StereoZoom and auto StereoZoom

Audiological background

The technical opportunities in hearing aid technology have developed gradually and user satisfaction with hearing aids has thus been steadily on the increase (Kochkin, 2010). A major contributor to this success was multi-microphone technology, as this system, both objectively and subjectively, significantly improves speech comprehension in noisy environments (Ricketts & Mueller, 1999, Chung, 2004). However, this type of system has its limitations which can have an impact on the everyday life of a hearing aid user when the source of noise is very close to the target sound source, usually a person the hearing aid user is listening to.

These limitations can be overcome through the use of true binaural signal processing methods which support the binaural hearing of hearing aid users, especially in complex acoustic environments. For this purpose, hearing aid algorithms use the well known approaches of natural binaural processing systems. A typical example of such an approach is "binaural directionality". By having two ears, humans as well as all mammals, are able to use binaural directionality to concentrate on the effective source right in front of the listener while subconsciously blocking out irrelevant noise signals around them. At the same time, the binaural auditory system processes the signals already directed toward the two ears, providing a directional characteristic towards the front that is even more effective. By using two ears, the human auditory system is optimized for effective sources from the front (Hawley et al., 1999).

This approach has been implemented in the StereoZoom algorithm. With a binaural fitting, the directional microphones of both hearing aids are wirelessly connected to each other in order to provide an extreme directionality towards the front, overcoming the previously mentioned limits of a simple microphone system. To ensure that binaural hearing support is as instinctive as natural hearing, StereoZoom is automatically activated without the need for any conscious effort from the hearing aid user, as soon as the system determines that extreme directionality towards the front is not only required but also advantageous.

Benefits for the hearing aid user

- Improved speech intelligbility and less listening effort in complex acoustic situations.
- Automatic activation of StereoZoom in acoustic situations where StereoZoom provides an additional benefit.
- Not restricted to specific designs (e.g. with a switch or an appropriately sized ITE device).
- No accessories such as remote control required.

Figure 1
Humans and other mammals have two ears which they use for binaural hearing.

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Technical description

When a conventional dual microphone system (i.e. a first-order microphone system) is no longer able to sufficiently separate the sources of noise from the target sound source, it is then necessary to increase the order of the microphone system with the help of binaural signal processing:

A binaural fitting can be considered to be a single system consisting of four microphones. This system is used for the StereoZoom feature, which already has a static directional microphone system (see figure 2). In the first stage, the input signals of both microphones in both hearing aids are used to calculate a standard dual microphone system. The respective output signal of the microphone system is sent to the contralateral side using wireless transmission to cover the full bandwidth of the audio data. It is then processed together with the output signal of the ipsilateral dual microphone system, using a weighting function. Figure 3 shows a comparison in polar diagrams of such a microphone array and of a normal static dual microphone system. A clearly narrower main lobe of the directional characteristic with zero points at approx. ±45° can be seen (figure 3b). In addition, there is also a clearly increased attenuation of all signals that do not come from the front and are interpreted and suppressed as noise signals. The directional characteristics shown are based on the assumption that the microphones are in sync with each other in terms of their phase and amplitude characteristics. The microphones are already matched before they are installed in the instruments. It can also be done automatically while the instruments are being worn, using an algorithm that compensates for possible differences in sensitivity or phase characteristics.

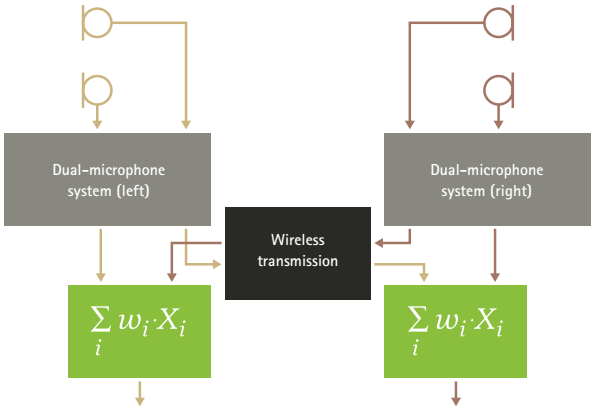

Figure 2
Block diagram of the technical implementation of StereoZoom

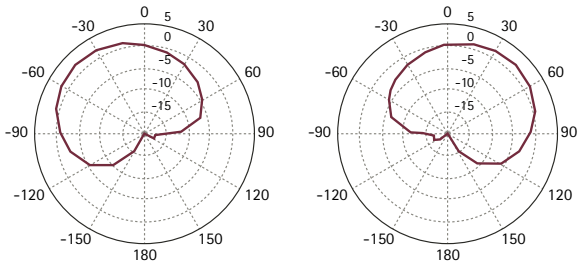

Figure 3a
Polar diagram of a dual microphone system for the left and right KEMAR ear with broad-band stimulation. Conditions: Free-field, low-reflection room

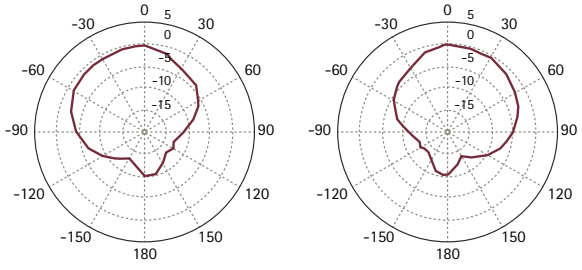

Figure 3b
Polar diagram of a binaural static directional microphone system (StereoZoom) for the left and right KEMAR ear with broad-band stimulation. Conditions: Free-field, low-reflection room

The "virtual" increase in the distance between the microphones allows the system to provide a more effective spatial effect, even at lower frequencies. In addition, figure 3 also shows that the polar diagrams for the left and right hearing aids are not identical, rather spatial separation is retained, which is important for spatial perception and localization.

Following the activation of StereoZoom, the main lobe of directionality is considerably narrower. This could potentially lead to a substantial decrease in loudness, since a large amount of energy is absorbed by the input signal. However, this is prevented by the automatic adjustment of the amplification parameters keeping the environmental loudness remains the same. When measuring SteroZoom in a test box, unexpected gains would be measured because it is in artificial enviropment, but this would be adjusted when wearing the hearing aids in everyday situations. StereoZoom can be activated manually or automatically. This means StereoZoom can also be used in the SoundFlow automatic program. In this situation, in addition to the microphone signals, the algorithm also analyzes the ambient levels in each hearing aid and compares them via the wireless connection. The two hearing aids only make the joint decision to activate StereoZoom if all of the following criteria are met in both hearing aids and where they remain stable over a defined period of 4 seconds both hearing aids make the common decision to activate StereoZoom. Once this has been achieved the hysteresis starts:

- The percentage of "Speech in noise" must be at least 85%.
- The measured ambient level must exceed 70 dB SPL (this value can be adjusted with the fitting software).

The activation is not sudden, but follows a time hysteresis curve over a defined period of time. These times can be also be adjusted with Phonak Target 3.0 onwards. These time constants ensure that the binaural directionality is only switched on and off when the parameters (gain, compression, noise reduction, etc.) that occur when switching to another class are set accordingly. This means that the time constants for SoundFlow and auto StereoZoom are linked in such a way that no noticeable artifacts occur on switching.

Clinical evidence

StereoZoom has already been available in Phonak premium products since the launch of the Spice platform and the effectiveness of the algorithm has been proved in a number of studies. (Nyffeler, 2010a, Nyffeler, 2010b, Nyffeler, 2010c, Timmer, 2010).

StereoZoom was compared with a monaural beam former and another system available on the market in a recent study carried out at the hearing center in Oldenburg. The Oldenburg Sentence Test (Wagner et al. 1999) was used in a defined noise environment, in which seven loudspeakers projected cafeteria noise from different directions (see figure 4). The noise signal was therefore considered to be diffused. The two front loudspeakers were located at 30° and 330°, so that the main lobe of the directional microphone system was very narrow in order to allow for the separation of the target and noise signals. Fifteen test subjects with moderate hearing loss took part in the study. Figure 5 shows the median of the speech reception threshold (SRT) for the different directional microphone approaches. A negative SRT indicates a better result. StereoZoom was significantly better than the two other directional microphone systems of the first order. The test subjects with StereoZoom could understand 80% of the words in a sentence at 1.65 dB lower than the equivalent threshold for the monaural beam former and 2.75 dB lower than that of the competitor system. The results are statistically significant. This shows that only a microphone system of a higher order is able to discriminate between target sound sources and noise sources when their directional distance is less than 30°. The study further confirmed that the StereoZoom clearly improves speech comprehension, not only under ideal conditions, but also with diffuse background noise, which is closer to a real life situation.

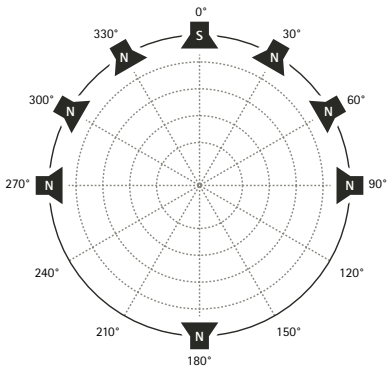

Figure 4
Test arrangement for the Oldenburg Sentence Test measurements to investigate the StereoZoom feature. Cafeteria noise was presented from loudspeakers located at 30°, 60°, 90°, 180°, 270°, 300° and 330° and their signals were shifted in time so that a diffuse noise signal could be assumed for this purpose. The speech signal was presented from 0°.

Figure 5
Results of the Oldenburg Sentence Test speech recognition measurement under the conditions described in figure 4. The results show the median of the SRT at which 80% of the speech can be heard for the three applications: monaural beamformer, StereoZoom and the competitors directional system.

Operation in the Phonak Target software

auto StereoZoom is pre-selected by default in the SoundFlow program "Speech in loud noise" (figure 6). The program can be fine-tuned to personal preferences. Changes to the settings in the program "Speech in noise" will be automatically transmitted to the program "Speech in loud noise".

Alternatively, manual StereoZoom can be selected as an additional manual program (figure 6).

Figure 6
auto StereoZoom as the SoundFlow program "Speech in loud noise" and StereoZoom as an additional manual program.

1. **Sensitivity**
   The control switch for adjusting the sensitivity of SoundFlow can also be used to adjust the activation time for StereoZoom. By default, the attack time is set to 15 seconds. This can be adjusted to 10 seconds (setting: "very high") or adjusted to 20 seconds (setting: "very low") (figure 7).

2. **Activation level**
   The activation level for auto StereoZoom can also be changed. This is set by default to 70 dB, but can be adjusted to 67 dB SPL ("Medium loud noise") or adjusted to 80 dB SPL ("very loud noise") (figure 7).

3. **Priority**
   The priority for recognizing the class "Speech in loud noise" can be adjusted upwards or downwards so the class share of 85% can be immediately identified and auto StereoZoom is more frequently activated (figure 7).

Figure 7
Fine tuning of auto StereoZoom. Sensitivity, activation level, and priority can be fine-tuned in the SoundFlow Program options.

Tips and Tricks

- Once the hearing aid is classified as "Speech in loud noise", only the settings for this program are effective. As with the music program, blending with other programs is not possible.
- "Speech in loud noise" can also be removed from SoundFlow, by deactivating "Speech in loud noise" (figure 8). As an additional alert, an orange exclamation mark will appear in the program list. Manual StereoZoom can still be used as a manual program.
- When hearing aids are linked to the fitting software, the effect of SoundFlow is deactivated. Thus, the chronological hysteresis of auto StereoZoom is not active either. In this case, the criterion for the relevant class "Speech in loud noise" is always met and that auto StereoZoom can only be manually connected and disconnected via the activation level. In this case, the system reacts very quickly and there is the possibility of nervous switching.
- The fitting should be as closed as possible, but this should not compromise the comfort or wishes of the hearing aid user to ensure smooth and effective running of (auto) StereoZoom. In addition, the fitting and technology should be checked on a regular basis, e.g. to find out whether the hearing threshold has changed or whether the microphones have degraded over time due to environmental influences.

  To influence how often the hearing aids are pushed into "Speech in loud noise" program, the noise floor level can be adjusted using the "Speech in loud noise" slider to reduce or increase the noise floor level setting and activate auto StereoZoom faster or slower. Additionally the priority setting can be selected and you can choose to make SPIN/SPILN highest priority so it reaches the 85% probability more often or the SoundFlow sensitivity slider can be adjusted to change the timer speed to switch into "Speech in loud Noise" faster or slower.

Figure 8
Switching off the «Speech in loud noise» program in SoundFlow.

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Demonstrations and more information

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