

Presence: Interacting in VR?

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ABSTRACT

An important concept in Virtual Reality (VR) is that of presence; the subjective perception that a mediated experience seems very much like it is not mediated. Many authors have assumed a strong relation between presence and the level of interactivity, and this article will look into this assumption. Several variables of interactivity show a clear relation to presence, but others are more complex. Knowing which elements of a Virtual Environment (VE) can attribute to presence is necessary for some applications such as treatment of phobia, necessitating further research into this area.

Keywords: interactivity, presence, virtual reality, human-computer interaction, phobia

1 INTRODUCTION

When using Virtual Reality people often experience a feeling of actually being in the computer generated environment, a feeling described as 'presence'. Presence can more explicitly be defined as a mediated experience that seems very much like it is not mediated [5]. When a user experiences a high level of presence, it is even possible for the user to develop fear in response to simulated anxiety-provoking stimuli. Experiments have for instance shown a significant positive relation between presence and fear of heights [16].

This makes it possible for VR to be used in the treatment of phobia, where patients have to be exposed to the stimuli they fear. VR has already been shown to be effective in the treatment of fear of heights, fear of flying, arachnophobia, claustrophobia and agoraphobia, the fear of being in places from which escape might be difficult or embarrassing. At the Delft University of Technology, in close cooperation with the University of Amsterdam, a generic system for the treatment of

phobia is being developed, taking into account the HCI-problems unique to such a system. One of these problems is the question how presence can be achieved. When designing VR there is a strong tradeoff between elements such as image quality and update speed caused by technological limitations [24], so it is important to choose the right elements to be incorporated into the VR to increase the level of presence and make the treatment more effective.

What causes presence remains somewhat of a mystery [8], although most authors have either implicitly assumed or explicitly suggested that a major or even the primary cause of presence *is the ability to interact with a mediated environment* [5]. In this paper we will look at some of these explicit suggestions and look at the extent to which these can be validated. First, we will take a closer look at presence and the various methods for measuring the level of presence. Then interactivity will be broken down into several variables.

After reviewing relevant research and literature regarding the relation between these variables of interaction and presence will be investigated, resulting in several conclusions in the last paragraph.

2 PRESENCE

There exist many theories regarding the nature of presence. In this paragraph one general theory will be reviewed, as well as several methods for measuring presence.

2.1 GENERAL THEORY OF PRESENCE

When interacting with a VE two mental models will be activated and shaped [25]:

1. The model of the Real World (RW)
2. The model of the Virtual World (VW)

Presence refers to the sense of "being in" a world, a state where these two models begin to overlap. It therefore only makes sense to speak about the degree of presence in one environment (the virtual environment) *relative to* another (the real environment) [21]. In other words: presence refers to the distinction made by the user between the RW and the VW.

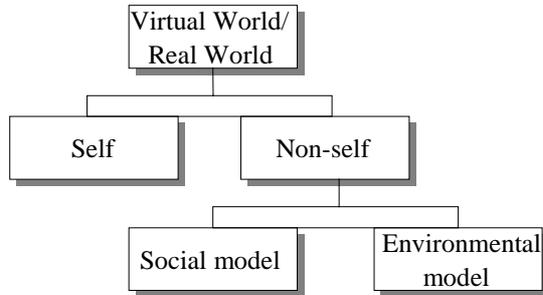


Figure 1: Mental models in a VR

Both models can be divided into the 'Self', which is a model of the individual him or herself, and the 'Non-self', a model of the environment as the individual experiences it. The non-self can even be further divided into a social model and an environment model. For each lower level model a specific type of presence can be defined [7]:

- Personal presence is related to the 'Self'. It is a measure of the extent to which one feels like one is in a virtual world.
- Social presence relates to the social model as part of the 'Non-self'. It is sometimes defined as the extent to which a medium is perceived as sociable, warm, sensitive, personal or intimate when it is used to interact with other people [18]. However, it is also possible that social presence is achieved using synthetic beings, for example using a creature that keeps coming back to you, asking you to pick it up and throw it away [4]
- Environmental presence refers to the environment model and indicates the extent to which the environment itself appears to know that you are there and to react to you.

2.2 MEASURING PRESENCE

As described in the previous paragraph, presence is very much a subjective concept. Measuring presence is therefore a difficult task, although several approaches have been suggested [20][2]:

1. Participants reported sense of presence

This is the most widely applied method, although very dependent on the participants' own subjective perception. Often questionnaires are used, but also attempts have been made to measure presence by letting the participant operate a continuous slider indicating the perceived level of presence at that time [12].

2. Observation of participants behavior

For instance, measuring reflex behavior to virtual objects directed at the participant. Also, during treatment of phobias, subjects displayed physiological responses to the simulated stimuli such as sweating, loss of balance and weak knees, suggesting a high level of presence.

3. Performance of tasks in real and virtual environments

This approach is based on the assumption that people perform better, i.e. more similar to the real world, in VR with higher presence. Therefore, presence can be measured by measuring the performance of the users, for instance the time taken to complete a certain task.

4. Discrimination between real and virtual events

When virtual and real experiences are cognitively processed in a similar fashion by the human brain, this indicates a high level of presence in the VE. For instance, presence could be measured by determining the differences between memories of real and of virtual events, such as differences in accuracy and in detail [11].

5. Incorporation of external stimuli

If the participant interprets an external event, such as a loud noise, in the context of the virtual environment then he/she must be present in that virtual environment.

All these approaches are still being investigated and a universal measurement for presence is not available. Comparing results from different research projects concerning presence will therefore inherently be somewhat inaccurate.

3. INTERACTIVITY

We will consider an interactive system to be one in which the user can influence the form and/or content of the mediated presentation or experience [19]. The degree to which a medium can be said to be interactive depends on a number of subsidiary variables. Five primary ones will be mentioned here:

1. The number of inputs from the user that the medium accepts and to which it responds [3].
2. The number (and type) of characteristics of the mediated presentation or experience that can be modified by the user [7].
3. The range or amount of change possible in each characteristic of the mediated presentation or experience. It has even been suggested that an unrealistic amount of responsiveness can increase the level of presence [7], such as rain starting upon entering a room!
4. The degree of correspondence between the type of user input and the type of medium response. It is a "widely accepted working hypothesis" that "using our familiar sensorimotor skills to manipulate virtual objects directly by means of whole-hand input devices...contributes to our sense of presence much more than writing programs, twisting knobs, or pushing a mouse to accomplish the same task" [26].
5. The speed with which the medium responds to user inputs. When forced to choose between responsiveness to motion and resolution of images, VR developers are choosing responsiveness as the more important factor [7].

These variables coincide with three variables proposed by Steuerer [23]:

1. Speed, corresponding to variable 5 mentioned above
2. Range, which covers variable 1, 2 and 3
3. Mapping, coinciding with variable 4

In this article the relation between this last set of variables and presence will be explored because a more detailed approach is not possible with the data available.

4 INTERACTIVITY AND PRESENCE

As stated earlier, interactivity of a medium is viewed as one of the key factors in facilitating the feeling of presence [17]. This could be explained with the use of an ecological perspective [6]: organisms such as humans perceive in their environment elements that have a meaning for the organism. This meaning can also be termed 'affordance', because it relates what the

element affords. For example, the ground affords walking, a chasm affords falling and hurting, an apple might afford eating and a tiger affords being eaten. In other words, the possible interaction with the element for the organism is what is primarily perceived by the organism. Indeed, ethnographic study of interactions in multi-user VR-systems has shown perception and action to be closely linked [14]. Perception of the real world is closely linked to the action possible (i.e. interactivity) and it is hypothesized that interactivity in VR will lead to a type of perception very similar to that of the real world, causing a sense of presence.

This does however not imply that all variables of interactivity defined in the previous paragraph have the same impact on presence. In fact, research has shown that increasing such a variable sometimes causes no increase in presence. The exact mechanism determining the amount of presence experienced is unclear, although some relations are getting visible.

4.1 SPEED

The variable of response-speed seems to have the most straightforward effect on presence: Research showed that the performance of people completing a task in VR degraded significantly with imposed response lags of 40 ms or more [22]. It has been shown that presence reported by the user drops drastically below a level of 15-20 frames per second [1]. This would mean that a certain update speed is a minimal requirement for presence, but it should be noted that above the mentioned threshold very little increase in presence is to be expected.

4.2 RANGE

The possible range of interaction is also related to the level of presence. It is clear that the use of 6 degrees-of-freedom head-tracking can greatly increase the level of presence [9], although people often need to be encouraged to use this input device. When they first don the head-mounted display (HMD) they frequently treat it as they would a computer screen and just stand rigidly looking ahead. Experiments where subject were required to move their head and even their entire body to perform a task showed that body movement had a positive effect on presence [13]. The use of tactile augmentation, where the user can actually touch a virtual object and feel it, has also been reported to increase presence [10]. This technique uses a real object with a tracker attached to it so a virtual object can be simulated in its exact position.

However, increasing the number and range of inputs not always increases the level of presence. In an attempt to find a relation between level of social presence and the number of social-presence-cues an increase in these cues such as the possibilities for making gestures to each other and choosing a personal 3D representation did not result in increased presence [25]. Social presence is based on the fact that if other beings recognize you as being in the virtual world with them, and interact with you, that offers further evidence that you exist in the virtual world [7]. It seems that this intersubjectivity reduces the need for visual appearance and 'material' structure of the environment [14]. We could even make the hypothesis that, once social presence has been established in a way that the users are aware of each others existence in the VR, the fidelity of the interaction is of minor importance. This again suggests that there is a threshold above which increases in the variable, in this case the range of social interaction that is possible, has little effect on presence.

4.3 MAPPING

The mapping between the type of user input and the type of medium response also has an influence on the level of presence. Research has at least shown that performance in a search task was greatly increased by using head tracking instead of a hand-tracking device to change the viewpoint [15]. But other experiments revealed there can also be no difference in presence for different types of user input [1]. Subjects using a joystick were compared to those using a space mouse. Both devices offered 3-degrees of freedom, so the only difference was mapping between input and response. The fact that no difference in presence was found indicates that the exact contribution of this mapping is not yet fully understood.

5 CONCLUSIONS, FUTURE RESEARCH

The research mentioned in this article clearly determines interactivity of virtual environments as an important cause of presence. Some aspects of interactivity, such as the speed of the responses of the environment, show a clear contribution to presence up to a point. Further research is required however to understand the influence of mapping between input and response, as well as the range of user inputs. As suggested it may be possible that social presence can be achieved using a minimal range of interactivity, although research should investigate what these minimal requirements are.

In HCI there are many methods for designing user-interfaces. However, for VR applications such as treatment of phobia, where presence is an essential part of the interface, a new method is needed. A conclusion of this article is that when designing the interaction between human and computer the effects of the design-decisions on presence should also be taken into consideration. Often the interaction should be less efficient to increase the level of presence, for instance requiring the user to move about and interact with many (synthetic) beings, using a type of input device very natural to use but less effective than other devices.

As a last point, it should be pointed out that even better methods for measuring presence are required [25] to facilitate a precise view of the relation between interaction and presence. Much research in this area is still needed.

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