Ethnographic research: The interrelation of spatial awareness, everyday life, laboratory environments, and effects of hearing aids

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Hearing is multidimensional. It affects the whole body and yet it is still an open question whether and how general factors of everyday life are affected by the use of modern hearing aids (HA) with different signal processing options. This study addressed, therefore, the question to what extent HA may shape the HA users' everyday life. Accordingly, the behavior of N=22 HA users and non-users was observed experimentally using a theory-based ethnographic research design that comprises written reports and several steps of theorizing and reasoning. Data were collected in two specific everyday life situations (road traffic and restaurant) and by three modes (unaided, omnidirectional, and directional microphone mode). The analytical results of the ethnographical studies were summarized and used for testing hypotheses in an advanced laboratory with virtual audio-visual environments reproducing the same everyday life situations. Different typical behavior patterns were identified by means of fieldnotes, indicating that hearing impaired users with the first experience of HA provision showed comparatively expressive orientation reactions towards spatial sound sources. The behavior analyses were partly confirmed by questionnaire data. The analytical results led to first suggestions and improvements for the ongoing (re-)creation of virtual audio-visual scenes.

INTRODUCTION

Audiological research relates primarily to a calculable space and thus refers accordingly to digital space-time assumptions (e.g., Lindemann, 2014; Bentler, 2005; Picou *et al.*, 2014; Ricketts and Henry, 2002). In scientific research of medical devices (e.g., HA), the emphasis is on measuring behavior patterns to explain the benefit of investigated technologies. Therefore, different signal processing options are evaluated by quantified body movements (Brimijoin *et al.*, 2014; Hendrikse *et al.*, 2017).

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Proceedings of the International Symposium on Auditory and Audiological Research (Proc. ISAAR), Vol. 6: Adaptive Processes in Hearing, August 2017, Nyborg, Denmark. Edited by S. Santurette, T. Dau, J. C.-Dalsgaard, L. Tranebjærg, T. Andersen, and T. Poulsen. The Danavox Jubilee Foundation, 2017.
 ISBN: 978-87-990013-6-1.

However, the question of the everyday life benefit of HA and the ecological validity of laboratory settings remains open (see Meis *et al*., 2017 in this volume). The emphasis is on whether and how HA improve the communication abilities, the social interaction, and participation (Ihde, 2007; 2016; Lindemann, 2014; Plessner, 1975; Zahnert, 2011).

The focus of this mixed methods study was, therefore, the enhancement of the ecological validity of outcome research in audiology and the evaluation of HA in more realistic settings. The goal was to detect differences in user behavior between different everyday life settings to improve the ecological validity in virtual audio-visual laboratory environments. One research method used for this purpose was the ethnographical approach. It is a radically qualitative oriented research method, which helps to understand the behavior of users in acoustically complex everyday environments to develop new outcomes methods and diagnoses in audiology in the long run (Paluch *et al*., 2015; 2017). These qualitative data were combined with quantitative data.

A further inquiry is planned, e.g., a confrontation with virtual audio-visual scenes in an advanced laboratory (Grimm *et al*., 2015; 2016). First pilot studies were completed in August 2017. Extensive laboratory evaluations are planned for September and October 2017.

METHOD

For the mixed methods study a specific setup was chosen. Data were gained in (1) a road traffic situation and (2) a restaurant situation in the field (i.e., (1) two different streets in the city of *Oldenburg* and (2) the university cafeteria).

Thus, a street was selected with a high traffic density, i.e., with many pedestrians, cyclists, cars, buses, trucks, etc., on both sides of the road. In addition, environmental sounds such as crows, magpies, dogs, the rustling of trees, etc., were present. The other chosen street was in comparison to the first one a quiet environment with a lower traffic density. The environmental sounds were perceived in the quiet street more clearly, since there was less traffic noise.

The cafeteria situation, on the other hand, was a typical dining situation, where the background noise was characterized by conversations, the rattling of cutlery, and the sounds of the cash desk as well as the kitchen.

Furthermore, for the study three provision conditions were chosen: Subjects were (1) unaided and/or (2) aided with HA with omnidirectional and (3) directional microphone modes. The *Phonak Audéo V90-312* HA were used for all subjects. These were fitted in accordance with the *Adaptive Phonak Digital* fitting formula (Latzel, 2013). All HA were receiver-in-canal (RIC) models with open domes.

The qualitative data were analyzed with relation to the Grounded Theory (GT) approach (Glaser and Strauss, 1967). So the method of data interpretation used here corresponded with a theory-based variant of the GT methodology (Corbin and Strauss, 1990). The interpretation was not based on the traditional GT approach, in which codes should only be interpreted with reference to data (Paluch *et al*., 2015; 2017). In contrast, a GT analysis was carried out with regard to certain theoretical assumptions (Matsuzaki and Lindemann, 2016, p. 503). This approach included positivistic assumptions about auditory spatial awareness and behavior patterns (Blesser and Salter, 2009). Thus, different typical behavior patterns in form of head movements and torso shifts were identified by means of fieldnotes. In addition, quantitative data were collected by questionnaires during the ethnographic walks.

N=22 study participants (age range from 51 to 72 yrs.; mean age = 66.6 ± 4.90 yrs.; 54% female) were recruited for the ethnographical walks. Three groups were involved: Group I included eight listeners with normal hearing (NH) according to WHO (2004); group II were seven unaided listeners with hearing impairment (HI) and a mild hearing loss (HL), who completed the walks in an unaided as well as aided condition during different study trails; and group III were seven aided listeners with mild to moderate HL. Group III only tested the aided condition.

RESULTS

The qualitative outcomes of the ethnographical walks can be summarized as follows: Subjects with NH demonstrated mainly civil inattention in the road traffic situation (Goffman, 1963, pp. 83-88) and were talkative in the restaurant situation. Unaided subjects with HI showed equally unobtrusive behavior patterns in the street and in the cafeteria. However, they had difficulties in understanding questions or sentences during talks. Furthermore, first-time HA users strongly related to the environment via body movements and were reserved in conversations. Experienced HA users, finally, lied between the subjects with NH and the unaided subjects: in the street they behaved as subjects with NH (e.g., civil inattention) and during conversations as unaided subjects (e.g., limited speech intelligibility). Nonetheless, they were also loquacious during conversations. For a detailed qualitative analysis and results of the ethnographical walks see Paluch *et al*. (2017).

Additionally, subjects with NH, unaided subjects with HI, first-time HA users, and experienced HA users were compared via quantitative data. Thereby, the behavior analyses were partly confirmed by questionnaire data. The quantitative results of the everyday life setting questionnaires are presented as box plots (see Figs. 1-3). All items were rated by subjects on a 5-point scale regarding mainly the perception of traffic sources, such as trucks/buses, cars and bicycles, and the perception of speech in the street. The questionnaires related to the cafeteria focused on speech and dining sounds.

Figure 1 shows the results of the road traffic questionnaires regarding volume perception of the subjects. First-time users of HA with omnidirectional microphone modes experienced their environment louder than in the unaided condition. Especially sound sources of objects like trucks, buses, cars, and bikes were experienced louder. The perception of speech was also affected, but not as much as by motor vehicles. This could be an explanation for the strong relation of head movements or torso shifts to sound sources. It could also be an indication of how the adaptation to HA was difficult at first.

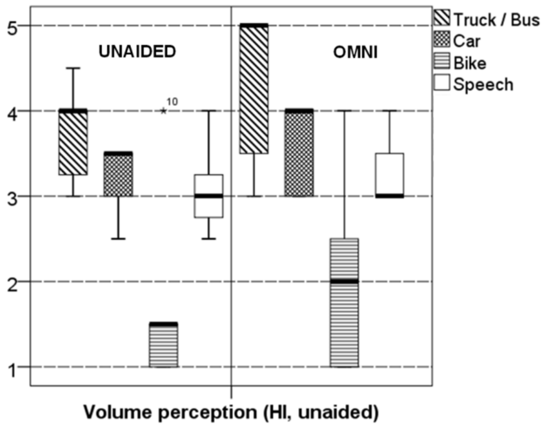

Fig. 1: Results of road traffic questionnaires rating volume perception, scale range from 1 to 5. 1 = too soft, 3 = adequate, 5 = too loud. Group II (N=7). Comparison of unaided conditions and omnidirectional conditions of first-time HA users. The box plots show the median, 25th and 75th quartiles, and outliers.

In other studies (Appleton and König, 2014; Latzel, 2015), it has been pointed out that better speech intelligibility is a crucial aspect of HA. Even though voices were not processed in the same way as technical objects, a louder perception of motor vehicles could lead to distraction towards the understanding of spoken words.

As a remark, it is interestingly to note that in the unaided condition bikes were too quiet for the unaided subjects. The use of HA allowed perceiving sound sources such as bikes more adequate, although subjects reported that bikes had to be quiet.

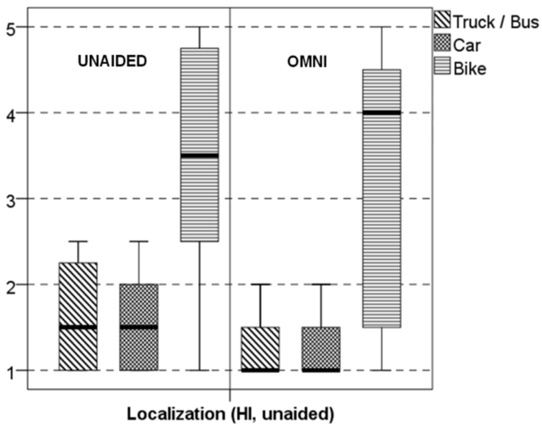

Fig. 2: Results of road traffic questionnaires rating localization, scale range from 1 to 5. 1 = very good, 3 = moderate, 5 = very poor. Group II (N=7). Comparison of unaided conditions and omnidirectional conditions of first-time HA users. The box plots show the median, 25th and 75th quartiles, and outliers.

Moreover, first-time HA users localized sound sources on average better in the aided condition than in the unaided condition. An exception was the localization of bikes, which had been on average better without HA. One explanation could be that sound sources were masked by HA. Besides, bikes were usually experienced in street situations with other traffic participants (e.g., trucks, buses, and cars).

This also confirms the assumption that first-time HA users refer strongly to their environment with body movements. If the direction of sound sources can be localized better, it is likely that this will also be reflected in the movement patterns. Certain sound sources may not have been explicitly perceived for a long time due to increasing hearing loss, so the subjects clearly refer to them with body movements if they hear them appropriately again.

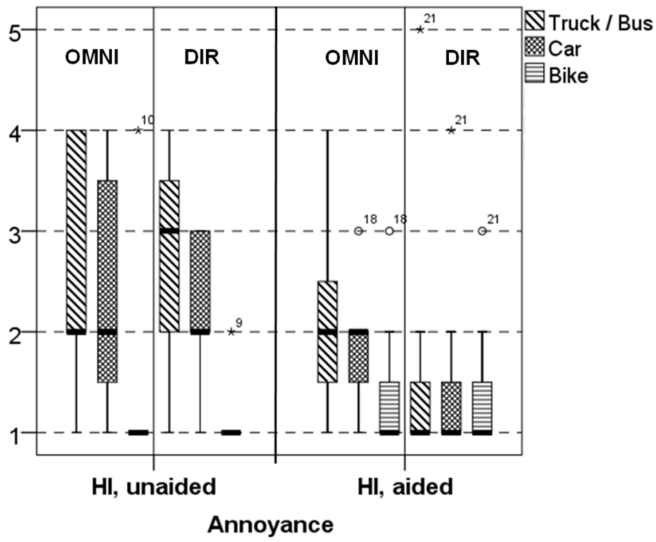

Fig. 3: Results of road traffic questionnaires rating annoyance perception, scale range from 1 to 5. 1 = not at all, 3 = moderately annoyed, 5 = highly annoyed. Group I and II (N=14). Comparison of first-time HA users and experienced HA users with omnidirectional and directional microphone modes. Significant values for annoyance by trucks/buses ($p < 0.05$, Wilcoxon). The box plots show the median, 25th and 75th quartiles, and outliers.

Furthermore, the quantitative data show that experienced HA users were less annoyed by environmental sound sources. Mainly first-time HA users were annoyed by different motor vehicles. This is a further explanation of why an explicit behavior occurred with first-time HA users. They were not only able to locate the sound sources better; they also experienced them too loudly and were thus more annoyed by them. For example, a woman during the walk was referring to a warning signal of a railway crossing gate and a crow with a torso movement when she perceived both. According to her, she was annoyed by the sounds due to the aided condition. Lastly, she looked at a car with a clear movement of her head, because the car was for her almost as loud as a train (Paluch *et al*., 2017).

Interestingly, omnidirectional microphone modes tend to increase the annoyance of sound sources relative to directional microphone modes. In a further study it is going to be examined in the laboratory whether and how the annoyance manifests itself regarding to different signal processing options. Probably, the directional microphone modes mask more sound sources. It remains open why bikes tend to annoy first-time HA users less.

Significant results, however, were almost not found in the plots ($p > 0.05$, Wilcoxon, see figs. 1-2). Only differences regarding trucks/buses shown in Fig. 3 were significant ($p < 0.05$, Wilcoxon, see Fig. 3). One reason for this is the limited number of subjects that participated in the study. Nonetheless, the tendencies of the box plots are in line with the qualitative results, which showed different experiences of the environment due to usage of HA (Paluch *et al*., 2017).

CONCLUSIONS

In this paper a mixed methods study was reported, which included both qualitative data and quantitative data. A first outcome of the study was the possibility to show whether and how different microphone modes of HA influence subjects' behavior. It has emerged that quantitative data also support the view that first-time HA users differ notably in their behavior patterns.

The volume perception and the localization of first-time HA users were compared with and without HA in the street situation. In addition, it was shown how the annoyance decreases in regard to sound sources by experienced HA users. The better localization plus the increased sensation of the volume and the annoyance could be a reason why clear body movements of first-time HA users were observed (e.g., strong torso shifts). It should be verified whether these outcomes can also be reproduced in an advanced laboratory with virtual audio-visual scenes.

Finally, the combination of qualitative and quantitative data leads to the assumption that the habituation to loudness decreases the noticeable body movements (Paluch *et al*., 2017). Probably a habituation to HA contributes to behavior patterns accordingly to shared social expectations (e.g., civil inattention). It would be of further interest to study how long people need to get used to HA and how their behavioral patterns differ over time (e.g., by head movements and torso shifts).

OUTLOOK

Based on the guided walk from phase 1, a virtual audio-visual environment was developed. This virtual environment partly simulates existing areas of the city of *Oldenburg*, and partly adds a fictive area with lower urban density as well as a cafeteria.

In the advanced laboratory the test design is repeated equally to the ethnographic walks. Subjects will experience going along the street in the laboratory and have to answer closed-ended questions at bus stops similar to the first study design. Also in the cafeteria there will be questions relating to the stories told by virtual characters. Thus, the questionnaires can be directly compared with one another.

Ultimately, qualitative field research about the laboratory situations will be conducted and the subjects are going to be recorded on video for analyses of their behavior (VIB-AICRAS©, Paluch *et al.*, 2015). In combination with qualitative interviews this is intended to test the ecological validity of the advanced laboratory and to work out how intensive the immersion by subjects in the laboratory is.

ACKNOWLEDGEMENTS

This work was supported by the Cluster of Excellence EXC 1077/1 "Hearing4all" funded by the German Research Council (DFG).

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