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Field Study News

Roger™ improves speech recognition in noise for cochlear implant users with single-sided deafness

This study, conducted at the University of Freiburg in Germany showed that the use of a digital adaptive remote microphone system (Roger) provides significant benefits in speech recognition for distant speakers in multi-source competing background noise for single-sided deaf (SSD) cochlear implant (CI) recipients. A significant benefit of the advanced remote wireless microphone system, Roger, was also shown for normal hearing participants.

Jennifer Appleton-Huber, June 2019

Introduction

This paper is a summary of a peer-reviewed article (Wesarg et al., 2018).

Many people with SSD report difficulties with speech recognition in competing noise and localization of sound sources (Wie et al, 2010). Since 2008, people with SSD have been successfully treated with CIs, and have reported a subjective improvement of hearing and speech recognition abilities (Vermeire and Van de Heyning, 2009; Buechner et al, 2010; Arndt et al, 2011). Various studies have also shown that people with SSD experience an objectively measurable improvement in speech recognition in noise and localization of sound sources after cochlear implantation (Vermeire and Van de Heyning, 2009; Buechner et al, 2010; Arndt et al, 2011; Jacob et al, 2011; Firszt et al, 2012; Távora-Vieira, 2015; Friedmann et al, 2016; Arndt et al, 2017).

Even though several improvements are achieved in SSD patients with cochlear implantation, there are still multiple listening situations in which their speech recognition is limited, especially during conferences, in classrooms, and in reverberating rooms (Giolas and Wark, 1967; Lieu, 2004; Wie et al, 2010).

Wireless remote microphone systems were developed to improve speech recognition in the challenging listening situations mentioned previously. With these systems, the physical distance between the speaker and listener is overcome by wireless audio signal transmission.

In 2013, Phonak introduced Roger, an advanced remote wireless microphone system (Phonak, 2013). In the Roger system a Roger receiver adjusts automatically the volume of the received wireless microphone signals according to the ambient noise level of the Roger receiver. This results in better speech recognition in noise than is achieved with Dynamic FM systems, especially in higher competing noise levels (Mülder and Smaka, 2013; Thibodeau, 2014).

Remote wireless technology has been shown to improve speech recognition in previous studies. Schafer and Thibodeau (2006) revealed that FM systems significantly improve speech recognition in competing noise in children with bilateral severe-to-profound hearing loss using two CIs (bilateral) or a CI and an HA (bimodal). Significant benefits of remote wireless microphone systems were also shown in adult participants with bilateral hearing loss using CI(s) or HA(s). Wolfe et al (2013) showed that Roger significantly improved speech recognition in noise in bilateral CI and bimodal recipients at higher noise levels (70, 75, and 80 dB[A]). In this study, Roger also outperformed fixed-gain and adaptive-gain analog FM systems. Speech recognition was significantly better with Roger compared with (fixed and adaptive gain) FM technology.

To the knowledge of the investigators in this study, there were no studies on the application of any remote wireless microphone system in SSD CI recipients.

Objective

The aim of this study was to determine whether SSD CI recipients benefit from the application of Roger with regards to speech recognition of distant speakers in competing multi-source background noise. In addition, a normal hearing (NH) group was also included in the study to investigate speech recognition of a distant speaker in background noise for different Roger applications and without Roger.

Methodology

Participants

Two participant groups were included in this study, eleven adult SSD unilateral CI recipients using a CIs from the company Cochlear and eleven adult NH participants. The SSD participants were 46.1 ± 14.3 years old, and the NH participants were aged 25.1 ± 5.5 years.

The SSD participants had used their CI for at least 12 months and had a Freiburg monosyllabic word recognition score of at least 50% at 65 dB SPL with the CI, when speech was presented in free field with the contralateral NH ear masked by speech-masking noise of 70 dB SPL. The NH in the better ear was defined as air conduction pure-tone thresholds from 125 Hz to 4 kHz of equal to or less than 30 dB HL.

The NH participants were required to show air conduction pure-tone thresholds of 20 dB HL or less for all frequencies with each ear. The ear with the smaller four-frequency (0.5, 1, 2, and 4 kHz) pure-tone average was considered the better ear.

Devices

Before testing, every SSD CI recipient was provided with a loaner speech processor CP910 to be used during testing. Their individual favorite everyday-program setting was altered according to the Roger for CP910 fitting guide (Phonak, 2014), with an accessory mixing ratio of 1:1. T- and C-levels were refitted based on subjective feedback and recipients wore these adjusted loaner speech processors for an hour before testing to allow for acclimatization.

The wireless microphone used was the Roger Pen™. The receivers used were the Roger 14 for use with the CP910 speech processor and the Roger Focus for the NH ears, both with a gain of 0 dB. The Roger Pen was set to lanyard mode. In this mode, an adaptive beamformer yielding a directional microphone characteristic is applied.

Room setup

Speech recognition in noise was assessed in a meeting room (8.12 x 6.11 m) with an ambient noise level of approximately 30 dB(A). For each test condition, one randomly selected list of the Oldenburg sentence test (OLSA; Wagener et al, 1999 a,b) with 30 sentences was administered, and speech recognition was measured in percent correct. The OLSA sentences were presented by a loudspeaker, 5.5 meters in front of the participant at 0° azimuth. The speech level was 65 dB(A) at a distance of 1 m from the front of this speaker. At the participant's head, the speech level was 56.5 dB(A), i.e., 8.5 dB lower than at the shorter distance of 1 m. The competing noise (classroom noise) was presented in an uncorrelated fashion from four loudspeakers located close to the four corners of the room. These speakers were positioned to face the middle point of the experimental setting, resulting in an angle of 32.2° azimuth. Noise levels investigated were 55, 65, and 75 dB(A), set to be the same at the location of the participants' head and at the position of the Roger Pen resulting in signal-to-noise ratios of 1.5, -8.5, and -18.5 dB at the participant's head, respectively. The Roger Pen was positioned horizontally at a distance of 20 cm in front of the loudspeaker at 0° azimuth, at a height of 1.15 m, mimicking the vertical position of a Roger Pen worn by a speaker around the neck.

Procedure

For both groups, SSD CI recipients and NH participants, speech recognition in competing noise was measured in five listening conditions, two no-Roger (I and II) and three Roger conditions (III, IV, and V), for each of the three noise levels, 55, 65, and 75 dB(A), i.e., in 15 test conditions (Table 1). The sequence of the test conditions was randomized across participants.

Listening condition	SSD CI recipients	NH participants
No Roger conditions		
I	NH ear, CI turned off	Better ear, weaker ear masked
II	NH ear, CI turned on	Better ear, weaker ear
Roger conditions		
III	NH ear, CI with Roger 14	Better ear, weaker ear with Roger Focus
IV	NH ear with Roger Focus, CI	Better ear with Roger Focus, weaker ear
V	NH ear with Roger Focus, CI with Roger 14	Both ears with Roger Focus

Table 1. Listening conditions assessed for both participant groups.

Before testing, a training of speech recognition in competing classroom noise was conducted in both groups. Before each training run and test, the participants were instructed to repeat the words of the OLSA sentences presented.

Results

Figure 1 displays the box-and-whisker plots of speech recognition in noise scores of the SSD CI recipients at three noise levels for each of five listening conditions. Post hoc analyses found that in all Roger conditions, speech recognition in noise was significantly better than in all no-Roger conditions at noise levels 65 and 75 dB(A) ($p < 0.001$ and $p < 0.01$). There was no significant difference between any of the Roger and no-Roger conditions at 55 dB(A). The speech recognition in noise shows a ceiling effect for all listening conditions at the lowest noise level (55 dB[A]) and for all Roger conditions at the higher noise levels (65 and 75 dB[A]).

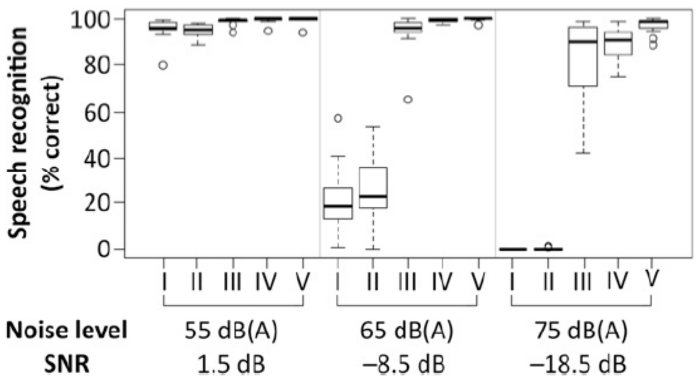

Figure 1. Box and whisker plots of speech recognition of 11 SSD CI recipients attained for OLSA sentences at 65 dB (A) at three noise levels of competing classroom noise for each of five listening conditions. For details of listening conditions I – V see table 1.

Figure 2 displays box-and-whisker plots of speech recognition in noise scores of the NH participants at three noise levels for each of five listening conditions. As with SSD CI recipients, speech recognition in noise was significantly better for all Roger conditions than for all no-Roger conditions at noise levels 65 and 75 dB (A) ($p < 0.001$ and $p < 0.01$). There were no significant differences between all Roger and no-Roger conditions at 55 dB(A). Similar to the SSD CI recipients, speech recognition in noise shows a ceiling effect for all listening conditions at the lowest noise level (55 dB[A]) and for all Roger conditions at the higher noise levels (65 and 75 dB[A]).

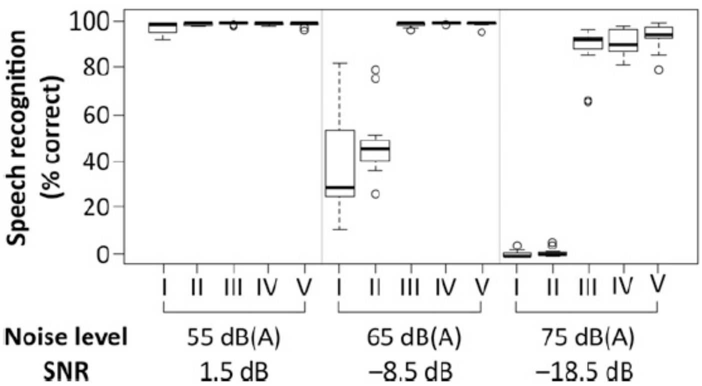

Figure 2. Box and whisker plots of speech recognition of 11 NH participants attained for OLSA sentences at 65 dB (A) at three noise levels of competing classroom noise for each of five listening conditions. For details of listening conditions I – V see table 1.

Conclusion

One of the greatest difficulties SSD CI recipients face is listening to a distant speaker with multi-source competing background noise. This analysis revealed that SSD CI recipients show a significant improvement in speech recognition for a distant speaker in multi-source noise at higher noise levels with the addition of Roger. Based on these results, remote wireless microphone technology should be recommended and tested in routine clinical practice by SSD CI recipients reporting difficulties in challenging listening situations. Comparing different applications of Roger in SSD CI recipients, no significant difference between unilateral (either NH ear or CI) or bilateral use was found.

Similar to the results of the SSD CI recipients obtained in our study, unilateral (either ear) and bilateral application of Roger technology was significantly beneficial in NH participants at higher noise levels. On the basis of our data, recommendation and testing of remote wireless microphone systems in difficult acoustic situations should be considered by ENT physicians or audiologists in NH participants, too. Especially for NH participants with subjectively perceived impairment of speech recognition in everyday noisy listening situations, the application of remote wireless systems could be a beneficial option.

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