auto UltraZoom and StereoZoom Features: Unique Naída CI Q90 Solutions for Hearing in Challenging Listening Environments

Most cochlear implant recipients with contemporary technology are able to understand speech in quiet. Nonetheless, having a conversation in noise can be a challenge. When compared to normal-hearing listeners, people with hearing loss and individuals who use cochlear implants still require significantly higher signal-to-noise ratios (SNRs) to achieve the same level of speech understanding (e.g., Dorman et al. 1998, Hamzavi et al. 2001, Killion 1997, Plomp 1978).

The Advanced Bionics (AB) Naída CI Q90 processor incorporates sophisticated directional microphone technology from Phonak with AB's T-Mic™ 2 microphone, AutoSound™ technology, and ClearVoice™* speech enhancement technology to provide the opportunity for AB implant recipients to hear speech more clearly in challenging listening situations. Specifically, the Naída CI Q90 processor introduces the auto UltraZoom and StereoZoom features, both designed to improve the SNR so that AB cochlear implant users have the opportunity to communicate effectively in the multiple environments they encounter every day.

This publication provides an introduction to the auto UltraZoom and StereoZoom features, and describes preliminary results on how these technologies provide benefit to AB cochlear implant users.

auto UltraZoom: How does it work?

auto UltraZoom is an automatic scene classifier that analyzes the listening environment to determine when to activate the T-Mic 2 or Phonak UltraZoom microphone options. auto UltraZoom uses continuous processing of 46 parameters of the sound environment (e.g., overall noise level, SNR, modulation). auto UltraZoom determines the probability for each auditory scene and the relationship of speech to noise. When it is a quiet or noise-only environment, the default T-Mic 2 microphone is used. When there is a high probability that speech is embedded in noise, UltraZoom is enabled (Figure 1).

auto UltraZoom is available in the Naída CI Q90 processor so that users can experience optimal listening in all environments without having to intentionally switch programs. Naída CI Q90 users still have the option of accessing the T-Mic 2 and UltraZoom programs manually if this option is what they prefer.

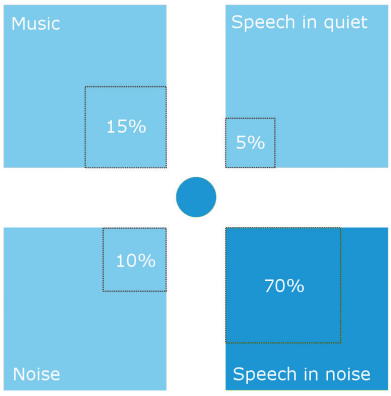

Figure 1. Principle underlying the auto UltraZoom classifier. The classifier calculates the probability for each auditory scene and selects the microphone option based upon a pre-defined probability. In this example, UltraZoom would be enabled.

Whether automatic or manual, both the T-Mic 2 and UltraZoom provide demonstrable listening benefit to AB cochlear implant recipients. Unique to AB, the ***T-Mic 2*** is a microphone placed at the ear canal that comes standard with all Q Series sound processors. The T-Mic 2 is designed to provide easy access to phones, headphones and other consumer audio electronics. In addition, because of the T-Mic 2 microphone's location within the concha, listeners are able to take advantage of the sound-filtering effects of the outer ear. Clinical studies that have measured the advantage of the T-Mic compared to a standard behind-the-ear processor microphone demonstrate that the T-Mic can provide improved speech understanding in noise, especially when speech and noise are spatially separated. For example, using an adaptive test procedure in fixed noise, the advantage can range from 0.5 to 4.4 dB (see figure 7 below, Gifford and Revitt 2010). In a fixed SNR procedure, the T-Mic provided 15% better speech recognition than a BTE processor microphone (Kohlberg et al. 2015). This listening advantage, combined with the ease of access to telephones, headphones, and other assistive devices, make the T-Mic 2 microphone a practical and effective everyday option for AB cochlear implant users, particularly when used with ClearVoice.

Phonak UltraZoom is an adaptive multi-channel dual-microphone beamformer that focuses on input originating from in front of the listener while attenuating sounds coming from the sides and behind (Figure 2). UltraZoom is the result of over 20 years of research and development by Phonak and is used by hearing instrument wearers worldwide. It is available on the Naída CI Q30, Q70, and Q90 processors and can be used by both unilateral and bilateral AB cochlear implant recipients.

Figure 2. UltraZoom directs its focus to the front of the listener while cancelling out interfering noise from the sides and behind.

UltraZoom works by exploiting phase differences in the signal arriving at two spatially separated front and back omnidirectional microphones on top of the processor. For sound coming from the front, the inputs are subtracted from each other after applying an appropriate delay, and a front-facing directionality pattern is created. UltraZoom is adaptive in that it dynamically attenuates sound originating from varying locations in the back hemisphere in a frequency-specific manner to constantly change the directionality of the null based on the loudest noise source in 33 separate channels (Büchner et al. 2014). Thus UltraZoom has the advantage of being able to suppress moving noise sources. In addition, precise microphone matching during manufacturing and *in situ* calibration of the dual microphones ensures that the adaptive directionality is maintained.

Recent studies have demonstrated the benefit of the UltraZoom feature compared to the T-Mic in AB cochlear implant recipients (Advanced Bionics 2015, Agrawal 2014, Büchner at al. 2014, Geissler et al. 2015). The improvement in SRT varied from 3.7 to 5.5 dB depending upon the speech materials and noise type used, and on the configuration of the speaker array. Furthermore, when UltraZoom and ClearVoice together were compared to the standard omnidirectional processor microphone, the improvement in SRT ranged from a remarkable 5.3 to 9.8 dB.

auto UltraZoom: Clinical Data

Researchers at the Medical School Hannover have conducted a preliminary study to determine the benefit of the auto UltraZoom feature in 10 bilateral adult AB cochlear implant users (Table 1). Two different lab situations were set up to simulate consecutive everyday listening situations which usually require manual program switching. The aim was to determine the accuracy of the scene classifier and the benefit experienced in both quiet and noise using the T-Mic 2 and UltraZoom without switching manually.

Table 1. Subject demographics.

	Mean (range)
Age at implantation	50 years (12-70 years)
Duration of implant use	9 years (3-15 years)
Duration of Naída CI sound processor use	1.5 years (1-2 years)

Subjects first were tested in quiet where Hochmair-Schultz-Moser (HSM) sentences originated from either 0, 135, or -135 degrees. Subjects listened using the T-Mic 2, UltraZoom, or auto UltraZoom. They were allowed to move their heads in order to make the situation more realistic. In the quiet condition, subjects scored over 95% correct for all target directions with the T-Mic 2. When auto UltraZoom was enabled, subjects scored the same as the with the T-Mic 2 because the classifier detected speech in quiet and remained in the T-Mic 2 configuration. For the UltraZoom setting, sentence recognition was compromised to about 70% correct for the two rear speakers because UltraZoom is most beneficial for targets in front of the listener. This front-facing advantage is reflected by the sentence score for the frontal speaker which is within the same range as for the T-Mic 2 (Figure 3).

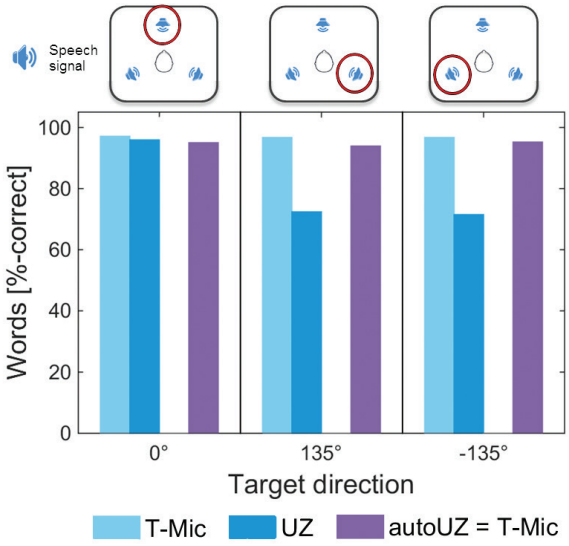

Figure 3. Average HSM word recognition scores in quiet for T-Mic microphone, UltraZoom (UZ), and auto UltraZoom (auto UZ) for speech originating from 0, 135, or -135 degrees azimuth.

Subjects also were tested in noise where the Oldenburg sentences were presented from in front of the subject and noise was presented from eight surrounding speakers, including in front of the listener. Canteen noise was presented at a constant level of 65 dB A and the sentence level was varied to achieve a 50% score, expressed as the speech reception threshold (SRT). Testing was conducted with the T-Mic 2, UltraZoom, and auto UltraZoom. The average SRT for the T-Mic 2 was -5 dB. The UltraZoom and auto UltraZoom SRTs were identical at -10 dB because the auto UltraZoom classifier determined that the scene was speech in noise and automatically switched to UltraZoom (Figure 4). Overall, the study showed that the auto UltraZoom feature classifies the speech-in-noise environment accurately and switches the microphone mode to enable optimal speech perception in quiet and in noise.

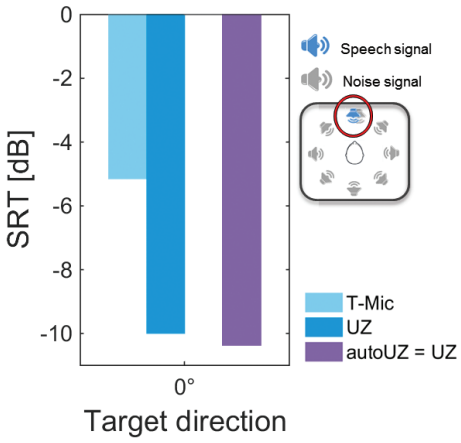

Figure 4. Average OlSa SRTs in canteen noise with T-Mic 2 microphone, UltraZoom (UZ), and auto UltraZoom (auto UZ).

Phonak StereoZoom: How does it work?

Dual-microphone beamforming technology is most effective when the speech signal is separated from noise. However, in some real life situations, the signal of interest is not well separated from the competing noise source, for example, at a party. The Phonak StereoZoom feature is a third-order directional beamforming system created by wirelessly connecting the four microphones across two Naída CI Q90 processors (Figure 5). StereoZoom can improve listening by providing a narrower directional beam than is provided by UltraZoom alone, thus allowing bilateral implant users to focus on a single speaker directly in front of them while reducing interfering noise from the sides, back, as well as from near the front (Figure 6).

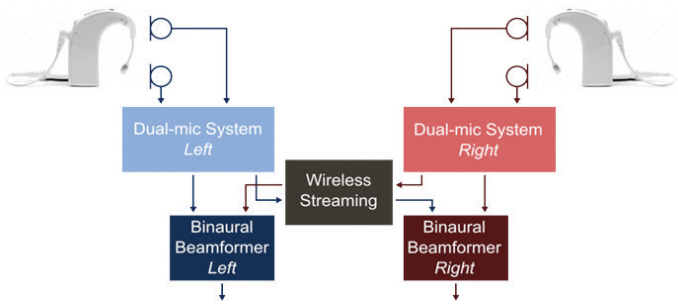

Figure 5. Block diagram of StereoZoom technology.

StereoZoom is one of several implementations of Phonak Binaural VoiceStream Technology™, which allows two hearing devices to be linked wirelessly to stream full bandwidth audio signals from ear to ear in real time with short transmission delays and low power consumption. StereoZoom has been used in Phonak hearing aids since 2010 and has proved to be effective at improving speech perception with noise presented from loudspeakers positioned as close as ±45° either side of the speech signal (Nyffeler 2010). Advanced Bionics offers the only cochlear implant system that incorporates Phonak Binaural VoiceStream Technology so that Naída CI sound processors not only process sounds at the same time, but actually communicate with each other to provide the best hearing for individuals with two implants.

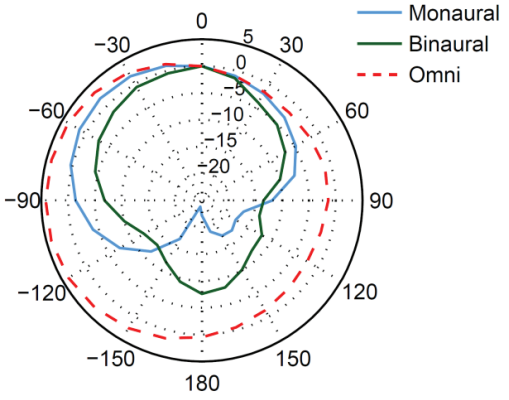

Figure 6. Polar plots for an omnidirectional microphone, monaural beamformer (UltraZoom), and binaural beamformer (StereoZoom) obtained using a single noise source from varying angles. Circles indicate the gain in decibels (dB) relative to the 0-degree response.

Phonak StereoZoom: Clinical Data

Using the same bilaterally implanted subjects as in the auto UltraZoom study described above, researchers at the Medical School Hannover evaluated the benefit of StereoZoom compared to the omnidirectional processor microphone, the T-Mic 2, and UltraZoom. OlSa sentences were presented adaptively in speech-shaped noise. The speech originated from a speaker in front of the listener, while noise was presented at 65 dB A from seven speakers located on the sides and back.

Results showed that StereoZoom provides 1.5 dB additional benefit compared to UltraZoom, 5.5 dB additional benefit compared to the T-Mic 2, and 6 dB additional benefit compared to the processor microphone (Figure 7). Thus the narrower beamformer offered by StereoZoom offers bilateral Naída CI Q90 users the opportunity to focus on a single talker for communication in an adverse diffuse noise situation.

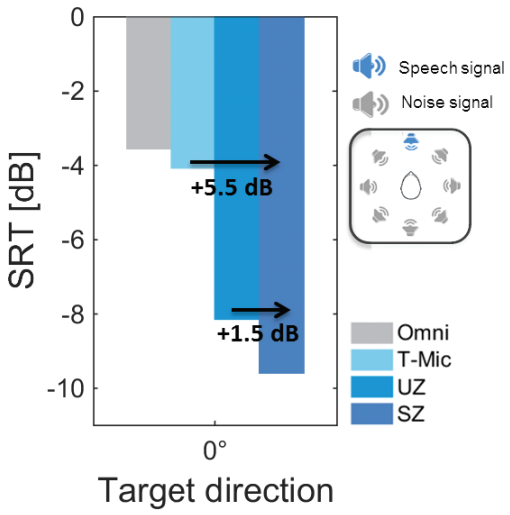

Figure 7. Average SRTs for an omnidirectional microphone, the T-Mic 2 microphone, UltraZoom, and StereoZoom.

CONCLUSION

The auto UltraZoom and StereoZoom options offered by the Naída CI Q90 processor give AB cochlear implant users the ability to hear speech better in the many listening situations encountered throughout the day. The auto UltraZoom feature switches automatically and effectively between the T-Mic 2 microphone for hearing in quiet and the UltraZoom feature for conversing in noise. Bilateral AB cochlear implant recipients with two Naída CI Q90 processors can take advantage of the StereoZoom feature's focused beam for communication in extreme adverse listening environments.

These microphone options, when combined with AB's AutoSound™ technology and ClearVoice™* sound processing, provide a variety of solutions to improve communication every day and everywhere.

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* Not approved for pediatric use in the United States.