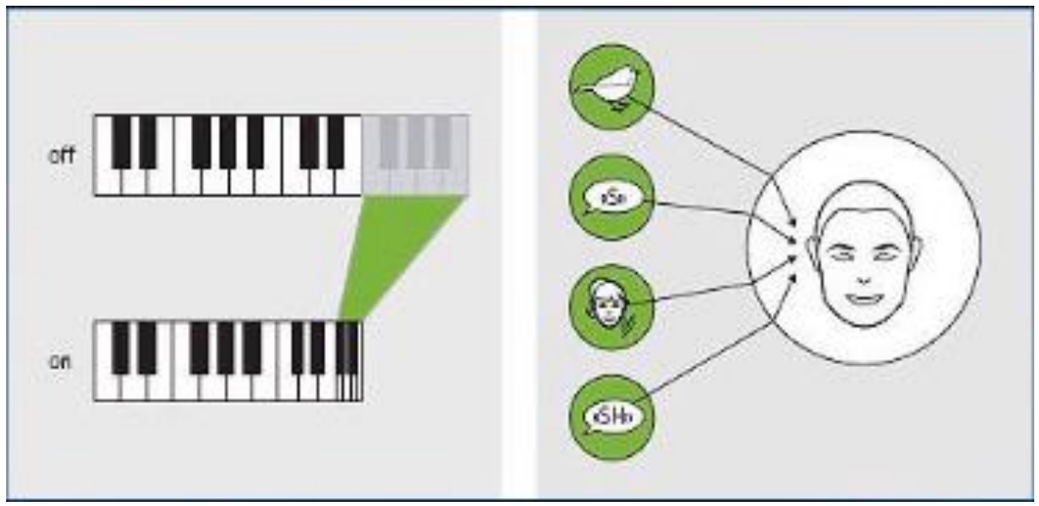
SoundRecover: non-linear frequency-compression scheme



PHONAK
life is on

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Progetti
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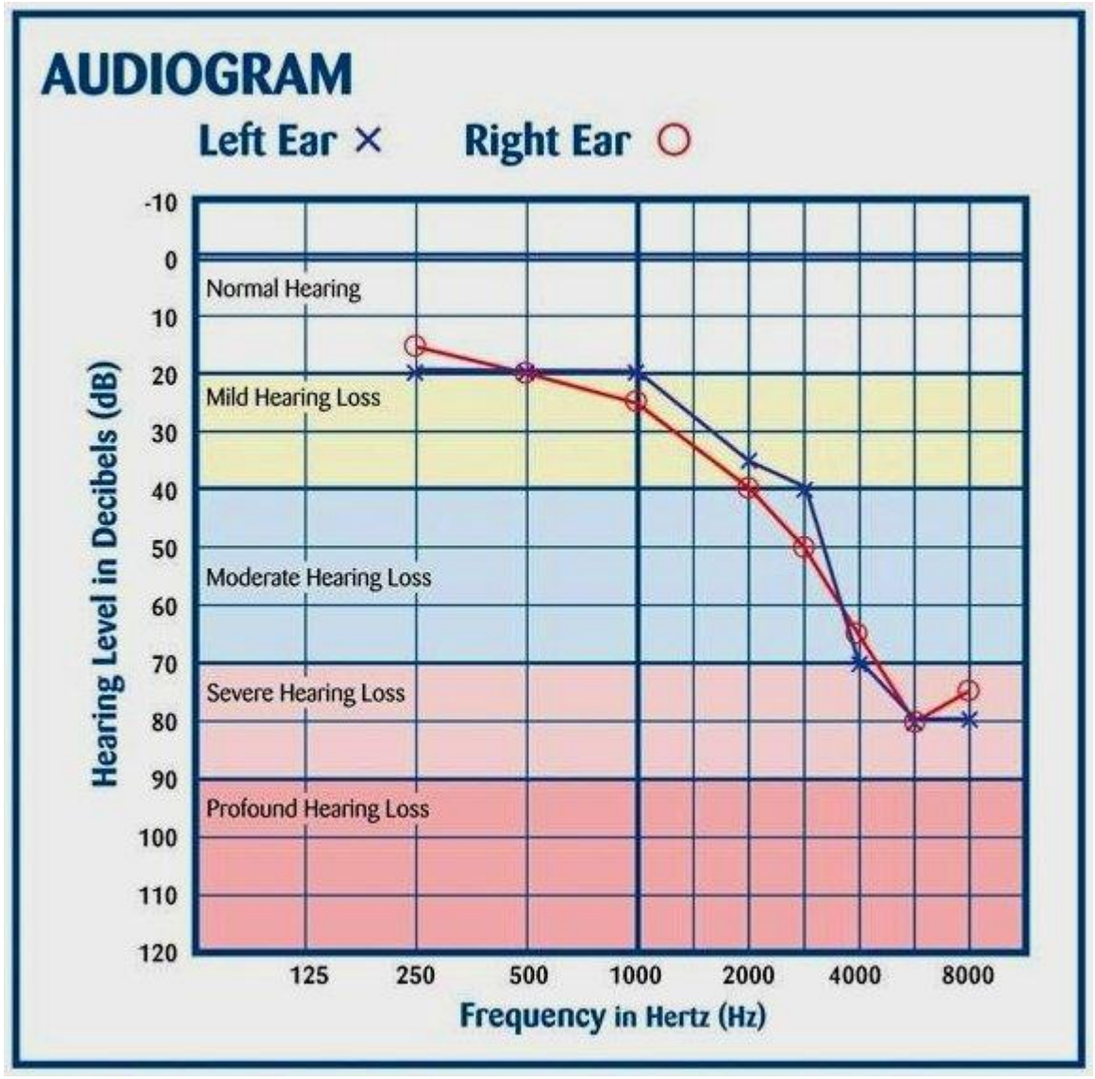
Outline of Backgound Information of Audiology and Social Relevance of Hearing Loss



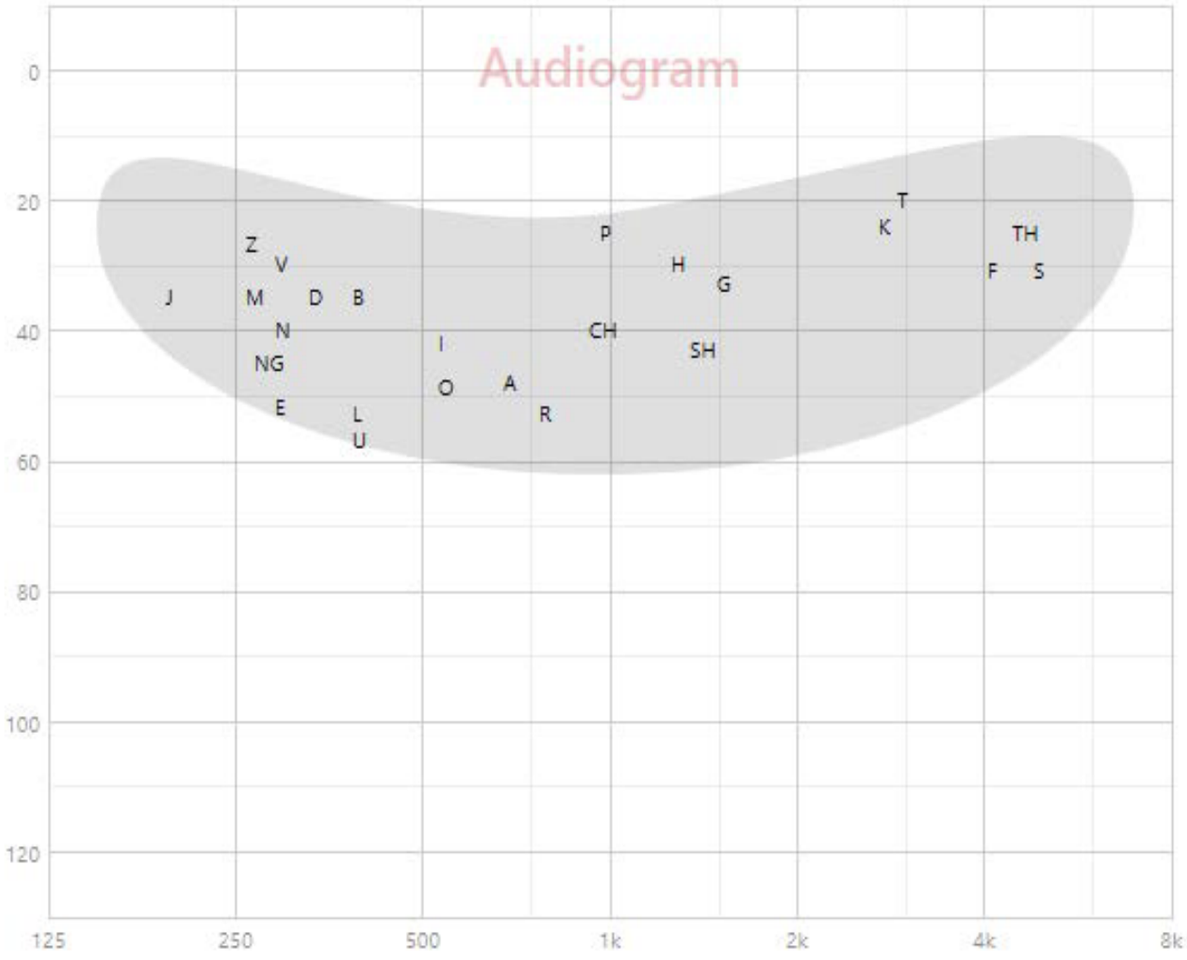
Social isolation — especially as we age — increases the risk of numerous mental and physical health (depression, heart disease, abnormal immune systems, dementia and Alzheimer's disease). According to several studies, social isolation is associated with a "reduction in lifespan similar to that caused by smoking 15 cigarettes a day." One big reason people become socially isolated is because of hearing loss. Often, as hearing becomes challenging, people avoid social, business situations where interaction is key — and instead choose to withdraw and isolate themselves.

Perceptual Bandwidth and Intoduction to SoundRecover

- It is commonly accepted that the normal human auditory bandwidth encompasses the range of frequencies from 20 to 20,000 Hz but hearing instrument bandwidth is part of range 100-8,000/10,000 Hz. However, the audibility of a sound such as a pure tone depends not only on its frequency but also on its level. The hearing instrument should amplify the sound in order to balance the hearing loss, but the maximum gain couldn’t be enough on the high frequencies and so people don’t sense the sound. The compression shifts the high-frequency information to lower-frequency region that is less damaged.
- Phonak led the way in modern frequency lowering technology with the introduction of SoundRecover in 2008. Since then, extensive worldwide field studies with adults and children have found increased detection, distinction and recognition of high frequency sounds, better speech understanding and significant improvement in intonation and overall voice quality for users.

Perceptual Importance of High Frequencies

- Speech Intelligibility
- Speech Understanding in noise
- Localization



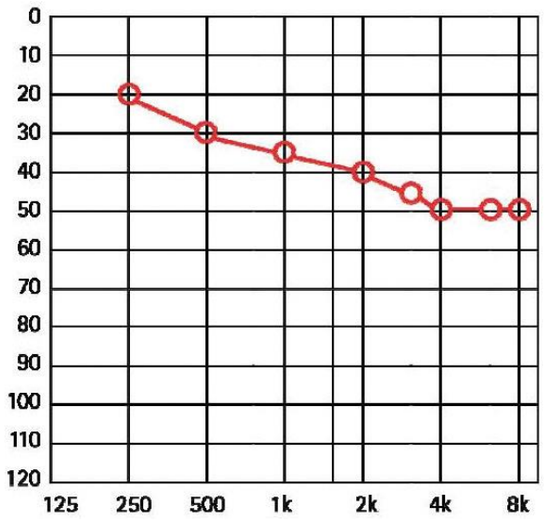
Hearing Instrument Bandwidth

- In the past, the high-frequency bandwidth limit of analog hearing aids usually resulted mainly from their electroacoustic performance. With high-powered instruments, it was often difficult to obtain adequate sound output levels at frequencies above about 4000 Hz.
- In all digital hearing instruments there is an absolute limit on bandwidth resulting directly from the sampling process. Unfortunately, the use of relatively high sampling rates can have undesirable side-effects: it reduces battery life.
- Consequently, it is common for the sampling rate in hearing instruments to be approximately 20,000 Hz. This choice means that the upper limit of the bandwidth in terms of sound produced by the HI must be about 10,000 Hz. In some devices, the sampling rate may be as low as 16,000 Hz, resulting in an acoustic bandwidth of less than 8000 Hz.

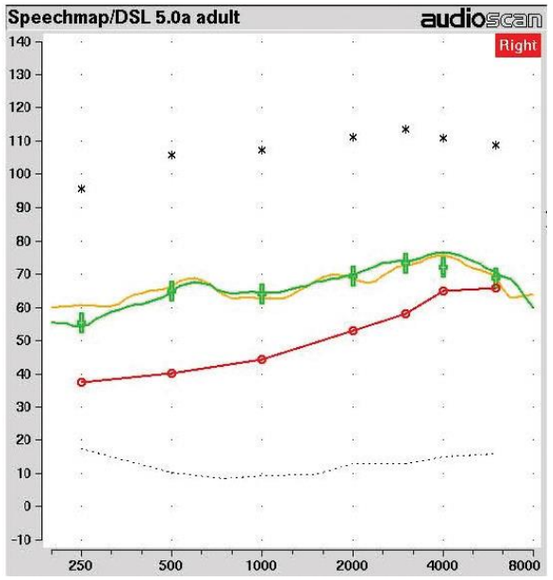
Percpetual Bandwidth

- How do previous considerations apply to a person who uses a hearing instrument? Interacting factors:

1. Particular configuration of each HI user's hearing impairment
2. Effective bandwidth of the HI, which depends on its gain and maximum output level, parameters that inevitably vary as a function of frequency.
3. Certain sound-processing techniques such as frequency lowering can affect the perceptual bandwidth.



The results of fitting two HIs for the audiogram (red curve). The Phonak HI (green curve) had SoundRecover disabled. The yellow curve shows comparable results from a different manufacturer's HI reported to provide extended bandwidth.



Techinical Description of SoundRecover

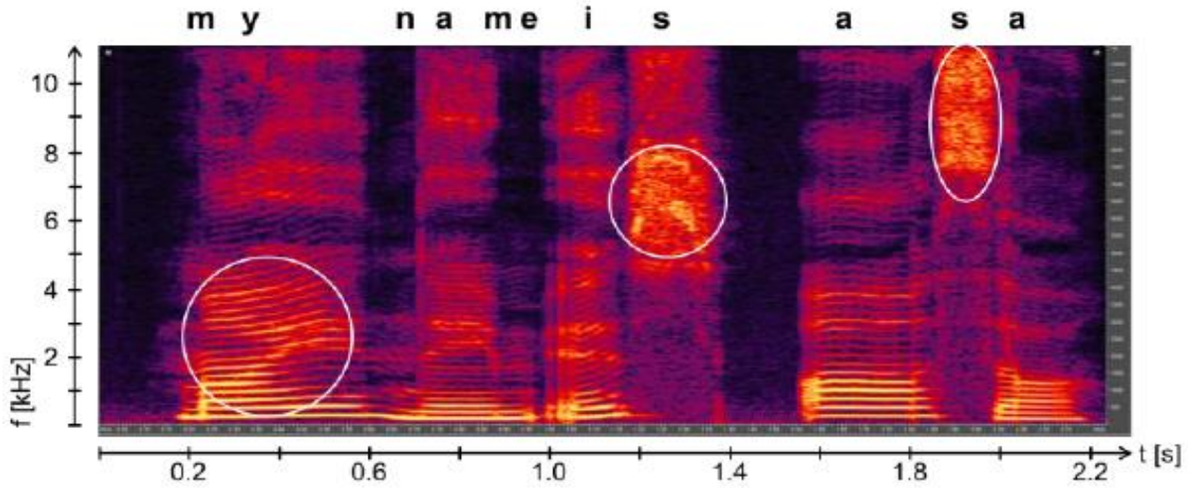
- Goal? Restore the audibility for high frequency inputs up to approximately 10 kHz. This unique approach is designed to compress the signal above a specified and adjustable cut-off frequency. The amount of compression applied to this frequency band is specified by the compression ratio. All frequencies below the defined cut off frequency starting point remain unchanged, preserving the quality of sounds delivered to the hearing aid user.
- It allows for an individual setting of the cut-off frequency dependent on the hearing loss between 1.5 kHz and 6 kHz. The compression ratio is automatically adjusted to a value between 1.5:1 and 4:1 according to the selected cut-off frequency.
- Strong SoundRecover: lower cut-off and higher compression ratio. Weak SoundRecover alternatively.

SoundRecover VS SoundRecover2

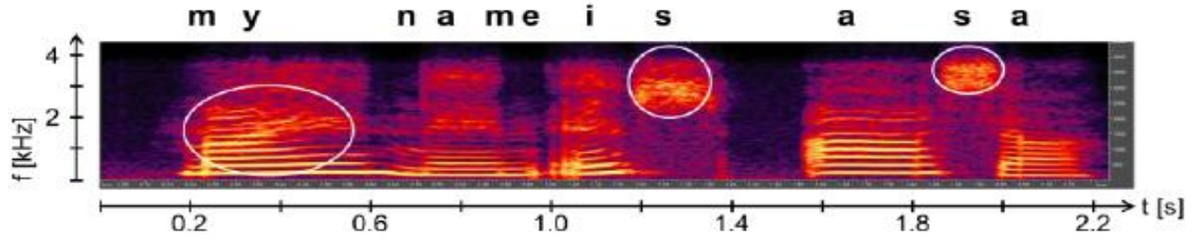
- In SoundRecover2 the extent of frequency lowering, i.e. the area of protection and the starting point of compression, is not fixed but is instead set adaptively as a function of the input signal. This adaptive nature is realized by the use of two cut-off frequencies, of which only one is active at any moment in time. Based on the momentary energy distribution in the input signal, the system determines instantaneously which one of the two cut-off frequencies is applied.
- In case of more low frequency content, frequency compression takes place with the upper cut-off frequency in order to “protect” the low frequency sounds from being compressed. In case of more high frequency content, frequency compression takes place with the lower cut-off frequency to restore audibility of the high frequency sounds. When applied to speech signals, this strategy leaves vowels intact while allowing compression of important high frequency information in fricatives down to sufficiently low output frequencies.

Outcomes

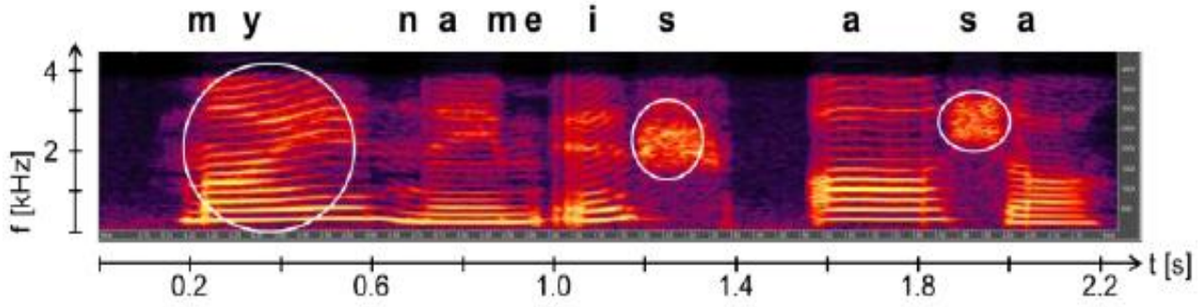
(A)



(B)



(C)



(A) Without frequency lowering: it shows pronounced formant structures up to 5.5 kHz at 0.2 seconds to 0.5 seconds and two high frequency /s/ phonemes at 1.2 seconds and 1.9 seconds.

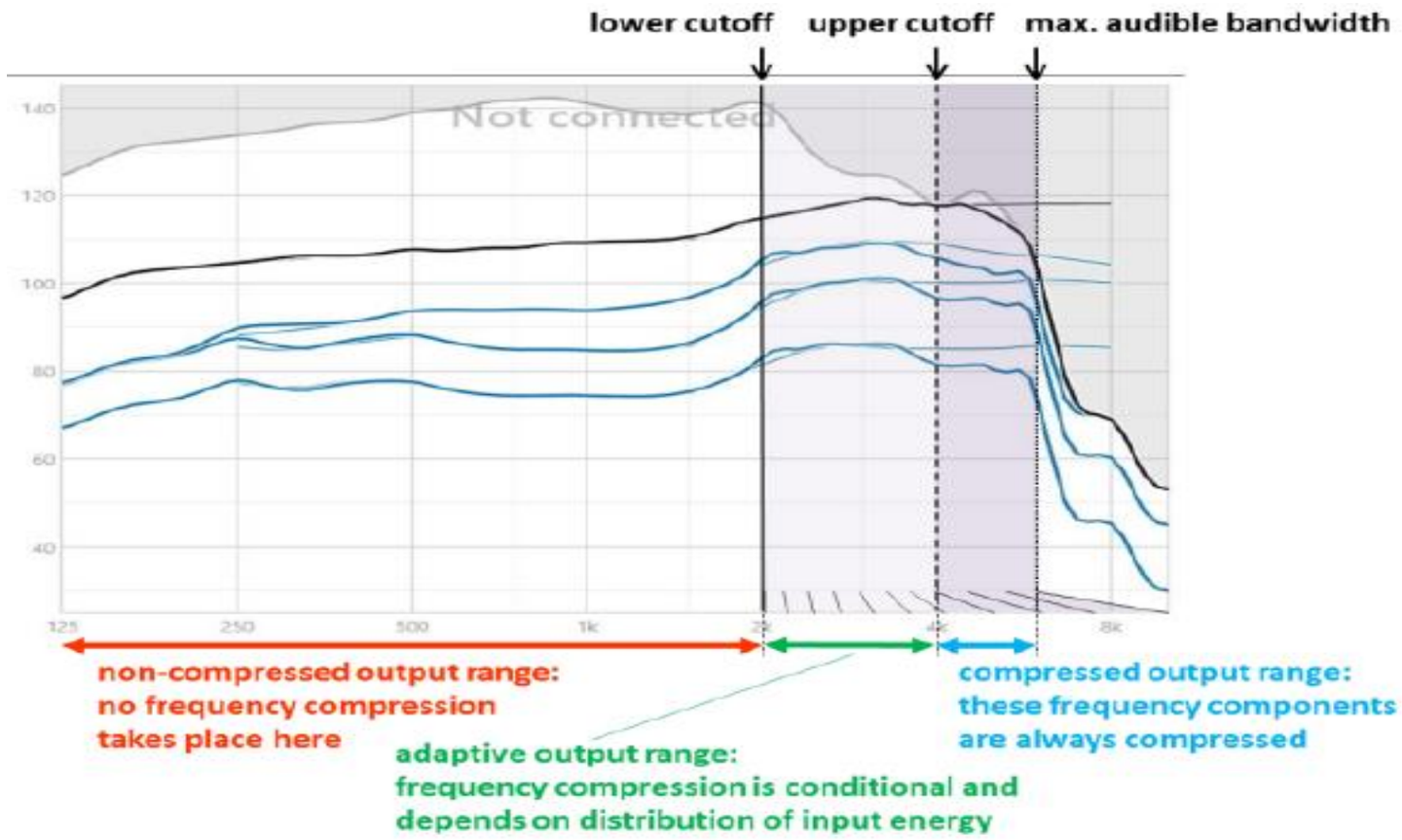
(B) With SoundRecover(cut-off: 1500 Hz, CR: 2.1): the audible bandwidth extends up to approximately 4000 Hz. The /s/ phonemes at 1.2 and 1.9 seconds are compressed down into a frequency area between 2.5 and 4 kHz. Note that the spectral structures above the cut-off frequency of 1500 Hz at the beginning of the sentence are not fully preserved at this maximum setting.

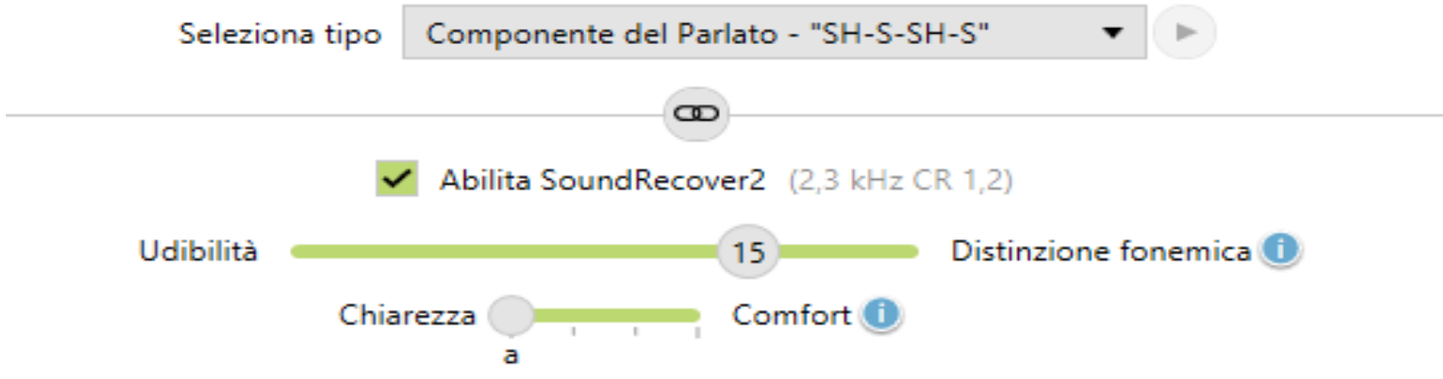
(C) With SoundRecover2 (lower cut-off: 1479 Hz, higher cut-off: 3600 Hz, CR: 1.4): the audible bandwidth extends up to approximately 4000 Hz as well. Note the preservation of the spectral structures up to the upper cut-off of 3600 Hz at the beginning of the sentence at 0.2 to 0.5 seconds, and the remapping of the two significant high frequency /s/ phonemes at 1.2 and 1.9 seconds down into a frequency area as low as between 2000 and 3000 Hz.

Clinical Evidence

- For vowel perception, it seems that the benefits provided by NLFC are limited, which are probably related to the parameter settings of the compression. For consonant perception, several studies have shown that NLFC provides improved perception of high frequency consonants such as /s/ and /z/. However, a few other studies have demonstrated negative results in consonant perception.
- In terms of sentence recognition, persistent use of NLFC might provide improved performance. Compared to the conventional processing, NLFC does not alter the speech sound quality appraisal and music perception as long as the compression setting is not too aggressive.
- The relevant factors that regard to NLFC settings are time-course of acclimatization, listener characteristics, and perceptual tasks.

Example of Fitting





Conclusions

There is none so deaf as he who will not hear

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THANK YOU FOR YOUR ATTENTION