Phonak Insight

Innovative speech understanding solutions: Lumity with Phonak SmartSpeech™ Technology

Phonak has developed innovative hearing solutions for over 75 years, supporting speech understanding in diverse listening environments, reduced listening effort, effective communication, and overall well-being. Two new features continue this long tradition: StereoZoom 2.0 and SpeechSensor. These build on existing evidence-based features aiming to further improve speech understanding (Appleton, 2020; Thibodeau, 2020; Latzel, Mejia, Young & Hobi, 2022).

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Key highlights

- Market research shows that improved speech understanding is one of the most important needs expressed by hearing aid users (Appleton 2022).
- Phonak SmartSpeech™ Technology combines two new features, StereoZoom 2.0 and SpeechSensor, with well-known, evidence-based features, to support speech understanding and reduce listening effort in a variety of quiet and noisy situations.

Considerations for practice

- Discuss which unique listening situations your client and their loved ones find important and where they have challenges.
- Explain the benefits of some key speech understanding features in relation to lifestyle, e.g. improvements in communication in noise.
- Demonstrate how the myPhonak app empowers clients to tailor settings in real time depending on their environment.

Why focus on speech understanding?

"Don't ever diminish the power of words. Words move hearts and hearts move limbs." (Hamza Yusuf; Economy, 2015). However, words mean nothing without understanding. Understanding speech is central to relationships, work, studying, well-being, connecting with the people around us and overall quality of life. Language is a lens through which we perceive the world (Shashkevich, 2019).

Indeed, the social and emotional impact of hearing loss was confirmed by a recent review, examining 78 articles and self-report data of over 20,000 participants.

Outcomes showed that people with hearing loss reported social consequences of their hearing loss, such as withdrawal and social isolation. Communication partners also had concerns related to their partners (with hearing loss) not joining when going out, being isolated at social events when going out as a couple, and enjoying social situations less than before (Vas et al., 2017).

In a recent market research survey (Appleton, 2022), hearing aid owners and non-owners rated the most important speech understanding factors to be:

1. 1:1 conversation in noise
2. Group conversation in noise
3. Soft speech in quiet
4. Speech without visual cues
5. Hearing speech at a distance

Based on an additional survey with hearing care professionals (HCPs) in the US and Germany with over 200 participants, the most important factors when selecting a hearing aid for a client were speech understanding, sound quality, and reliability (Knorr, 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).

Speech understanding, spatial awareness and listening effort

In addition to communication and social-emotional well-being, the sense of hearing also guides listeners where to look and how to position their body in the surrounding environment, which helps to form a mental representation of the auditory world (Derleth et al., 2021). This enables a focus on not only direct conversations, but also an awareness of indirect speech and sounds in the surrounding environment. While vision is focused on the front, the auditory sense picks up important information from all directions.

In addition, listeners with hearing loss may spend more effort on maintaining awareness of their surroundings than listeners with normal hearing. Similar to compensating for reduced speech intelligibility by "filling in the gaps", extra effort spent on auditory tasks such as environmental awareness may compromise the availability of cognitive resources for other purposes (Edwards, 2016).

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 all other directions, thus forming a virtual 'beam' (Derleth et al., 2021).

Beamformers tend to be more sensitive to sounds from the front, and attenuate sounds coming from behind. As people are inclined to look at their conversation partners, the most important speech signal most frequently comes from the front, and the background noise often from all around or behind. The benefits of beamforming technology in boosting signal-to-noise ratio (SNR) have been shown in several studies (e.g., Lewis et al., 2004).

Phonak's well-known beamforming features which help improve speech understanding and reduce listening effort

1. Real Ear Sound: designed to restore the natural directionality of the pinna & reduce front/back confusions

Phonak developed a low-strength beamformer called Real Ear Sound (RES) in 2005 to help mimic the directionality of the pinna, also called the Pinna Effect (Derleth et. al., 2021). The pinna provides monaural spectral cues to help resolve front/back confusions when localizing sounds. However, placement of the hearing aid microphone, particularly in Behind-the-Ear (BTE) and Receiver-in-the-Canal (RIC) instruments, can compromise these monaural spectral cues because the hearing aid microphones pick up incoming sounds before they are filtered by the pinna. Therefore, these monaural spectral cues are reduced which can result in poor front/back localization (Xu & Han, 2014). RES 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 benefit of such '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).

RES is designed to be helpful for conversations in quiet situations or when speech is coming from behind. For example, when chatting with one or two friends in a quiet room. However, how can speech understanding be optimized in a noisy environment, such as conversations in a café?

2. UltraZoom: supports speech understanding in noise with speech from the front

Introduced with the Spice Platform, in 2010, UltraZoom (UZ) is a multi-band monaural adaptive beamformer to help improve signal-to-noise ratio (SNR). UZ aims to create a narrower beam to the front compared to RES. The position of the null (where the directional response is least sensitive) is adaptively varied to the back of the listener to maximize the SNR benefit (Stewart et al., 2019). UZ has been shown to increase speech recognition in comparison to RES for hearing aid listeners in both diffuse and localized noisy listening conditions (Ricketts & Henry, 2002).

UltraZoom is designed to help clients understand speech from the front in noisy environments. Although the beam is narrow compared to RES, the beam is wide enough to still support a more general perception of the sounds around the client, to help an awareness of the acoustic environment.

However, with a relatively wide beam comes some disadvantages too. As noise becomes louder and more diffuse, the wider beam picks up both noise and speech and such a monaural system may not be able to separate the noise source from the target speech signal. How is it possible to focus on a conversation partner in really noisy environments such as a lively party with friends? The answer: an even narrower beam.

3. StereoZoom: improved speech intelligibility in loud noise for speech from front

The performance of a beamformer can be significantly improved by increasing the number of microphones that are used to create the beam, allowing the formation of an even narrower beam. StereoZoom (SZ), introduced in 2012 with Quest products, is a binaural beamforming system which combines the signals from four microphones (two on the left, two on the right) via a wireless link. This means the dual microphone system on one ear is wirelessly linked to the dual microphone system on the other and is able to create a narrow beam form pattern which is designed to enable a better SNR. At a defined level of noise (activation level), the microphones of both hearing aids work together to focus on sounds coming directly from the front while minimizing competing noise from all directions, so that the listener can concentrate on the conversation. As mentioned, usually the conversation partner is directly in front, so the SZ microphone configuration will amplify the voice of the desired talker and attenuate the noise. Additionally, SZ has a variable null which reduces localized and lateralized noise sources. The combined effect of a 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) and competitor devices (Latzel & Appleton-Huber, 2015). Additionally, Picou et al. (2014) investigated sentence recognition performance for adults with moderate to severe hearing loss, and found that in moderate reverberation, performance with SZ was better than RES or UZ directional processing.

The benefits of SZ have also been found in interesting areas outside of these traditional speech intelligibility measures, such as listening and memory effort. Winneke et al., (2020) investigated the effect of SZ on listening effort and memory effort compared to RES, using subjective, behavioral, and neurophysiological (EEG) measurements with clients with a severe hearing loss. They concluded that a narrow and focused directional microphone allows for a more efficient neurocognitive processing than a wide directional microphone.

Schulte et al., (2018) found a significant increase in the amount of social interaction when using SZ, using a relatively newly developed tool called communication analysis. This has been shown to detect changes in passive and active communication behavior in response to different hearing aids/ settings. They found that the use of SZ over a fixed directional beamformer approach led to significantly increased overall communication and less leaning in towards the talker.

Taken together, these studies demonstrate the benefits of SZ in challenging noisy situations, using both traditional and newer study methods. SZ is activated by default in the 'Speech in Loud Noise' program, one of the programs available in AutoSense OS, the automatic classification system in Phonak hearing aids (Derleth et al., 2021). However, hearing other sounds around the listener will be more difficult when the beamformer is very narrow. This leads to a conundrum: how is it possible to focus on a single speech source for optimal speech intelligibility in noisy environments, while also allowing an awareness of the surrounding sounds when necessary?

Resolving outstanding challenges: StereoZoom 2.0 and SpeechSensor

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.

StereoZoom 2.0: improved focus in noise or spatial awareness depending on the environment
StereoZoom 2.0 is a blend of UZ and SZ with the aim to maintain more spatial awareness at lower activation (noise) levels, or speech focus, depending on the listening environment (Fig. 1). As the level of noise surrounding the client increases, the beamformer gradually moves from UZ to SZ. Once SZ 2.0 is activated, it's strength will be adapted to the environment (increased focus with increased noise level). In addition, now SZ 2.0 can be adjusted within the Target fitting software by the HCP or via the 'Speech Focus' slider in the myPhonak app by the client. This enables the client to take control of how much focus they would like depending on who they want to listen to in challenging environments. The myPhonak app controls the strength of SZ 2.0 in real-time with the aim to improve access to the main frontal speech source.

Indeed, technical measurements have demonstrated that SZ 2.0 provides a 3.0dB better signal-to-noise (SNR) ratio compared to Real Ear Sound (with a power dome). The ability to increase the focus strength of SZ, provides an additional 2.5dB in SNR when increasing the strength from default to maximum strength.

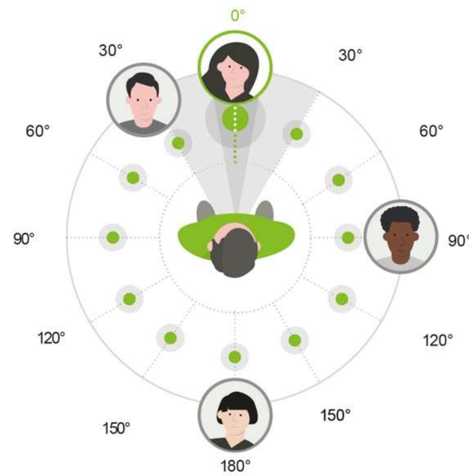

Fig 1: StereoZoom 2.0
As the level of noise surrounding the client increases, the microphone directionality gradually transitions from UltraZoom to StereoZoom 2.0. This provides a balance between providing more spatial awareness and speech focus to the front, depending on the listening environment. The strength of StereoZoom 2.0 activates smoothly as the noise level increases and can now be personalized by the client via the myPhonak app.

SpeechSensor: detects the direction of speech
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. 20% is therefore still a significant number of listening situations where clients may not be looking directly at the speaker (Hayes, 2019). An example of such situations would be, typically, when vision is focused to the front and the communication target is to the side or back. For example, cooking in the kitchen and chatting with loved ones, working at a machine while communicating, or while having a conversation on a noisy street.

Modern hearing aids are able to point the region of highest sensitivity not only toward the front (SZ) but also towards the sides and back of the user. Additionally, the region of reduced sensitivity can be adaptively changed over time to maximally suppress a single noise source in the desired direction. The new Phonak automatic feature SpeechSensor (Fig 2), detects where the dominant speech is located. This information is sent to AutoSense OS, the automatic operating system in Phonak hearing aids, to adjust the directionality, in order to provide better access to speech from the side and behind while in a Speech in

Noise (SpiN) or Speech in Loud Noise (SpiLN) environment.

There are several possible directions:

1. Speech from side (left/right): fixed directional (monaural beamformer)
2. Speech from rear: Real Ear Sound
3. Speech from front/ no dominant direction: StereoZoom

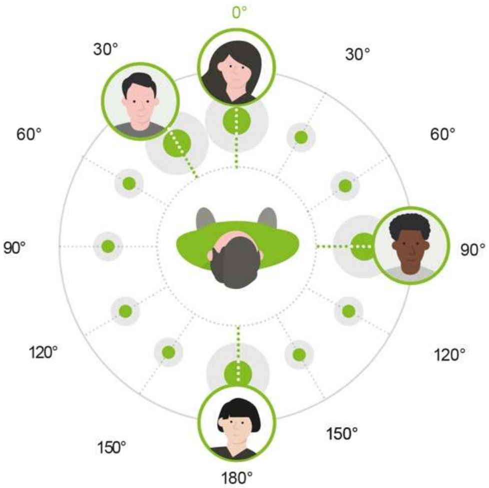

Fig 2: SpeechSensor
SpeechSensor automatically detects where the dominant talker is located and sends this information to AutoSense OS 5.0 to adjust the microphone mode accordingly. SpeechSensor helps provide better access to speech from the side and rear in Speech in Noise (SpiN) or Speech in Loud Noise (SPiLN) programs.

SmartSpeech Technology: bringing together all the features that help improve speech understanding and listening effort

SmartSpeech Technology is defined as a collection of features that are adaptively activated, in a seamless way to improve speech understanding and reduce listening effort in many listening environments (Appleton, 2020; Thibodeau, 2020; Latzel et al, 2022). Controlled by AutoSense OS™ 5.0, SmartSpeech Technology utilizes existing features in combination with the new features StereoZoom 2.0 and SpeechSensor.

AutoSense OS™ 5.0 scans and then classifies the environment and decides whether it is calm, reverberant, noise-only or speech-in-noise. If speech is detected, the appropriate SmartSpeech features are activated for speech understanding and/or reduced listening effort (Appleton, 2020).

Additional well-known features in SmartSpeech technology:

1. Dynamic Noise Cancellation (DNC): reduces listening effort in noise

DNC is a spatial noise cancellation system that works in combination with a directional beamformer and has been found to reduce listening effort in noise (Appleton, 2020).

2. Motion Sensor hearing (MSH): supports speech understanding in challenging environments when on the move

MSH is a 3D motion sensor that detects movement and enables AutoSense OS to steer both the directionality and DNC. A recent study (Appleton & Voss, 2020) compared the experience of a short walk with a conversation partner along a busy street with and without MSH and found that:

- 73% preferred MSH for speech understanding
- 78% preferred MSH for environmental awareness
- 71% preferred MSH for overall listening experience.

3. Speech Enhancer: reduces listening effort in quiet

Speech enhancer is an adaptive feature designed to enhance the relevant cues of a speech signal in quiet situations and is active with input signals of 30-50dB SPL. Appleton (2020) demonstrated that Speech Enhancer has been shown to:

- be preferred for hearing at a distance in a quiet environment.
- reduce listening effort of soft speech in quiet.

4. ActiveVent™ Receiver: better speech understanding with natural sound quality

ActiveVent is a mechanically variable vent that can be electronically switched between open and closed states. It combines the hearing performance of a closed fit when in noise with the comfort of an open fit (Winkler et al., 2016). ActiveVent provides on average 10% better speech understanding in noise than conventional acoustic coupling while providing natural sound in different listening situations (Latzel et al, 2022).

5. Roger™ Technology: better speech understanding in group conversations and over distance

Roger technology has been scientifically proven to help hearing aid users with moderate to severe hearing losses understand more speech in noise and over distance than with hearing aids alone (Thibodeau, 2014). Additionally, a later study found improved speech understanding in group conversations in noise, when comparing a Roger system to hearing aids or cochlear implants alone (Thibodeau, 2020). Using a binaural beamformer in combination with Roger technology has also been shown to yield better speech intelligibility results in the near field, when compared to Roger and omnidirectional mics (Wagener et al., 2018).

Conclusions

Market research has shown that speech understanding is one of the most important needs expressed by hearing aid users (Appleton, 2022). Speech understanding and communication in a variety of listening environments are important for well-being, connection with loved ones and to fully engage with life. Phonak has developed SmartSpeech technology, combining the new features of StereoZoom 2.0 and SpeechSensor, with well-known evidence-based features, orchestrated through AutoSense OS 5.0. SmartSpeech Technology delivers the appropriate combination of features for optimal speech understanding and reduced listening effort. In addition, clients can use the myPhonak app for personalized, real-time adjustments to suit their unique listening needs.

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Author

Jane Woodward, MSc
Audiology Manager, Phonak HQ, Switzerland

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.

Experts

Volker Kühnel, PhD
Principle Expert Hearing Performance, Sonova, Switzerland

Volker Kühnel got his doctorate in Physics in 1995. From 1995 to 1997 he worked in Oldenburg as a post-doc in the group of Medical Physics of Prof. Dr. B. Kollmeier, Oldenburg, Germany. Since 1998, he has worked at Phonak/Sonova in product development at the interface between hearing aid algorithms, fitting software and audiological design. His work focuses on the audiological quality of hearing instruments in order to achieve the highest benefit for clients.

Matthias Latzel, PhD
Clinical Research Manager, Sonova, Switzerland

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.

Christoph Lesimple
Audiological Researcher

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.

Jan Brunner, PhD
Hearing Performance Engineer, Sonova, Switzerland

Jan Brunner studied nanosciences at the University of Basel. After finishing his doctorate in molecular electronics in 2012, he worked as a researcher at the University of Applied Sciences and Arts Northwestern Switzerland (FHNW), at the Institute of Medical Engineering and Analysis Technology and as scientific assistant, scientific employee and lecturer at the Zurich University of Applied Sciences (ZHAW). After joining Sonova in 2019, he has worked on the parametrization, verification and development of beamformer features.

Stina Wargert, MSc
Research Engineer, Sonova, Switzerland

Stina Wargert joined Sonova as an acoustic engineer in 2014. She has been working in the research department as well as with product development focusing on beamforming and microphone technology for improving communication in challenging listening situations. She holds a Master of Science in Engineering Physics from Lund University, Faculty of Engineering, with a specialization in signal processing and acoustics.