Phonak
Field Study News

AutoSense OS – Superior speech intelligibility and less listening effort in complex listening situations

This study, conducted at the Hörzentrum Oldenburg, Germany, found that AutoSense OS leads to better subjective speech intelligibility and reduced listening effort compared to two competitor devices. This was found to be the case for a typical conversation setting when the listener focuses on someone speaking from the front and also for a situation where attention is shared, focusing on multiple talkers.

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Introduction

Understanding speech in the presence of background noise is one of the most difficult tasks for individuals with sensorineural hearing loss, even when wearing appropriately-fit hearing aids. In complex, noisy environments, hearing aid users require a more favorable signal-to-noise ratio (SNR) than their normal-hearing peers to achieve the same level of performance (e.g., Killion, 1997). Further, the ability to understand speech in noise has been found to correlate with hearing aid satisfaction. According to MarkeTrak IX, the most satisfied hearing aid users feel their hearing aids successfully minimize background noise, are comfortable to wear when listening to loud sounds and improve the ability to tell the direction of where sound is coming from (Abrams & Kihm, 2015).

Over the last decades, hearing aid manufacturers have implemented increasingly advanced noise reduction technologies to improve SNR and consequently enhance speech recognition. One of the most commonly used noise reduction technologies in hearing aids is known as beamforming. It involves the use of two microphones operating in tandem to allow the hearing aid to produce a directional signal and thus act as a 'spatial noise canceller'. This microphone setup is designed to improve speech understanding when background noise is present, since it is typical for the signal of interest to be in front of the hearing aid user and unwanted background noise to come from the sides and / or behind.

Based on models of cognitive psychology (Shinn-Cunningham (2008) and with regard to ecological validity (Paluch et al. (2017), Meis et al. (2018)), a typical group conversation is described as listeners constantly switching between shared and focused attention. It may be that when a conversation begins, listeners share their attention amongst speakers within a group in order to decide which person they most want to listen to or which conversation they would like to join. Once they have decided, then they are likely to try to focus their attention on a single speaker and try to block out the other conversations and noise around them. It could however be the case, that if someone else would like to get their attention, it would still be useful for them to be able to hear speakers coming from other directions. This implies that in a group conversation, it is useful for a listener to be able to switch between focused and shared attention.

The objective of this study was to compare localization ability, subjective speech intelligibility and subjective listening effort in complex listening situations for an AutoSense-OS device and two competing devices, that also provide automatic scene classifiers. A second objective was to determine whether there was any difference in performance when focusing attention on one talker and sharing attention between multiple talkers.

Methodology

Participants

30 experienced hearing aid users with moderate hearing loss (figure 1) took part in the study. They ranged in age from 44 to 86 years (mean age was 72.6 years). They had normal cognitive values which were assessed via the 'DemTect' test (Kalbe et al., 2004) and reported normal head-movement abilities.

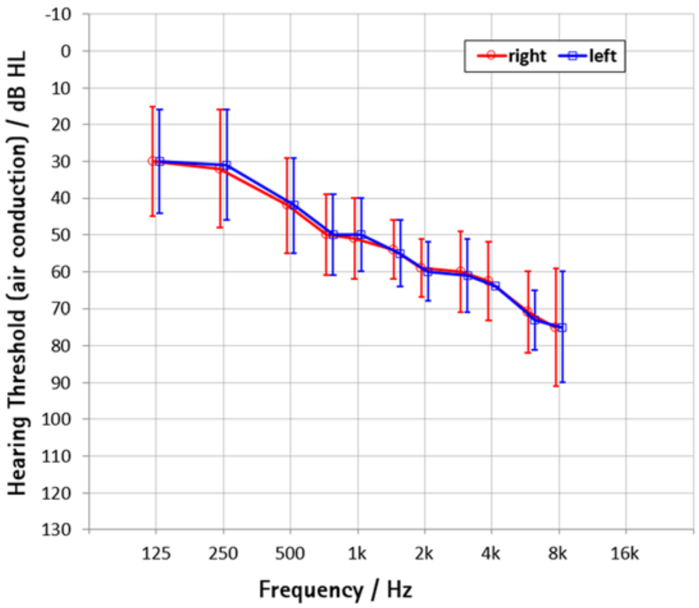

Figure 1. Mean audiogram for all 30 subjects for the right and left ear.

Devices

Participants were fitted with Phonak Audéo B90-312T hearing aids (equivalent in performance to Audéo Marvel for the specific aspects tested in this study), plus premium hearing aids from two competitors. Devices were fitted to the manufacturer's default fitting formula and fine-tuning was conducted if necessary. Phonak devices were programmed with AutoSense OS which classified the scene described below as Speech in Noise with UltraZoom being active. The two competitive devices were also programmed with their automatic programs. Occluded SlimTips were used for all devices.

Methods

A dynamic localization test was performed in order to test the hearing aids' ability to help the user to localize sounds in daily situations. Participants wore a head tracker and were seated in a free-field room in the center of a horizontal circular 12-channel loudspeaker array. The scene consisted of street noise, schoolyard noise (both presented at 65 dB SPL) and a conversation from behind at 5 dB SNR. Moving targets (a low-frequency diesel truck and a motorbike with more emphasis on higher frequencies) passed by, in the front hemisphere (figure 2). They occurred at angles of -90°, -30°, 30° or 90°, then drove around the corner and disappeared (see colored lines in figure 2). Movements occurred in both directions. These movements always covered 60° of azimuth in the front hemisphere. Between the two target sounds, two static distractor sounds were presented: a hammer (74 dB SPL) and a jackhammer (71 dB SPL). The order of sound events can be seen at the bottom of figure 2.

Participants were equipped with an optical head tracker system and they were instructed to precisely orient towards the moving target sources with their head. They performed sequences of 180 seconds per hearing aid condition, containing 18 target stimuli per test sequence. The data was analyzed for reaction times and deviations from the target angles.

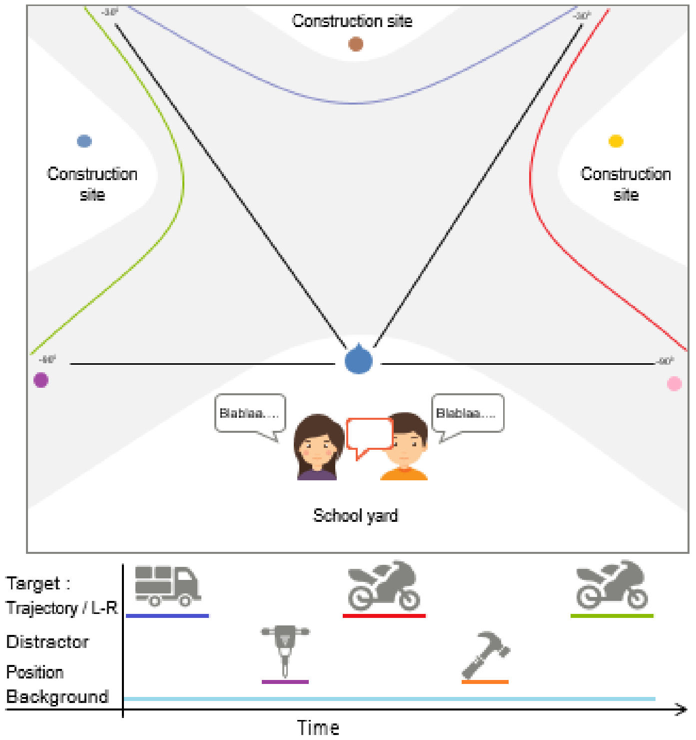

Figure 2. Test setup of the street noise scene used for the dynamic localization test. Red, blue and green lines show the path of the moving targets. The hammer and jackhammer noise occurred at the points marked as 'construction site'. School yard noise and a conversation took place behind the participant. The sequence of target and distractor sound presentations can be seen as a function of time at the bottom of the sketch.

Following the localization test, a paired comparison test was performed to assess preference for each hearing aid with regards to speech intelligibility and listening effort. For this test the virtual hearing aid concept was applied (Helbling et al. 2013). The virtual hearing aid concept consists of 2 steps: (1) *in situ* recordings were made with the three hearing aids under investigation fitted to the individual participant's ears. (2) These recordings were played back to the participants via insert earphones.

The scene used for this task was generated as follows: participants sat in the center of 12 loudspeakers, facing the speaker at 0° and at 300° (-60°) (figure 3 left and right, respectively). Diffuse cafeteria noise was played from all 12 loudspeakers at a total level of 65 dB and speech material from the Oldenburg sentence test (OLSA) was played constantly and simultaneously from three loudspeakers at 0°, -60° and +60° with an SNR of 0 dB for each speaker. This scene represented a person sitting in a busy cafeteria speaking with three people. The speaker at 0° was the German-speaking female OLSA voice (Wagener et al. 2014) whereas the other two speakers were German-speaking male (Wagener et al. 1999 & Hochmuth et al. 2015). Recordings were made with all three hearing aids while the participant faced the speaker at 0° and at -60°. The task of the participants was to directly compare the recordings of two hearing aids at a time (paired comparison) and rate speech intelligibility ('With which hearing aid can you hear the female speaker better?') and listening effort ('With which hearing aid is it most strenuous to follow the female speaker?'). When participants were asked about the female voice they heard, the recordings done with the head facing at 0° represented focused attention (figure 3 left) and the recording with the head facing at-60° represented shared attention (figure 3 right).

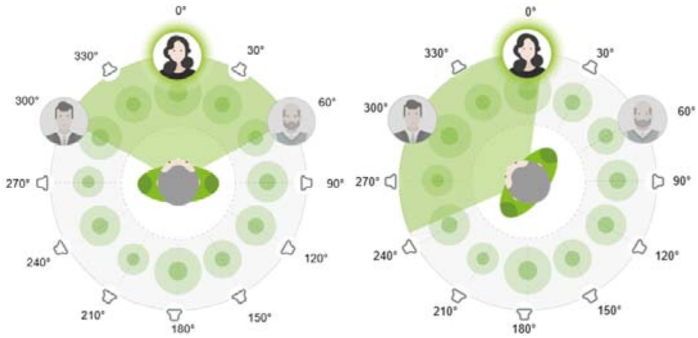

Figure 3. Cafeteria noise was presented from all 12 loudspeakers simultaneously. In addition, OLSA speech material was presented from the speakers marked in this figure with a face. The female speaker at 0° was defined as the target whereas the speakers at 60° and 300° (–60°) were defined as an interferer. The scene on the left where the participant faces the female speaker at 0° represents focused attention. The scene on the right where the participant faces –60° but focuses on listening to the female speaker at 0° represents shared attention.

Results

Dynamic localization test

Figure 4 shows the analyzed data from the head tracker used during the dynamic localization test. The graph on the left shows the median reaction time the participants needed to localize the noise of a moving object for each pair of hearing aids tested. The graph on the right shows the angle of deviation (tracking accuracy) when the participants were following the target. Each of these graphs has two parts: the left side shows the difference when the movement took place directly in front of the listener (-30° to 30° and vice versa), and the right side when the movement took place more laterally to the listener (-90° to -30° or 90° to 30° and vice versa). It can be seen that a target moving in front is clearly (statistically significant) easier to track than one which moves more laterally. No significant difference between the three sets of hearing aids in terms of reaction time or azimuth deviation for the dynamic localization task was observed. This indicates all three devices perform equally well in the dynamic localization test.

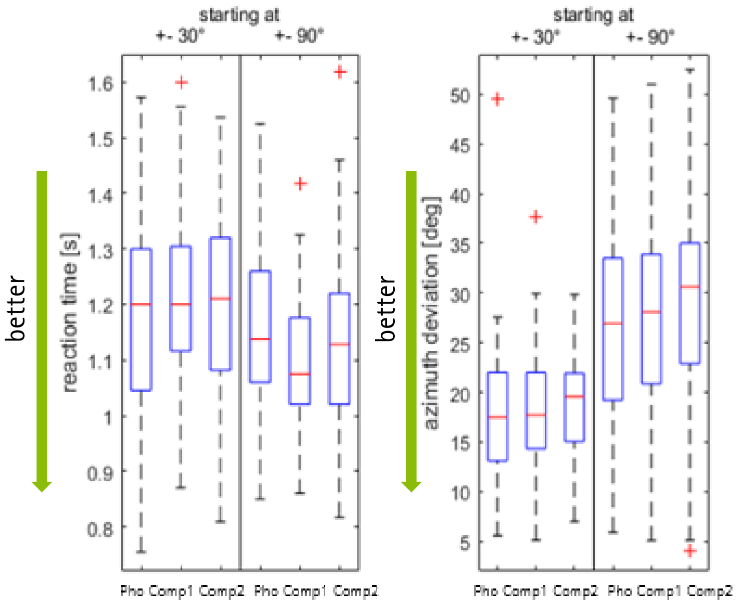

Figure 4. Reaction times (left subplot) and azimuth deviations (right subplot) for the dynamic localization task in the virtual street environment, analyzed for starting angles of +/-30° (left panels in subplots) and +/-90° (right panels in subplots) separately. Pho = Phonak. Comp1 = Competitor 1. Comp2 = Competitor 2.

Paired comparison test

Results of the paired comparison tests can be seen in figures 5 and 6. For each paired comparison, it can be seen how many participants preferred one hearing aid over the other with regards to speech intelligibility or listening effort. Figure 5 shows the results of the paired comparison test with respect to speech intelligibility preference for both the focused attention and shared attention condition. Phonak provides better subjective speech intelligibility than both competitor devices. The difference is significant for competitor 1 for speech from the front (focused attention) and speech from 60° (shared attention).

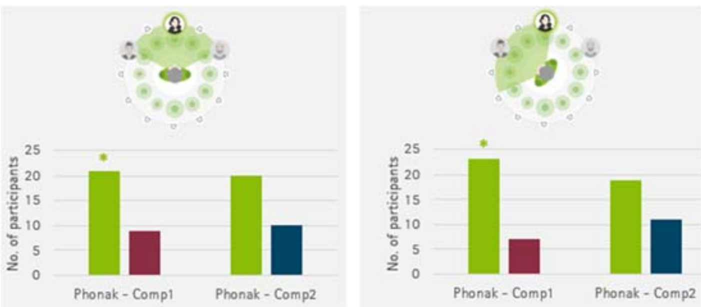

Figure 5. Subjective speech intelligibility (paired comparison), displayed as the number of participants who preferred the respective hearing aid of the given pairs, in terms of speech intelligibility. The graph on the left represents the focused attention condition (head facing 0°) and the graph on the right represents the shared attention condition (head facing -60°). * = significant difference (p<0.05).

Figure 6 shows the results of the paired comparison test with respect to listening effort. The Phonak hearing aids required significantly less listening effort than both competitor devices when focusing on the speaker to the front (focused attention condition). When listening to the speaker at -60° (shared attention condition), Phonak also required less listening effort than both competitor devices but the difference was only statistically significant when Phonak was compared to Competitor 2.

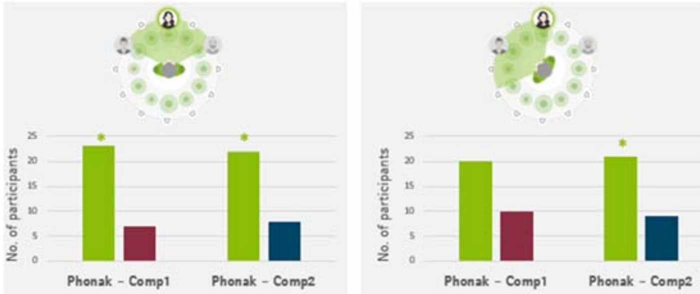

Figure 6. Listening effort (paired comparison), displayed as the number of participants who preferred the respective hearing aid of the given pairs in terms of *less* listening effort. The graph on the left represents the focused attention condition (head facing 0°) and the graph on the right is represents the shared attention condition (head facing -60°). * = significant difference (p<0.05).

Conclusion

Listening to speech within a noisy environment is often still very challenging, particularly for hearing aid wearers. A typical group conversation involves switching between focusing attention on one talker and sharing attention between multiple talkers. Although Phonak adopts an approach to focus on and improve speech intelligibility from the front, it has been shown, to have no disadvantage in comparison to different competition approaches in terms of localization ability.

Paired comparison tests showed that AutoSense OS leads to better rated speech intelligibility and reduced listening effort than two competitor devices, both when the speaker is directly in front (focused attention) and also if the speaker is at the side (shared attention). This means Phonak hearing aid wearers can benefit from better speech understanding with the least amount of listening effort, when in a typical complex listening situation with multiple talkers.

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Authors and investigators

External principle investigators

Since 2004, Michael Schulte has been with Hörzentrum Oldenburg GmbH, Germany, where he has been responsible for audiological studies in publicly funded projects as well as in cooperation with the industry. In 2002, he received his Ph.D. from the Biomagnetism Centre at the Institute of Experimental Audiology, University of Münster, Germany. From 2002 to 2003, he worked as a postdoc at the F.C. Donders Centre for Cognitive Neuroimaging, Nijmegen, Netherlands. Michael Schulte's research interest is in the evaluation of hearing systems with a special focus on listening effort.

Dr. Matthias Vormann received his diploma in physics in 1995 and his Ph.D. in 2011 from University of Oldenburg. Since 2005 he has been with Hörzentrum Oldenburg GmbH, Germany, where he works mainly in industrial research projects for hearing aid manufacturers. His interest is about new methods for measuring the subjective and objective benefit of hearing aids.

Jan Heeren studied Physics at the University of Oldenburg, Germany, and graduated in the Medical Physics group in 2014. From 2012, he worked on several projects in the field of hearing aid evaluation and virtual acoustics at the university and the Hörzentrum Oldenburg. In 2016, he started in the R&D department at HörTech GmbH, Oldenburg, working on hearing aid evaluation methods. Apart from his scientific activities, he has conducted more than 500 events as a free-lancing audio engineer since 2008.

Study coordinator

Matthias Latzel studied electrical engineering in Bochum and Vienna in 1995. After completing his Ph.D. in 2001, he carried out his Postdoc 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

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Jennifer Appleton-Huber received her M.Sc. in Audiology from the University of Manchester in 2004. Until 2013, she worked as an Audiological Scientist mainly in the UK and Switzerland, where she worked with adults and pediatrics, in the areas of hearing aids and cochlear implants. Her current role is Technical Editorial Manager at Phonak Headquarters.