Phonak
Field Study News

Remote hearing system evaluations in the time of Covid-19

A “Remote Hearing Lab” consisting of a suitcase fitted with remote hearing aid evaluation equipment was delivered to study participants from Hörzentrum Oldenburg during the Covid-19 crisis. It was successfully used to determine that the new hearing aid feature from Phonak Speech Enhancer clearly reduces listening effort.

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Key highlights

- During the Covid-19 crisis, many people with age-related hearing loss belong in the risk group and therefore there is a need within hearing research for no-touch Audiology research methods.
- A "Remote Hearing Lab" consisting of test equipment was delivered to subjects’ home and was used to determine listening effort of a new hearing aid feature: Speech Enhancer.
- Testing via the Remote Hearing Lab was successful and the Speech Enhancer was found to clearly decrease listening effort.
- Both test subjects and testers liked conducting the experiment remotely with the Remote Hearing Lab.

Considerations for practice

- When no-touch Audiology research are required, such as during the Covid-19 crisis, the Remote Hearing Lab offers a promising method of conducting hearing aid evaluations and research.
- This method of remote hearing aid research has the added benefit of being able to test hearing aids in the subjects’ home which is where they often report hearing problems.
- Use of such equipment may lead to more real-life testing of hearing aids even in other environment outside of the home.

Introduction

During the Covid-19 crisis, many activities around the care of hearing impaired people became much more difficult. People with age-related hearing impairment are often in the risk group due to their age and frequent comorbidities (e.g: cardiovascular diseases, diabetes, hypertension see e.g. Besser 2018). Therefore, a radical rethinking in the direction of low- and no-touch audiology research became necessary (Swanepoel, 2020), especially for research in the field of hearing systems. Hearing impaired people can no longer come to the laboratories of central research facilities to evaluate hearing systems, and therefore solutions for remote fitting and remote evaluation must be found. In the project presented here, a hardware and software package has been developed by the Hörzentrum Oldenburg, that allows low, or even no-touch evaluation and testing of hearing systems including hearing experiments, even if the systems to be tested are not prepared for remote fitting by the manufacturer. In this paper we will introduce our "Remote Hearing Lab": A calibrated hardware setup in a suitcase. We will show first exemplary results from a recent study with a new hearing aid.

Methodology

The Remote Hearing Lab

The "Remote Hearing Lab" (picture 1) consists of a calibrated hardware setup in a case containing a tablet computer with Long-Term Evolution (LTE) Internet connection, audio hardware (audio interface with connected headphones, speaker, microphone) and a hearing instrument fitting module (Noahlink Wireless).

The tablet is remotely controlled via the LTE network. During the appointment it is possible to communicate with the test person via video call. Special operating instructions help to set up the hardware at home, e.g. for a speech test or hearing aid fitting. So far, the following procedures for remote performance have been implemented in the "Remote Hearing Lab": Video call connection to the subject, room impulse measurements (to estimate the reverberation time on site), sound level measurement (to estimate the background noise level in the remote environment and to monitor the stimulus level during the experiments), hearing aid fitting (with Noahlink Wireless), measurements using headphones and free field (e.g. paired comparisons, speech test in quiet and noise, scaling procedures).

Picture 1: The top photo shows the opened suitcase with the positioned tablet, the loudspeaker, the microphone, and the emergency button. The subjects have to switch on the tablet (see bottom photo) so that the acoustician can log on to the tablet via remote connection.

The headphones (Sennheiser HD 600) and the loudspeaker (Genelec 8010) were used to present different sound signals to evaluate e.g. speech intelligibility, listening effort etc. All signals and programs are saved on the remote tablet, so that an interruption of the Internet connection cannot lead to problems. The case is also equipped with an emergency stop button. When it is pressed, the sound coming through the headphones or the loudspeaker is immediately stopped.

Subjects

A total of 20 subjects (10 male and 10 female) participated in the study. The mean age was 71.3 (standard deviation = ±9.4). All subjects were experienced with hearing aids. The audiograms were taken from the existing database of the Hörzentrum Oldenburg subject database.

For the study, the suitcases were brought/sent to the home of the test person, so that all measurements could take place in the home environment without physical contact between tester and subjects.

Listening effort scaling

One major focus of the remote study was the investigation of a new feature to improve the perception of soft speech (Speech Enhancer (SE)). Soft speech is often an important and relevant issue for hearing impaired people especially when the distance to the talker increases. In this study the subjects had to rate the listening effort when listening to speech from different distances.

To set up such a test with the Remote Hearing Lab, room impulse responses were recorded in 1st order Ambisonics format in the foyer of the house of hearing, Oldenburg, for distances of 1, 2, 4, and 8 meters. The foyer has a T60 reverberation time of 550ms. Theses room impulse responses were used in a TASCAR system with 16 loudspeakers (Grimm, 2019) to present sentences of the Oldenburg sentence test (German: Oldenburger Satztest (OLSA)) (Wagener et al., 1999) from the front at four distances. The hearing aids were attached to an artificial head (KEMAR) in the middle of the loudspeaker circle. For each remotely-located participant, the hearing aid outcomes for his/her individual fitting was recorded.

The recordings were copied to the tablet in the Remote Hearing Lab and the subjects were able to listen to them at home via headphones. On a scale of no effort to extreme effort the subjects had to rate the listening effort when they listened to the OLSA sentences (Krüger, 2017). This was conducted for the two conditions (SE feature on and off) and for the different distances (randomized, each distance was presented four times).

Paired comparison

With the same setup OLSA sentences were recorded with the KEMAR artificial head. These recording were also copied to the tablet and subjects had to compare them regarding the loudness (for which one is the speaker louder?). Comparisons were done for all four recorded distances and both SE settings.

Results

Figure 1 shows the results of the background noise level measurements in the living room of all 20 subjects. As can be seen, the overall long-term average is between 27 and 38 dB (A), which is rather low. The maximum level is between 30 and 47 dB (A).

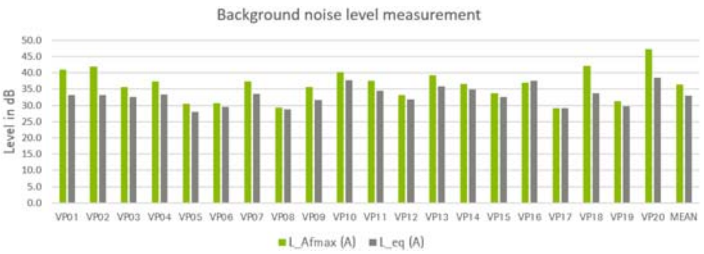

Figure 1: Results of the background noise level measurements in the living rooms of the 20 subjects. The L_eq (A) is the A-weighted long-term average sound level and the L_Afmax (A) is the A-weighted maximum level.

Figure 2 shows the result of the paired comparison for all possible paired comparisons. They demonstrate the high reliability of the data as they clearly indicate that the loudness is perceived as less louder the longer the distance was. And this could be proven as when SE was switched ON and as it was switched OFF.

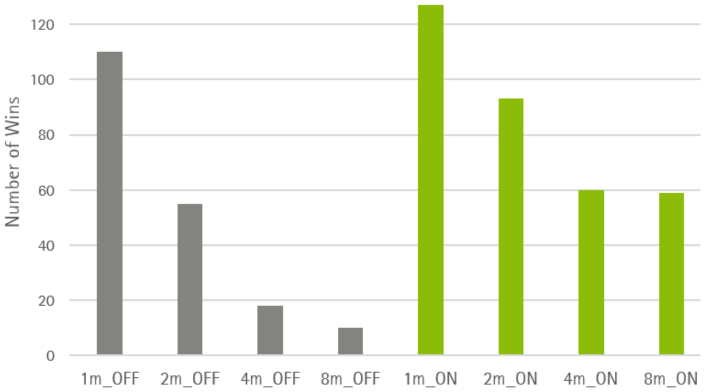

Figure 2. The bars show the number of wins of the complete paired comparison with regards to loudness of speech at the distances of 1m, 2m, 4m, and 8m with different hearing aid settings (SE ON and SE OFF).

In figure 3, the results of the listening effort scaling are shown. Results show that the listening effort increases with increasing distance. From 1m to 8m the rating increases by about 4 scale units. The SE feature significantly reduces the listening effort at all distances (p<0,01, T-Test, Bonferroni corrected).

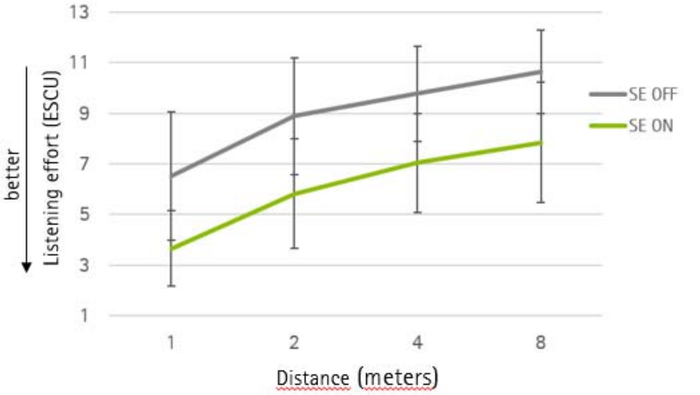

Figure 3: The results of the listening effort scaling at the distances of 1m, 2m, 4m, and 8m with different hearing aid settings (SE ON versus SE OFF). ESCU = Estimated Scaling Unit (ESCU): 1 = no effort, 7 = moderate effort, 13 = extreme amount of effort.

At the end of the study the Remote Hearing Lab was rated very positive by almost all subjects. One person with the rating "difficult" said that "it was difficult without the help of the partner". Three test persons said that they missed the personal contact with the audiologist. 16 out of 17 test persons rated the idea of the remote lab as "very good/good". Overall, the subjects were very satisfied with the Remote Hearing Lab.

Discussion and conclusion

The Remote Hearing Lab has allowed us to carry out an evaluation study of modern hearing aids without any physical contact with the subjects. The low background levels in the living rooms of the subjects indicate that a masking of sounds presented at 50 dB or more should not be relevant for the different hearing experiments. In this no-touch evaluation the hearing aids were tested by the subjects at home and this is a major advantage of the Remote Hearing Lab: The ecologically valid evaluation in the home environment, i.e. where hearing impaired people typically report problems hearing.

Listening experiments at participants' homes open the opportunity to use the most relevant acoustical environment for participants to conduct free-field listening tests. Trivially, the tester has less control over the environment. However, the occurring variances can be dealt with if the acoustical conditions are monitored (background noise, reverberation time, and levels during the experiments). The noise levels of this study show that the living rooms of these participants offer quite good acoustical conditions for free-field tests. These findings can be considered in the study design of future applications of the Remote Hearing Lab.

Even more complicated measurement setups can be realized using headphones. This study demonstrated this in a listening effort scaling experiment with new hearing aids to evaluate a new feature that enhances the perception of soft sounds. A typical entrance hall situation was simulated in which the increasing distance to a talker made it more and more difficult to follow the target speaker. The new feature clearly reduces the listening effort.

Overall, the subjects really liked to work with the Remote hearing Lab. Many reported it as "phenomenal". They especially really enjoyed and appreciated that the measurements could be taken in their home.

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Authors and investigators

External principle investigators

Dr. Michael Schulte has been with Hörzentrum Oldenburg GmbH, Germany since 2004, where he has been responsible for audiological studies in publicly funded projects as well as in cooperation with the industry. In 2002, he received his Ph.D. from the Biomagnetism Centre at the Institute of Experimental Audiology, University of Münster, Germany. From 2002 to 2003, he worked as a postdoc at the F.C. Donders Centre for Cognitive Neuroimaging, Nijmegen, Netherlands. Michael Schulte's research interest is in the evaluation of hearing systems with a special focus on listening effort.

Dr. Matthias Vormann received his diploma in physics in 1995 and his Ph.D. in 2011 from University of Oldenburg. Since 2005 he has been with Hörzentrum Oldenburg GmbH, Germany, where he works mainly in industrial research projects for hearing aid manufacturers. His interest is about new methods for measuring the subjective and objective benefit of hearing aids.

Müge Kaya has been working as a medical-technical assistant at the Hörzentrum Oldenburg since 2000, focusing on audiological hearing system evaluation, special audiological diagnostics, cross-project organization and subject acquisition.

Jan Heeren studied Physics at the University of Oldenburg, Germany, and graduated in the Medical Physics group in 2014. From 2012, he worked on several projects in the field of hearing aid evaluation and virtual acoustics at the university and the Hörzentrum Oldenburg. In 2016, he started in the R&D department at HörTech GmbH, Oldenburg, working on hearing aid evaluation methods. Apart from his scientific activities, he has conducted more than 500 events as a free-lancing audio engineer since 2008.

Study coordinator

Dr. Matthias Latzel studied electrical engineering in Bochum and Vienna in 1995. After completing his Ph.D. in 2001, he carried out his PostDoc from 2002 to 2004 in the Department of Audiology at Giessen University. He was the head of the Audiology department at Phonak Germany from 2011. Since 2012 he has been working as the Clinical Research Manager for Phonak AG, Switzerland.