Field Study News

September 2015

StereoZoom

Adaptive behavior improves speech intelligibility, sound quality and suppression of noise

A study conducted at the Hörzentrum Oldenburg in Germany, has shown that the new generation of StereoZoom (adaptive binaural beamformer) from the Phonak Venture platform, significantly improves speech intelligibility in noisy environments. This was found to be the case when comparing to static and monaural beamformer approaches, including approaches from two competitors. Furthermore, significant subjective improvements were identified for both sound quality and suppression of interfering noise, both in the laboratory and in real life.

Objective

The objective of this study was to evaluate the benefit of the new generation of Phonak StereoZoom (Venture platform) compared to its predecessor (Quest platform), UltraZoom and two approaches from competitor devices.

Introduction

Directional microphones improve understanding in difficult listening situations, particularly situations where there is a lot of background noise (Ricketts, 2006; Wouters et al., 1999; Chung, 2004; Hamacher et al., 2005). In general, they focus on speech coming from the front whilst attenuating noise from behind. Table 1 categorizes Phonak directional microphones in terms of their beamformer characteristics.

Phonak beamformers	Better adaptation to a specific scene & suppression of distinct prominent noise sources →		
Higher directionality (& SNR) e.g. in diffuse noise ↓		static	adaptive
	monaural	Fixed directional	UltraZoom
	binaural	StereoZoom (Quest)	StereoZoom (Venture)

Table 1: Phonak beamformers

The adaptive monaural beamformer, UltraZoom, has been shown to improve speech understanding in situations with a prominent source of background noise present (Wouters et al., 2002; Ricketts & Henry, 2002). It focuses on speech from the front which improves the signal-to-noise ratio and enhances speech understanding. A typical example of this situation can be seen in figure 1, which shows a hearing aid user (head in the center of the picture) listening to three other people within the green shaded area. Noise comes from two prominent directions (the people seated at the two gray round tables). This kind of beamformer does not create a narrow beam in one specific direction but adaptively attenuates the most prominent noise, while retaining gain from the front. So it is possible to have a conversation with people within one's individual field, even if they are not talking directly from the front.

PHONAK life is on

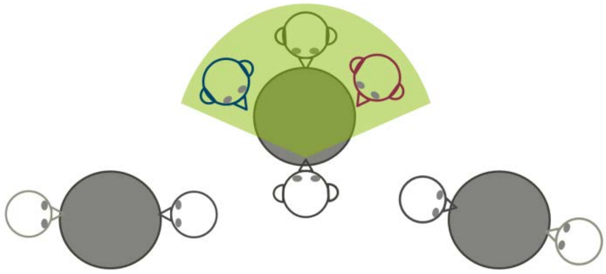

Figure 1: An example of a listening situation where UltraZoom has been shown to be of significant benefit. A hearing aid user is sitting listening to the people within the green shaded area. Noise comes from two prominent sound sources (the people sitting at the gray tables)

On the other hand, the static version of the binaural beamformer, StereoZoom, has been shown to provide directional benefit in situations where the noise environment is diffuse (Nyffeler, 2010; Stuermann, 2011; Picou et al., 2014; Latzel, 2013). A typical example of this situation can be seen in figure 2 which shows a hearing aid user (head in the center of the picture) having a conversation with three other people within the green shaded area. Noise is coming from many directions which creates a diffuse noise environment.

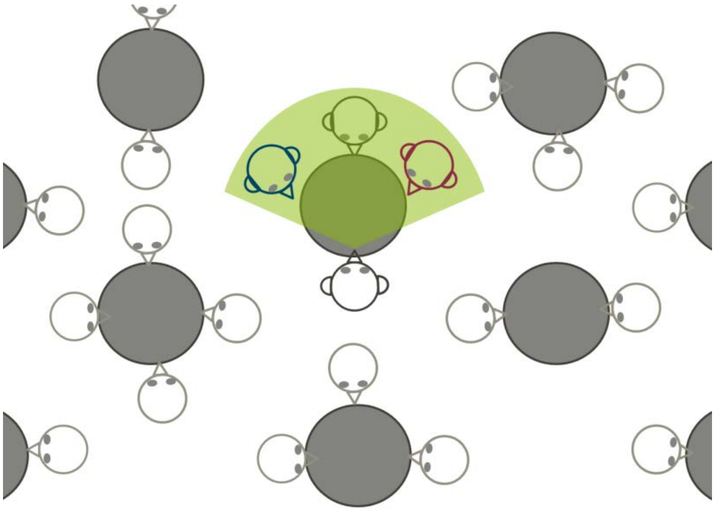

Figure 2: An example of a listening situation where StereoZoom has been shown to be of significant benefit. The hearing aid user is listening to people within the green shaded area. He is surrounded by noise sources from several different directions which creates a diffuse noise environment.

This static binaural beamformer, StereoZoom, works by creating a bidirectional network of four microphones which produces a strongly focused directional effect.

The enhanced directional characteristic, which provides a considerably improved attenuation of background noise, produces a very narrow focus compared to the monaural beamformer and thereby improves the signal-to-noise ratio (SNR) further.

Benefits of the advanced beamformer variants can be summarized as follows:

- Adaptive beamforming in comparison to static beamforming: Better suppression of distinct prominent noise sources and capability to adapt to specific sound fields.
- Binaural beamforming in comparison to monaural beamforming: Improved directionality with a narrower front beam (focus). This leads to a higher SNR improvement (e.g. in a diffuse noise field).

A new generation of StereoZoom has been developed for the Venture platform which aims to incorporate the benefits of a binaural system with those of an adaptive system. Appleton and König (2014) revealed the significant benefit of the adaptive behavior of StereoZoom, both in terms of speech intelligibility and subjective rating when compared to static monaural or binaural beamformers. This study aims to provide further evidence and also to make a comparison with competitor beamformers.

Study design

The study participants were 20 hearing aid users with hearing losses within the moderate to severe range (mean pure tone average 50 dB HL, range 37-63 dB HL). Audéo V90 hearing aids were used, in order to test UltraZoom and the adaptive behavior of StereoZoom. Audéo Q90 hearing aids were used in order to test the static behavior of StereoZoom. For comparison, two hearing aids from competitors were also used. All hearing aids were set up with Real Ear Sound (RES) or in omnidirectional microphone mode (dependent on availability) in order to act as a reference condition. Frequency lowering was deactivated. These settings enabled the focus to be only on the difference between directional microphone approaches. Acoustical parameters for all hearing aids were set according to the recommendation made by the fitting software.

Speech intelligibility of the various beamformers was assessed using the Oldenburger Satztest (OLSA), a speech-in-noise sentence test. Subjects heard sentences consisting of five words (open set) in the presence of background noise. Subjects were asked to repeat what they heard and they were scored on the number of words which they repeated correctly. All five beamformers were tested in two different spatial set-ups which can be seen in figure 3. In both set-ups, the subject was seated at the center of a circle of 12 loudspeakers, facing the speaker at 0° azimuth. The OLSA speech material was presented from this speaker. In set-up 1, cafeteria babble noise was presented from all other 11 loudspeakers which created a diffuse noise environment. In set-up 2, cafeteria babble noise was presented from loudspeakers at angles 90° and 270° only, creating a situation where only noise from the sides was present. Speech levels were adaptive whereas noise levels were constant at 65 dB (A). This produced Speech Reception Thresholds (SRT) (i.e. the signal-to-noise ratio with which 50% of all words are correctly understood) for all subjects using all five beamformers in both test set-up versions.

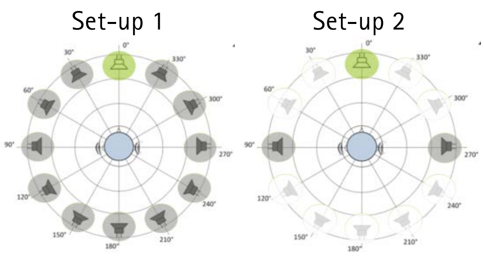

Figure 3: In set-up 1 for the OLSA measurement, a diffuse noise environment was created by all 11 gray speakers presenting cafeteria babble noise. In set-up 2, noise from the sides was created by presenting cafeteria babble noise from only the speakers at 90° and 270° azimuth.

Subjective assessment was carried out both in and out of the laboratory. It aimed to compare StereoZoom (adaptive binaural) versus UltraZoom (adaptive monaural). Static StereoZoom was not included in this part of the study as it would have involved changing hearing aids. Audéo V90 hearing aids were set up with an adaptive StereoZoom program and an UltraZoom program. The order of these two programs was randomized across subjects. Subjective assessment outside of the laboratory consisted of two parts. Firstly, the subjects went on a short walk with the tester where they had a conversation both at a street crossing and in a cafeteria. Test subjects were then asked to fill in a questionnaire where they rated the two programs on a scale of -5 (program 1 much better) to +5 (program 2 much better) for a variety of performance characteristics. Following on from this, subjects wore the device for 3-4 weeks and were asked to compare the two programs in as many challenging listening situations as possible. Subjects switched between programs manually and were blinded as to which programs they were switching between. They filled in a questionnaire in order to compare the two programs. Subjects judged a variety of performance aspects such as listening effort, sound quality and loudness of interfering noises.

In the laboratory, subjective assessment used set-up 1 which had been used for the OLSA measurement (diffuse noise environment). A sound sample of a party scene was presented from all loudspeakers at 65 dB, whilst speech was presented from the front at 60 dB. Subjects were asked to switch between program 1 and 2 and to rate the two programs on a scale of 0 (very bad) to 8 (very good) in terms of speech intelligibility, suppression of noise and general sound quality.

Results

Objective results from the OLSA measurement can be seen in figures 4 and 5. Both figures show the speech reception threshold (SRT) benefit of the different beamformers relative to the SRT measured with omnidirectional or RES settings.

Figure 4 shows the SRT benefit when using spatial set-up 1 - a diffuse noise environment. A t-test analysis revealed a statistically significant difference (p = 0.005) between the SRT benefit of adaptive StereoZoom versus both that of UltraZoom (the monaural beamformer) (p = 0.005) and that of competitor 2 (p = 0.001).

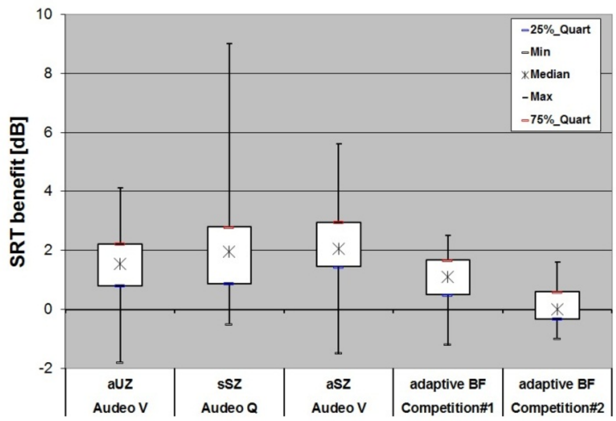

Figure 4: SRT benefit of the directional setting compared to the respective omnidirectional/RES setting. SRT was calculated from OLSA measurements using set-up 1, a diffuse noise environment. aUZ = UltraZoom, sSZ = StereoZoom (Quest), aSZ = StereoZoom (Venture).

Figure 5 shows the SRT benefit when using spatial set-up 2 where noise is present from the sides only. A t-test analysis indicated that there were statistically significant differences between the SRT benefit of adaptive StereoZoom versus that of all other beamformers.

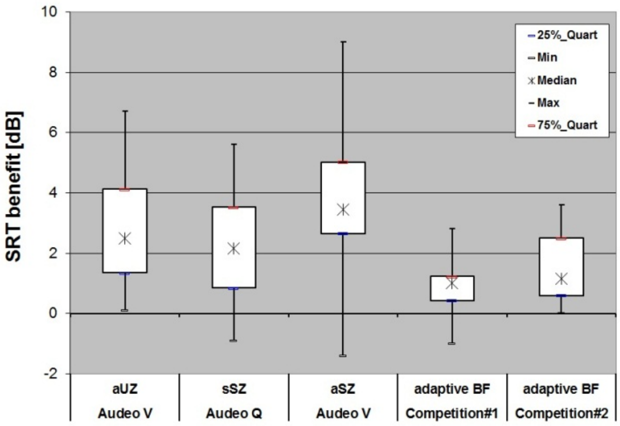

Figure 5: SRT benefit of the directional setting compared to the respective omnidirectional setting. SRT was calculated from OLSA measurements using set-up 2 where noise was present from the sides only.

A Wilcoxon rank sum test (p=0.05) indicated some significant differences between adaptive StereoZoom and UltraZoom when compared during the home trial. Adaptive StereoZoom was found to yield significantly better sound quality in noisy situations compared to UltraZoom. Interfering noise was rated significantly softer (better) for adaptive StereoZoom than for UltraZoom, both when conversing in a car/bus and when in a large discussion group.

Subjective testing in the laboratory revealed that the mean rating of adaptive StereoZoom was better than that of UltraZoom for all three categories; speech intelligibility, suppression of noise and general sound quality (figure 6). The ratings of speech intelligibility and sound quality were statistically significant on the 0.05 level (Wilcoxon rank test). This correlates well with the objective results from the OLSA test which indicated that speech intelligibility was also better with adaptive StereoZoom than with UltraZoom.

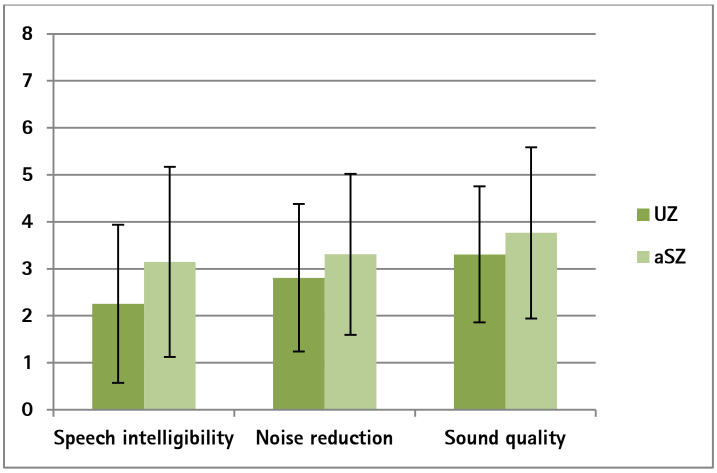

Figure 6: Mean subjective ratings for 18 test subjects using a scale of 0-8 (0=very bad, 8= very good). Subjects compared UltraZoom versus adaptive StereoZoom with regards to speech intelligibility, noise reduction and sound quality.

Conclusion

Objective assessment indicates that the new generation of Phonak StereoZoom (Venture) with its binaural adaptive behavior, improves speech intelligibility in noisy situations when compared to the static version, the monaural adaptive beamformer (UltraZoom) and competitor products. This is particularly true when noise is present from the sides only. Subjective assessment correlates well with the objective findings, as subjects rated StereoZoom (Venture) to provide better sound quality and speech perception than UltraZoom both in the laboratory and at home. Furthermore, StereoZoom (Venture) was rated significantly better than UltraZoom at suppressing interfering noise, both in the laboratory and in noisy situations outside of the laboratory.

In conclusion, this study has shown superiority of the new adaptive binaural beamforming technology from Phonak via both subjective and objective testing.

References

Appleton, J., König, G., 2014. Improvement in Speech Intelligibility and Subjective Benefit with Binaural Beamformer Technology. *Hearing Review October 2014*

Chung, K., 2004. Challenges and Recent Developments in Hearing Aids. Part I. Speech Understanding in noise, microphone technologies and noise reduction algorithms. *Trends in amplification*, 8(3), p. 83-124.

Hamacher, V., Eggers, J., Fischer, E., Kornagel, U., Puder, H., Rass, U., 2005. Signal Processing in High-End Hearing Aids: State of the Art, Challenges, and Future Trends EURASIP. *Journal of Applied Signal Processing*, 18 p. 2915–2929

Latzel, M., 2013. Concepts for Binaural Processing in Hearing Aids. *Hearing Review*, 20(4), p. 34

Nyffeler, M., 2010. StereoZoom - Improvements with directional microphones. Field Study News. Phonak AG: 2010

Picou, E. M., Aspell, E., Ricketts, T. A., 2014. Potential benefits and limitations of directional processing in hearing aids. *Ear and Hearing*, 35(3), p. 339-352

Ricketts, T. A., Henry, P., 2002. Evaluation of an adaptive, directional-microphone hearing aid. *International Journal of Audiology*, 41 p. 100-112

Ricketts, T. A., 2006. Directional hearing aid benefit in listeners with severe hearing loss. *International Journal of Audiology*, 45, p. 190-197

Stuermann, B., 2011. StereoZoom - Improved speech understanding even with open fittings. Field Study News. Phonak AG: 2011

Wouters, J., Litièrère, L., van Wieringen, A., 1999. Speech intelligibility in noisy environments with one- and two-microphone hearing aids. *Audiology*, 38 p. 91-98

Wouters, J., Vanden Berghe, J., Maj, J.-B., 2002. Adaptive noise suppression for a dual-microphone hearing aid. *International Journal of Audiology*, 41 p. 401-407

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