Phonak Field Study News.

Advancements in beamformer technology demonstrate an advantage of a steered beamformer vs. static for off-axis speech in noisy environments

Subjective listening effort ratings are reduced when target speech is on the side or back when using Phonak Audéo™ Lumity compared to Phonak Audéo™ Marvel in a noisy environment in a study at the Phonak Audiology Research Center.

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Key highlights

- In this study, participants reported having significantly reduced listening effort with Audéo Lumity, compared to Audéo Marvel, when speech was from the side and back in a noisy environment.
- In this study, participants performed significantly better on a speech intelligibility task with Audéo Lumity over Audéo Marvel when speech was from the side and back in a noisy environment.

Considerations for practice

- When patients are considering upgrading their Audéo Marvel hearing aids, consider demonstrating the benefits of Audéo Lumity SpeechSensor and StereoZoom 2.0, both part of SmartSpeech™ Technology.
- Trialing Audéo Lumity in the real-world will allow the user to experience the benefits of the various beamformer capabilities in real-time.
- Show how the myPhonak app can further tailor the needs of the patient and make StereoZoom 2.0 even more focused to the front.

Introduction

Understanding speech in a noisy environment can be difficult for people with hearing loss, even with hearing aids. Hearing aid manufacturers have established various methods (e.g., directional microphones) to improve the signal-to-noise ratio (SNR) to increase speech understanding in these difficult listening situations.

One of the early directional microphone systems by Phonak used a dual-microphone directional microphone in the programmable behind-the-ear (BTE) Piconet Audio-Zoom hearing aids and provided an improved SNR by about 8 dB relative to the omnidirectional microphone in a lab setting (Valente et al., 1995). Since that time, Phonak has introduced other directional microphone systems. Real Ear Sound (RES), introduced in 2005, is a microphone mode in Phonak hearing aids that mimics the directional benefit that is provided naturally by the shape and resonances of the pinna. UltraZoom (UZ) was introduced with the Phonak Spice platform in 2010 and is a monaural adaptive beamformer. StereoZoom (SZ) was first introduced in Quest hearing aids in 2012 as a static binaural beamformer creating a narrow focus. With Venture hearing aids in 2014, SZ became an adaptive binaural beamformer that is active in the Speech in Loud Noise (SPiLN) program (Stewart, et al., 2019).

SZ has shown a 1 to 1.5 dB improvement over the monaural beamformer, UZ, in noise when speech is in the front in various studies summarized by Stewart et al. (2019). SZ is beneficial when the dominant speech is located to the front in a noisy environment, however, if the dominant speech is located to the sides or back, a narrow beamformer to the front is not ideal.

The majority of the time, conversations happen from in front of us. But, according to Walden et al. (2004), approximately 20% of the time, speech is on the side or behind us, and there are occasions when we don't want to or can't move our head towards the speaker (e.g. cooking in the kitchen while talking with family, working at a computer while communicating with co-workers, watching a sporting event while communicating with friends). This is when an automatic operating system that can steer the degree of directionality, to have access to the dominant speech from the side or the back is beneficial. SpeechSensor is a feature that is new with Lumity that determines if the dominant talker is located in the front, back, or side and steers the beamformer to a different/wider directional setting.

SZ 2.0 has also been introduced with Lumity and there are three main updates compared to its previous iteration. The transition into the SPiLN program for Lumity is smoother, only one hearing aid needs to meet the criteria to switch into this program from AutoSense OS™ 5.0 and it allows for activation at a lower noise level compared to the earlier version. The activation of SZ 2.0 at a lower noise level is beneficial, because research has indicated that the typical "speech in noise" environment is around 68 dB and typically with a positive SNR (Smeds et al., 2015 and Wu et. Al., 2018). SZ 2.0 is now even more narrowly focused to the front and can be adapted by the patient using the myPhonak app. Figure 1 summarizes the focus of the microphone beam for UZ, SZ and SZ 2.0.

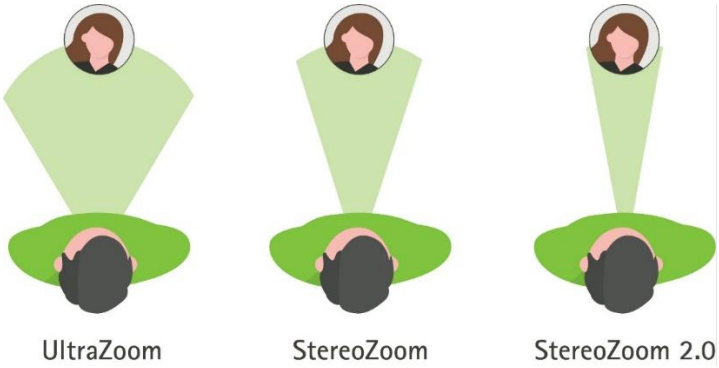

Figure 1. Illustrations of the focus of the microphone beam for US, SZ and SZ 2.0

Previous studies looking at Adaptive Phonak Digital (APD) in Marvel compared to APD 2.0 in Paradise (Wright, A., 2020) and Paradise hearing aids with AutoSense OS 4.0 with the Speech Enhancer and Dynamic Noise Cancellation features (Appleton, J., 2020) showed that these advancements in the Paradise platform reduced subjective listening effort. Lumity builds on Paradise, with the upgrade to AutoSense 5.0, and the addition of SpeechSensor and SZ 2.0 and therefore, we would expect reduced listening effort in noisy environments compared to Marvel with APD, AutoSense OS 3.0 and SZ but this has not yet been directly compared. Table 1 summarizes Lumity and the two previous Phonak hearing aid platforms.

Platform	**Feature**		
	AutoSense OS	APD	SZ
Marvel	3.0	APD	SZ
Paradise	4.0	APD 2.0	SZ
Lumity	5.0	APD 2.0	SZ 2.0

Table 1. Hearing aid platform summary

Methodology

Participants

Fourteen participants (6 male, 8 female) from the Aurora, IL area with moderate to moderately severe hearing loss (Fig. 2) took part in the study at the Phonak Audiology Research Center (PARC) in Aurora, IL between August and October 2022. The average age was 75 years and all participants had experience with hearing aids.

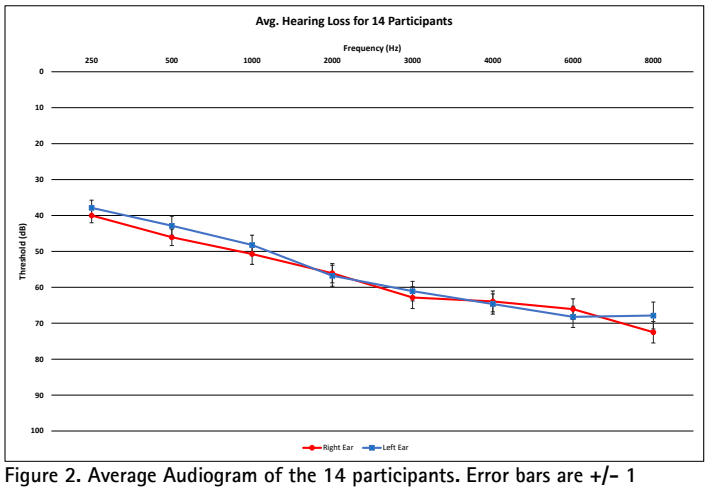

Figure 2. Average Audiogram of the 14 participants. Error bars are +/- 1 standard error.

Procedure

The study included three lab appointments with two one-week home trials between each appointment.

Appointment#1

At the first visit, all participants were first-fit with both Audéo Lumity 90-RT and Audéo Marvel 90-R receiver-in-the-canal (RIC) hearing aids according to their audiogram, and a feedback test was conducted. Hearing aids were fit using an M receiver and the dome that was recommended by the fitting software in Target. In five instances for Marvel, the software recommended different domes for the right and left ears, so the dome that was recommended for Lumity was used in these instances. Eleven of the participants were fitted with Power domes and 3 with Vented domes. For the lab testing, 13 of the participants were fit to 100% Target Gain and 1 of the participants was fit to 80% Target gain in the Target fitting software based on their hearing aid wearing experience.

Due to the different behavior of Lumity and Marvel in a noisy environment with target speech located to the side or back, a technical lab validation prior to the first appointment, was completed to ensure that the test setup would activate the relevant microphone modes automatically for both Lumity and Marvel hearing aids. In order to ensure that the programs and microphone modes did not change during lab testing with the research participants, manual programs were created. To simulate how SpeechSensor in Lumity would detect the dominant speech and adapt the beamformer, the investigator created two unlinked manual Speech in Noise Programs; one with the hearing aid microphone setting at fixed directional microphone (setting 12 in the Target Fitting Software) for speech from the side, and the other with RES (setting 4 in the Target Fitting Software) for speech from the back. The multi-function button was disabled for volume. For Marvel the hearing aid would adapt into the SPiLN program with SZ as the microphone mode so the investigator created an unlinked manual SPiLN program (microphone mode SZ) and made this the startup program and disabled the multi-function button.

In a cross-over design, speech intelligibility in noise was measured using AZBio sentences (Spahr et al., 2012). Multi-talker babble was presented from 11 loudspeakers at a combined level of 67 dB(A) (marked with "N" in Fig. 3). The target speech material (marked with "S" in Fig. 3) was presented at 72 dB(A) from 180° for the speech from the back condition and from 270° for the speech from the side condition. Subjects were seated in the middle of the loudspeaker setup (1.5 meters from speakers) and were instructed to always face forward (towards 0°).

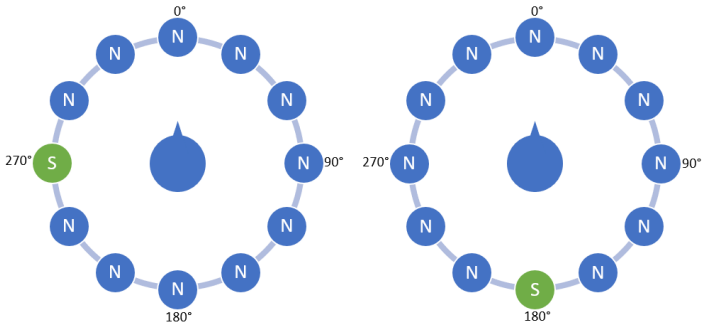

Figure 3. Lab set-up for speech (S) in noise (N) testing. Left: speech (S) from the side. Right: speech (S) from the back.

The speech location (i.e., side and back) was randomized, and the hearing aid order within each of these conditions was also randomized. There were 8 AZBio Sentence Lists that were randomized among the various conditions and each condition had a test-retest.

For speech from the side, the investigator compared Lumity with a fixed directional microphone setting to Marvel with SZ. For speech from the back, Lumity with RES was compared to Marvel with SZ.

A subjective listening effort questionnaire with a 10-point scale that included questions from the Speech, Spatial and Qualities of hearing Scale (SSQ; Gatehouse & Noble, 2004) was given after each condition. There were five questions

(Table 2) and on the rating scale the lower the number, the better.

Question	Response Scale (0 to 10)
Did you have to concentrate very much when listening?	Not need to concentrate/Concentrate hard
Did you have to put in a lot of effort to hear what was being said?	No effort/Lot of effort
Could you easily ignore other sounds when trying to listen?	Easily ignore/Not easily ignore
How well could you maintain your focus and attention?	Easily maintain/Not easily maintain
How mentally/physically drained are you right now?	No drain/Lot of drain

Table 2. Subjective listening effort questionnaire

The participants were asked which hearing aid they preferred for each of the conditions. The speech intelligibility scores for the AZBio Sentences were also recorded.

The participant was then prepared for the Home Trial with the Audéo Lumity 90-RT hearing aids. If any minimal fine tuning was needed, adjustments were made in the software. Only four participants requested fine tuning changes, and these were related to gain and occlusion compensation. Three participants requested different domes (smaller or more open) for the home trial; for these participants, a new feedback test was administered, but no other fine tuning was performed.

Participants used a proprietary ecological momentary assessment (EMA) app either on their own Android phone or a loaner phone from PARC. During the two-week home trial, participants received a daily retrospective survey via the app at a time they designated to the investigator in the evening. The investigator instructed them on how to respond to the survey questions via the app during this visit.

Daily use and care as well as guidance of the charger was also discussed. The participants were provided with either a Combi Charger or Charger Ease for the one-week home trial (the order was randomized). They were instructed to return the charger after one week along with the 'Ease of Use Charger Questionnaire.'

Appointment #2
Participants came into the lab to read the data from the EMA app, including the daily retrospective survey responses, to make sure that data was logging as expected. The investigator collected the 'Ease of Use Charger Questionnaire' and the charger issued at appointment 1 and provided them with the other charger for the final home trial.

Appointment #3/Final Appointment
Participants came into the lab to read all the data from the EMA app including the daily retrospective survey responses, collect the 'Ease of Use Charger Questionnaire,' and the charger and hearing aids. The investigator also asked which charger they preferred and gathered any other additional comments about the hearing aids from the two-week period.

Results

In the lab, participants showed a significant improvement in overall listening effort with the steered beamformer in Lumity, as well as a significant preference for the steered beamforming behavior over the static behavior in Marvel. The average rating of listening effort from the subjective listening effort questionnaire for Audéo Lumity in the side and back conditions on the 10-point scale was 5.82 and for Audéo Marvel was 6.82, which was a 14.7% improvement. Two way repeated measures Analysis of Variance (ANOVA) with within-subject effects of device and location were administered using JASP software. There was a significant main effect of the hearing aid on listening effort ($F[1, 13] = 6.618$; $p = 0.023$; $\eta^2_p = 0.337$). The main effect for speech location and interaction term were not significant. Seventy-one percent of the participants preferred the Audéo Lumity hearing aid when speech is to the side and back compared to Audéo Marvel. A binomial exact test found that the observed preference rate of 71% was significantly higher than what would be expected due to random chance (50%) ($p = 0.036$).

In this study, Audéo Lumity had an 8 percentage point improvement in speech intelligibility over Audéo Marvel when speech is from the side and back in a noisy environment (Average Lumity=85%, average Marvel=77%). Two way repeated measures ANOVA with within-subject effects of device and location were again performed. There was a significant main effect of the hearing aid platform on speech intelligibility ($F[1,13] = 14.957$, $p=0.002$, $\eta^2_p = 0.535$) and a significant interaction effect ($F[1,13] = 7.695$, $p=0.016$, $\eta^2_p = 0.372$); the main effect of speech location was not significant. Post hoc testing using pairwise t-tests with a Bonferroni correction applied revealed a significant improvement for Lumity over Marvel when speech was presented from the side ($t = -4.724$, $p = <.001$), but other pairwise comparisons were not significant.

Seventy-one percent of the participants preferred the Charger Ease compared to the Combi Charger. A binomial exact test was again applied to compare the observed preference rate to random chance and found no significant

difference (p = 0.18)[1]. The Charger Ease was also rated as easier to use and more appealing compared to the Combi Charger by participants in this study (Fig. 4 and 5).

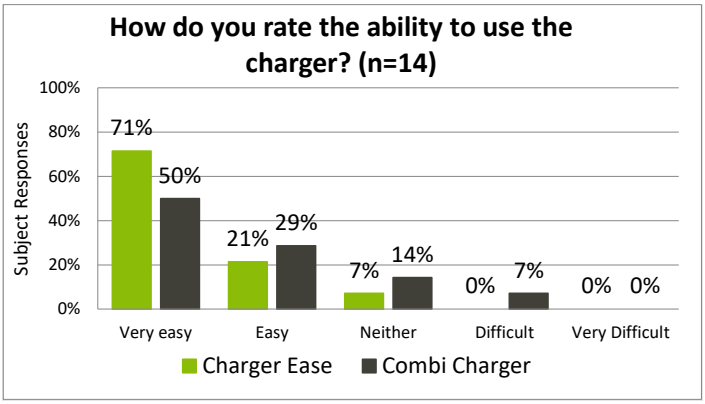

Figure 4. Ratings of ability to use each charger after one week home trial with each

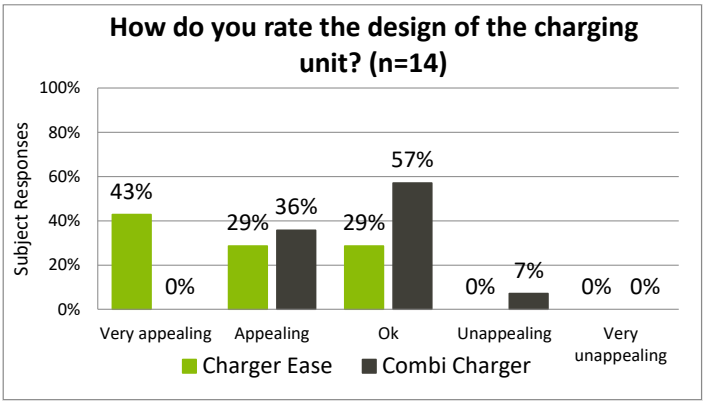

Figure 5. Ratings of the design of each charger after one week home trial with each

Additionally, a total of 163 daily in-field surveys were returned from the two-week home trial, giving a daily assessment of participants' listening effort in noisy environments and their satisfaction with the Audéo Lumity study hearing aids throughout the day. Surveys also captured open-ended feedback from participants (in written or voice-note format) to provide context for their categorical responses. A number of daily responses, 31%, reported not experiencing noisy environments at all during the day. Of the remaining responses, 64% responded less than 5 on the categorical scale indicating that little effort was needed to hear what was being said in noisy environments (Fig. 6).

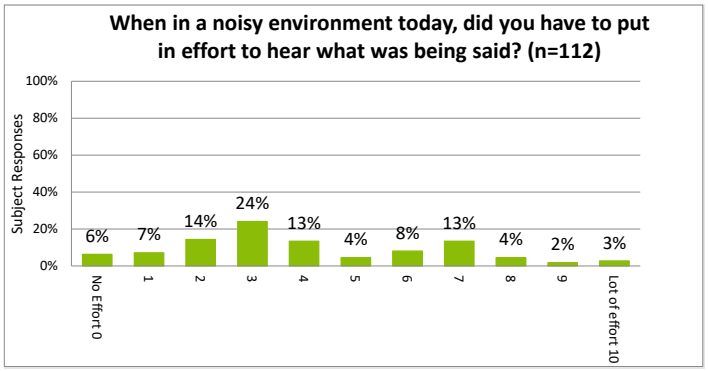

Figure 6. Daily satisfaction listening effort rating in noisy environment from EMA app (Does not include the 31% (n=51) indicating "I was not in a noisy environment today")

Participants were overwhelmingly satisfied with the Audéo Lumity study hearing aids, with 90% of all daily surveys reporting satisfaction (Fig. 7).

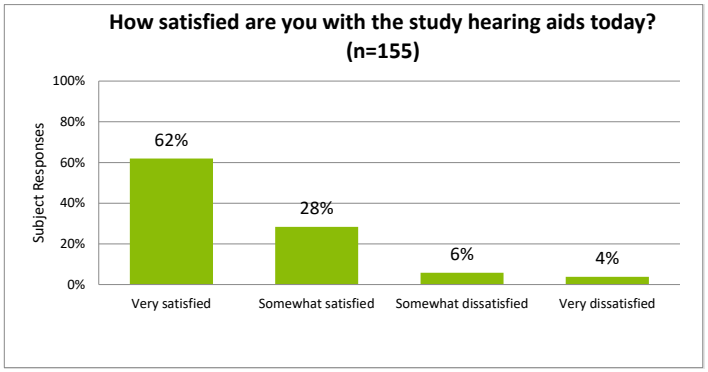

Figure 7. Daily satisfaction ratings from EMA app.

Conclusion

In conclusion, the results of this investigation provide evidence to support that a hearing aid with steered beamforming provides a lower perceived listening effort when speech is from the side and back in a noisy environment compared to a hearing aid with a static beamformer.

Results show that a steered beamformer offers benefits to listening effort and speech intelligibility in the lab environment, and EMA results overall show a high degree of satisfaction with hearing aids using such a beamformer. A wide range of subjective listening effort experienced by participants during daily life were reported with a preponderance of participants indicating not experiencing noisy situations at all during the day. Results also show a high degree of satisfaction with the Audéo Lumity hearing aids, measured daily over a two-week period.

[1] Participants made two independent ratings when selecting a preferred hearing aid, resulting in N = 28. When selecting a preferred charger, participants made only one rating (N =14). The difference in sample size results in a significant result for one preference rate but not the other, despite the two preference rates being equivalent.

References

Appleton, J. (2020) AutoSense OS 4.0 – significantly less listening effort and preferred for speech intelligibility. Phonak Field Study News retrieved from https://www.phonak.com/en-us/professionals/guides/evidence-library, accessed December, 2022.

Gatehouse, S. & Noble, W. (2004). The Speech, Spatial and Qualities of Hearing Scale (SSQ). *International Journal of Audiology, 43,* 85-99.

Smeds, K., Wolters, F., & Rung, M. (2015). Estimation of Signal-to-Noise Ratios in Realistic Sound Scenarios. *Journal of the American Academy of Audiology*, *26*(2), 183–196.

Spahr, A. J., Dorman, M. F., Litvak, L. M., Van Wie, S., Gifford, R. H., Loizou, P. C., Loiselle, L. M., Oakes, T., & Cook, S. (2012). Development and validation of the AzBio sentence lists. *Ear and hearing*, *33*(1), 112–117.

Stewart, E. et al. 2019. StereoZoom Part 1: The benefit of wirelessly connected narrow directionality in Phonak hearing aids for speech intelligibility. Phonak Compendium, retrieved from www.phonakpro.com/evidence accessed on May 13, 2022.

Valente M, Fabry D, Potts L. (1995) Recognition of speech in noise with hearing aids using dual microphones. *Journal of the American Academy of Audiology* 6:440–450.

Walden BE, Surr RK, Cord MT, Dyrlund O. Predicting hearing aid microphone preference in everyday listening. Journal of the American Academy of Audiology. 2004 May;15(5):365-96.

Wright, A. (2020). Adaptive Phonak Digital 2.0 – Next-level fitting formula with adaptive compression for reduced listening effort. Field Study News. Retrieved from https://www.phonak.com/en-us/professionals/guides/evidence-library, accessed December, 2022.

Wu, Y. H., Stangl, E., Chipara, O., Hasan, S. S., Welhaven, A., & Oleson, J. (2018). Characteristics of Real-World Signal to Noise Ratios and Speech Listening Situations of Older Adults with Mild to Moderate Hearing Loss. *Ear and hearing*, *39*(2), 293–304.

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Kevin Seitz-Paquette, AuD is the director of the Phonak Audiology Research Center (PARC), located in Aurora, IL. Kevin earned his AuD at Northwestern University, and a master's degree in Linguistics from Indiana University. His team works at various points along the product development pipeline, to ensure new products solve real problems for patients or professionals, and to provide data to evidence-based hearing care providers, so they can have confidence when selecting a Phonak product. Prior to arriving at Phonak, he held other roles in Clinical Research and Product Management within the hearing aid industry.