Field Study News

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Comparison of wireless microphones

Study indicates that Roger delivers superior listening performance in moderate-to-high background noise

For many years, people with hearing loss have been able to use a remote microphone, located closer to the signal of interest, in order to improve speech recognition in the presence of competing noise. This study compared speech recognition in quiet and in noise with a new wireless remote microphone versus the Roger wireless system. Roger applies several signal enhancement features including an adaptive gain model that adjusts the level based on the background noise. Speech recognition scores were measured for 7 hearing impaired listeners in quiet and in the presence of noise at 55, 65, 75 and 80 dBA. Results indicated that, compared to all other device configurations, the use of the Roger system led to significantly better speech understanding at moderate and high noise levels with a 25% improvement with Roger at 65 dBA and a 49% improvement with Roger at 75 dBA.

Introduction

In spite of significant advances in hearing instrument technology over the last 15 years, patients continue to struggle when listening over distance and in background noise. In fact, of the 11 sound quality factors studied in Kochkin (2011), hearing aid performance in noisy situations was rated highest in dissatisfaction among adult hearing instrument users. Analog FM systems have historically been the recommended solution when hearing aids alone cannot meet the listening needs of an individual. However, there has been a recent trend toward the use of wireless, digital radio frequency technologies instead of analog FM systems. Digital wireless microphones, operating in the 2.4 GHz band, are now available for use with hearing instruments. These remote microphones utilize digital radio frequency transmission to 'stream' audio signals directly to the instruments or via a relay worn by the hearing instrument user. Typically these accessory microphones are less costly than traditional FM systems and offer little by way of signal enhancement features.

Another remote microphone solution available for hearing assistance is the Phonak Roger system. Roger is a proprietary digital wireless technology that allows the listener to receive a radio broadcast via miniature receivers attached to their hearing instruments. Roger transmits on the 2.4 GHz Industry, Science, Medical (ISM) band. Depending on the user's needs and applications, Roger technology is available in a variety of different transmitter-microphone models, including the Roger inspiro for classroom applications and the Roger Pen, designed as a personal communication tool to meet the wide range of listening needs of teenagers and adults.

The Roger Pen features context-dependent sound enhancement features that are designed to improve speech perception compared to a basic remote microphone. The adaptive gain control system monitors the ambient noise levels in the speech pauses and adjusts the receiver gain accordingly. Specifically, receiver gain is automatically increased when the ambient noise level increases. This feature was designed to deliver improved speech understanding in noise without having to compromise audibility from the onboard microphone of the hearing instruments. Previous research (Thibodeau, 2014 & Wolfe, 2013) has demonstrated the superior performance of the adaptive Roger compared to traditional, fixed-gain and adaptive analog FM systems.

Additionally, the Roger Pen features an internal accelerometer that informs the device about its orientation in space. This component allows the device to predict and activate the most appropriate microphone mode according to the expected use case. The end result is adaptive noise cancelling, beam forming and gain adaptation to optimize hearing in response to the varying characteristics of the scene and physical orientation of the Roger Pen.

The objective of this study was to evaluate the benefit of two digital, wireless remote microphone technologies. Sentence recognition in quiet and in noise was evaluated with the use of two hearing aids alone and with the use of the hearing aids and the two remote microphone technologies. The remote microphone technologies evaluated in this study were:
1) a competitor's digital, wireless remote microphone accessory that streams audio signals on the 2.4 GHz band directly to hearing aids from the same manufacturer, and
2) the Phonak Roger Pen, an adaptive, digital wireless remote microphone that transmits on the 2.4 GHz band and incorporates fully adaptive beam forming and digital noise reduction/speech enhancement processing.
The Roger Pen was used with Phonak Bolero Q hearing aids and Roger receivers.

Methodology

This paper summarizes preliminary results from 7 adult subjects who participated in this study. The participants all had moderate to profound sensorineural hearing loss and were users of a variety of different hearing instruments. The average audiograms for all participants can be seen in figure 1..

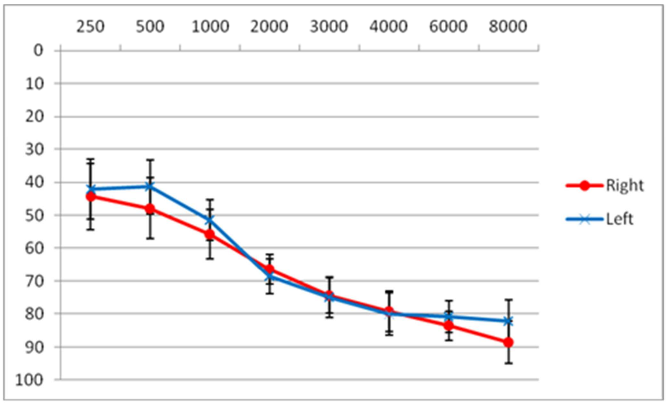

Figure 1
Average air conduction thresholds for the seven patients in the right ear (red) and left ear (blue). Error bars represent the standard error of the mean.

Each participant was fitted binaurally with the competitor's premium behind-the-ear (BTE) hearing aids and Phonak Bolero Q90 SP BTE aids. Using the Audioscan Verifit, in situ real ear probe microphone measures were used to match the output of both hearing instruments to prescribed NAL-NL1 targets for 55, 65 and 75 dB SPL Standard Speech inputs. MPO targets were not exceeded. The real-ear-to-coupler difference was measured for each participant. There was no greater than a 2 point difference in the Speech Intelligibility Index (SII) obtained at each input level for the two different types of hearing aids.

The feedback cancellation system was enabled for both hearing aids, but all other advanced signal processing features (e.g., digital noise reduction, directional microphones, wind noise reduction, de-reverberation strategies, adaptive scene analysis, etc.) were all disabled for use in this study. The competitor's remote microphone was paired to the competitor's hearing instruments, and the Roger X universal receivers were attached to the Bolero Q90s and connected with the Roger Pen. Each pair of hearing aids and the corresponding remote microphone technologies were programmed so that the output of the hearing aids to a 65 dB standard speech signal, delivered to the hearing aid microphone was identical to the output of the hearing aids when the same 65 dB standard speech signal was delivered to the remote microphone (i.e., transparency was achieved). This step was in accordance with the American Academy of Audiology published HAT Guidelines (2008).

Subjects were tested in a carpeted classroom environment, measuring 4.7 meters by 6.8 meters (15'5" feet by 22'4" feet). Four loudspeakers were placed in the corners of the classroom to present diffuse cafeteria noise. A loudspeaker, placed at 0 degrees in front of the subject was used to present AzBio sentences (Spahr, et, al, 2012). Patients were tested in quiet and in low (55 dBA), moderate (65 dBA) and high level (75 and 80 dBA) background noise. The competitor's remote microphone and the Roger Pen were hung 15 cm (6 inches) below the center cone of the speaker presenting the target signals. This set-up was intended to simulate a use case where a primary speaker would be wearing the microphone around his/her neck or clipped onto his/her shirt. The beamformer in the Roger Pen was expected to be activated by this condition resulting in a microphone polar plot pattern that focuses on the speech signal of interest while attenuating the competing noise. The level of the target sentences was 80 dBA at the location of the wireless microphones and 65dBA at the location of the subject. The reported noise levels were consistently measured to be equivalent at both the remote microphone and the position of the patients' ears (figure 2).

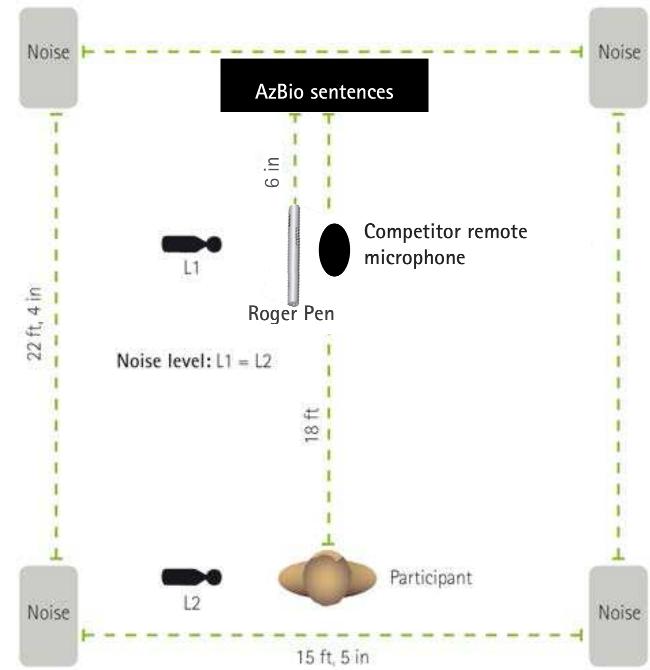

Figure 2
Test room set up. Conditions included quiet, 55 dBA, 65 dBA, 75 dBA and 80 dBA as measured at both the remote microphone location and the patients' ears. The target signal was measured at 80 dBA at the remote microphone and 65 dBA at the patients' ears.

Results and Discussion

Figure 3 shows mean scores for each device configuration as a function of the background noise. The data was analyzed using two-way repeated measures analysis of variance (ANOVA) which showed significant effect for device ($F[3,18] = 115.5$, $p < .0001$) and listening condition ($F[4,24] = 314.5$, p=<.0001). There was also a significant interaction between device and noise ($F[12,72] = 26.4$, $p < .0001$).

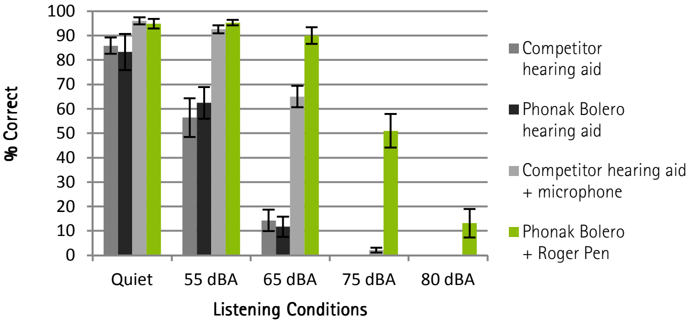

Figure 3
Group performance data across all 5 conditions with each of the 4 device configurations. Errors bars represent the standard error of the mean.

A post-hoc Tukey HSD multiple comparisons test was used to perform pair-wise comparisons. In quiet, there were no significant differences between any devices ($p > .05$). In the presence of low-level (55 dBA) background noise, significantly ($P = .001$) better speech recognition scores were obtained with the Roger and Bolero Q hearing instrument relative to those measured with the use of Bolero Q hearing aid alone. Similarly, the competitor's remote microphone and hearing instrument improved ($p < .0001$) the recognition scores measured with the competitor's hearing instrument alone. However, when evaluated in the presence of low-level noise, there were no significant differences in speech recognition obtained with Roger coupled to the Phonak hearing aid versus that obtained with the competitor's remote microphone and hearing aid. At moderate (65 dBA) to high-level competing noise, performance obtained with the Roger system was significantly better ($p < .01$) than sentence recognition obtained with the competitor's remote microphone.

These results indicate that the four different device configurations provide similar benefit to hearing impaired users in quiet listening conditions. The use of remote microphones such as the Roger microphone or the competitor's remote microphone provides better speech understanding than that achieved by hearing aids alone in the presence of low levels of background noise (+10 signal-to-noise ratio or better). However, in the presence of moderate- to high-level noise (65 to 80 dBA), Roger delivered significantly better sentence recognition when compared to the competitor's remote microhone audio streaming accessory with a 25% improvement with Roger at 65dBA and a 49% improvement with Roger at 75dBA.

This study highlights the potential benefits of using wireless remote microphone technologies to improve speech recognition in quiet and in noise. Results indicate that each remote microphone system provided improvements in sentence recognition in quiet and in noise, particularly when the competing noise was presented at low levels. However, at moderate to high noise levels, sentence recognition obtained with use of the Roger Pen was substantially better than sentence recognition obtained with the competitor's remote microphone. The superior performance associated with use of the Roger Pen is most likely attributed to adaptive gain changes in combination with the adaptive beam forming provided by the Roger Pen. Use of Roger technology should be recommended for all persons with hearing loss who are struggling to understand in complex listening environments such as classrooms, restaurants, sporting events and conferences where moderate and high levels of background noise may occur.

References

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