Hearing assistive technologies (HATs) have been used in audiological treatment plans for many years, predominantly in educational settings. HATs include listening and alerting devices that utilize auditory, visual and/or tactile information to improve communication and promote environmental awareness (Chisolm, Noe, McArdle & Abrams, 2007).

One major category of HATs is frequency modulated (FM) technology. An FM system consists of an audio transmitter, which is also called a remote microphone, and a wireless receiver that routes audio into a hearing aid. Remote microphones provide the benefit of bypassing the hearing aid microphone and providing a direct audio input that results in a consistent input level to the hearing aid while overcoming negative effects of talker distance, ambient noise and reverberation (Lewis, 1994).

Previous studies suggest that remote microphone use improves speech recognition in the classroom when compared to hearing aid microphones alone (Hawkins, 1984; Boothroyd & Iglehart, 1998; Anderson & Goldstein, 2004; Anderson, Goldstein, Colodzin & Iglehart, 2005; Lewis, 2008). Several studies have shown that these acoustic benefits, in turn, yield significant improvements in academic achievement (Crandell, Smaldino & Flexor, 2005).

The improvement of speech recognition in noise using remote microphone technology is also documented in several studies outside of the classroom (Boothroyd, 2004; Lewis, Crandell, Valente & Horn, 2004; Fitzpatrick et al., 2009). Specifically, Lewis and colleagues (2004) investigated the effects of remote microphone technology on speech perception in noise relative to unaided and hearing aid only conditions. The investigators recruited a group of participants ranging in age from 24 to 84 years with mild to severe sensorineural hearing loss. Speech recognition performance was assessed with the Hearing in Noise Test (HINT) (Nilsson, Soli & Sullivan, 1994) in five different listening conditions. Results revealed that the use of bilateral FM audio streaming significantly improved the signal-to-noise ratio (SNR) relative to the omnidirectional hearing aid.
aids alone by 16 to 22.7 dB, confirming that adult listeners with hearing loss benefit from the use of a personal remote microphone system.

This study, among many others, clearly illustrates the tangible benefits of remote microphone technology. As such, the SurfLink® Mobile wireless hearing aid accessory was introduced with an integrated remote microphone. SurfLink Mobile also serves as a hearing aid remote control, as well as an audio or mobile phone streaming device. The improvements in speech recognition from the remote microphone technology offered by Starkey Hearing Technologies were assessed in a recent study in our research facility.

Methods

Sixteen adults, 10 females and six males, with mild to moderately severe sensorineural hearing loss were selected for this laboratory study. The age range of the participants was 52 to 81 years with a mean age of 68.5 years. Ten participants were experienced hearing aid users while six participants had limited exposure to hearing aids. None of the participants had used remote microphone technology prior to the study. All participants completed an informed consent process that reviewed study methodology, their required involvement and any risks or benefits. Participants were fit with bilateral 3 Series™ i110 wireless mini behind-the-ear hearing aids (BTE) and occluded earmolds with size #13 tubing. The hearing aids were paired with a SurfLink Mobile device. At the time of fitting, real-ear measures were completed using an Audioscan Verifit and the International Speech Test Stimulus (ISTS). All participants were fit to DSL v.5 adult targets (Scollie et al., 2005).

HINT stimuli consisted of 26, 10-sentence lists combined with speech-spectrum noise. For the purpose of this study, the HINT was used in its adaptive form in which the noise is presented at a fixed level and the sentence levels are varied depending on the accuracy of the listener’s response. The HINT SNR-50, or the signal-to-noise ratio required for correct repetition of 50 percent of the sentences, was recorded for the following conditions: unaided, hearing aid only, SurfLink Mobile microphone only, and hearing aid microphone plus SurfLink Mobile microphone. Each condition was assessed one time using two lists (20 sentences for each condition). The speech was presented at 0° azimuth and an equally distributed, continuous, speech-shaped noise was presented from four speakers surrounding the participant (45°, 135°, 225° and 315°). The presentation level of the noise was 55 dB SPL. The participant was seated both six feet and 12 feet away from the talker loudspeaker.

Hearing in Noise Test performance was investigated in several listening conditions:

1. **Unaided**
   - An omnidirectional hearing aid only fitting to the DSL v.5 adult targets generated by the Audioscan Verifit. Except for feedback suppression, all other features and noise reduction algorithms were deactivated.

2. **A SurfLink Mobile remote microphone streaming only setting to the same DSL v.5 adult targets. Except for feedback suppression, all other features and noise reduction algorithms were deactivated.**

3. **A SurfLink Mobile remote microphone streaming plus hearing aid microphone fitting to the same DSL v.5 adult targets. The SurfLink Mobile microphone and the hearing aid microphone were set such that each contributed equally to the audio signal. Except for feedback suppression, all other features and noise reduction algorithms were deactivated.**
Results

Figure 1 shows a box plot of HINT SNR-50 for all conditions six feet away from the loudspeaker. The main effect of microphone condition was examined using a one-way, repeated measures analysis of variance (RMANOVA). Results of the one-way RMANOVA showed a significant main effect of microphone condition ($p < 0.001$). Post-hoc analysis included a Tukey pairwise multiple comparison test. The SurfLink Mobile microphone streaming only setting significantly improved the speech recognition in noise ($p < 0.001$) when compared to the hearing aid only condition. Individual participants’ improvement in speech recognition ranged between 4.9 and 16.5dB with a mean improvement of 12.6dB. In the test conditions when the hearing aid microphone was enabled, improvement in speech recognition in noise ranged between 7.5 and 17.5dB with a mean range of improvement of 12.7dB. These results are consistent with previous studies (Lewis et al., 2004; Hawkins, 1984).

Figure 2 shows a box plot of HINT SNR-50 for all conditions 12 feet away from the loudspeaker. The main effect of microphone condition was examined using a one-way RMANOVA. Results of the one-way RMANOVA showed a significant main effect of microphone condition ($p < 0.001$). Post-hoc analysis included a Tukey pairwise multiple comparison test. The SurfLink Mobile microphone only significantly improved the speech recognition in noise ($p < 0.001$) when compared to the hearing aid only. Individual participants’ improvement in speech recognition ranged between 12.0 to 21.9dB with a mean improvement of 15.7dB. In the test conditions when the hearing aid microphone was enabled, improvement in speech recognition in noise ranged between 11.3 and 18.8dB with a mean range of improvement of 15dB.

Conclusion

Remote microphone technology has a proven track record of improving speech recognition in noisy environments. The results of this study were consistent with previously documented performance trends (Lewis et al., 2004; Hawkins, 1984). Participants in the present study experienced significantly improved speech recognition in noise
when comparing the SurfLink Mobile remote microphone both with and without the hearing aid microphone enabled to hearing aid only and unaided listening. Increasing distance between the listener and talker did not affect these benefits. In fact, the amount of benefit observed with the remote microphone integrated into SurfLink Mobile was similar to that observed with traditional FM remote microphones (Lewis et al., 2004).

These results, when taken in sum with previously published studies, clearly illustrate the benefits of the remote microphone technology available in SurfLink Mobile. This remote microphone offers patients the benefit of minimizing the negative effects of talker distance and reverberation while improving SNR. Few other hearing aid technologies address these common complaints of hearing aid patients.
References


