Study report, assistive listening devices

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Introduction

In a noisy environment assistive listening devices can offer a person with hearing impairment the opportunity to improve his or her speech perception.

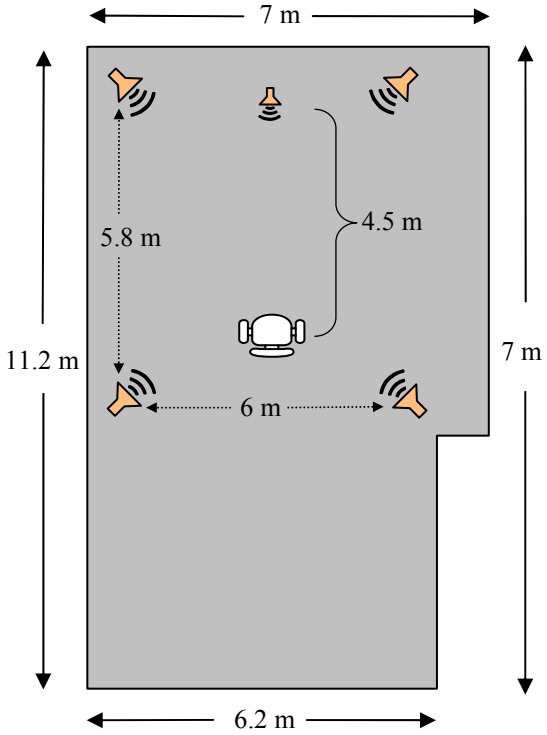
Three different wireless systems were tested in a controlled setting. Comparisons were made for speech perception in noise, perceived loudness and system preference. All testing was performed by the team at Audiological Research Centre at the Örebro University Hospital. The study was financed by Phonak Communications AG.

20 subjects with different degrees of hearing loss were chosen to participate in the study. Testing was performed using the Swedish version of the Hearing In Noise Test (HINT).

Methods

Room and equipment

The room in which the tests were performed was a conference room similar in size to a small classroom. The background noise in the room was measured to be below 40 dB(A).



The speech material was presented via a small speaker – the Fostex 6301B – which was positioned 4.5 meters in front of the test person. Four larger active PA speakers - RCF ART 310A's - were used to present the surrounding noise.

All sounds were played back from a laptop computer running Cockos Reaper under Windows XP. The five speakers were connected to an external RME FireFace UC USB soundcard. The audio resolution was set to 44.1 kHz, 16 bits.

Systems under test

The different systems tested were:

Name	Type	Serial no.
Phonak ZoomLink+	microphone transmitter	0932NY02F
Phonak MLxi	miniature receiver	0814C121J, 0818C10JD
Phonak MyLink+	receiver w neckloop	1024NY3V6
Comfort Audio DC-20	microphone transmitter	DC1020321
Comfort Audio DH-10	receiver w neckloop	DH1020241

All brands and model types were taped/de-branded to ensure objectiveness.

Throughout this report the following names will be used:

System A Phonak ZoomLink+ with MLxi
System B Phonak ZoomLink+ with MyLink+
System C Comfort Audio DC-20 with DH-10

The order in which these three systems were tested by each subject was randomised.

Participants

20 adult subjects participated in the evaluation - 7 female and 13 male. Subjects had a mean age of 59.7 years, with ages ranging from 28 to 72 years. All of the participants had sensorineural sloping hearing losses (see audiogram in figure 1), and they used their own BTE hearing aids during the evaluation. The microphones of the BTE hearing aids were always active (System A: FM+M, Systems B and C: T+M).

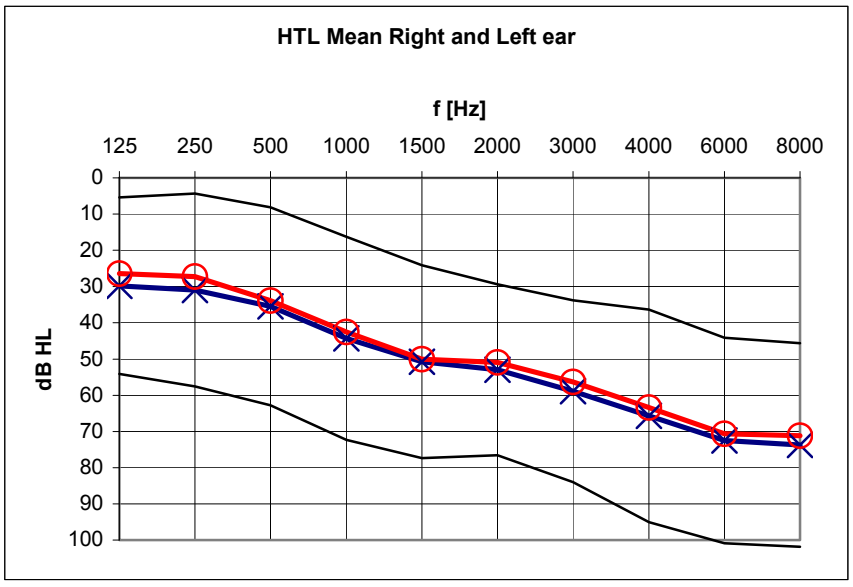


Figure 1. The right and left mean values of hearing threshold for participants in the evaluation study.

Speech material

A total of 25 sentence sets was used, with each set consisting of ten sentences. The sentence sets and the order in which they were played was different for each subject and each of the three systems.
The HINT CD itself contains sentences read by both female and male voices. In this test only the female voice was used.
Each test began with a test in no noise (to measure the subject's individual speech perception) followed by a test at 55 dB(A) and a further five tests at increments of 5 dB (up to a maximum of 80 dB(A)). At each noise level one set of ten sentences was played back. Therefore a total of 70 sentences were used for each of the three systems. After each increase in noise level there was also a 10 second delay to allow the system in question to adapt to the surrounding noise.

Noise

The surrounding noise used was unmodulated ICRA noise. The noise was time shifted to ensure there was no correlation between the noise of the four speakers.

Evaluation

During the test the transmitter microphone was placed 20 cm in front of the small Fostex speaker. The Phonak ZoomLink+ microphone was set to SuperZoom and the Comfort Audio DC20 to Zoom mode.

Calibration

A Brüel & Kjaer PULSE system with two 4190 microphones was used for calibration. The noise level was measured with one 4190 microphone in the exact position at which the FM microphones were placed, 20 cm in front of the small speaker. The other 4190 was placed at the listening position 4.5 m from the speaker, 120 cm above the floor. The noise was calibrated with an A weighted filter to be 55, 60, 65, 70 and 75 dB(A) respectively, and equally loud in both positions.
The speech level was measured to be 70 dB, 1 meter in front of the Fostex speaker. A calibration tone (1 kHz frequency modulated sine) from the HINT cd was used and the measurement in PULSE used a 1/3 octave CPB filter at 1 kHz. Calibration was performed at the start and end of each session to ensure consistent sound levels.

Results

Volume settings

Before starting the test every subject listened to a trial sentence and had the opportunity to change the volume setting of their hearing instrument and/or bodyworn receiver. No further volume changes were allowed after the test had started. Given the chance to alter volume settings, all participants left system A in the default setting.
Four people raised the volume of system B. One raised the volume to maximum level (and would have raised it more if possible), one person preferred it 2 steps louder and two people preferred it 1 step louder sound than the default. Only one person lowered system B's volume (by two steps). These five subjects had varying hearing thresholds and the changes of volume could not be explained by the configuration of the audiogram. Variation in volume settings can be explained by orientation and sensitivity of the T-coil in the hearing instruments.

For system C seven of the twenty participants made volume changes. One person reduced the volume by one step, the remaining six persons preferred it louder (ranging from 1 step louder up to max volume).

Speech recognition

When testing the three different systems differences could be observed in the scoring of the HINT tests. The result is presented in table 1.

Table 1. Speech in Noise Test with HINT lists. Scoring in percent of correct answers.

Noise Level	System A Phonak MLxi	System B Phonak MyLink+	System C Comfort Audio
	97.4	98.05	98.25
55	98.95	97.7	98.05
60	98.5	97.05	97.35
65	96.1	92.8	90.9
70	93.1	85.9	65.55
75	77.95	65.55	29.65
80	41.2	21.15	8.6

Throughout the test the speech level remained at 70 dB.

Across the three systems there were significant differences in the performance of the participants when noise levels exceed the speech level. System A, indicated at a group level, scored the highest whereas system C scored lowest. This difference was most clearly expressed when the noise level exceeded 70 dB SPL.

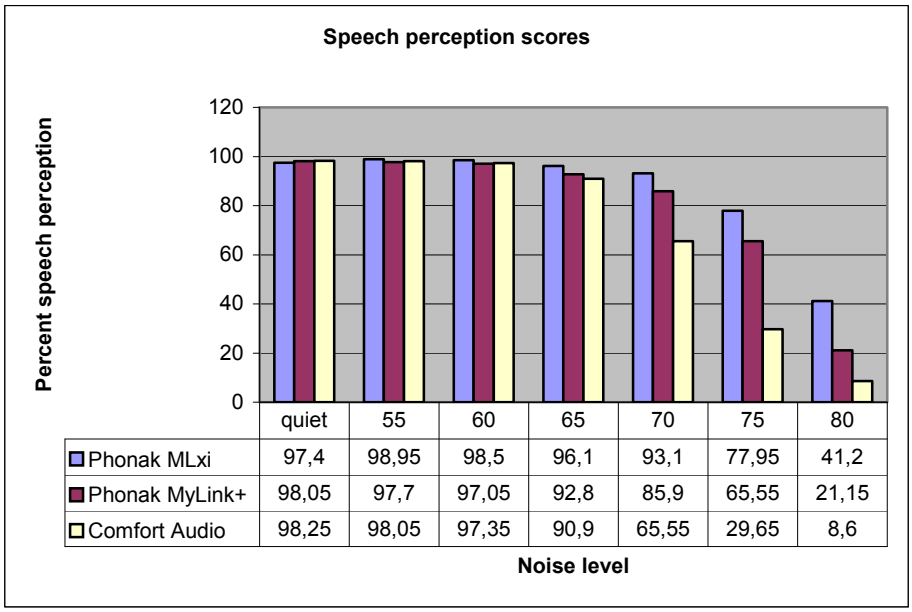


Figure 2. Speech recognition with different assistive listening systems. Background noise levels are indicated on the horizontal axis (in dB(A)), and speech recognition on the vertical axis (in %).

Perceived loudness

After each system test subjects judged the perceived loudness of the loudest noise. A 7-point scale was used (1 = "not audible", 2 = "very soft", 3 = "soft", 4 = "comfortable", 5 = "loud", 6 = "very loud", 7 = "too loud"). The result, at a group level, is shown below in table 2.

Table 2. Perceived loudness of noise at 80dB

		System A Phonak MLxi	**System B Phonak MyLink+**	**System C Comfort Audio**
Loudness Scaling for Noise at 80dB	Mean	5.95	6.18	6.39
	Median	6	6	6.5
	Variance	4 – 7	5.5 – 7	5 - 7

System A was the most comfortable, System C the least. The ambient noise reached the listeners through two signal paths: through the wireless system and through the hearing instruments microphones and the contribution to the loudness of each path is unknown.

Preference

Every participant judged which of the tested assistive listening systems they preferred, and they were able to give comments about these systems.

Table 3.

System	**Best**	**Medium**	**Worse**
A	13	2	2
B	3	8	6
C	3	5	8
A=B	1		
B=C		2	
A=C		2	

In table 3 the subjective preferences for the systems are shown. There were some discrepancies between the statements given since the participants judged the systems slightly differently. Some considered speech perception to be the most important factor while others considered comfort more important. In some cases subjects had difficulties separating speech perception and comfort and so made an overall judgement. Below are some examples of the comments given by the participants.

Subject 1: Had difficulties in deciding between systems A and C. A was considered the best system for understanding speech but was considered unpleasant. System C allowed easy listening with good comfort, but speech recognition was poor with noise present.

Subject 2: System A was the preferred system to use thanks to its clear and distinct sound. The subject felt as though she heard whole sentences, which she felt was not the case with the two other systems. Systems B and C where judged as equally preferable but for system C the subject commented on the negative background noise.

Conclusion

Under the specific conditions described above system A scored the highest in the hearing in noise test as well as in the subjective preference survey. It also had a slightly better loudness rating for the loudest noise level, reinforcing client comfort.