Phonak Insight.

What is behind the numbers? Understanding how quality, robust evidence is achieved through realistic technical assessments.

Signal-to-noise ratio (SNR) values are commonly used by different manufacturers as an indication of the performance of a hearing aid or feature in improving speech understanding in noise. This paper outlines the importance of simulating real-world listening environments when conducting technical assessments and highlights the impact of the various approaches as seen across the industry. Phonak's audiological leadership is exemplified by the realistic design of technical measurements used to demonstrate an SNR improvement of up to 10.2 dB with Spheric Speech Clarity (Raufer et al., 2024).

Preuss, M., Hobi, S., Raufer, S. November 2024

Key highlights

- Comparing the improvement in SNR across manufacturers is difficult due to the lack of industry standards for technical measurements.
- Realistic end user benefit from a hearing aid/feature is defendant on technical measures that have taken two major variables in account - the loudspeaker array and choice of background noise.
- Publicly available noise scenes, with no static noise component, ensure a realistic setup , while also allowing anyone to reproduce the measurement.
- DNN based signal processing to effectively separate speech from noise is a new approach to improving speech understanding in noise, hence a more sophisticated and realistic study design has been chosen to evaluate the benefit.

Considerations for practice

- It is not possible to directly compare SNR statements from each brand due to the variability of study setup.
- Take the time to critically analyze the scientific publication(s) that are published to support each brands' SNR statements.
- Listen to it! Since it is not possible to directly compare SNR statements from each brand the proof remains in listening for yourself.

Introduction

The SNR describes the difference in level between a desired signal (i.e. speech) and the background noise. Hearing aid wearers require a better SNR compared to normal hearing listeners for the same speech intelligibility performance (Killion, 1997). Technological innovations aiming at improving speech intelligibility are therefore often described by delivering a certain SNR benefit. However, for the SNR benefit to translate to a client benefit, a realistic test environment must be chosen for the measurement setup. This includes Commitment 1) the spatial setup of the loudspeakers, which affects the measurable benefit of directional microphone technology and Commitment 2) the type of background noise, which affects the measurable benefit of conventional noise cancelling features. This paper highlights the effect of study setup and background noise-type on SNR benefit and outlines our commitments at Phonak to producing high quality evidence through strong, reliable and realistic study setups and designs. This paper will help you interpret the SNR values and marketing messages from various brands, enabling a more critical assessment of scientific publications and how robust study setups actually are.

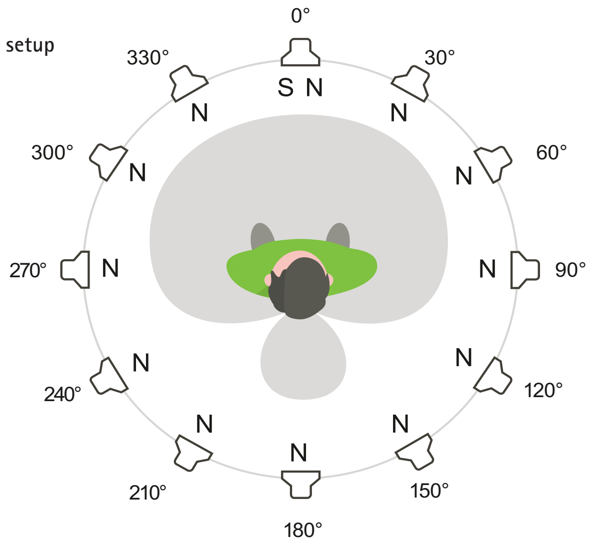
Commitment #1 – Using a realistic loudspeaker setup

The chosen loudspeaker array in a study design is critical in relation to the study objective. For example: using a single loudspeaker with co-located speech and noise placed at 0 degrees is required for some clinical tests, but would not be representative for assessing real-world complex noise situations. In the case of investigating the expected benefit of directional microphone technology and/or noise reduction algorithms, the number and position of the loudspeaker array is critical in creating a realistic scene.

It is known that directional microphone technology can significantly improve the SNR, especially for noise sources coming from the back. Figure 1A and B shows two different approaches to loudspeaker array with N indicating noise being presented and S indicating a speech signal. Fig. 1A is the Phonak setup used to measure the SNR benefit from the DNN-based speech separation feature Spheric Speech Clarity. A realistic complex challenging communication situation was simulated using a 12 loudspeaker array, with speech and noise co-located at 0 degrees. Fig. 1B is the technical setup described in publications from two other manufacturers. This setup used two speakers at approximately 240 degrees and 120 degrees for noise and a speech signal at 0 degrees.

The gray shaded areas in Figure 1A and B show a polar sensitivity plot for a supercardioid directional microphone. The further the gray shaded area is from the circumference, the more noise is attenuated by the directional microphone. The maximum noise attenuation for this type of directional microphone is in the back hemisphere, around 240 degrees and 120 degrees, as indicated by the "notch" where the distance between gray shaded area and enclosing circle is greatest.

A Phonak setup



B Setups from other publications (approximated)

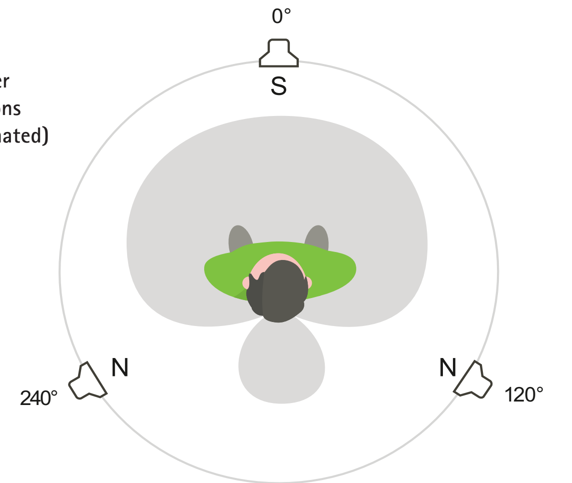


Figure 1: A: Phonak study setup with polar plot of the directional microphone. The noise sources are placed all-around, making it a challenging but realistic setup to evaluate the benefit of the directional microphone.
B: Approximated study setup of publications from other manufacturers with the same polar plot of the directional microphone. The noise sources are placed in the back hemisphere, close to the maximum attenuation of the directional microphone, which will overestimate the performance of the directional microphone.

In the setup of Fig. 1B, the location of the noise sources coincides with the location of maximum attenuation of the directional microphone, resulting in an overestimation of the SNR benefit achieved by the directional microphone. In real-world environments we are exposed to noise not just from 120 degrees and 240 degrees but from many directions, often including reflections and reverberation. The reproduction in a 12-channel loudspeaker setup as shown in Fig. 1A reflects a more realistic listening situation.

To demonstrate the impact of loudspeaker setup, we measured the SNR benefit of Phonak's UltraZoom feature with the above two setups. The result from this technical measure showed that with the same feature, UltraZoom, it is possible to get two very different SNR values as the result of two different loudspeaker setups. Figure 2 on the left is the SNR benefit of UltraZoom achieved by the setup described in Fig. 1B with IF-noise (Holube et al., 2010) at 72 dBA presented at 240 and 120 degrees. On the right is the SNR benefit of UltraZoom achieved by the setup described in Fig. 1A with IF-noise at 72 dBA presented from 12 speakers (0, 30/330, 60/300, 90/270, 120/240, 150/210 and 180 degrees). The speech signal was kept constant in both configurations, with ISTS-target at 76 dBA, presented at 0 degrees.

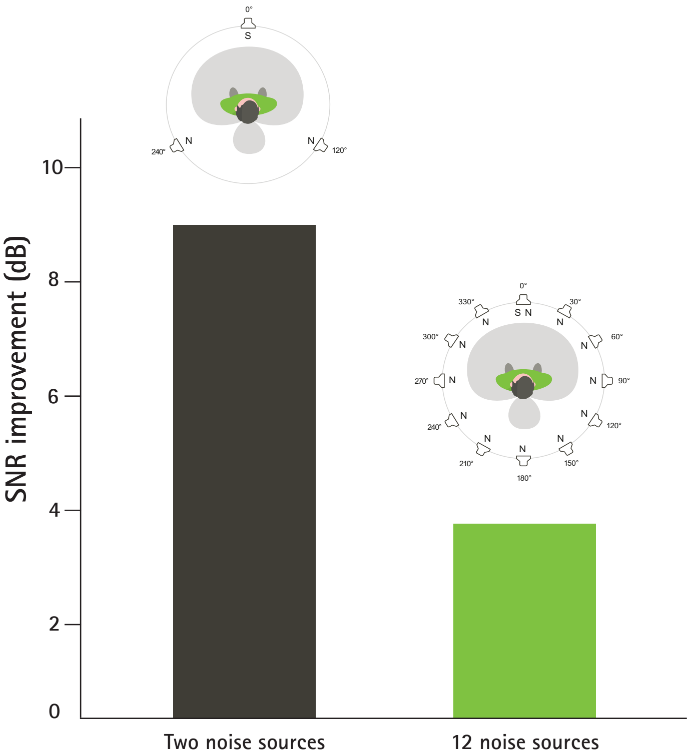


Figure 2: Using noise sources only in the back (left) overestimates the benefit of directional microphones compared to using a realistic setup with 12 noise sources from all-around (right).

Results clearly indicate that with a 2 loudspeaker array, SNR benefit is more than double compared to using a realistic 12 loudspeaker array.

Audéo Sphere Infinio with Spheric Speech Clarity suppresses the background noise from any direction, leading to remarkable speech intelligibility improvements for individuals using hearing aids (Diehl et al., 2023). Objective technical measures are an integral part of determining audiological benefit of a feature/hearing aid and also an important precursor to clinical studies. To examine how Phonak Audéo Sphere Infinio with Spheric Speech Clarity performs in realistic and challenging listening environments, we used a 12-loudspeaker setup, as shown in Figure 1A. We played background noise from all 12 loudspeakers, including the direction of speech at 0°. This technical measurement setup simulates a complex communication scenario, like a cocktail party, where noise is present in all directions including 0 degrees. This differs from other publications that utilize only a few noise sources in the back hemisphere, see Figure 1B.

Commitment #2 – Using realistic and publicly available background noise stimuli

Conventional single channel noise reduction algorithms are most effective when targeting static broadband noise (e.g. vacuum cleaner, air conditioner). While a spatial noise reduction algorithm can be applied in conjunction with directional microphone mode, to reduce background noise source from behind. Real life complex speech in noise environments are rarely made up of static broadband noise but instead are a combination of modulated noise such as speech babble and transient sounds such as cutlery noise.

Phonak's Spheric Speech Clarity is a DNN-based signal processing feature that has been trained with over 22 million sound samples to separate speech from noise. This means Spheric Speech Clarity is able to effectively reduce complex types of background noise which conventional single channel noise reduction algorithms can not. To account for this, the benchmarking of Spheric Speech Clarity was conducted using realistic and publicly available noise scenes from the Ambisonic Recordings of Typical Environments (ARTE) database (Weisser et al., 2019). Specifically, the measurements used the café, dinner party, and food court scene. The three scenes are at SPL levels above 70 dB SPL, which represent levels at which the Spheric Speech in Loud Noise program is active.

Other current industry whitepapers use static noise sources, which can be handled well by conventional noise reduction algorithms but do not reflect the type of background noise clients encounter in social settings.

Figure 3 shows an example of how a conventional single channel noise reduction feature and Spheric Speech Clarity lead to a similar SNR benefit when a static noise (IF-noise) is used. When the ARTE food court file is used, Spheric Speech Clarity in the Audéo Sphere Infinio maintains the SNR benefit, but a conventional noise cancelling feature drops in performance by more than 50%.

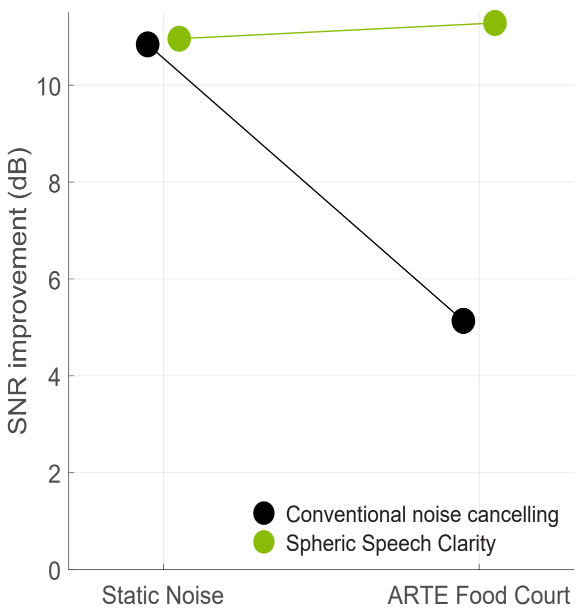


Figure 3: Spheric Speech Clarity and conventional noise cancelling show similar SNR improvement when tested with a static noise. Spheric Speech Clarity maintains the SNR improvement in a realistic listening environment, whereas conventional noise cancelling loses 50% of its effectiveness.

Summary

Phonak has a reputation for publishing high quality evidence. When interpreting evidence published across manufacturers, it is important to consider the setup and stimulus/noise used, and if the testing reflects real-world scenarios. For measuring the SNR benefit of the Audéo Sphere Infinio with Spheric Speech Clarity, we used 1) realistic and challenging listening situations with noise coming from all directions and 2) publicly available background noise scenes with no additional static noise component.

This Insight highlighted the effect of technical measurement setup and noise-types across publications. Figure 4 shows a comparison of SNR improvements with respect to unaided across brands (Raufer et al., 2024). In realistic listening scenarios Phonak I90 Sphere and I90 R are outperforming key competitors for clear speech in noise.

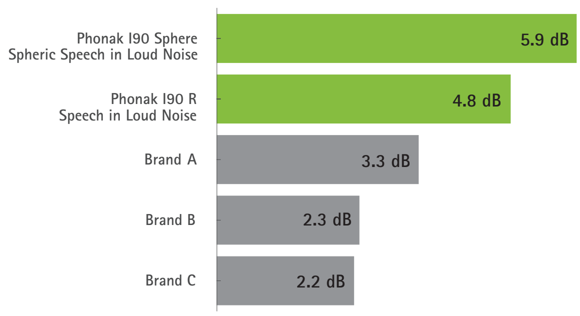


Figure 4: Competitor comparison: SII-weighted SNR improvements with respect to unaided, averaged across three realistic scenes. Results are presented for a fully occluded coupling and for the better ear. For further details on the study design and execution, visit Phonak.com/evidence.

This advantage in realistic listening situations translates to significant benefits for hearing-impaired people in their everyday lives.

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Authors

Michael Preuss, Audiology Manager at Phonak HQ
Michael joined Phonak HQ in 2020. Benefitting from his lecturing background at the Academy of Hearing Acoustics in Lübeck and living with hearing loss, Michael delivers comprehensive expert training sessions and provides audiological input during product development. Michael studied Hearing Acoustics at the University of Applied Sciences in Lübeck, Germany.

Shin-Shin Hobi, Senior Product Manager for Audiological Performance at Phonak HQ
Shin-Shin joined Phonak HQ in 2006 and has worked on various projects as an Audiology Manager. In her current role as Senior Product Manager for Audiological Performance, she ensures end user and hearing care professional needs are taken into account during product development of audiological features. Originally from Australia, Shin-Shin earned her Audiology qualifications from University of Melbourne. She gained wide clinical experience in private practice, in Perth, before making the move to Switzerland.

Stefan Raufer, Audiological Researcher
Stefan joined Sonova in 2021 and is developing audiological concepts for new hearing aid features. Together with other teams, Stefan brings the latest technology to our products, making sure that new technologies translate to user benefits. Stefan holds a PhD in speech and hearing sciences from Harvard University.

028-2716-02 /V2.00/2024-12/km