The role of display technology and individual differences on presence

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ABSTRACT

Motivation –Several factors such as the kind of display technology and the level of user interaction have been found to affect presence (e.g., IJsselsteijn et al, 2000). Generally, it had been concluded that the more immersive types of display result in higher levels of presence. However, studies comparing the effect of display technology on presence are mostly based on rendering the same content across different displays. Previous studies have typically not attempted to optimize the content for each display type individually. Furthermore, it has not been considered before that some viewers may not benefit as much as others from higher levels of technology.

Research approach

First, we investigate the relationships between perceived presence and some human factors, including stereoscopic ability, depth impression, and personality. We describe this experiment here in some detail. Second, we focus on the potential maximum presence that can be obtained for specific devices, for example, by manipulating the size, perspective and viewing distance. Third, we will investigate how monocular depth cues can be used to maximize presence for different display types. Finally, we will look specifically at how presence can be maximized on small hand-held devices, for example by incorporating compensation for display movement. In all our experiments we will focus on public speaking and person-to-avatar communication. Presence is measured in three different ways: 1) through questionnaires, 2) behaviourally, and 3) physiologically.

Originality/Value – Having a better understanding of the relation between human factors and feelings of presence may facilitate the selection of people that are most likely to benefit from virtual reality applications such as virtual reality exposure therapy (e.g. Krijn et al, 2004). A better understanding of how presence can be optimized on different displays, may also lead to the possibility to use less complex display types (as compared to HMD's or CAVE's) to create virtual reality consumer applications. It also opens the possibility to tailor the virtual reality display to the individual, optimizing presence.

Keywords

Presence, individual differences, human factors, virtual reality, display technology, public speaking.

INTRODUCTION

Presence is defined as the sense of being in one place or environment, when one is physically situated in another (Witmer & Singer, 1998). In effect, presence involves feeling as if one is more a part of the simulated environment than of the real world, in which the observer is physically located. A high level of presence is required for various types of virtual reality applications such as virtual reality exposure therapy, training, education and entertainment.

Earlier studies have found that the degree of presence depends mainly on aspects of the technological device, such as the fidelity of sensory components, the field of view, and the occurrence of stereoscopy, on the nature of required interaction, on the task, and on individual differences such as the user's knowledge of, and prior experience with, the technology (e.g., IJsselsteijn, de Ridder, Freeman, & Avons, 2000; Juan & Perez, 2009; Krijn, et al., 2004; Schuemie, 2003; Witmer, Jerome, & Singer, 2005).

A variety of display devices has been developed for displaying virtual reality, ranging from very small ones on mobile devices to large, CAVE-like virtual reality systems. Although a larger field of view generates higher levels of presence (Lin, Duh, Parker, Abi-Rached, & Furness, 2002), it is nevertheless possible to create virtual 3D spaces on (small) 2D displays. This can be achieved by optimizing monocular cues. Motion parallax, realistic shading and correctly rendered perspective can go a long way in creating believable 3D virtual reality. For example, the art of "trompe l'oeil" painting, in which the painting is supposed to fool the believer's eye into believing the painted scene is real, has been around for many centuries. However, it is unclear whether adequate levels of presence can be obtained on, for example, small 2D screens. The use of consumer-style devices instead of large professional virtual reality systems such as CAVE's would facilitate the implementation of virtual reality in the workplace, therapist office etc.

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A second important factor in presence is individual differences. Not everyone experiences the same amount of presence in similar virtual realties. For example, Krijn et al (2004) excluded 10 out of 37 patients from an experiment on virtual reality exposure therapy, because the virtual environment did not arouse sufficient anxiety. Patients who showed no anxiety scored significantly lower on the presence scales than the patients who finished the experiment. Wallach, Safir, & Samana (2010) found that experienced presence level is partly determined by individual characteristics such as personality and cognitive processing ability. A deeper understanding of the personal determinants of presence will help identifying people that may benefit most from virtual reality and help the people that have problems immersing themselves in the virtual world.

Visual (non-clinical) anomalies are surprisingly common and most people do not know or are not aware of having them. For example, binocular anomalies such as strabismus and amblyopia have been found to affect at least 5% of the population (Evans, 2007). Richards (1970, 1971) reports even higher percentages up to 20% of the non-clinical population. Nefs, O'Hare, & Harris (2010) also report that up to 20% of people have some kind of anomaly in binocular motion-in-depth perception. Incidental case studies however reveal the effect stereoscopy can have when stereoscopic vision is restored (Sacks, 2006). While watching the stereoscopic displays, people who have binocular vision anomalies may suffer from double vision instead of having a vivid stereoscopic impression or just do not notice the difference at all. On the other hand, people without stereoscopic vision have advantage in viewing 2D pictures, because there is no conflicting disparity information that tells the brain the scene is flat. Apart from a group of people having binocular anomalies that prevent stereopsis, there is also a large group of people who have stereopsis, but are nevertheless highly susceptible to visual discomfort when viewing stereoscopic displays (Lambooij, Fortuin, IJsselsteijn, & Heynderickx, 2009). Visual discomfort may also bring down the presence level. The relationship between visual discomfort and presence level will therefore also be studied.

Figure 1: The virtual room used in the current experiment

RESEARCH PLAN

In this section we describe a four-year research plan. In the first part, we raise the question which individual characteristics are important for experiencing high levels of presence. Furthermore we are interested to find out to what extent presence can be improved by adding stereoscopic rendering to the virtual world, and whether this potential benefit can be predicted from individual characteristics. We currently are in the process of collecting data for this experiment. In the second part of this section we briefly describe our plans for the coming years.

All studies involve a public speaking scenario. Work conducted earlier on public speaking in front of a virtual audience showed that a strong presence response can be obtained, including effects in self-performance rating, when confronted with a negative, neutral or positive responding audience (Slater, Pertaub, & Steed, 1999). We therefore also use a public speaking scenario in our experiments.

CURRENT EXPERIMENT

We currently conduct a first experiment, which is divided into two phases. In the first phase, data is collected about potentially relevant human factors. In the second phase, data is collected about the level of presence experienced by the participants in virtual environments. To ensure sufficient statistical power for correlation analysis at least 84 participants will be invited to participate in the experiment. They will be recruited among university students and staff. After signing an informed consent form, data will be collected to measure individual differences by using the following tests:

- A vision questionnaire containing questions about the participant's background, visual abilities, eye health, state of alertness, etc.
- Several vision tests including visual acuity, binocular vision state, stereovision acuity, and colour vision.
- Several more tests to measure various personal traits:
  - The Immersive Tendencies Questionnaire (ITQ) (Witmer & Singer, 1998), which measures differences in the tendencies of individuals to experience presence.
  - Locus of Control questionnaire, which refers to the extent to which individuals believe that they can control events that affect them (Rotter, 1966).
  - Tellegen absorption scale, which is a measure of absorption and defined as 'openness to absorbing or self-altering experiences' (Tellegen & Atkinson, 1974).
  - Empathy questionnaire, which assesses an individual's spontaneous emotional response to

the experience of other people (Eisenberg, 1994).

- Mental rotation test (the ability to mentally rotate 3D shapes), which is thought to take place largely in the same brain areas as perception and can be used to measure spatial processing and intelligence (Hertzog & Rypma, 1991; Johnson, 1990).

Once the participant has completed the first phase, the experiment will move to the second phase. Participants will be shown a virtual environment (see figure 1) wearing a Z800 3DVisor from eMagin (The field of view measures 40 degrees diagonally and has a resolution of 800 x 600 triad pixels per display). One of the avatars will give some instruction at the beginning and the end to the participants:

- <u>At the beginning</u>: *"Hello, welcome. My name is Alicia. This is Susan, Bob, Zach, and this is Mike. Could you give us a five-minute talk please? You can talk about anything you want, but please keep talking. If you can't keep talking about the same topic any longer, you may change to a different topic and continue. When the five minutes are up, we will remind you to stop. We will not interrupt you during the talk. You may start your talk now."*
- <u>5min later: "T</u>*hank you. You may stop now. Could you please take off the visor? The experimenter will then ask you to fill in some questionnaires about your experience."*

To elicit variance in the participants' behaviour and experience (Slater, et al., 1999), in our scenario the attitude of the audience changes over time between a *positive attitude,* where all the avatars show an interest in the talk by looking at the participant (Figure 1), a *neutral attitude,* where some avatars are interested but others are not, and a *negative attitude* where the avatars show no interest in the participant (they look away, talk amongst each other, stretch their arms, etc).

The participants will be asked to give two talks, one with stereoscopic rendering and one without stereoscopic rendering of the virtual world. We hypothesize that the importance of individual factors for feelings of presence depends on the way the virtual world is rendered.

Presence will be measured in the following three ways:

- *Subjective measures*. We use two presence questionnaires, namely, the Igroup Presence Questionnaire (Schubert, Friedmann, & Regenbrecht, 2001), and the Slater-Usoh-Steed Questionnaire (Slater, Usoh, & Steed., 1994).
- *Behavioural measures.* We record the behaviour of the participant whilst talking to the audience, with a camcorder. We are interested in for example the number of changes in the style of presenting that coincide with changes in the audience's attitude.
- *Physiological measures*. We record heart rate, heart rate variability, skin temperature, and the galvanic skin response.

FUTURE EXPERIMENTS

In year 2, we will continue with the question how to render content in order to enhance the level of presence obtained with a specific device. The study will therefore examine whether there is a difference in presence between life-size avatars and scaled ones displayed on different devices. Displays with large fields of view can display relatively large object sizes, which is not the case for smaller devices, especially not when the perspective is held constant. For example, a projector can show the user a whole life-size avatar, whereas a small size display can only display scaled ones or parts. This might be the reason for a lower level of experienced presence when looking at small size displays.

In an experiment, we will manipulate the kind of device and avatar size. We will use three kinds of displays: namely a 2D monitor, a 3D monitor and a projector. There will be two avatar sizes: life-size, and scaled-down.

In year 3, we will investigate whether monocular depth cues can improve the sense of presence. Not only binocular disparity and vergence can induce depth perception; there are lots of monocular depth cues that also can yield a depth impression. Examples are motion parallax, structure from motion, and light and shading. For example, by slightly rocking displayed objects backward and forward, a strong impression of depth results. This simple 'structure from motion' can easily be implemented on any display.

In year 4, we will investigate whether presence caused by a small-size mobile display is adequate to support interactivity between user and avatars. Small mobile devices are considerably different from other types of displays. For example, they are viewed from smaller distances making the accommodative cues to depth relatively more important. Moreover they are often hand-held instead of desktop mounted. Therefore, it is worthwhile to investigate in a separate experiment how presence is best achieved on such devices (e.g., using motion acceleration sensors to add motion parallax).

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