

2.4 GHz Table Microphone

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Introduction

Separating the signal of interest from unwanted noise has long been the focus of the hearing industry. Starkey brings the most advanced, modern technologies to tackle this challenge with innovation to provide critical benefits to patients.

With the recent release of Livio Edge AI, Starkey introduced on-demand help for patients in noise through Edge Mode for help in uniquely challenging environments. One environment that is commonly challenging for hearing aid wearers is a multi-speaker situation, such as a business meeting or the dinner table. This multi-speaker environment is one of the most complex, and as a result, understanding speech in this environment can be difficult for patients. Our latest wireless accessory, Starkey's new 2.4 GHz Table Microphone {Figure 1}, provides a highly innovative solution to this complex challenge, by dynamically focusing on the active speaker in the group setting and sending that signal directly to the patients' hearing aids. This versatile device can also function as a remote microphone and a multimedia streamer.



Figure 1. Table Microphone in Automatic Mode. The active direction of the beamformer is shown by the illuminated segment.

The Table Microphone is a new multipurpose wireless hearing aid accessory designed to improve speech understanding in noise. It uses eight spatially separated microphones and sophisticated directional beamforming technology to divide the acoustic environment into eight 45-degree segments. In Automatic mode, the Table Microphone dynamically switches the direction of the beam to focus on the active speaker in a group, while simultaneously reducing competing background speech or noise from other directions. In Manual mode, the user can select either one or two speakers to focus on in a group, and can change the direction of the beam or beams by simply touching on the top of the device. In Surround mode, all microphones are active so that sound is amplified from all directions around the listener. Automatic and Manual modes are optimized for listening to speech in noise, and Surround mode is optimized for listening to speech in quiet. The Table Microphone provides the best listening benefit when placed at the center of a group, or close to a single conversational partner.

The Table Microphone can also be used as a remote microphone when worn by a conversational partner. It comes with a lanyard with a magnetic interface, to which the accessory attaches. When placed in the vertical orientation, the directional beam changes automatically to point upward toward the mouth of the speaker. Additionally, the Table Microphone can be connected to the audio output of a television, computer, smartphone, or other device to stream audio to the hearing

aids. In other words, the Table Microphone is a speech enhancement tool for group settings in noise or quiet, a remote microphone for enhanced one-on-one conversation, and a multimedia streaming device – an all-in-one hearing aid accessory!

Clinical Validation

Performance of the Table Microphone was evaluated by hearing aid users both in the laboratory and in the field {Figure 2}.

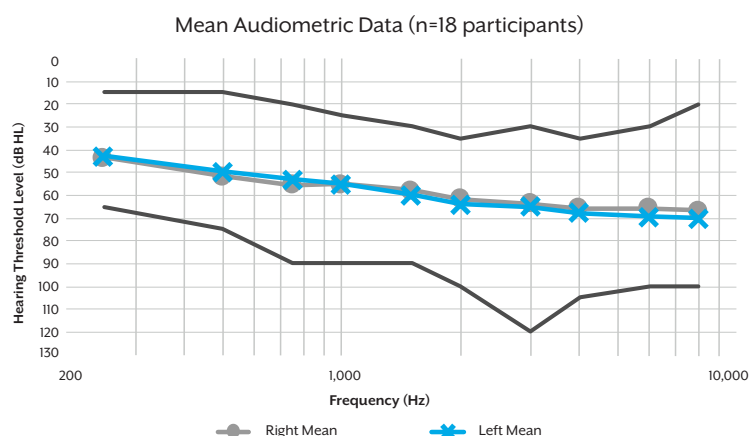


Figure 2. Mean audiometric values for all participants.

In the laboratory, eighteen hearing-impaired participants (10 females, 8 males; mean age: 66.9 years [range: 50 – 80 years]) completed a speech intelligibility test while unaided, aided with Edge AI custom rechargeable hearing aids alone, aided with Starkey's 2.4 GHz Remote Microphone +, and aided with the Table Microphone. The Table Microphone was placed on a small table in front of the target speaker, and the Remote Microphone + was clipped to a stand directly below the target speaker to simulate lapel use. A subjective rating of listening effort was obtained to evaluate the Table Microphone when listening to speech in noise. All laboratory testing was completed with

hearing aid settings matched to target under default conditions for the *Normal memory. In all conditions, noise presentation started prior to sentence presentation so that the adaptive hearing aid features were fully engaged.

Hearing In Noise Test

The Hearing In Noise Test (HINT) is a standardized speech intelligibility test that calculates the signal-to-noise ratio (SNR) required for correct repetition of 50 percent of the sentences presented in a background of speech-shaped noise (Nilsson, Soli & Sullivan, 1994). The level of the noise is fixed at 65 dB SPL, and the level of the speech is adapted based on the participant's responses. After a correct response, the speech presentation level is decreased for the next sentence (decreasing the SNR and increasing difficulty), and after an incorrect response, the speech presentation level is increased for the next sentence (increasing the SNR and decreasing difficulty). The lower the final score, reported in dB SNR, the better the performance. On average, a 1 dB improvement in SNR results in an 8.9% improvement in sentence intelligibility (Soli & Nilsson, 1997).

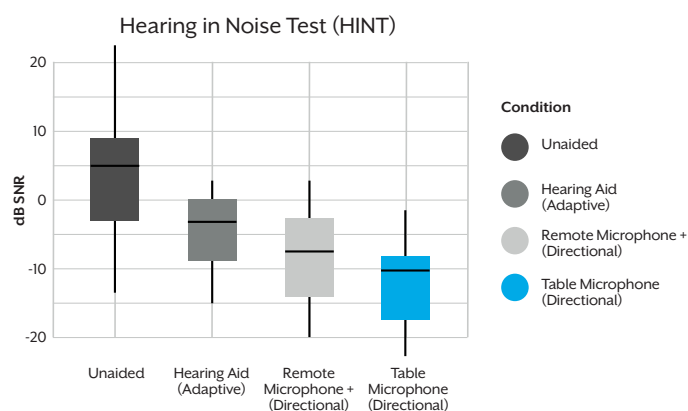


Figure 3. Boxplot of HINT results.

As shown in Figure 3, the Table Microphone had a median SNR improvement of 4.1 dB compared

to the Remote Microphone +, a 7.2 dB SNR improvement compared to hearing aids alone, and a 15.0 dB SNR improvement compared to the unaided condition. A linear mixed effects model indicated a statistically significant difference ($p < 0.001$) in SNR between the Table Microphone and all other test conditions, when controlling for individual participants.

Listening Effort

To measure listening effort, participants listened to a target male speaker reading sentences among competing female speakers and conversational background noise. The recordings of the target male speaker and competing female speakers were selected from the AzBio sentence task, and the conversational background noise was selected from the Connected Speech Test. The male speaker was presented at 65 dB SPL, and the combination of the female speakers and conversational noise was presented at 70 dB SPL (-5 dB SNR). The configuration of the test is shown in Figure 4.

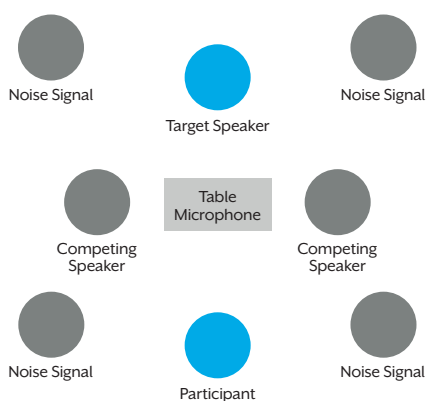


Figure 4. Laboratory configuration.

Participants rated their perceived listening effort in two conditions: aided with Livio Edge AI custom hearing aids alone, and aided with the Starkey Table Microphone. The test conditions were randomly counterbalanced across

participants. After one minute of listening to the target stimulus in each condition, participants used the Listening Effort Scale to rate their effort [Johnson et al., 2015].

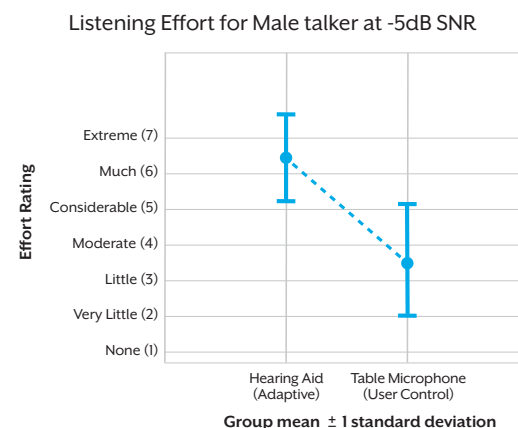


Figure 5. Mean Subjective Rating of Listening Effort for Male Talker at -5dB SNR.

As shown in Figure 5, the Table Microphone decreased listening effort in noise when compared to hearing aids alone. On a 7-point scale with 7 meaning “extreme effort” and 1 meaning “no effort,” the average rating with hearing aids alone was 6.6, and with hearing aids and the Table Microphone the average rating was 3.3. A Wilcoxon signed-ranks test indicated a significant difference between the listening effort for hearing aids alone and hearing aids with Table Microphone, $z = 2.5$ ($p < 0.05$). This demonstrates that significantly less effort was required when participants used the Table Microphone.

Field Trial

Nine of the 18 participants from the laboratory study (6 females, 3 males; mean age: 66.5 years [range: 51 – 80 years]) also completed a 2 week field trial to evaluate the Table Microphone in real world listening situations. Prior to the field trial, participants were familiarized with the Table Microphone’s three directional modes,

and were also shown the other functions of the Table Microphone. At the end of the field trial, participants answered a questionnaire regarding their experiences with the Table Microphone.

Subjective Ratings

Participants used the Table Microphone in a variety of modes and listening environments, ranging from one-on-one conversations at home to large group conversations at home and in public. Subjective ratings of the streaming sound quality and overall satisfaction with the Table Microphone were positive across participants. The average sound quality rating was 5.6 on a 7-point scale, and the average overall satisfaction rating was 7.3 on an 11-point scale.

All nine participants rated the Table Microphone either “easy” or “very easy” to use. The Automatic directional switching mode was a feature that several participants found useful. One participant noted that the “different microphones respond very quickly and in real time.” Another participant who works in a common office environment reported that the Automatic mode reduced listening effort when people approached her workstation from various directions.

In addition to the questionnaire responses, participants also provided their overall reactions to the Table Microphone. One participant reported that it was “very clear and easy to hear conversation in background noise.” Other participants reported, “So much better,” “Background noise disappeared,” and “I love it!”

Conclusion

Starkey’s 2.4 GHz Table Microphone is an innovative new wireless accessory that can be used in a wide variety of use cases. Laboratory tests demonstrated that the Table Microphone provided statistically significant and clinically meaningful improvement for speech-in-noise listening over hearing aids alone and hearing aids with the Remote Microphone +. Participants also reported significantly less effort listening to a target speaker in the presence of competing speech when using the Table Microphone versus hearing aids alone. Real world use by participants demonstrated that this accessory is intuitive to operate, and provides noticeable benefit in a number of listening situations.

The Table Microphone is a speech enhancement tool for group settings in noise or quiet, a remote microphone for enhanced one-on-one conversation, and a multimedia streaming device – an all-in-one hearing aid accessory!

References

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