The technization of self-care in hearing aid research

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Introduction

Nowadays it is possible to observe how caring for one's own body occurs with reference to measurable data on the body. In contemporary society the experience of our own body is shaped not only by fitness bracelets, but also by health apps on the smartphone (Lindemann, 2015; Mau, 2017). Similarly, audiological measurements influence the self-perception of subjects. The data collected in audiological experiments can have many effects on self-image. Our research, however, concerned not only how the self-perception of subjects is mediated by research data, but also conversely how this self-perception influences the research process itself. The focus was therefore to explore this interrelation and to illuminate it from both sides.

This was done through a measurement procedure in which we carried out investigations with subjects in everyday life as well as in a laboratory (for everyday life analyses see Paluch et al., 2017, 2018). For both conditions (everyday life and the laboratory) two situations were used. The first situation was that of a street with loud and quiet surroundings, the second situation was a cafeteria environment. In the real world, the subjects walked down a street and had a conversation in the cafeteria.

These situations were recreated virtually in a lab (Grimm et al., 2015, 2016; Roosendaal, 1995). How the subjects behaved in these animated environments was investigated in comparison to their behavior in everyday life. The aim of the study was to work out if and how the simulated environment in the laboratory is a plausible environment. That means studying whether the subject’s everyday behavior could also be observed in the animated environment (Fritz-Hoffmann, 2017; Lindemann, 2014).

We used two research methods in the analysis of plausibility, collecting qualitative and quantitative data. The subjects (N = 21) experienced the simulated environment in the laboratory and afterwards underwent interviews on the experiment. An experimenter asked open questions in these interviews. Subjects were to describe how they perceived the situation, how they experienced the environments, what they liked and what they found to be less satisfactory and in need of improvement. The subjects were able to answer in their own words. In addition, quantitative data were collected by asking the subjects questionnaires with closed questions. We used the Igroup Presence Questionnaire (IPQ) to identify how people felt in virtual environments (Schubert et al., 1995, 2001).

Material and Method

This study used a mixed methods approach. Both quantitative and qualitative methods were used to capture the sense of presence in the virtual world. The Commission for Research Impact Assessment and Ethics of the University of Oldenburg gave their ethical approval to the study (Drs. 1r69/2016). In total, 21 subjects participated in the laboratory experiments. Seven of the subjects had normal hearing (NH), seven were first-time hearing aid users with hearing impairments (FTU) and additionally seven were experienced hearing aid users with hearing impairments (EXPU) (WHO, 2004). Inexperienced hearing aid users with hearing impairments participated both unaided and aided with hearing aids in the study. We did not include aided FTU into statistical evaluations, since the second participations here were not comparable with the first participations.

For the subjects with normal hearing, the mean of the pure tone thresholds (PTA_4 in dB HL, average of 500 Hz, 1, 2, and 4 kHz) in their better ear was detected as 7.05 dB HL (PTA_4; min. -1.3 dB HL, max. 16.3 dB HL). In the better ear, the PTA_4 values from the first-time users were 34.5 dB HL (min. 31.3 dB HL, max. 38.8 dB HL). For experienced hearing aid users, the PTA_4 was 43.9 dB HL in the better ear (min. 32.5 dB HL, max. 57.5 dB HL).

The study consisted of two parts: everyday life and laboratory measurements. The first part, in which subjects were given a tour through a street and chatted in a cafeteria, has been described in earlier contributions (Paluch et al., 2017, 2018). It will therefore not be further discussed at this point. In the second part, the subjects participated in a laboratory study. In the laboratory subjects were shown a virtual street walk and a virtual cafeteria in which animated characters were having a conversation (Grimm et al., 2015, 2016). The animated images were presented via the Blender game engine (version 2.78a, Roosendaal, 1995).

Since this contribution is about the experience of virtual reality, the focus is placed on this aspect. Regarding the evaluation of the virtual environment, interviews were conducted with the subjects and their behavior was recorded on video as well as in observation protocols. The formation and confirmation of indicators and concepts was based on the Grounded Theory approach (Glaser & Strauss, 1967; Przyborski & Wohlrab-Sahr, 2009).

In addition, closed questionnaires were used. The main focus was on the IPQ, whose psychometric qualities have already been approved in other studies (Felnhofer et al., 2015; Rosakranse & Oh, 2014). The IPQ compares the sense of presence in different virtual environments (Schubert et al. 1995, 2001). It was used here to compare the animated street with the animated cafeteria. We assumed that in the real world an experience of being fully present would have been detected.

Usually 14 items are used in the IPQ questionnaire. In this study, we added two more. It was also asked, “How real did the virtual acoustic world seem to you?” and “How real did the visual world seem to you?”. We were able to differentiate the influence of acoustic and visual factors on the sense of presence with this distinction. The assessment was made on a 5-point scale. The scale was a Likert type, with “1” indicating that it was not real at all and “5” indistinguishable from the real world. To allow a greater variety, the answer options differed with the questions.

Four factors form the basis of the IPQ. The first is the general presence. With the general presence, the subjects state the degree to which they felt they were present in an environment. The general presence was differentiated from the spatial presence as second factor. Involvement, the third factor, can be used to evaluate the extent to which a subject refers to a place with his or her attention. The question “I was completely captivated by the real world” was used to determine whether the subjects felt that they were in the virtual world or in a laboratory in which an animated environment was presented on a screen. Realism was the fourth and final factor that was analyzed. The subjects could indicate how real they felt an animated scene in the questions related to this factor (Felnhofer et al., 2015, p. 51).

Results

By constantly comparing video recordings and interviews, we identified similarities, differences, and interrelations in the perception of virtual environments (e.g., comparing key words regarding the subjects' descriptions). 16 subjects (5 NH, 5 unaided FTU, 6 EXPU) were identified as **Type A** and 5 subjects (2 NH, 2 unaided FTU, 1 EXPU) were identified as **Type B**.

The first mode of experience, which we have referred to here as **Type A**, experiences the virtual world as corresponding to the real world. For example, these subjects experience that they are watching a movie in the lab and they are passive viewers. This is different in subjects classified as **Type B**. For these subjects, the experience in the laboratory corresponds to an everyday experience and they experience being able to actively participate in the virtual environment (see Tab. 1).

Table 1: Grounded Theory analysis.

	Video recordings	Indicators	Concepts
Type A		“Why wasn't I inside? Mh that's difficult to say. I was, let's put it this way, in the second **movie** a little more than in the first one. Because in the first **movie** there was a lot to **watch** […]. Maybe that's why I was more [present].”	- Mediated experience - Difference between everyday life and virtuality
Type B		“I was a bit stinky because I did not understand **the one to the left** […]. Whereas, the **person sitting across** […], spoke a bit more quietly […]. And then the **man**, **on the right there**, **this dark-haired man** […]. He was more of a **listener**.	- Experiences the virtual characters as interlocutors - Conversation in the lab is an everyday experience

These qualitative results were then compared again with the quantitative data of the IPQ questionnaire (see Fig. 1).

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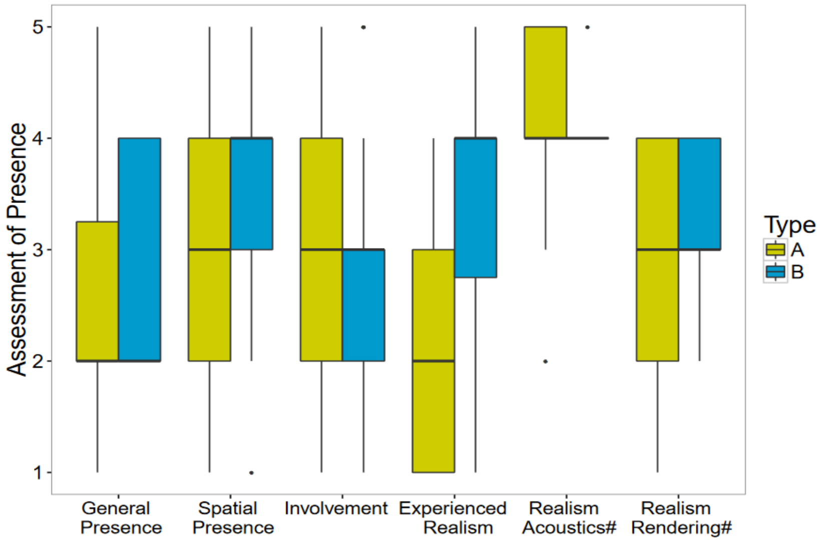

Figure 1: Comparison of Type A and Type B (N=21) in the animated cafeteria (IPQ). Scale range from 1 to 5 (1= strongly disagree, 5= strongly agree). # questions additional to the IPQ. Statistically significant differences regarding experienced realism ($p = 0.0046$, Wilcoxon).

With regard to the IPQ questionnaire, it was found that **Type B** subjects in particular experienced the simulated environment as more realistic than **Type A** subjects. This experience was also statistically significant ($p < 0.005$, Wilcoxon).

Discussion

Although the acoustic and visual presentation of the situation is identical for the subjects, their experiences differ. For **Type A**, a mediated experience is labeled as a movie. This refers to a difference between everyday life and virtuality. **Type B** experiences the behavior of the animated characters as communicative acts, which makes the conversation in the laboratory an everyday experience. Furthermore, **Type B** subjects assessed via the IPQ questionnaire experienced a greater degree of realism than **Type A** subjects ($p = 0.0046$, Wilcoxon). In addition, subjects identified as **Type B** claimed to be spatially present to a greater degree in the virtual world than **Type A** subjects ($p = 0.0913$, Wilcoxon, not statistically significant).

It became clear that the **Type A** subjects did not experience themselves as being spatially present in the animated room. They experience themselves outside, which is why the experience is labeled as a movie. They can therefore also be touched or affected by the animated environment only as a movie. The **Type B** subjects, however, experience themselves spatially in the events that they perceive on the projection screen. They are involved in the situation and feel that they are experiencing an everyday situation and are, for instance, touched or affected by the animated characters as in an everyday situation. In this way, a **Type B** subject in the situation perceived the animated characters as having spoken unintelligibly (see Tab. 1). Thus, animated environments could be used to test when subjects consider other people to be responsible for acoustic misunderstandings and when they refer the misunderstandings to their own hearing.

It is possible to find explanations why subjects perceive simulations as more or less realistic with qualitative methods: Distant subjects have the experience of watching a video (**Type A**), whereas open subjects actively take part in virtual environments (**Type B**). In further studies, it would be helpful to investigate the influence of the subjects' acoustic and visual relatedness on their sense of presence (see Fig. 1). It may be necessary to concentrate on the acoustic aspect in order to be present in a situation. A **Type A** subject also referred primarily to visual details in the interview, whereas a **Type B** subject has highlighted hearing-specific factors (see Tab 1). This, too, would be worth investigating in another research project.

A related issue that may be considered in the future is how the virtual environment would have to be created so that the sixteen **Type A** subjects experience the environment like the five **Type B** subjects. If this were to be realized, the laboratory measurements would be closer to everyday life.

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