for a small variation in frequencies above 1.5 kHz, where frequency compression is active. A second comparison was made, this time with one algorithm (SoundRecover) in two different hearing aids, Naída Q (gray) and Naída V (red). In this case, the resulting ATs are more similar than in the first comparison. Taken together, these results indicate that ATs are more sensitive to differences between the algorithms than other differences between the hearing aids. It is therefore assumed that it is valid to compare the two algorithms in Naída V hearing aids only.

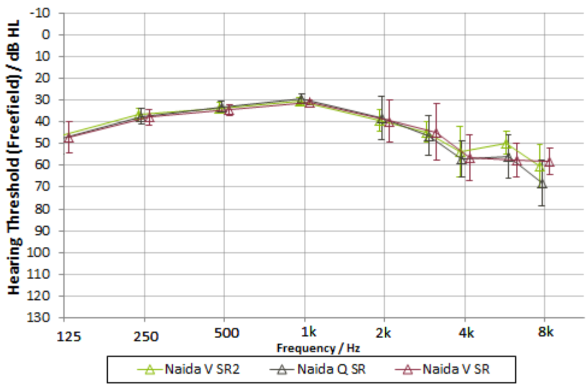

Figure2. Aided thresholds for 14 participants with 6F AHL<90 dBHL. Thresholds are for SoundRecover in Naída Q/Naída V and for SoundRecover2 in Naída V.

As stated earlier, Figure 2 shows the ATs for participants with 6F AHL<90 dBHL. These participants have an average hearing threshold at 2 kHz (adjacent to the 1.5 kHz cut off) at around 80 dBHL, shown in Figure 1. Figure 3 shows the aided thresholds for 10 participants with 6F AHL >90 dBHL and an average threshold at 2 kHz of 110 dBHL shown in Figure1. It is likely that while the former have adequate hearing to benefit from a 1.5 kHz cut off, the latter participants may have insufficient hearing near the lowest SoundRecover cut-off frequency of 1.5 kHz, to benefit.

If this is correct, the remapping of frequencies to a lower cut-off frequency may extend the perceptual auditory bandwidth for these participants. For those with a 2 kHz threshold around 110 dBHL, the ATs for high-frequencies would be expected to be better with SoundRecover2 (and the lower cut-off frequency) than with the 1.5 kHz cut-off.

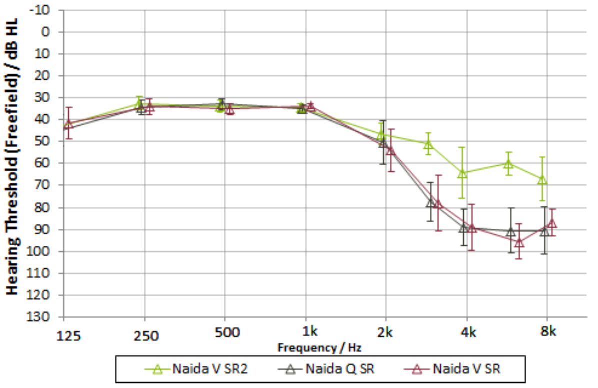

Figure3. Aided thresholds for 10 participants with 6F AHL >90 dBHL. Thresholds are for SoundRecover in Naída Q/Naída V and for SoundRecover2 in Naída V.

The results for participants with 6F AHL >90 dBHL confirm improved high-frequency hearing thresholds (2kHz to 8kHz) for SoundRecover2 compared to SoundRecover. The improvement in that frequency range is in the order of 10 to 20 dB. At the same time the aided thresholds for low and mid frequency warble tones (250 Hz to 1 kHz) are unchanged. Given these results, we expect the detection thresholds for high-frequency consonants (when measured with the PPT and SoundRecover2), to improve for participants with 6F AHL >90 dBHL and expect no change for those with 6F AHL≤90dBHL with SoundRecover2. For all participants, no change would be expected in consonants and vowels where the dominant energy falls in low and mid frequencies.

Detection and recognition of high-frequency consonants

The results of the Phoneme Perception Test (PPT) indicated improvement in thresholds for SoundRecover2 compared to SoundRecover for those with 6F AHL>90 dBHL only, as predicted by the aided thresholds. For the Detection Test, SoundRecover2 showed better detection thresholds at a statistically significant level for sh5 and s6 ($p<0.001$) and for s9 ($P=0.01$). As seen in Figure 4, the reduction in the detection threshold was in the order of 10 to 20 dB.

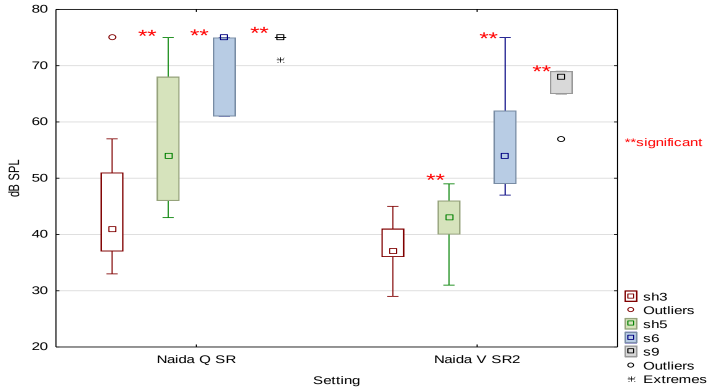

Figure 4. Detection thresholds for 8 participants with 6F AHL >90dBHL. measured with SoundRecover in Naída Q and SoundRecover2 in Naída V hearing aids.

The Recognition Test indicated a better recognition threshold for Asha5 for SoundRecover2, again, only for those with 6F AHL>90 dBHL. The recognition threshold for Asha5 was lower at a statistically significantly level for SoundRecover2 ($p<0.001$). As seen in Figure 5, for this recognition threshold, there was also less range in thresholds for SoundRecover2. The reduction was again in the order of 20 dB.

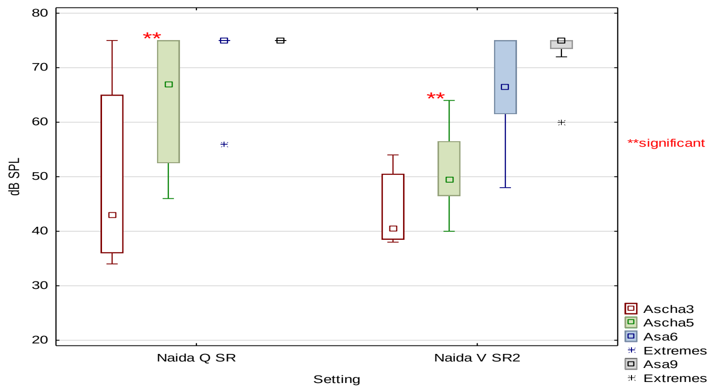

Figure5. Recognition thresholds for 8 participants with 6F AHL >90 dBHL. Measured with SoundRecover in Naída Q and SoundRecover2 in Naída V hearing aids.

The benefits of SoundRecover2 measured here, were evident in real world experience. Many of the participants wore Naída V and SoundRecover2 at home. Their subjective reports confirmed that the increased audibility of high-frequency sounds was a benefit in their everyday life experiences. Some examples of their comments follow:

> "I am now able to hear birds and forest noises. This is great as I was not able to hear this with my previous hearing aids."

> "I was always able to hear the sound of the fountain in the reception area. But now, I can actually recognize that it is a fountain."

> "I can now hear people talking behind me even when they are further away."

> "I can now hear the clock ticking which I could not hear with my own hearing aids."

Conclusion

For those with a 6F AHL>90 dBHL and an average 2 kHz threshold around 110 dBHL, we can conclude that remapping of frequencies to a lower cut off frequency using SoundRecover2 resulted in an extended perceptual auditory bandwidth. For them, SoundRecover2 increases the audibility of high frequency sounds significantly.

The aided threshold measurements were a good indicator of the further findings with the PPT. For those with a 6F AHL≤90 dBHL, it may be assumed that improved audibility of high-frequency sounds was achieved with SoundRecover and that SoundRecover2 did not increase the benefit for them. This was confirmed using the PPT where, for these participants, no significant difference was found in detection and recognition thresholds between the two algorithms.

These test results show that SoundRecover2 in Naída V BTEs improve the detection and recognition of voiceless high frequency phonemes for adults with severe to profound hearing loss. In particular, those with audiograms that resulted in a more restricted audible bandwidth in which frequency compression could be applied, can now enjoy the benefit of frequency compression with SoundRecover2.

References

Boretzki M, Schmitt N, Kegel A, Krueger H, Rehmann J, Eichhorn F, Meisenbacher K, Raether J. (2011) Future Directions in Evaluating Frequency Compression. In: A Sound Foundation Through Early Amplification. Proceedings of the International Pediatric Audiology Conference. November 8-10, 2010, Chicago, USA, 201-203.

Glista, D., and S. Scollie. (2009) Modified Verification Approaches for Frequency Lowering Devices. In Audiology Online. Vol. November. 1-11.

Hopkins K, Khanom M, Dickinson AM, Munro KJ (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. International Journal of Audiology 53: 219-228.

McCreery, R.W., J. Alexander, M.A. Brennan, B. Hoover, J. Kopun, and P.G. Stelmachowicz. (2014) The influence of audibility on speech recognition with nonlinear frequency compression for children and adults with hearing loss Ear and Hearing. 35(4):440-447

McDermott, H. (2010). SoundRecover - The importance of wide perceptual bandwidth. Phonak Background Story.

Rehmann, J., Allegro Baumann, S., Siddhartha Jha, S., (2016) SoundRecover2 – the first adaptive frequency compression algorithm: More audibility of high-frequency sounds. Phonak Insight.

Schmitt, N., Winkler, A., Boretzki, M., Holube, I. (2015). A phoneme perception test method for high-frequency hearing aid fitting. Journal of the American Academy of Audiology.

Scollie, S., D. Glista, J. Seto, A. Dunn, B. Schuett, M. Hawkins, N. Pourmand, and V. Parsa. (2016) Fitting frequency-lowering signal processing applying the AAA Pediatric Amplification Guideline: Updates and protocols. Journal of the American Academy of Audiology, 27(3):219-236
International Journal of Audiology.

Wolfe, J., Duke, M., Schafer, E., Rehmann, J., Jha, S., John, A., Jones, C. (2016). Preliminary evaluation of a novel non-linear frequency compression scheme for use in children. Submitted to International Journal of Audiology.

Wolfe J, John A, Schafer E, Nyffeler M, Boretzki M, et al. (2010)

Uys, M and Latzel, M (2015), Long-Term Effects of Non-Linear Frequency Compression on Performance of Music and Speech Perception. Commun Disord Deaf Stud & Hearing Aids, 3:3.

Wolfe, J., Duke, M., Schafer, E., Rehmann, J., Jha, S., John, A., Jones, C. (2016). Preliminary evaluation of a novel non-linear frequency compression scheme for use in children. Submitted to Evaluation of nonlinear frequency compression for school-age children with moderate to moderately severe hearing loss. Journal of the American Academy of Audiology 21: 618-628.

Wolfe J, John A, Schafer E, Nyffeler M, Boretzki M, et al. (2011) Long term effects of non-linear frequency compression for children with moderate hearing loss. International Journal of Audiology 50: 396- 404.

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Investigators

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