Phonak
Field Study News.

New implementation of directional beamforming configurations shows improved speech understanding and reduced listening effort

Speech intelligibility in noise tests conducted at Hörzentrum Oldenburg, showed that two new Phonak Audéo™ Lumity features further improved speech understanding from the front but also from the side and back. Additionally listening effort scaling indicated a reduction of listening effort when speech originated from both the side and rear.

October 2022: Latzel, M., Lesimple, C., & Woodward, J.

Key highlights

- 15% better speech understanding in noise when speech is from the side/ behind*
- 11% reduced listening effort in noise when speech is from the side/ behind*
- 16% better speech understanding in noise with speech from the front**
- More access to sound not only provides clarity but reduces listening effort (Hornsby, 2013, Picou et al., 2013; Pichora-Fuller & Singh, 2006).

Considerations for practice

- Discuss the key listening challenges your client experiences and explain how the new directional beamforming configurations may help overcome them.
- Using Trial devices, demonstrate the benefits of different directional microphones depending on the listening environment.
- Show how the myPhonak app allows clients to tailor the hearing aid settings in real-time, to take into account their listening needs.

*Fixed Directional/ Real Ear Sound compared to StereoZoom (microphone mode is focused to the front)
**StereoZoom 2.0 default strength (24) over Fixed Directional

Introduction

The importance of speech understanding and hearing performance

Understanding speech is central to so many aspects of our lives: relationships, work, studying, well-being, connecting with the people around us and overall quality of life. Market research shows that improved speech understanding is one of the most important needs expressed by hearing aid users (Appleton, 2022).

Communication in noise is one of the most challenging listening situations for people with hearing loss and one of the most important factors for hearing aid satisfaction (Abrams & Kihm, 2015). Hearing aid wearers need a better signal-to-noise ratio (SNR) compared to their normal hearing peers for the same level of performance (Killion, 1997).

How do modern hearing aids help improve speech understanding, reduce listening effort, and support an awareness of the world around us? One well-known concept is multi-microphone processing known as beamforming. Beamforming uses spatial information from two microphones operating together on the hearing aid, to significantly increase the sensitivity in one direction and reduce the sensitivity to other directions, thus forming a virtual 'beam' (Derleth et al., 2021).

The benefits of Phonak's well-known beamforming technologies have been shown in several studies (for a full review of the evidence see Woodward, Kühnel & Latzel, 2022).

Real Ear Sound

Real Ear Sound (RES), developed in 2005, is designed to restore the natural directivity pattern of the outer ear by applying directionality only at the high frequencies (above 1.5kHz) and combines the advantage of surround sound pick up while also reducing front/back confusions common with omnidirectional microphones (Appleton, 2020; Keidser et al., 2009; Raether, 2005). Several studies have shown the benefits of these 'digital pinna-cue preserving technologies' compared to omnidirectional/directional microphones in quiet, laboratory environments, with some individual self-reported benefits for specific real-world experiences (Xu & Han, 2014; Jensen et al., 2013).

Monaural beamforming

The beamformer known as 'Fixed Directional' is a monaural static beamformer with a fixed null (where the directional response is least sensitive) at the back. However, communication situations are not always static, and UltraZoom is a monaural adaptive beamformer that continuously adapts the null to maximize the SNR benefit (Stewart et al., 2019).

StereoZoom

StereoZoom (SZ) is a binaural beamformer with an adaptive null that utilizes the four-microphone array of a binaural fitting to create a narrower beam compared to a monaural beamformer. This narrow focus improves speech intelligibility in loud noise for speech from front. The combined effect of an even narrower beam and an adaptive null allows speech recognition to be maximized in the presence of diffuse as well as localized sound sources (Stewart et al., 2019). A number of studies have demonstrated better speech intelligibility with SZ compared to other beamforming technologies in Phonak devices (Appleton & König, 2014, Picou et al., 2014) and competitor devices (Latzel & Appleton-Huber, 2015). Improvements in listening effort and memory effort with SZ compared to RES have also been found (Winneke et al., 2020). Additionally, the use of SZ over a fixed directional beamformer approach has shown an increase in overall communication and less leaning in towards the talker (Schulte et al., 2018).

The performance of these different beamformers can be measured when the talker moves around the listener (Fig.1). The output hearing aid was recorded and the SNR can be calculated using the inversion technique (Hagerman & Olofsson, 2004). These measurements show the benefit of the narrow beamformer (SZ) when the talker is placed in front of the listener. However, the hearing aid output SNR is much better with wider beamformers like Fixed Directional or RES when the talker is located to the side or back.

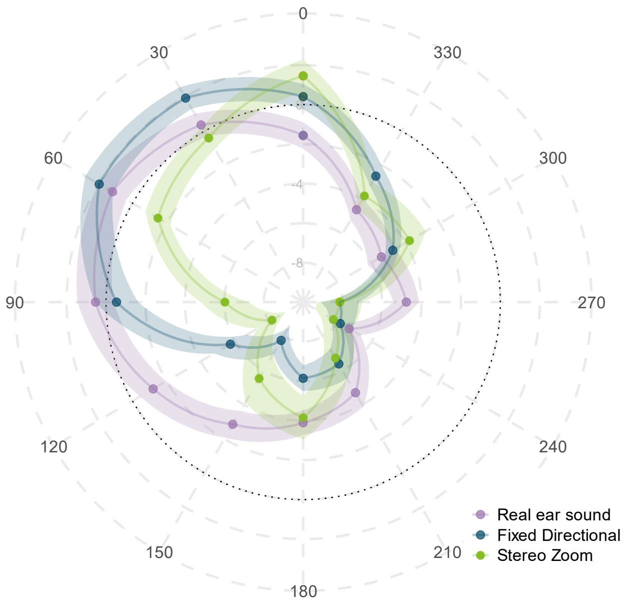

Fig. 1: Average differences between input SNR and hearing aid output SNR measured on the left ear with Real Ear Sound (violet), Fixed Directional (blue) and StereoZoom (green). The hearing aid is placed on a model head (KEMAR) and the talker moves around in 30° steps. Recordings are measured with input SNRs from -5 up to +10dB SNR and with 4 different background noises.

More access to sound not only provides clarity but reduces listening effort (Hornsby, 2013, Picou et al., 2013; Pichora-Fuller & Singh, 2006). However, directionality has the potential to interfere with the users' ability to maintain awareness of their listening environment and their ability to shift attention to other sound sources in the environment (Jespersen et al., 2021). It is therefore very important to be able to select the microphone mode depending on the acoustic environment. Two new features, StereoZoom 2.0 and SpeechSensor, now in Phonak Audéo Lumity hearing aids, aim to resolve the outstanding challenges of (1) maintaining more spatial awareness or speech focus depending on the listening environment; (2) the ability to listen to speech coming from a direction other than the front.

StereoZoom 2.0

StereoZoom 2.0 (SZ 2.0) shown in Fig. 2, which replaces SZ from previous generations, is a narrow binaural directional microphone mode, active in the Speech in Loud Noise program. Compared to SZ, there is now a gradual transition from Speech in Noise (UltraZoom) into Speech in Loud Noise (SZ 2.0) for a smoother switch between listening programs. The strength of SZ 2.0 is also level-dependent with the aim to maintain more spatial awareness at lower noise levels and better speech focus at higher noise levels. The client can now personalize this beamformer mode via the myPhonak app.

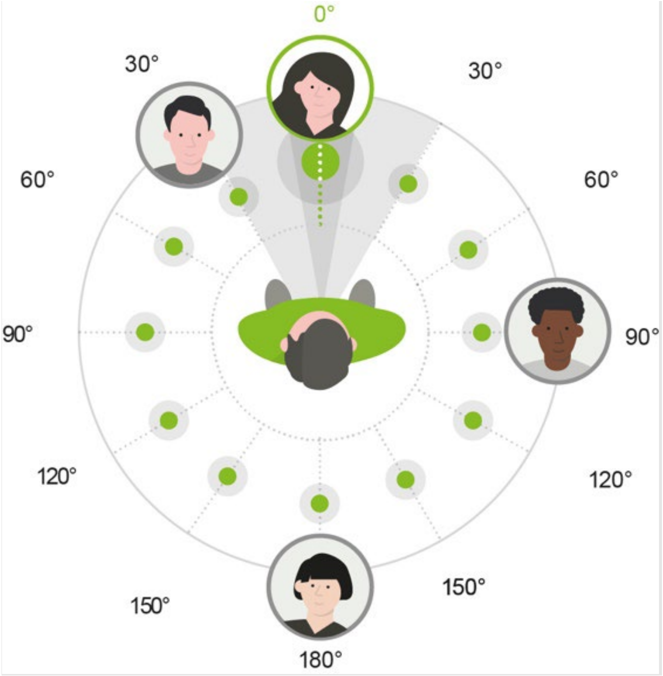

Fig. 2: StereoZoom 2.0
As the level of noise surrounding the client increases, the microphone directionality gradually transitions from UltraZoom (wider beam) to StereoZoom 2.0 (narrower beam). This provides a balance between providing more spatial awareness and speech focus to the front, depending on the listening environment. The strength of StereoZoom 2.0 activates smoothly as the noise level increases.

SpeechSensor

Walden et al. (2004) evaluated the responses of hearing aid users who tracked signals and noise over a 4-week period. They reported that 80% of the time, signals came from the front and 20% came from another direction. Therefore, clients may not be looking directly at the speaker in a substantial number of listening situations (Hayes, 2019). The main benefit of SZ is achieved when speech comes from the front as hearing aid users tend to look in the direction of the talker. However, Walden et al.'s research shows that this is not always the case. SpeechSensor (Fig. 3) automatically detects where the dominant speaker is located and sends this information to AutoSense OS 5.0, the automatic classification system in Phonak hearing aids, to adjust the directional microphone mode accordingly. If the speech comes from the left/right a Fixed Directional beamformer is triggered. When the speech originates from behind Real Ear Sound is activated, and if the speech comes from the front SZ 2.0 is used.

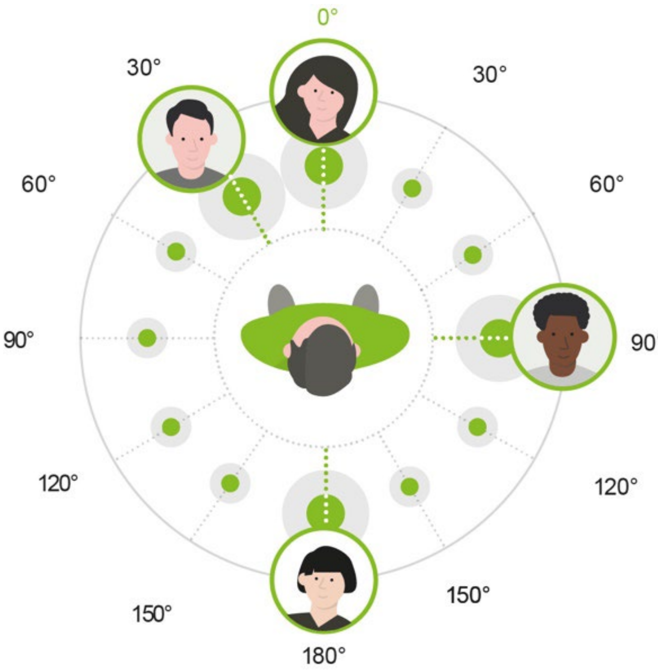

Fig 3: SpeechSensor
SpeechSensor automatically detects where the dominant talker is located and sends this information to AutoSense OS 5.0 to adjust the microphone mode accordingly. SpeechSensor helps provide better access to speech from the side and rear in Speech in Noise (SpiN) or Speech in Loud Noise (SPiLN) programs.

The objectives of the current study were to:

1. assess whether SpeechSensor provides better speech reception thresholds (SRTs) in noisy situations with speech from the side and behind compared to the former system where SZ was active in these situations.
2. evaluate whether SpeechSensor enables less listening effort in noisy situations with speech from the side and behind compared to SZ.
3. To assess whether SZ provides better SRTs in very noisy situations with speech from front compared to Fixed Directional.

Methodology

Participants

22 subjects (14 male, 8 female) with mild-severe hearing loss (Fig. 4) took part in the study between March and July 2022. All subjects had experience with hearing aids. They were fit with Phonak Audéo Paradise 90-R (Receiver in Canal, RIC) hearing aid devices with rechargeable batteries. The average age of the participants was 76 years.

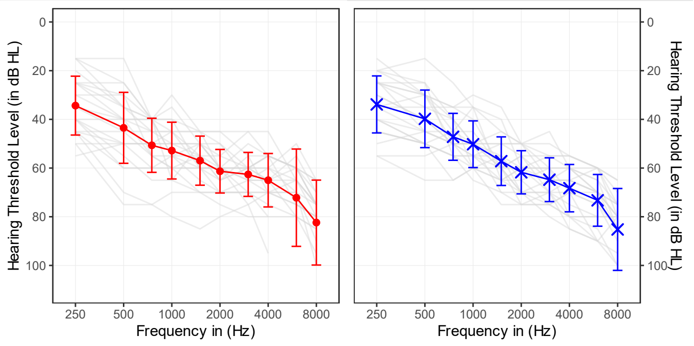

Fig 4: Hearing thresholds: mean hearing loss per frequency and ear for the 22 subjects who took part in the study.

Test Set-Up

Fig. 5 shows the test set up for SpeechSensor benefit with speech from the side, front and back. All tests were carried out with Audéo P devices as Lumity devices were not yet available for testing. In order to simulate and evaluate SpeechSensor in Audéo P devices, the following hearing aid settings were programmed:

- Adaptive Phonak Digital (APD) prescription formula: gain level 100%
- Adaptive parameters: deactivated
- Frequency lowering systems: deactivated
- Reference program: Speech in Loud Noise (SiLN); Microphone: SZ (REF)
- Speech from side program (mimics SpeechSensor from side): SiN (Speech in Noise); Microphone: Fixed Directional
- Speech from back program (mimics SpeechSensor from back): SiN (Speech in Noise); microphone: RES

SZ 2.0 in Lumity devices has a range of strengths from 21 to 27, with a default strength of 24. SZ in Paradise devices only has one strength (24), which mimics the default strength in Lumity, therefore allowing an equivalent comparison. An additional study is ongoing to further evaluate the benefits of SpeechSensor and SZ 2.0 in Lumity devices, after the launch.

Speech Reception Thresholds (SRTs) were measured using the Oldenburg Satztest, OLSA (Wagener et al.,1999) in a test-retest design. The SRT is the SNR (in dB) necessary to achieve 50% intelligibility of the presented words. Diffuse cafeteria babble noise was presented from 11 loudspeakers at 71 dB(A) (marked with 'N' in Fig. 5). The target speech material ('T') was OLSA sentences presented from 90°, 180° and from 0° (Fig. 5). Subjects were seated in the middle of the loudspeaker circle and were instructed to look to the front.

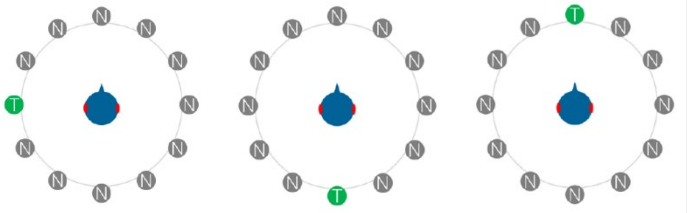

Fig. 5: Test set-up for SpeechSensor benefit with speech from the side, back and front.

The test features were activated via Phonak Target by the investigator. The test order was randomized to counterbalance any learning and fatigue effects. As all test conditions were implemented in the same hearing aid, the tested condition could not be identified by the subject.

Listening effort was measured in dB SNR using the Adaptive Categorical Listening Effort Scaling (ACALES) test (Luts et al., 2010; Krueger et al., 2017) in a test-retest design. This adaptive test allows the subject to rate how much effort is required to understand sentences at different SNRs. The SNR is adapted to cover a range of listening conditions rated as no effort (1) to extreme effort (13). The results are then summarized in dB SNR for three effort ratings: no effort (1); moderate effort (7) and extreme effort (13). Lower SNRs indicate that the participant can tolerate more noise for the same subjective listening effort rating, indicating better results.

Results

The improvement in SRTs with the new feature SpeechSensor can be seen in Fig. 6. The results showed that SpeechSensor provided an improvement in speech reception thresholds (SRTs) of 1.7dB in noisy situations with speech from the side and a 1.4dB improvement with speech from the back compared to the former system when SZ would have been activated for each listening situation. A lower dB SNR on the Y-axis indicates better speech understanding. In percentage improvement, this equates to 17% better speech understanding with Fixed Directional when speech is from the side, and 14% better speech understanding with RES when speech is from behind, compared to SZ. Taken together, these results showed that SpeechSensor gave a benefit of 1.55 dB SRT (15%) ($p < 0.001$) in the speech in noise test in comparison to SZ, when speech is presented to the side or back. The calculation from dB to percentage is based on an estimation suggested by Wagener & Brand (2005).

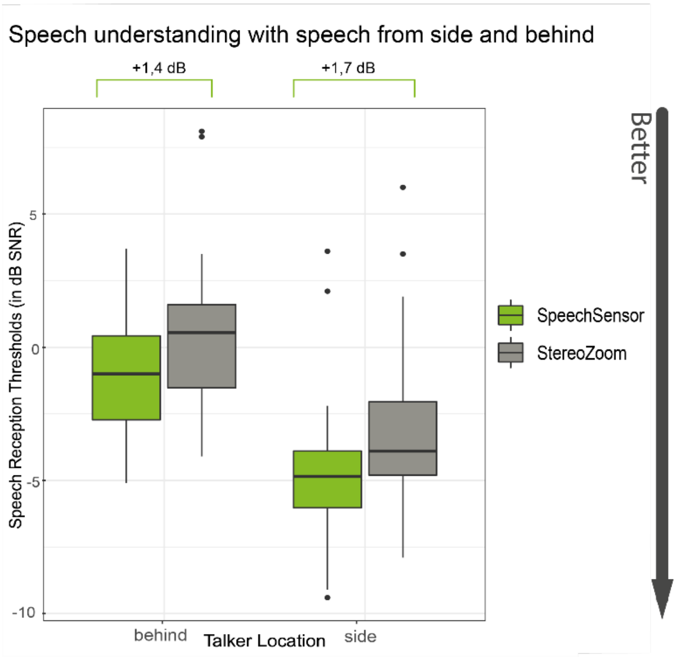

Fig 6: Speech Reception Thresholds distribution by talker location (x-axis) and tested beamformer. Boxplots show the median value (thick line), the interquartile range (boxes) and values within 1.5 times the IQR (the vertical lines).

Fig. 7 shows how SpeechSensor provided less listening effort in noisy situations with speech from the side and behind compared to SZ. There was an overall benefit of 1.37dB ($p < 0.001$) in listening effort with SpeechSensor in comparison to SZ, when speech is presented to the back (0.7 dB SNR) or side (2.0 dB SNR). This equates to a reduction in Listening Effort of 11%.

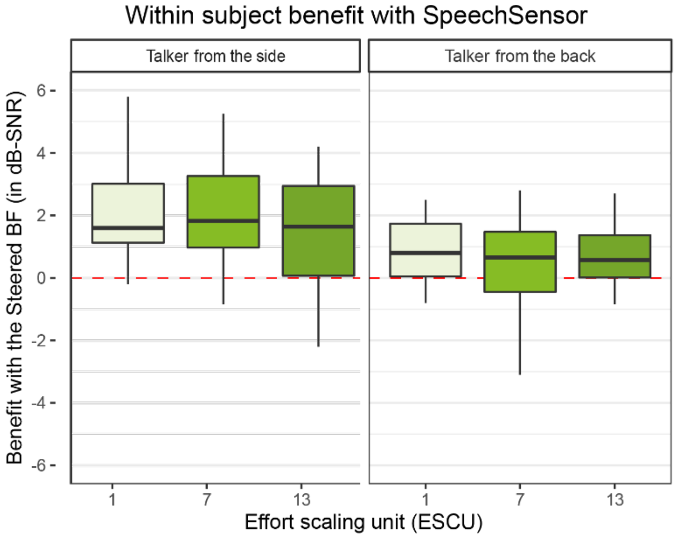

Fig. 7. Within subject benefit provided by SpeechSensor in dB SNR for a given listening effort (1 = no effort, 7 = moderate effort, and 13 = extreme effort) when the talker is located on the side (left) or in the back (right).

The SpeechSensor results have shown the benefit for users when speech is coming from the back and side. The benefit of SZ was measured in order to demonstrate the clinical benefit of the hearing aid when speech is coming from the front. Fig. 8 illustrates that SZ provides better SRTs in very noisy situations with speech from the front compared to Fixed Directional. Results showed an improvement of 1.6dB (p < 0.001) in the SRT levels with SZ compared to Fixed Directional, when the target speech is coming from the front and noise is coming from the surrounding speakers. This is an improvement in speech understanding of 16% with SZ over Fixed Directional. Fig. 8 also demonstrates that both Fixed Directional and SZ provide a significant improvement over the unaided condition (p < 0.001).

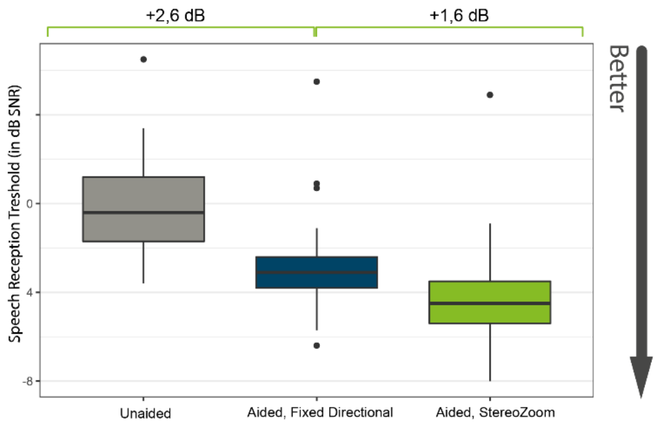

Fig. 8: Distribution of the SRTs measured in the Fixed Directional and SteroZoom conditions. Boxplots show the median value (thick line), the interquartile range (IQR, the box) and values within the IQR (the thin, vertical line).

Discussion

With reference to the study objectives presented in the introduction, the new Lumity feature SpeechSensor showed improvements in both speech understanding and listening effort for clients with mild-severe hearing loss. SpeechSensor, automatically detects which direction the speech is coming from. When speech originates from the side, the Fixed Directional microphone mode is activated, resulting in an improvement of 17% on the OLSA speech in noise test compared to the former system when SZ would have been activated. When speech originates from the back, RES is activated by SpeechSensor, and the results showed an improvement of 14% compared to SZ. Taken together, these results showed that SpeechSensor gave a benefit of 15% in the speech in noise test.

A second objective of the study was to evaluate whether SpeechSensor provided less listening effort in noisy situations with speech from the side and behind compared to when the microphone direction is focused to the front (SZ), using the ACALES test. SpeechSensor showed an improvement of 11% in listening effort compared to SZ when speech was presented to the side or back.

Finally, in order to evaluate the clinical benefit of a binaural beamformer (SZ) compared to a monaural beamformer (Fixed Directional), the OLSA speech in noise test was carried out when the target speech was presented from the front. Speech understanding improved by 16% (1.6dB SRT) with SZ (default strength 24) in comparison to a Fixed Directional beamformer.

Conclusion

Market research has shown that improved speech understanding is one of the most important needs expressed by hearing aid users (Appleton 2022). In addition, Walden et al., (2004) demonstrated that around 20% of the time the speech of interest may not come from the front. The results of the current study indicate that SpeechSensor can provide 15% improved SRTs for speech coming from the side and back, in comparison to SZ. In the other 80% of situations where speech tends to originate from the front, SZ can provide 16% better speech understanding. These results indicate that SZ and SpeechSensor can help provide better speech understanding, even in the most challenging listening environments.

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Authors and investigators

External investigators

Dr. Michael Schulte has been with Hörzentrum Oldenburg GmbH, Germany since 2004, where he has been responsible for audiological studies in publicly funded projects as well as in cooperation with the industry. In 2002, he received his Ph.D. from the Biomagnetism Centre at the Institute of Experimental Audiology, University of Münster, Germany. From 2002 to 2003, he worked as a postdoc at the F.C. Donders Centre for Cognitive Neuroimaging, Nijmegen, Netherlands. Michael Schulte's research interest is in the evaluation of hearing systems with a special focus on listening effort.

Jan Heeren studied Physics at the University of Oldenburg, Germany, and graduated in the Medical Physics group in 2014. From 2012, he worked on several projects in the field of hearing aid evaluation and virtual acoustics at the university and the Hörzentrum Oldenburg. In 2016, he started in the R&D department at HörTech GmbH, Oldenburg, working on hearing aid evaluation methods. Apart from his scientific activities, he has conducted more than 500 events as a free-lancing audio engineer since 2008.

Müge Kaya has been working as a medical-technical assistant at the Hörzentrum Oldenburg since 2000, focusing on audiological hearing system evaluation, special audiological diagnostics, cross-project organization and subject acquisition.

Internal investigators

Dr. Matthias Latzel studied electrical engineering in Bochum and Vienna in 1995. After completing his Ph.D. in 2001, he carried out his post-doc from 2002 to 2004 in the Department of Audiology at Giessen University. He was the head of the Audiology department at Phonak Germany from 2011. Since 2012 he has been working as the Clinical Research Manager for Phonak AG, Switzerland.

Christophe Lesimple studied music in Stuttgart, audiology in Lyon, and statistics in Paris and Bern. He is working as a research audiologist and contributes to various aspects of development including concepts, supporting clinical trials and analyzing data. Besides his activities with Sonova, he teaches audio analytics for machine learning at the University of Applied Science in Bern, hearing aid verification at the Akademie Hören Schweiz, and volunteers for a hearing-impaired association.

Author

Jane first joined Phonak HQ in 2005. In her role as Audiology Manager, Jane strives to provide evidence-based, impactful products, features and training. She has over 20 years of experience in audiology, working clinically in university hospitals in the UK and Switzerland, in hearing system and software development, and in training. Jane holds an MSc (Audiology) and BSc (Psychology) from Southampton University, UK.

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