Being there again – Presence in real and virtual environments and its relation to usability and user experience using a mobile navigation task

Jennifer Brade[a,1], Mario Lorenz[a,b,1,*], Marc Busch[c], Niels Hammer[d,e], Manfred Tscheligi[c], Philipp Klimant[a]

[a] Technische Universität Chemnitz, Professorship for Machine Tools and Forming Technology, Reichenhainer Straße 70, 09126 Chemnitz, Germany
[b] University Hospital Leipzig, Department of Orthopedics, Trauma and Plastic Surgery, Liebigstrasse 20, 04103 Leipzig, Germany
[c] Austrian Institute of Technology GmbH, Innovation Systems, Donau-City-Str., 1 1220 Vienna, Austria
[d] University of Otago, Department of Anatomy, Clinical Anatomy Group, 270 Great King Street, Dunedin 9054, New Zealand
[e] University of Leipzig, Department of Anatomy, Liebigstraße 13, 04103 Leipzig, Germany

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ABSTRACT

The possibility of using virtual environments instead of real field or laboratory environments is a promising research field. However, before virtual environments are able to replace the traditional environments the differences between the methods must be worked out. We take up on previous studies which compared different real and virtual environments concerning presence and usability and expand the research on the factor of user experience. We compared a virtual field environment (CAVE – Cave Automatic Virtual Environment) and a real field environment (city center of Chemnitz, Germany) in a between-subject-design concerning presence, and evaluate its impact on the usability and the user experience of a geocaching game. The data of 60 participants was analyzed and shows significantly higher ecological validity for the real field environment but higher values for engagement and negative effects in the virtual field environment. Concerning usability, significant differences were verified between the two environments. All presence factors correlated significantly with usability in the CAVE, but did not correlate in the real-field environment. Concerning user experience, the CAVE showed significantly higher hedonic quality values, whereas the real field environment had higher pragmatic quality values. In both conditions presence and user experience factors were partly correlated. Our results indicate that virtual environments can be an alternative to real environments for user experience studies, when a high presence is achieved.

1. Introduction

Technical inventions such as interactive maps are increasingly enriching our lives. These applications do not only show the places of interest, but they also track the user's position, provide the best local traffic route, reveal which restaurant is nearby and how other users rated it. However, comprehensive information is not satisfactory for the user. Two factors – usability and user experience (defined in Table 1) – are essential for interactive products and therefore for mobile navigation applications. Both factors determine the success of a product, because a good usability supports us when using applications and a good user experience leads to using an application with pleasure.

Typically, researchers conduct field or laboratory studies to get products or systems evaluated by users. Both of these settings exhibit

different strengths and weaknesses: field studies are more ecologically valid but confounding variables can be less controlled, whereas laboratory studies are characterized by better experimental control, but are less realistic to participants. The use of virtual environments offers the possibility to combine the benefits of both environments (Loomis et al., 1999). Due to advances in the field of virtual reality (VR), a variety of systems are providing a lot of different options for human computer interaction studies. However when using such VR systems for these kinds of studies, they have to meet high requirements concerning realistic visualization and a plausible storytelling. Without a convincing presentation of the setting, the user will not have the feeling of being in the mediated environment and the benefits of the virtual setting compared to laboratory or field studies are nullified. This phenomenon is described by the term "presence", the participant's

Table 1
Definition of the factors usability, user experience and presence.

Factor	Definition
Usability	Usability describes the fitness of use of a product and summarizes pragmatic aspects of the product or system. Contrary to user experience, usability does not respect hedonic quality aspects.
User experience	User experience is characterized as "a person's perceptions and response that result from the use or anticipated use of a product, system or service" (Law et al., 2009). User experience includes the holistic assessment of the user because it extends common usability factors with aesthetics, joy-of-use and attractiveness (Rauschenberger et al., 2013).
Presence	Presence is described as the "sense of being in the virtual environment" and is seen as a cognitive state that results from information processing of stimuli in the environment from various senses (Slater and Wilbur, 1997).

feeling of "being there" (Barfield et al., 1995) (see Table 1).

Because of the advantages of virtual environments, it might be reasonable to use them instead of field or laboratory environments for product evaluation studies. However, we must first examine the influence of the environment on the perceived presence. Some studies research the concept of presence in different virtual environments (Gorini et al., 2011; Lorenz et al., 2015; Tang et al., 2004), whereas others compare virtual and real environments concerning perceived presence (Busch et al., 2014; Mania, 2001; Mania and Chalmers, 2004; Nisenfeld, 2003; Usoh et al., 2000). But only one study by Busch et al. (2014) directly addressed influences on presence and usability caused by different environments (virtual versus real laboratory). Unfortunately, this study lacks the comparison of virtual and real laboratory environments in terms of user experience, as well as the evaluation of a real field environment. As described in Table 1 it is insufficient to consider usability alone and it is also important to compare both kinds of environments with virtual environments to make meaningful statements. In addition, in this said study investigating usability, user experience was not considered. Only the fitness of use was assessed but not the acceptance.

Our study tries to approach the fundamental understanding of the relationships between presence, usability and user experience by examining them using a mobile navigation task in a virtual and a real field environment. Our results were in line with previous studies (Busch et al., 2014) and confirmed that a virtual field environment may be used as a substitute for a field environment even if the influences of presence have to be considered. The results showed a positive connection of a virtual field environment and hedonic qualities and confirmed the effect of usability on perceived presence. We offer guidance for usability and user experience researchers and practitioners for performing virtual user experience and usability product evaluations and discover important factors that have to be considered for the interpretation of the results.

The results presented in this paper are part of larger study and relevant for different scientific areas. The parts of the results that are important for an industrial/ergonomic viewpoint were cited in (Brade et al., 2016), where we concentrated on discussing the benefits virtual reality offers for the user. In (Brade et al., 2016) we show how traditional industrial approaches for product development can benefit from using virtual environments in industrial product development to increase productivity. Contrary to this, the results are interpreted from the psychological viewpoint in this paper.

2. Related work

2.1. Presence in real and virtual environments

Virtual reality provides the possibility to immerse someone into a computer-generated environment. To understand the differences between the technical aspects necessary to immerse someone, and a person's psychological involvement in a virtual scenario it is important that one understands the differences between the terms immersion and presence and how they are related. Slater and Wilbur (1997) define immersion as "a description of a technology, and describes the extent to

which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant". Whereas presence is described as in Table 1. The perceived presence is therefore influenced by the level of immersion in different virtual environments. Coelho et al. (2006) divides the concept of presence into media and inner presence; the experience of presence resulting from a set of parameters of a medium that enables the virtual environment, is known as media presence. This technological definition disregards the involvement of psychological components; therefore they are included in the definition of inner presence: which is the psychological experience of the virtual environment, including human perception, cognition and psychomotor capacities. For our study we relate to the concept of inner presence as we examine the psychological experience.

In order to measure presence, Schuemie et al. (2001) list several methods that can be divided into subjective (using questionnaires) and objective measures, with post-experiment questionnaires being the most common approach for assessment. One of the most validated questionnaires, the Independent Television Commission Sense of Presence Inventory (ITC-SOPI) by Lessister et al. (2001), has been used previously within the literature (Busch et al., 2014; Usoh et al., 2000; Nisenfeld, 2003; Tang et al., 2004; Gorini et al., 2011) and was shown to produce reliable results.

Several studies have researched the effects of presence in virtual environments: Gorini et al. (2011) compared the effects of using an external computer screen with a virtual environment that utilized a head-mounted display (HMD) when assessing presence in a virtual hospital task. Presence values were significantly higher for all items of the questionnaires ITC-SOPI and University London College Questionnaire (UCL) (Slater et al., 1994) in the immersive HMD condition. Comparatively, Tang et al. (2004) also utilized a HMD, but compared it with an augmented reality (AR) environment and showed significantly higher values for the presence factor *sense of physical space* for the AR environment. However, there were no significant differences concerning the other factors of the ITC-SOPI questionnaire.

The study of Usoh et al. (2000), which was extended by Nisenfeld (2003), also compares a HMD virtual environment with a real environment. The authors assessed presence by using the ITC-SOPI questionnaire and found significantly higher presence values for the real environment as well as a significantly increased, sense of physical space and ecological validity. Simultaneously, significantly higher values for the negative effects scale for the virtual environment were recorded. This study is very relevant for our work, but disregarded the examination of user-oriented factors between real and virtual environments. Another study that assessed presence and usability when comparing a laboratory environment with a specific type of virtual field environment, the five-sided Cave Automatic Virtual Environment (CAVE), is the work of Busch et al. (2014). The differences between the environments concerning usability (assessed with the System Usability Scale (SUS) by Brooke (1996)) and presence (measured with the ITC-SOPI questionnaire) showed significantly higher values for engagement and the negative effect scale for the virtual field environment. Similarly, significantly higher values for the ecological validity scale in the real laboratory environment were observed. The authors did not find