Streamline Mic

Eric Branda, AuD, PhD

A primary goal for any hearing aid fitting is to improve speech intelligibility. It is well known that one of the most difficult listening situations for any hearing aid wearer is understanding speech in background noise[1,2].

The primary reason for poor speech understanding in noise is the necessary signal-to-noise ratio (SNR) for intelligibility. Background noise can cover or mask the speech signal. This often will have a considerable impact on the softer speech sounds in the higher frequencies that are critical for intelligibility, which are also often the most affected by hearing loss.

A popular approach to improving speech understanding in background noise is use of directional technology. This is standard on the majority of RICs and BTEs and is available on larger custom devices as well. And for smaller devices, Signia offers binaural OneMic directionality.

Limiting Factors for Directional Technology

As popular and effective as directional microphone technology is, there are some limitations to the benefit it can provide. And some of those limitations are more obvious than others.

1. The position of the talker is very critical for successful use. If the competing noise is coming from the same direction as the target speech, the two signals are not spatially separated in a way the directional technology can maintain the separation. Speech and noise are mixed.
2. In highly reverberant areas, noise from behind the wearer may be reflected to the front of the wearer and can mix with the target speech. This limits directional performance because, again, speech and noise are mixed.
3. Benefits are smaller when the listener to talker distance is greater. The further the target speaker is from the listener, the softer the speech signal is by the time it reaches the hearing aid microphones, again making it difficult to hear speech louder than competing noise and reverberation.
4. If the SNR for the hearing aid user is too good or too poor, directional benefit may not be noticeable. For example, someone who only has 10% speech intelligibility in a +4dB SNR may have hearing aids with directional technology providing 3 dB SNR improvement. If this wearer is in a room with a 0dB SNR, it improves it to +3 dB SNR via directional microphones, but he still is not even getting 10% correct.
5. Venting/openness of the coupling can reduce benefits. With an open fit or a large vent, sound can bypass the directional processing and pass directly to the eardrum. Froehlich and Littmann[3] observed a 3 dB improvement in SNR with closed fittings compared to open fittings. In addressing patient comfort and satisfaction for their own voice, open fittings are very prevalent. Some features like Signia's Own Voice Processing (OVP) have shown success at providing satisfaction with a closed fitting comparable to that of an open fitting[4]. However, clinical practices often apply open fittings which can compromise directional performance. Generally, the higher frequencies will have directional benefit maintained, but the lower frequencies are more likely to pass directly to the eardrum without directional microphone benefit.

6. Directional technology does not address streamed signals. It stands to reason that hearing aid wearers also need improved SNR for signals that are wirelessly transmitted, such as telephone calls or personal music. In the case of telephone calls, competing noise in the background can be distracting and mask the speech signal, especially noticeable with an open fitting.
7. Natural speaking behavior can reduce benefits. During face-to-face conversation, the talker is facing the listener, which is optimal for directional technology. However, there are often very natural moments in a conversation when head turns or positional changes occur, considerably reducing the level of speech at the hearing aid microphones.

Remote Microphone Addresses Limiting Factors

One solution to help overcome most of these listening-in-noise challenges, and the limitations of directional technology, is the use of a remote microphone with Bluetooth capabilities. The remote microphone aspect of such a device provides many advantages to help the hearing aid wearer in difficult listening environments due to its close proximity to the speaker's mouth. The Bluetooth capabilities also provide the option to pair with virtually any Bluetooth-enabled device in order to stream signals such as a phone call directly to the hearing aids. This combined functionality added to the hearing aid's processing enables the wearer to hear better in a larger number of soundscapes than with just hearing aids alone.

If we consider some of the earlier mentioned challenges to providing an improved SNR to the hearing aid user, we quickly see some key advantages for remote microphones:

1. Position of the speaker. With the microphone placed close to the speaker's mouth, the speech signal is usually stronger than any of the competing noise signals in the environment, transmitting a much better SNR for the hearing aid wearer.
2. Reverberation. Again, with the close proximity the speaker's mouth, the non-reverberant signals are dominant, noticeably reducing reverberation.
3. Distance from the hearing aid wearer. Distance from the hearing aid wearer not an issue with a remote microphone. The speaker's mouth remains a close, constant distance from the microphone no matter how far the hearing aid wearer and the speaker are from one another. The distance between the speaker's mouth and the remote microphone remains stable.
4. The SNR improvement with a remote microphone nearly always is higher than that of directional technology. This means that in cases where the SNR is quite poor (as in the 0 dB SNR example above), the remote microphone provides benefits that typically are large enough to be noticed by a hearing aid wearer.
5. Venting/openness. With a remote microphone, venting will still limit low frequency gain and allow background noise into the ear canal. However, with dedicated frequency responses for the streamed signal that increases low frequency gain, a remote microphone can overcome these challenges in a way not possible with directional technology.
6. Remote microphone with Bluetooth capabilities. For phone use, this is extremely advantageous as most any Bluetooth-enabled phone can be paired with the remote microphone to allow direct streaming of the phone signal to the hearing aids. This reduces interference with external sounds around the hearing aid user that may mask the signal. Also, for bilateral hearing aid use, the remote microphone can be paired with both instruments providing a binaural advantage for the hearing aid wearer with the phone call[5].

7. Natural speaking behavior. With a remote microphone worn by the hearing aid user's communication partner, natural movements or changes in head position will have minimal effect on the strength of the speech signal. This results in maintaining an optimal SNR when direct face-to-face conversation cannot be managed.

An additional advantage for phone conversation is that the remote microphone can pick up the hearing aid wearer's voice for transmission to the communication partner. The benefits of the remote microphone's directionality and close proximity to the hearing aid wearer's mouth maintains the same acoustic advantages for the conversation partner that were discussed for overcoming noise surrounding the wearer. This improvement in the SNR helps facilitate hands-free communication between the two parties.

The Bluetooth streaming capability also provides the hearing aid wearer with music as well as other audio signals streamed directly to the hearing aids. Again, this helps overcome competing environmental signals that may mask the desired audio, so music can be more enjoyable.

Streamline Mic: Research Validation

The Signia Streamline mic is a remote microphone that pairs with most Bluetooth devices and streams directly to Signia Bluetooth-enabled hearing aids. The Streamline Mic can provide all of the advantages listed above. To validate the SNR benefit of the remote microphone for speech recognition, measurements were obtained with different SNRs and remote microphone placement conditions. Laboratory measures were obtained at Vanderbilt University Medical Center to evaluate the improved SNR provided by the Streamline Mic.

Methods

A pair of Pure Xperience 312 receiver-in-the-canal hearing aids were fitted to the KEMAR using occluding, non-custom eartips. The hearing aids were programmed to a mild-to-moderate hearing loss and paired with a Streamline Mic.

Two speech in noise conditions were simulated and measured. SNR levels were based on the average data reported by Pearsons et al[6]. Condition 1 was based on the SNR of an outdoor speech situation with speech presented at 66 dB SPL and competing noise presented at 61 dB SPL (+5 dB SNR). Condition 2 was based on the SNR in train with speech presented at 73 dB SPL and the competing noise at 74 dB SPL (-1 dB SNR).

Target speech was presented from a speaker placed 1.5 meters from the KEMAR. The Streamline Mic was placed directly in front of the target speaker at 0 degrees. The Streamline Mic was measured in two positions. The first position was directly below the speaker and angled up toward the speaker to simulate being worn on a cord around the neck (Referred to as "Below Chin"). The second position was with the Streamline Mic position flat in front of the speaker to simulate the user holding the it directly in front of the mouth (Referred to as "At Mouth").

Speakers presenting competing speech babble were placed 3.5 meters from the KEMAR. Each condition included 2 noise loudspeaker configurations, either with the noise signals directly behind the KEMAR (speakers at 135 and 215 degrees; referred to as the two speaker condition, Figure 1), or the noise signals surrounding the KEMAR (speakers positioned at 45, 135, 225, and 315 degrees; referred to as the

four speaker condition, Figure 2). Therefore, recordings of speech and noise were made in 8 conditions (2 microphone locations x 2 SNR conditions x 2 noise configurations).

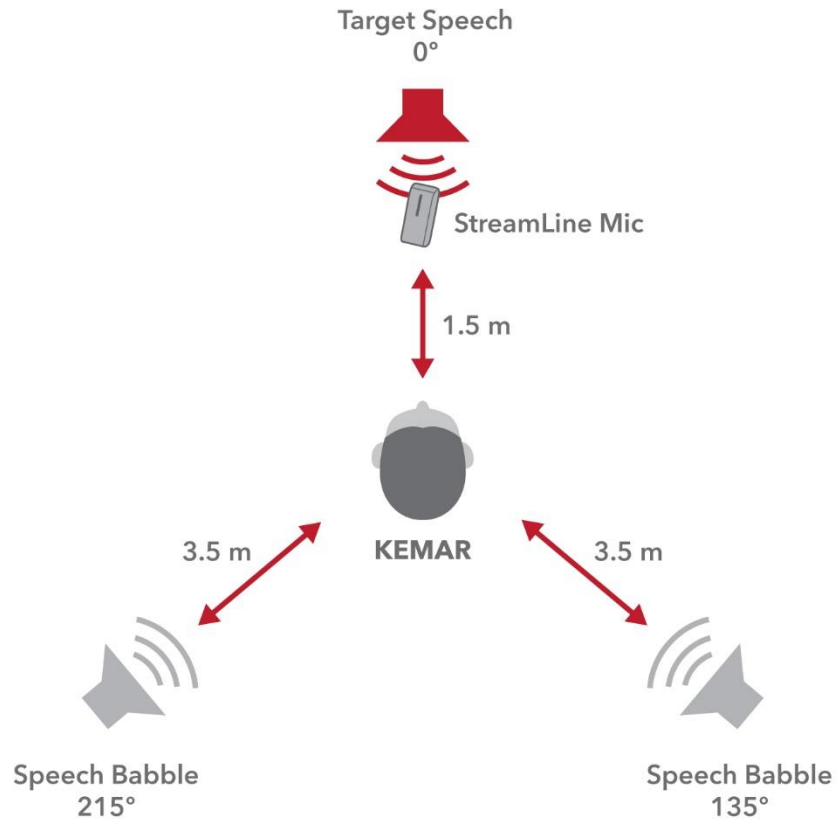

Figure 1. Two Speaker Condition

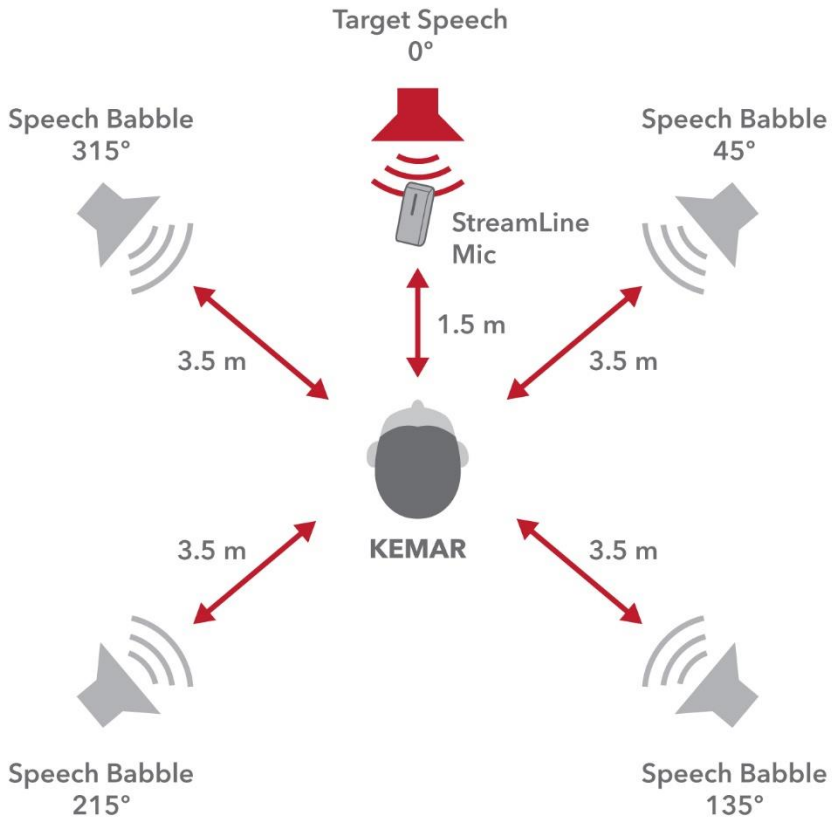

Figure 2. Four Speaker Condition

In each of the 8 conditions, sentences from the Connected Speech Test[7] were presented from the loudspeaker located directly in from of the KEMAR. The background noise, a multi-talker babble with 4 talkers, was presented from the 2 or 4 loudspeaker condition. One passage pair of 10 sentences was recorded in each condition. Recordings were made through the KEMAR with IEC 7-11 microphones, routed to a pre-amplifier, and into a Dell laptop using Adobe Audition (v1.5). The levels of the speech in noise were measured in Audition, in addition to the noise levels (taken during the silence between the sentences). The first 2 seconds of noise were ignored for the purpose of analysis.

Total RMS values for each measure were recorded from Amplitude Statistics in Adobe Audition. The remote microphone advantage was calculated first by determining the signal-to-noise-to-noise ratio (SNNR) by measuring the difference between a noise only presentation to a speech-with-noise presentation. The difference between the omni-directional SNNR and remote microphone SNNR is the remote mic advantage.

Results

Figure 3 shows the recordings in the time domain for omni-directional and Streamline Mic (At Mouth) recordings of the +5 dB SNR, 2-speaker condition, respectively. The reduction in competing background noise is visually apparent when comparing the two figures. The Streamline Mic advantage for each condition and microphone position is presented in Figure 4.

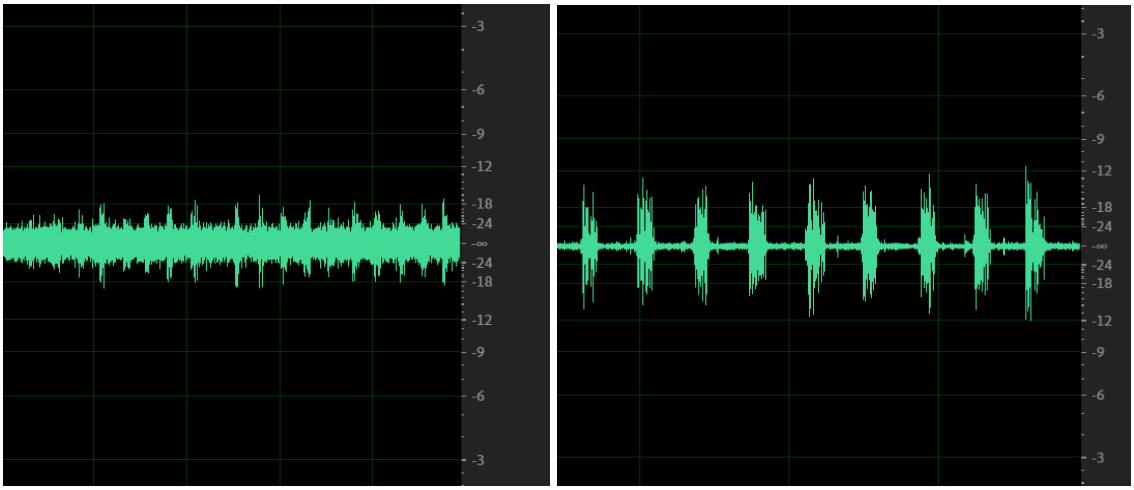

Figure 3. Omni-directional recording of the +5 dB SNR scenario with 2 background speakers and Remote microphone (At Mouth position) recording of +5 dB SNR speech scenario with 2 background speakers.

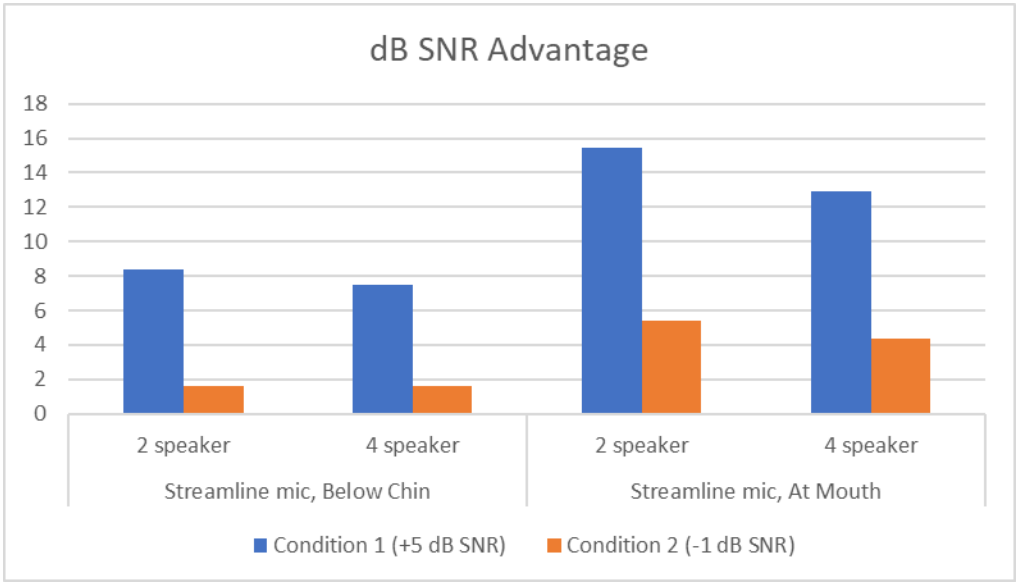

Figure 4. Signal advantage results for +5 and -1 dB SNR conditions for 2 and 4 speaker configurations with Streamline microphone position Below Chin and At Mouth.

In all situations, the Streamline Mic provided an improved SNR. The differences between the 2 speaker and 4 speaker conditions were not large, suggesting benefit for difference listening conditions. The lowest improvement was ~2 dB in the very difficult –1 dB SNR situation for the Below Chin placement. The maximum advantage was observed at over 15 dB for the +5 dB SNR speech condition for the At Mouth placement.

Summary

These data clearly demonstrate the potential for Streamline Mic to improve the SNR in a variety of listening situations. Even in circumstances of very difficult listening, the Streamline Mic can positively affect the SNR for the hearing aid wearer. Based on the degree of benefit afforded by the Streamline Mic, we would expect hearing aid users to have 15 to 100% improvements in speech intelligibility for a variety of listening conditions, if we assume an approximate 10% improvement for every 1 dB change in the SNR. Although the actual benefit experienced by a hearing aid wearer will vary based on their auditory abilities and the acoustic environment, we certainly would expect wearers to benefit in nearly all listening situations. Even in cases where speech recognition is at or near 100%, the SNR advantage provided by the remote mic will provide more relaxed listening and reduce listening effort.

Hearing aid wearers often put high demands on their amplification technology. Situations like speech understanding in background noise are often the most challenging and require SNR improvement. These needs carry over to use of smart phone and other streaming opportunities. Providing a remote microphone accessory such as the Streamline Mic can support these SNR improvement needs while also opening up more streaming opportunities with phones and other devices.

Acknowledgements:

The author would like to thank Erin Picou for insights and assistance in data collection and analysis. Additional thanks to Anna Javins for assistance with the data analysis.

References:

1. Rogin, C., & Abrams, H.B. (2016, March). MarkeTrak 9 points the way in a time of change. *AudiologyOnline*, Article 16512. Retrieved from http://www.audiologyonline.com.
2. van Knijff EC, Coene M, Govaerts PJ. Speech understanding in noise in elderly adults: the effect of inhibitory control and syntactic complexity. Int J Lang Commun Disord. 2018; 53:628–642.
3. Froehlich M, Littmann V. Closing the open fitting: an effective method to optimize speech understanding. Hearing Review. 2019;26(4)[Apr]:16-20.
4. Powers T, Froehlich M, Branda E, Weber J. Clinical study shows significant benefit of own voice processing. Hearing Review. 2018;25(2):30-34.
5. Picou, E. M., & Ricketts, T. A. (2011). Comparison of wireless and acoustic hearing aid-based telephone listening strategies. Ear and Hearing, 32, 209-220.
6. Pearsons, K., R. Bennett, AND S. Fidell. SPEECH LEVELS IN VARIOUS NOISE ENVIRONMENTS. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/1-77/025 (NTIS PB270053), 1977.
7. Cox, R., Alexander, G., & Gilmore, C. (1987). Development of the connected speech test (cst). Ear and Hearing, 8, 119s - 126s.