Final report

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31st October 2005

The question of 'Where are you?': Immersion and Presence

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Contents

1 Introduction

The report at hand describes a literature study assignment on Immersion and Presence in the framework of the course *Interactive Virtual Environments (2IV50)* as it is given at the Technische Universiteit Eindhoven in 2005-2006. The aim of the course is to give an introduction to the main concepts of Virtual Environments (VEs), particularly focussing on the techniques needed to implement them. The formulation of several assignments that require either to perform a programming task or a literature study is the basis for student's assessment and grading.

2 Problem statement

One of the main objectives scientific researchers strive for in the field of VEs is to get as close as possible to a real world perception. Ideally, a participant of the VE should see, feel, smell, hear, act etc. in a similar way in a VE situation as if s/he would have done in a real life situation. To better catch up with the problems involved in reaching and dealing with such an ideal virtual environment, researchers have introduced some terminology to cope with. *Immersion* and *Presence* are two issues that comprise this notion.

As the introductory paragraph has already mentioned, it is the aim of this literature study to show how the concepts of *immersion* and *presence* in the context of a VE are defined and perceived in common literature. Furthermore, the assignment requires to discuss different methods for measuring presence along with their advantages and disadvantages.

3 Concepts of immersion and presence

In order to get the reader acquainted with the terminology and the position in the field of VEs, the paper first elaborates on the underlaying concepts of immersion and presence. Giving definitions of both notions will serve as starting point of further descriptions on both concepts. This section will then present some necessary conditions for creating the feeling of 'being there'.

One should remark that no commonly agreed upon definitions exist, some definitions of the same concept are even contradictory in their kind and hence in their formulation. This is not only due to the fact that research on this field is still at an early stage in development, but also due to the fact that these topics are studied from different points of view.

Nevertheless, nowadays the notion of presence has gained much relevance for the development and evaluation of a wide spectrum of interactive and non-interactive media, especially for applications in the field of training, medicine, psychology, entertainment etc. However, that the concept of presence is determined by multiple factors, is generally accepted by most of the researchers.

Often, the effectiveness of VEs is closely related to the sense of presence that users of that VE experience. According to Witmer and Singer [4], this 'normal awareness phenomenon' rests on the interaction between sensory stimulation, environmental factors encouraging involvement and enabling immersion, and internal tendencies to become involved.

Furthermore, it can be shown that a VE, which produces a greater sense of immersion, will produce higher levels of presence. [4]

The following paragraphs will go into more detail on either subject and show how these are perceived in common literature, relating it to the field of VE.

3.1 Immersion

On the issue of *immersion*, various definitions do exist and some authors do not even agree with the definitions of their colleagues. Witmer and Singer [4] handle the following definition:

Immersion is a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences.

Slater in his elucidation in [5, 8] however, argues that the above definition more corresponds to his notion of presence. In his view, immersion is:

The extent to which the actual system delivers a surrounding environment, one which shuts out sensations form the 'real world', which accommodates many sensory modalities, has rich representational capability and so on.

One should therefore not wonder that Witmer and Singer, on their turn, dismiss that definition as an objective description of the VE technology and maintain that immersion is something the individual experiences.

To distinguish between these two notions, Slater respectively introduces terms like 'system immersion' and 'immersive response' to denote one another. Likewise, a system is immersive if it immerses a representation of the person's body in the computer-generated environment and therefore depends on the hardware, software and peripherals (like e.g. body sensors, display etc.) of that system. This is what Slater's perception of immersion distinguishes it from that of Witmer and Singer [4], in such that immersion describes the applied technology, rather than a psychological characterization of what the system supplies to the user. [5]

The following paragraphs separately discuss both notions of the aforementioned authors.

3.1.1   Immersive response

Among those that have propagated *immersion* as a psychological response of a participant in a VE, are Witmer and Singer [4]. In their perception, it is something the individual experiences, like the notion of involvement and presence. Factors that contribute to the notion of immersion, according to them, are the degree of isolation from the real world, the perception of self-inclusion in the VE, as well as the perception of self-movement, and natural modes of interaction and control.

By providing some isolation, e.g. through head-mounted displays, deprives participants from distracting disturbances out of the physical world. The degree to which one is able to move through the simulated environment and feeling as being inside that world, largely contributes to the notion of immersion too. Another contributing factor in becoming more immersed in a VE, is the ability of interacting with other entities in that environment. It is thereby important that interaction takes place in a natural and usual way. [4]

Contrary, when users are outside the VE and looking into it will not give them the particular feeling of being immersed. Nevertheless, it may be the case that they feel involved as they are presented a coherent and meaningful set of stimuli. Another diminishing factor for immersion is the way interaction takes place. If that interaction has to be performed with a clumsy and thus unnatural device, the participant will not at all feel immersed. [4]

3.1.2   System immersion

System immersion, also distinguished as physical immersion, is in its perception different from the aforementioned notion of immersion as coined by Witmer and

Singer. Most of the authors agree on the fact that immersion is characterized by factors that relate to the physical properties of a VE. [5, 7, 8, 9, 10, 12]

As Slater states in [5], the definition of immersion by Witmer and Singer (cf. section 3.1.1) is rather a psychological characterization of what the system supplies to the human participant and therefore more contributes to the notion of presence, as will be discussed later.

According to Slater, immersion is more a description of the technology of a mediated system than a description of participant's responses to that system. In fact, based on this definition one is able to establish more objective measures. [5]

The degree of immersion can objectively be judged as characteristics of a technology, assessing the extent to which a system can deliver an inclusive, extensive, surrounding, vivid and matching illusion of the VE to a participating user. Other dimensions of measures may include the degree of body matching and the extent of how well the user can act in a self-contained plot providing autonomous responses. [7]

A system is inclusive if it is able to shut out external sensations from the physical reality. Furthermore, a system is more extensive the more sensory systems it accommodates, whereas the degree of surrounding denotes the extent information arrives from any, possibly virtual, direction.
Also contributing to that notion is the extent a participant of the VE can turn around in any direction but still having the impression of being in the environment. Last but not least, matching refers to the degree of mapping of the user's proprioceptive feedback about body movements and the information that is generated in the VE (i.e. matching between proprioception and sensory data). [7]

3.2   Presence

Before actually discussing the matter of presence, it is worthwhile to have a look on its commonly agreed upon definition first. Presence is defined as *the subjective or psychological experience of being in one place or environment, even when one is physically situated in another.*
It is the extent to which a person fails to perceive or acknowledge the existence of a medium during a technologically mediated experience, which is generally be described as the user's notion of 'being there'. [1, 2, 4, 5, 6, 8, 9, 11, 12]

In fact, presence is the participant's reaction to (system) immersion (cf. section 3.1) and one should not wonder that when given the same immersive system, different users may experience different levels of presence. Analogously, different immersive systems may lead to the same level of experiencing presence with different participants. [8]

In [8], Slater argues that the notions of immersion and presence are logically separable, but empirically it may be the case that they are strongly related.

'Being present' in a VE signifies that the participant's perceptual, vestibular, proprioceptive and automatic nervous systems are stimulated like it would have been in similar real life situations. Though the user cognitively knows that s/he is not in a real life situation, s/he will tend to behave as if it were the case, the more if the virtual world mediates a high feeling of presence. [8]

Literature identifies six main conceptualizations of presence: realism, immersion, transportation, social richness, social actor within medium, and medium as social actor. These conceptualizations lend themselves to be divided into two categories: physical and social presence. With the physical category the sense of physically being somewhere is grasped, whereas the social category addresses the feeling of being together and possibly communicating with someone. [1, 2]

These two notions can meaningfully be distinguished, but are nevertheless related to each other, as they exhibit common determinants that are relevant for both. In fact, one can identify a third category, the intersection of both physical and social, combining characteristics of either category. IJsselsteijn refers to it as co-presence. [1, 2]

3.2.1 Determinants of presence

Although research on the causes and effects of presence are still in a preliminary phase, literature comes up with a bunch of factors that are likely to influence the participant's sense of presence. In the elucidation of IJsselsteijn et al. [1] and Freeman et al. [2], the results of various theoretical analyses have been compiled.

Based thereon, one might conclude that the following factors play a crucial role in generating presence [1, 2]:

- The extent and fidelity of sensory information: the quantity of appropriate and useful sensory information that is consistently presented to the user.

- The match between sensors and the display: the mapping between actions of the participant and the occurrence of their effects in the VE.

- Content factors: the way objects, actors and events are represented by the VE, including their fidelity, their autonomy, their meaning etc. It also includes the ability of the participants to interact with and modify the content of the VE.

- User characteristics: these factors are related to the participant's perceptual, cognitive and motor abilities, their personality, their mood state, their expectations, but also previous experiences with a mediated environment, which are likely to affect the sense of presence as well.

When following the elucidation on (system) immersion (cf. section 3.1), the reader will have noted that some of these factors also come to the fore in Slater's discussion on immersion.

3.2.2 Involvement

In [4], Witmer and Singer state that involvement and immersion (immersive response) are both necessary for experiencing presence. They define involvement *as the psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities or events.*
Generally speaking, the more users become involved in the VE, the more they focus attention on the VE stimuli, which automatically leads to higher senses of presence. The amount of involvement is subject to variation, according to how well the activities and events of the VE attract and hold the user's attention.

Slater however argues in [8], that the notion of involvement needs to be separated from the notion of presence, as both exhibit different logical levels. One can be present but not be involved, and similarly one may be involved but not present. This stems from the fact that involvement is related to content, but not to form (as presence is).

4   Measuring presence

As we have seen before, scientific research on the matter of presence is still at an early stage and it is rather difficult to come up with a commonly accepted theory thereon. Nevertheless, much effort has already been spent on developing methodologies for measuring presence. As the viewpoints on presence vary, so also do the measuring methods.

The main target of developing a reliable, robust and useful measure is to obtain a tool that allows developers to evaluate a VE with respect to its contributing factors of presence. It should make it possible to identify and test these factors in order to gain an optimal level of presence, i.e. to maximize presence in a VE.

The following sections will discuss some major approaches for measurement along with their (dis)advantages, but as the field is relatively broad, only a few will be discussed in greater detail. Sections 4.3.2 and 4.3.3 will more thoroughly discuss the concepts of Presence Questionnaire (PQ) and Immersive Tendencies Questionnaire (ITQ), respectively.

Intuitively, one might distinguish between two general categories of measuring presence: subjective and objective corroborative measures. In order to come to thorough presence measurement, it is therefore important to develop and employ an aggregate measure of presence that involves both notions of measurement.

4.1   Subjective measures of presence

In order to come to a good understanding of how VE participants experience presence in a mediated environment, various methods for measuring its degree have been proposed. Most of the early methods were more subjective measures which mainly involved the users of a VE in assessing their feeling of being present.

The following paragraphs will shortly discuss some of these subjective measures, along with their (dis)advantages. Two of these methods are more thoroughly discussed in section 4.3.

4.1.1   Post-test rating scales

One of the most common ways to measure presence till now, is the use of so-called self-report questionnaires. These questionnaires make use of post-test rating scales, which requires to compare the VE experience with either real life or another mediated environment after being in the VE. [1, 12]

Presence Questionnaire: Different types of questionnaires exist, one is the Presence Questionnaire (PQ), which measures the amount of presence individuals experienced in a VE and the influence the factors used to contribute to the

intensity of this experience. [4] The concepts around PQ are set out in detail in section 4.3.2.

Immersive Tendencies Questionnaire: Another type is the Immersive Tendencies Questionnaire (ITQ). This questionnaire measures the capability of the involved individuals in order to get a good perspective on the outcome of the individual's PQ. [4] The concepts around ITQ are discussed in detail in section 4.3.3.

ITC-Sense of Presence Inventory: The ITC-Sense of Presence Inventory (ITC-SOPI) is a questionnaire measure which "focuses on users' experiences of media, with no reference to objective system parameters"[9]. It is an effort to create a questionnaire that measures cross-media – both interactive as well as non-interactive – presence.

604 people participated in the ITC-SOPI, the group was split in six subgroups. Each group received a different experience with six different levels of immersion: ranging from watching a 3-D IMAX films to watching a VHS film on a 2m × 1m screen at Goldsmiths College Students' Union (GCSU).

After the experience, the participants were asked to fill out a questionnaire about their experience. Statements like "I felt that the characters and/or objects could almost touch me" (immersion) and "I felt involved (in the displayed environment)" (presence), but also "I felt nauseous" (physiological effects).

The results unsurprisingly showed high presence in the high fidelity presentations (IMAX 3-D) and low presence in the low fidelity presentations (like the film evening at GCSU). However, the negative effects also were the highest at the high fidelity presentations, such as dizzyness and uncomfortable appliances (polarized glasses). [9]

4.1.2   Continuous presence assessment

The method of continuously assessing presence experienced in the mediated environment, involves asking questions and noting the verbal reactions from the participant. [1]

These measures track the entire immersed experience, from moment to moment, not being influenced by temporary negative effects of being immersed. This in contrast to the post-test rating tests, which only measure *after* the experience, possibly containing results influenced by for instance nausea near the end of the test.

4.1.3   Psychophysical methods

Psychophysics is the study dealing with the relation between physical stimuli and their psychological effects (perception). Very little empirical research was

available at the time of writing of [1], but various methods had nonetheless been proposed.

Free-modulus magnitude estimation: VE participants are presented with a variety of stimuli and are asked to give each of these stimuli a number according to their subjective sensation. In a variation, the user is asked to assign to the first stimuli any number and grade all other stimuli accordingly.

Cross-modality matching: This method is in someway similar to magnitude estimation, but allows to grade certain stimuli non-verbally. The participant is asked to express his/her degree of sensation to a particular stimulus by adjusting parameters in a different modality. This measure allows to rate particular notions which cannot (easily) be done verbally.

Paired comparisons: Different stimuli in a VE are assessed by letting the participant compare between the notion in the virtual and the equivalent one in the real world.

4.2 Objective corroborative measures of presence

As we have seen in the previous sections, the aforementioned methods of subjectively measuring presence lack a great deal of objectivity which makes it necessary to come to additional or alternative ways of measuring presence. However, objective measures can be applied to support and complement subjective measures in order to compensate for their limitations, coming to more aggregate measures on presence.

One of the greatest shortcomings in subjective measures is the high concern participants have in it. Lot of users are not familiar with the concept of presence, yielding potentially unstable subjective measuring results. Also, depending on the raters and the rating situation, measuring results show lot of inconsistencies and may be not free of personal biases. [1]

Objective measures however, focus on factors that are related to automatic and reflexive responses of the VE participant, happening without conscious awareness. Like before with the subjective measures, various approaches have been suggested to formulate meaningful objective corroborative measures of presence. The following paragraphs give a glimpse on some of these objective measures and shortly discuss their benefits, but also their weaknesses.

4.2.1 Postural responses

To come to objective corroborative measures, one could for example study postural adjustments a VE participant makes during a mediated session. Postural and balancing adjustments are proprioceptive responses to various sources

of information, including sensory information from the vestibular organs, visual information from the eyes and sensory information through feet and ankle joints. [3]

In fact, participants may be subject to the illusionary feeling of self-motion (i.e. so-called vection), which leads to the behavior of mostly unconscious postural adjustments. Although it is not fully proved that vection is the sole cause for postural adjustments, it is likely to assume that both notions are highly correlated and triggered by identical visual factors. [3]

Scenarios in which measuring postural responses may play a significant role are, for example, racing in a car in which the virtual driver moves his/her body in order to provide counterweight when racing through bends. Similarly, a VE participant may duck when (virtually) being shot, and so on.

Practically, postural responses can be measured in various ways using all possible kinds of position tracking devices. [1, 3, 12]
Some authors have suggested to relate measures of vection and presence, based on the assumption that it is not unlikely that a VE participant will feel present in a mediated environment in which the user experiences vection. [1, 3]

Like other measures of presence, measuring postural responses lends itself to be used as an objective corroborative measure in addition to subjective measures. These responses happen unconsciously and reflexively and, in addition, they provide various degrees of responses which makes it easier to link them to subjective measures. As IJsselsteijn argues in [1], measuring postural responses cannot replace subjective measures as there is only low correlation across subjects. [1, 3, 12]

However, the postural response measure is very content-dependent as not all VEs will (or can) induce high levels of vection, but nevertheless create a high sense of presence. This content-dependency makes it impossible to generally apply it to a great variety of VEs, but may certainly be useful in the aforementioned scenarios. [12]

4.2.2   Physiological responses

A way to come to objective corroborative measures is to include a bunch of physiological indicators which measure stress of VE participants. These metrics could e.g. include the measuring of the participant's heart beat, his/her skin conductance or temperature etc. [1, 12, 13]

In a stress-like situation the heart beats faster or, in a similar situation, participants are going to sweat having higher conductance values as a consequence. Also, the skin temperature of the user is affected in a stressful environment, which will be colder due to a slow-down of the blood-circulation in the extremities. [12, 13]
Similarly, pleasant stimuli cause an increase in heart rate, whereas unpleasant stimuli just cause the opposite. [1]

Advantages of physiological responses, like with postural responses, is the fact that the displayed behavior of the human beings happen without conscious deliberation. It is therefore unlikely that a VE user is able to alter physiological responses of his/her body, which gives already a good indication for the objectivity of these measures. [12]

Till now, there has been no real proof to show the exact correlation between physiological responses and presence and further research has to be performed in order to show that physiological responses can indeed yield a general, sound and reliable objective corroborative measure. Nonetheless, subjective measures will be needed to come to a coherent view on presence. [1]

4.2.3   Social responses

In social oriented VEs, objective corroborative measures can be developed that more focus on social conditioned responses of a VE participant. Moreover, these measures lend themselves to assess the notion of social presence, which is mentioned in section 3.2.

It is in the nature of every human to display social behavior towards other humans, expressed verbally of non-verbally. Often, socially conditioned responses happen automatically and without conscious deliberation, yielding the potential to be used as relevant measures of social presence, as it is assumable that this social behavior will equally likely occur in a VE of a social nature. [1]

Social responses that lend themselves to be used for measuring, are manifold in kind. One could e.g. consider eye contacts and movements, gestures (e.g. bending over to slap someone's back), facial expressions (e.g. frowning), body and head movements (e.g. nodding), vocal cues (e.g. tone of voice), turn-taking behavior in dialogues (e.g. frequency of interruptions), spatial behavior (e.g. approaching a virtual conversation partner) and acknowledging verbal expressions (e.g. 'I see what you mean'). [1]

However, it is not unlikely to assume that assessing social responses for measuring presence will yield more stable and reliable results if done in addition to other trustworthy objective and subjective measurements. [1]

4.2.4   Dual task measures

The main target of dual task measures is to measure the reaction time of a task inside the VE. The underlying assumption for these measures is the fact that when more effort is spent for a primary tasks, fewer attention will be attributed to secondary tasks. With increasing presence, more attention is said to be assigned to the mediated environment, leading to an increase in errors and secondary reaction times. However, this measure still needs to be empirically tested. [1]

4.3 Presence and Immersive Tendencies Questionnaires

Witmer and Singer introduced the post-test rating couple Presence Questionnaire (PQ) and Immersive Tendencies Questionnaire (ITQ) in their article 'Measuring Presence in Virtual Environments: A Presence Questionnaire'[4]. Before going deeper into the concepts of PQ and ITQ, the framework around which the questionnaires have been developed is discussed.

4.3.1 The framework

Users of a VE are continuously influenced by factors that enlarge or weaken their feeling of presence, some are quite significant others are rather negligible. To more or less structure the various points of attention, the authors describe a classification based on the work of Sheridan as well as Held and Durlach that underly the concept of presence. They claim presence is influenced by factors on a level of control, sensory, distraction and realism. As these categorization plays an important role in the PQ and ITQ concepts, a summary is given in the following paragraphs:

Control factors

- *Degree of control*
  A factor that greatly enhances the feeling of presence is the ability for the user to control objects in a VE. The ability to interact with objects is just a primary skill of sense organs.

- *Immediacy of control*
  Another aspect is the smoothness by which a person can interact with an object. The more it resembles the immediacy of control in real live, the more the feeling of presence is improved.

- *Anticipation*
  The ability of a participant to anticipate the outcome of an occurrence is important to its feeling of presence. One can imagine releasing a fluff from one's hand, after which the fluff gently sails down to the floor. If the fluff would drop like a brick, the feeling of presence would be significantly less.

- *Mode of control*
  The feeling of presence of a participant can be elevated if an interaction with a VE, by means of a mode of control, resembles a natural method for that particular situation. The more artificial the mode of control, e.g. a control glove, the more one's feeling of presence decreases.

- *Physical environment modifiability*
  The ability to physically modify objects in a VE is a natural reflection of the behavior of people in real life situations. For example, opening a door or squeezing a ball greatly enhances the feeling of presence of people.

Sensory factors

- *Sensory modality*
  The human sense organs are the primary channels through which information is perceived. Visual perception are of primary importance to the feeling of presence, but also other sensory information (e.g. hearing, sensing, smelling, etc.) may significantly contribute.

- *Environmental richness*
  The more a VE environment is enriched with information that stimulates the sense organs of a human, the greater the feeling of presence. One can imagine seeing a waterfall without hearing the typical rattling of water, the feeling of presence will be much less. Adding more accurate environmental richness, the more one believes s/he is actually at a romantic waterfall scenery.

- *Multimodal presentation*
  The more coherently and completely a participant perceives the environmental information, the higher its feeling of presence. For example, with a waterfall the appropriate sound should be associated.

- *Consistency of multimodal presentation*
  The environmental information in a VE should be consistent in order for a participant to increase its level of presence. One can for example imagine a room with four similar walls, walking against one should give the same sound as walking against another one.

- *Degree of movement perception*
  In order for a participant, active in a VE, to have a high feeling of presence, he or she should perceive some degree of movement. For example, the further the distance of a table, the smaller the table should resemble to a participant.

- *Active search*
  The ability for a participant of a VE to reposition its viewpoint greatly enhances the feeling of presence. For example, being able to look at every position a person wants is a natural requirement for any human being.

Distraction factors

- *Isolation*
  To avoid distraction factors in the physical environment of a participant of a VE, devices might be helpful to increase the feeling of presence. For example, a head-mounted display isolates a participant from its physical environment.

- *Selective attention*
  The ability of a participant to ignore distractions of its physical environment, is beneficial for its feeling of presence.

- *Interface awareness*
  The feeling of presence of a participant of a VE decreases if one is aware of a device that is needed to interact or interpret the VE. For example, a very heavy head-mounted display can distort the feeling of presence of a participant.

Realism factors

- *Scene realism*
  The feeling of presence significantly increases if the scenes in a VE are more realistic.

- *Consistency of information with the objective world*
  The feeling of presence is increased substantially if the information presented in the VE is consistent with the information a participant has perceived in its natural environment.

- *Meaningfulness of experience*
  The ability of a participant in a VE to identify itself out of interest with the environment presented is beneficial to the feeling of presence. For example, if one finds itself driving in a virtual racecar from which one has always dreamed about, its feeling of presence is higher than a person that is not interested in racing.

- *Separation anxiety or disorientation*
  Disorientation or anxiety may be experienced by a participant of the VE when returning to its physical environment.

In 'Measuring Presence: A Response to the Witmer and Singer Presence Questionnaire' [5], Slater argues that all the factors above are subjectively defined. To illustrate his opinion, he gives an example of playing tennis with a racket and virtual tennis balls: one player reports a high response to control the racket whereas another reports a low ability within the same VE.

He argues that the player with a low ability might not be able to play tennis in the real world as well, hence indicating, although the VE is giving him or her a high feeling of presence, that s/he experienced 'a low ability of controlling events' within the VE. [5]

Slater states that the differences in the individuals' personal responses can be tracked back to their different perceptions, make-ups or senses of the real world and has hence nothing to do with the feeling of presence with respect to the VE capabilities of the system itself. [5]

Note that Slater handles different definitions for immersion and presence (cf. section 3).

In their research, Witmer and Singer verify each measure of presence with respect to its reliability and validity [4]:

Reliability   A measurement scale is considered reliable if differences in scale scores are solely due to differences in the characteristics to be investigated. Differences in individuals or testing conditions do not contribute to this property. If a scale is reliable then it is easily replicable.

Validity   A measurement scale is considered to be valid if it measures exactly that what it is supposed to measure. On one hand this is considered in content validity, on the other hand in construct validity.

- *Content Validity*
  Content validity refers to the degree of covering a certain part of the behavioral domain under investigation by the questions.

- *Construct Validity*
  Construct validity refers to the degree by how far the measurement scale covers a theoretical topic.

4.3.2   The Presence Questionnaire

The PQ consists of a list of questions, solely based on self-report information. Its aim is "to measure the degree to which individuals experience presence in a VE and the influence of possible contributing factors (described above, cf. section 4.3.1) on the intensity of this experience" [4].

Witmer and Singer use a seven-point scale, derived from the semantic differential[1] principle but extended with a midpoint anchor, to give the ability to the user to express his feeling towards a question. [4]

A participant of a VE is asked to 'score' his degree of agreement towards a question with respect to the descriptive labels on the scale. The seven descriptive labels correspond to a response category on an ordinal level of measurement, without magnitude of difference between them. For example, an inherent order from 'not compelling' to 'moderately compelling' and finally 'very compelling'. [4]

In the research, Witmer and Singer investigated the utility of the PQ using four experiments. Two of them were simple psychomotor tasks, the other two asked the participants to learn a route through a virtual representation of a

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[1]Refer to `http://en.wikipedia.org/wiki/Semantic_differential` for a description

complex office building. Different means of control were used in all of these experiments. [4]

In the questionnaire, Witmer and Singer categorize the questions in two ways. Firstly, the *factors* as mentioned in the previous section: Control factors, sensory factors, distraction factors and realism factors. Secondly, a categorization they call *subscale* – not a subdivision of the factors, since they partly overlap multiple factors: Involvement/control, Auditory, Haptic, Resolution, Interface Quality.

4.3.3   The Immersive Tendencies Questionnaire

In 'Measuring Presence in Virtual Environments: A Presence Questionnaire', Witmer and Singer describe a concept which measures by how far an individual experiences presence within an environment, namely the Immersive Tendencies Questionnaire (ITQ) [4].

According to Witmer and Singer, presence measures should address the individual differences of a participant in a VE as well as the characteristics of the IT itself. They state that the strength of feeling presence varies both as a function of these two tendencies as both may effect presence. [4]

The ITQ consists of a list of questions and is solely based on self-report information. Its aim is to identify individual differences that could affect how much presence might be experienced in any given situation. The questionnaire focusses on measuring the tendency of individuals to become involved in every day activities and the ability to focus on a specific activity. In particular, the questions focus on immersive tendencies, on one's current fitness or alertness and on the ability to focus or redirect one's attention. [4]

Like with PQ, Witmer and Singer use a seven-point scale for the ITQ. [4]

With the help of the properties mentioned in section 4.3.1, Witmer and Singer found out that there is sufficient correlation between their questions and the overall result of the questionnaire. Hence, they conclude that the ITQ is well-established and useful for measuring psychological characteristics of individuals. [4]

Slater addresses some criticism with respect to this approach. He states that, already by construction of the scale, there just have to be a correlation between the individual questions and their sum. Hence, although Slater accedes the reliability and consistency of the questionnaire, this approach is not so waterproof as it ought to be. [5]

However, he would use the ITQ as it stands alone and is not based on factors influencing the feeling of presence of a participant in a VE. Nevertheless he believes that questionnaires are not the elusive silver-bullet for measuring presence, but it describes some approach for quantification.

5   Conclusion

The research performed in the field of immersion and presence is still at an early stage. Like in every new field, not all scientists agree on what is exactly understood under the concepts of immersion and presence and moreover address different perceptions.

Particularly, measuring presence can be addressed objectively as well as subjectively. Subjective measurements of presence requires, to a certain extent, a high degree of user participation in assessing, whereas objective measurements focus on participant's behavior as a result of unconscious and reflexive responses to the mediated environment.

The main criticism on subjective measurements is that a user needs to be sufficiently aware of the notion of presence. In contrast, objective measures assess the degree or presence by evaluating unconscious behavior of the participant automatically. Nonetheless, most of the objective measurements still need to be empirically tested.

However, as research on subjective measurements will gain maturity, one can expect that more reliable, sound and solid questionnaires will be developed adhering to the desired fathoming of the structure of presence. Nevertheless, some standards for subjective measurements will need to be developed such that they can be used in other situations than the ones they were originally unfolded for.

Similarly, more founded and appropriate sensitive measurements will result from elaborate academic studies on objectives measurements.

Anyhow, substantial progress can be beheld in the act of measuring presence. It is clear that for most situations in which the desire exists to measure presence, not one single objective or subjective measurement should be addressed, but both objective and subjective ones, in order to come to a more thorough and decent measuring of presence. It is a fact that currently both suffer from some limitations, both using and combining their strengths will enforce good measurements of presence in the future.

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