3 ways custom hearing aids help cut through the noise

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Abstract

Hearing in noisy situations remains the most significant issue faced by people with hearing loss. Apart from amplification, hearing aids tackle hearing in noise issues in different ways depending on available technology and the specific problem to be solved. This paper presents three important ways that Beltone Serene custom hearing aids help users hear better in different noisy situations: 1. The microphone placement within the pinna provides natural directivity; 2. Digital wireless connectivity allows hearing aid users to receive sound from phones and other audio sources directly to their ears; and 3. 4-microphone binaural beamforming in Beltone Serene in-the-ear (ITE) styles provides astounding directional benefit compared to conventional 2-microphone directionality.

A common advertising technique is known as the band-wagon fallacy. This involves claiming that something is true just because everyone believes it. Although illogical, the appeal is powerful; if everyone else is doing/thinking/buying something, there must be something to it, right? When it comes to sales of hearing aid styles, the shift in the market over the past two decades might make you wonder if the bandwagon fallacy is at least somewhat in play. Just prior to the introduction of the first digital open fit thin tube behind-the-ear (BTE) hearing aids in the early 2000s, custom hearing aid sales made up just over 80% of the US market. Today, the tables have completely turned, with custom hearing aid sales plunging to less than 15% of styles dispensed. The receiver-in-the-ear (RIE) style dominates at 79%.[1] Given these statistics, it might be tempting to conclude that custom hearing aid styles are mostly not worth the trouble.

This conclusion would be incorrect! There are unique advantages that make custom hearing aids attractive for many hearing aid users. One is simply that they are easy to use. People can easier manage insertion and removal and operation of controls than BTE styles.[2,3,4] With rechargeable models, it has been shown that hearing aid users can correctly remove custom hearing aids and place them in their ears twice as fast as rechargeable RIEs.[5] Due to the in-ear location, custom hearing aids can be comfortably worn with glasses, and may be less susceptible to hair noise and wind noise.[6,7] And with advanced features, wireless connectivity, and rechargeability, it isn't necessary to make compromises when users prefer custom hearing aids. Finally, market research conducted by GN suggests that new hearing aid users gravitate toward custom styles.

Cut through the noise with natural microphone location advantages

Spatial hearing refers to our ability to place sounds within 3-dimensional space. This ability is important for orientation in the environment and safety, but also helps us to focus on sounds that we wish to hear and to better pick out speech in noisy backgrounds. Humans rely on contrasts in timing, intensity and frequency differences between the ears for spatial hearing. An important aspect is the spectral cues provided by their unique anatomy. It follows that sound picked up by hearing aids that have the microphone location in the ear will preserve more of these cues because the filtering properties of at least the pinna and potentially also the concha are naturally applied.[8]

Multiple studies have documented that performance on speech-in-noise tasks is similar for ITE, in-the-canal (ITC) and (BTE) hearing aids with directional microphones. However, directional benefit is consistently less with ITE and ITC.[9,10,11] This finding is well illustrated in the data in Figure 1. In this study, hearing aid users were fit with one of two custom styles and with BTE hearing aids. They participated in lab testing of speech recognition in noise and the signal-to-noise ratio (SNR) for 50% speech recognition (labeled "SRT" in Figure 1) was determined for omnidirectional and conventional fixed directionality. While the average performance with directionality active was not significantly different depending on hearing aid style, the difference in performance with the omnidirectional response was highly significant. On average, participants showed a 2.44 dB SNR benefit when tested with custom hearing aids compared to BTE hearing aids. People wearing custom styles will have a directional and

spatial hearing advantage all the time they use the hearing aids regardless of which microphone mode is active. With older directional technology, a small additional directional advantage aligns performance with hearing aids that have the microphones located above and behind the ear.

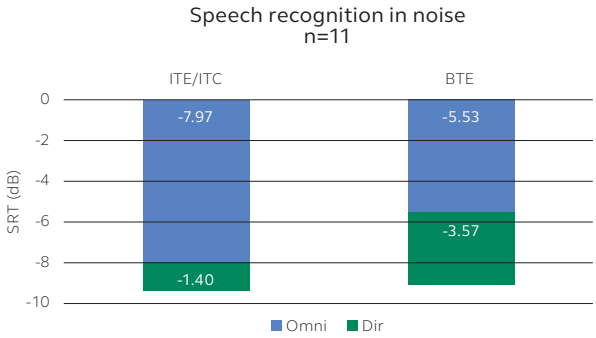


Figure 1: Participants showed equal performance when fit with custom hearing aids compared to BTE hearing aids with conventional 2-microphone directionality. However, performance with custom hearing aids was significantly better than with BTE hearing aids when in omnidirectional mode. A lower score is better.[12]

Cut through the noise with connectivity options

Wireless connectivity to desired sound sources is well-established to vastly improve SNR by mitigating or eliminating the acoustic effects of distance to the desired sound and noise in the environment. This benefit is not dependent on the type of wireless technology; it can be achieved with telecoils, FM systems or digital wireless systems. The past decade saw a surge in digital wireless connectivity options for people who wear hearing aids. The point was to make phone conversations easier and to bring the benefits of digital connectivity enjoyed by other consumers to hearing aid users in as simple a way as possible. Hearing aid users with moderate-to-severe hearing loss have been shown not only to understand phone conversations better with wireless streaming to their hearing aids, but to subjectively rate ease of understanding and usage better when compared to a telecoil used unilaterally with one hearing aid.[13] With Beltone hearing aids, users have been able to wirelessly connect bilaterally to phones either with a phone streaming accessory or directly via special wireless communication protocols developed by phone manufacturers (see Quilter & Groth, 2021[14], for a review of options).

Despite the benefits, the technology that supports connectivity for hearing aids has been fractured with proprietary solutions such as Made for iPhone™ and Android™ Streaming as well as hearing aid manufacturer proprietary solutions. For decades, hearing aid users have had analogue wireless access to remote sound that was convenient and, for them, without additional expense – the telecoil! It was with the telecoil user experience in mind that EHIMA (European Hearing Instrument Manufacturers Association) approached the Bluetooth® SIG (Special Interest Group) with the suggestion to standardize digital wireless connectivity for hearing aids. The idea was so appealing to Bluetooth SIG members that the hearing aid telecoil user experience has served as a model for accessing streamed audio that will be adopted broadly and available to anyone with compatible devices. A new Bluetooth audio standard called Bluetooth Low Energy (LE) Audio brings clear streamed sound with a lower power consumption compared to classic Bluetooth. It also enables Auracast™, a technology that can stream to multiple devices simultaneously with new broadcasting and audio sharing opportunities. It is one of the most exciting advances that the hearing care landscape has seen and will revolutionise the way the world consumes streamed audio.

Wireless models of Beltone Serene custom hearing aids offer the same connectivity options as Beltone Serene RIE and BTE devices, including Bluetooth LE audio and Auracast. Not only are consumer electronics such as phones, TVs and PCs being introduced with support for the new Bluetooth LE audio standard and Auracast at an increasing rate, Beltone has introduced two new wireless accessories based on this updated technology. The TV-Streamer+ was tested in typical living room noise backgrounds compared to aided listening with TV sound coming from a TV sound bar. People with moderate-to-severe hearing losses performed significantly better with streamed sound, even when the hearing aid microphones were active.[15] Similarly, test participants experienced a 7.7 dB advantage over advanced 4-microphone binaural beamforming in a speech-in-noise test of the new remote microphone technology, the Multi-Mic+.[16]

Cut through the noise with unique multiband 4-microphone beamforming

As reviewed above, custom hearing aids offer hearing aid users advantages in hearing in noise by virtue of the microphone location in the ear. Since they have been available in 2-microphone designs for many years, there can also be additional modest hearing-in-noise benefit. Beltone Serene wireless 2-microphone custom ITE hearing aids also offer the same advanced 4-microphone binaural beamforming as RIE and BTE premium models. The microphone pair on each device are connected wirelessly to allow for a higher order directional system to be formed.[17,18,19] While similar technology based on 4 microphones of bilaterally fitted hearing aids is used in some other hearing aid brands, the Beltone binaural beamformer has a unique 3-band structure that provides equivalent sound quality across microphone modes and preserves binaural hearing cues that enable hearing aid users to focus on the sounds they want to hear while remaining connected to their surroundings. This system has been shown to provide an impressive mean directional benefit of 8.6 dB, with a mean directional benefit of 4.3 dB over previous technology.[19]
The 4-microphone binaural beamformer is incorporated within the automatic CrossLink Directionality 4, but also made available to users in a manually selectable program as a feature called Ultra Focus II. Given the observation that directional benefit is less for custom hearing aids than those with microphones located above and behind the ear, it was of interest to investigate the degree of benefit offered by the Beltone Serene custom styles.

Methods

Participants

Seven adult hearing aid users (6 males and 1 female) with bilateral mild-to-moderate sensorineural hearing loss participated in the study. All participants were experienced hearing aid users with a median of 24 years of experience with amplification (1st quartile: 17 years and 3rd quartile: 30 years). The median age of the participants was 76 years with a first quartile of 63 years and a third quartile of 82 years.

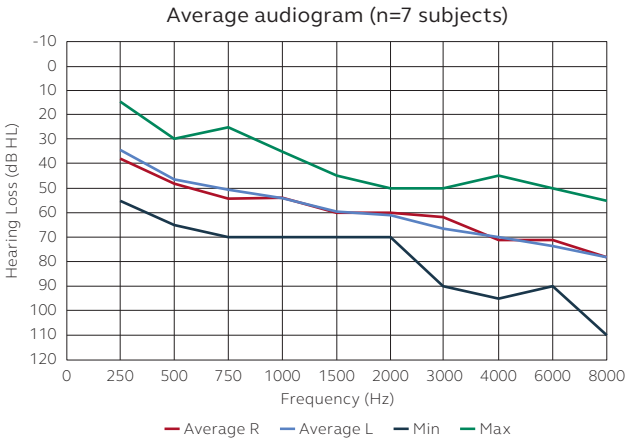


Figure 2. Mean hearing threshold levels for the 7 participants in the study.

Hearing aids and fitting

The participants were fitted with Beltone Serene ITE hearing aids. The hearing aids were fitted with the default gain prescription for experienced hearing aid users in the Hear in Noise program with binaural beamforming processing, and two duplicate programs in which the directionality was set to fixed directionality and omnidirectionality while other settings were kept constant.

Test conditions, material, and setup

The participants completed a speech recognition in noise test that was a slightly modified version of the Dantale II test.[20] The test is comprised of 5-word sentences and was presented in a background of static speech-shaped noise at 65 dB SPL. Thirty sentences are administered for each test. The level of the speech is manipulated to determine a speech reception threshold (SRT) of 50% correct performance, resulting in a dB SNR score, with better performance revealed through lower dB SNR scores. The hearing aids tested have adaptive features that rely on identification of speech and noise in the environment. To ensure that all adaptive features were activated during testing, the Dantale II test noise was started 60 seconds before testing was initiated. The test was conducted in an idealised situation to maximise possible benefit from the advanced directional feature, as demonstrated in earlier studies with RIE styles.[19,21] In addition, the speech and noise material was band-pass filtered from 550-4000 Hz to increase task difficulty and avoid ceiling effects.

Testing was completed with the participants seated in a sound booth with speech presented at 0 degrees azimuth, and static noise presented at 75° azimuth to the right. The setup is illustrated in Figure 3.

Three conditions were completed for the Beltone Serene custom hearing aids, and these were the binaural beamformer, fixed directionality and omnidirectional processing in the Hear in Noise program. The testing order of conditions and the sentence lists were counterbalanced among participants.

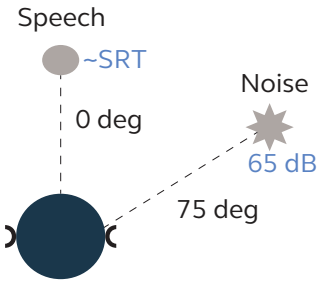


Figure 3. Test setup used for measuring SRTs with adaptive SNRs for a front talker with omnidirectional- and directional processing in hearing aid programs intended for hearing speech in noise.

Statistical analysis

The directional benefit was analyzed using an analysis of variance, and statistical comparisons between the conditions were made using Tukey's honestly significant difference procedure.

Results and discussion

Absolute directional performance and directional benefit

The test participants' mean speech reception thresholds for 50% correct performance (dB SNR) with Beltone Serene custom hearing aids fitted with a Hear in Noise program (with binaural beamformer), a duplicate Hear in Noise program with fixed directionality, and a third Hear in Noise program with omnidirectional processing are shown in Figure 4.

The mean SRT for the binaural beamformer in the Hear in Noise program was significantly better than omnidirectional ($p<0.001$) and fixed directionality ($p<0.05$) processing. Similar to earlier results, the conventional fixed directional response yielded a 1.4 dB advantage over omnidirectional, which was not a significant finding for this small group ($p=0.08$).

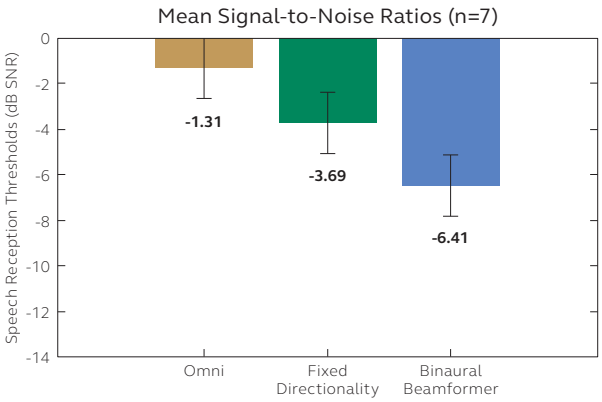


Figure 4. ITE test participants' mean speech reception thresholds for 50% correct performance (dB SNR) with Beltone Serene ITE hearing aids. The hearing aids were fitted with a Hear in Noise program and two duplicate programs with different microphone modes: one with fixed directionality and another with omnidirectional processing. Lower scores are better. Error bars show 95% confidence intervals.

The test participants' mean directional benefit with Beltone Serene ITE hearing aids is shown in Figure 5.

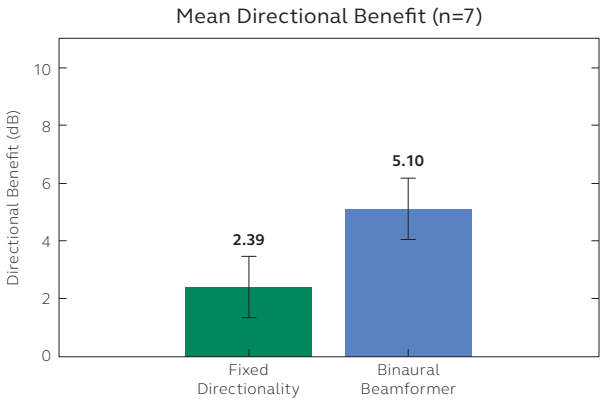


Figure 5. Test participants' mean directional benefit with Beltone Serene custom hearing aids. The hearing aids were tested with a Hear in Noise program and two duplicate programs with different microphone modes: one with fixed directionality and another with omnidirectional processing. Error bars show 95% confidence intervals.

The Hear in Noise program with the 4-microphone binaural beamformer provided a significant benefit in the Beltone Serene custom hearing aids. The mean directional benefit was 5.10 dB ($p<0.001$). The benefit of the 4-microphone binaural beamformer was significantly greater than that for fixed directionality ($p<0.05$). Directional benefit of this magnitude is extraordinary in custom hearing aids.

Conclusions

Beltone custom hearing aids offer hearing in noise benefits as a function of the advantageous microphone location in the ear. Natural directivity characteristics of the outer ear that are leveraged by Beltone custom hearing aids have been shown to give a 2.44 dB advantage compared to BTE microphone location. With added directional benefit from 2-microphone conventional directionality, performance on speech recognition in noise testing aligns with that provided by BTEs.

Wireless Beltone Serene hearing aids are the first to introduce compatibility with Bluetooth LE Audio and Auracast. These Bluetooth technologies will define the consumer audio experience for years to come, and users of Beltone Serene hearing aids will be on the cutting edge. Additionally, new digital wireless accessories that support the new Bluetooth standards are compatible with Beltone Serene, providing users with enhanced SNR when watching TV or using remote microphone technology.

Finally, the onboard wireless 4-microphone network in bilaterally worn Beltone Serene ITE hearing aids allows binaural beamforming. This provides users with unheard of improvements in SNR for speech understanding in noise. In a test with both speech and noise in the front hemifield, Beltone Serene custom devices provided 5.1 dB directional benefit.

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