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# The Sense of Presence Exploration in Virtual Reality Therapy

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**Abstract:** The primary objective of this concise collection is to explore the sense of presence that participants experience in Virtual Reality Therapy experiments. In this article, sense of presence is briefly defined, followed by a discussion of factors effecting sense of presence, continuing with methods to measure sense of presence and assertions concerning virtual presence, and finally, conclusions and discussions are presented.

**Keywords:** Virtual Reality, Computer Graphics/Applications, Information Systems/General, User/Machine Systems
**Categories:** I.3.7, I.3.8, H.0, H.1.2

## 1 Introduction

Based on extensive research reports in current decades, Virtual Reality Therapy (VRT) has proven to be an effective treatment for many psychological disorders [North et al. 1995, North and North 1996, North and North 1994, North et al. 1996, North et al. 1997]. VRT utilizes technology to generate virtual environments in which the patients are immersed and provided treatment. In general, one of the major attributes of virtual reality is the sense of presence that users experience while immersed in a virtual reality scene (what the authors term "virtual presence", including telepresence, to distinguish it from physical presence). For convenience, the terms “presence” and “virtual presence” may be used interchangeably. Our basic understanding of virtual presence, however, is still primarily anecdotal in nature. There is a great need to rigorously explore the basic questions concerning the nature of virtual presence. Several innovative experiments using virtual reality to combat psychological disorders have been conducted by the authors [North et al. 1996]. In these experiments, the sense of virtual presence was the defining factor that resulted in successful outcomes and provided the authors with experimental evidence upon which to formulate assertions about the characteristics and nature of virtual presence

Specifically, the authors have conducted several experiments in virtual

environments as a way to identify and explore issues related to the concept of sense of presence. In the first set of experiments, VRT was utilized to treat subjects who suffered from agoraphobia. VRT was used as an alternative and potentially more effective and efficient approach to treating agoraphobia compared to in vivo treatment, a gradual exposure of the subject to phobic situations in the real world [North et al. 1996]. In addition, the authors have also conducted several other experiments to investigate the effectiveness of virtual reality technology in motivating learners and in other fields. Extended descriptions of VRT experiments are not within the scope of this article. However, the authors have provided a summarized description in Appendix A. In addition, the authors have provided several references to detailed VRT experiments within this article. Readers are encouraged to see references [North et al. 1995, North and North 1996, North and North 1994, North et al. 1996, North et al. 1997].

Limited in-depth studies into the sense of presence are currently being explored, but because of the complex nature of this subject, they have been very focused and limited to specific studies, leaving more unanswered questions. This article expands on some of those unanswered questions: What is presence exactly? Does presence go beyond the physical attributes and into the cognitive mind? What is virtual reality, and how does a person's sense of presence change in the virtual environment? What factors contribute to the sense of presence in an environment, either virtual or real? What is the best method and device used for measuring presence?

## 2 Sense of Presence Defined in Brief

The primary aspects of virtual reality technology that make a simulated environment feel as "real" as possible is the "sense of presence" in the virtual scene: the sense of "being there." In the 1990's, several theoretical research articles were published in the journal of *Presence, Teleoperators and Virtual Environments*. In the decades since, more researchers have been exploring the topic of virtual reality and using the knowledge gained from various studies, including virtual reality therapy experiments [Virtual Reality Lab 2016]. Even though research in this topic has progressed through the years, literature is still limited. We echo a brief excerpt from our earlier research here: "there is a great need to develop a scientific body of knowledge or a theory to assist researchers in the development of efficient virtual environment applications," and within this to "rigorously investigate the sense of presence" [North 2002, Pausch at al. 1997, Sheridan 2000, Slater at al. 1994, Slater 1999].

A concise history of the definition of presence begins with Marvin Minsky (1980), who coined the term "telepresence" [Coelho at al. 2006]. Minsky described telepresence as "when the virtual experience dominates the real world experience. This describes the feeling of actually being in the environment generated by technology instead of being in an actual physical environment" [Steuer 1992]. Gradually, the study of "telepresence" transformed into the general study of "presence," since telepresence is more commonly used in the narrower field of teleoperations [Coelho at al. 2006]. In recent literature, presence is defined as "how realistically participants respond to the environment as well as their subjective sense of being in the place depicted by the Virtual Environment" [Slater at al. 2009].

Furthermore, a number of classical articles have been published on the experience of presence in a virtual or remote environment. Both Naiman [Naiman 1992] and Loomis [Loomis 1992] have argued that the normal human experience is not of the physical world, but created of our perceptions of the physical world. That is, reality is what we perceive it to be. In his taxonomy of graphics simulation systems, Zeltzer [Zeltzer 1992] identified presence with the number and fidelity of available sensory input and output channels. Heeter [Heeter 1992] discussed three dimensions—personal, social and environmental—of the subjective experience of presence. Fontaine [Fontaine 1992], based on analysis of international and intercultural encounters, identified sense of presence with a state of consciousness in which one experiences "realness, vividness, and feeling very much alive," "attending to the immediate situation," "a perception of thinking and acting in new and innovative ways," and "a broad awareness of everything around." Held and Durlach [Held and Durlach 1992] discussed the need to define sensorimotor and cognitive factors that determine a sense of presence. Mowafy, Russo and Miller [Mowafy at al. 1993] investigated the role of presence in training tasks involving construction of mental models of spatial relationships. Finally, Pausch, Shackelford and Proffit [Pausch at al. 1997] have demonstrated a generic search task in which users perform better in an immersive environment than in a stationary display window.

Due to the complex nature of the sense of presence, there are a good number of unanswered questions. This and prior studies attempt to provide some insights. Therefore, the authors will use their experiences from the VRT experiments that they have conducted over the prior decades. For simplicity, in this article, the main definition of presence that will be used is the awareness or state of the mind of being in an environment, either real or virtual [Psotka 1993, Usoh at al. 1999, Nunez and Blake 2001].

## 3 General Factors Affecting Presence

A broad search of literature on the topic demonstrates that there are many factors that contribute to one's sense of presence. Many studies have been conducted, but one in particular by Sheridan summarizes and gives some additional enlightenment on the subject. According to Sheridan, there are four major categories of variables that affect a person's immersion in an environment. The first variable proposed is the amount of "information quantity" that gets through to the participant, which depends on whether the participant is paying attention or experiencing visual distractions, noise variances, etc. The second variable presented is "sensor position/orientation," which deals with the head-tracking devices and the degree of corresponding visual feedback. The third variable suggested is the "change of relative location of objects" in response to both static feedback, such as gravity, and direct manipulation commands. The fourth variable projected is "the active imagination in suppressing disbelief." This factor is the most difficult to control and generally relies on a large enough participant base to even out differences [Sheridan 2000]. Although several different categories of factors affecting presence have been proposed by other researchers, one is worth particular mention here. According to J. Steur [Steuer 1992], there are three more factors involved with a person's presence in virtual reality: *vividness, interactivity,* and

*influence of user's characteristics.*

Because there was no direct manipulation in any of the VRT experiments examined by this study, the third variable that Sheridan lists was not used. However, care was taken to keep a standard across participants so that the other variables introduced above, especially sound, visual distractions and the head-tracking device, were constants for the data sample. Both environmental and psychological complex factors are what make typical subjective measures of presence hard to work with. On the other hand, studies deploying objective measures of presence are not reporting easier approaches.

## 4 Basic Measuring of Presence

Based on related literature reviews and the authors' extensive research on VRT, there are several practical methods to measure presence. One conventional method to measure presence is to observe how people react to the stimulation physically or virtually (under the VRT influence); this may be termed "behavioral presence" [Witmer and Singer 1998, Zeltzer 1992, Ashcraft and Kirk 2001, Wiederhold and Wiederhold 1998, Pugnetti at al. 1996]. Simply put, behavioral presence is focused on the movements of the subjects and on spontaneous speech. Furthermore, a study headed by Dillon [Dillon at al. 2001] discussed some of the issues that arise when attempting to measure presence. To resolve these issues, physiological measures of presence have been proposed to be the most accurate and objective possible measurement. While post-test subjective rating scales seem to be most common way of measuring presence, "the objective and continuous measures could provide additional information about viewing experiences which are not tapped by post-test subjective rating scales, which may be prone to demand characteristics and memory biases." [Dillon at al. 2001] Finally, in an in-depth study that compared heart-rate monitoring, skin-conductance monitoring, and survey methods, Dillon concluded that "physiological measures are an addition to, not a replacement for, subjective presence measures." [Dillon at al. 2001] For these reasons, the authors utilized post-test and self-reported subjective rating scales that were administered by questionnaires either during or immediately after each experiment [North and North 2016].

## 5 Assertions Concerning Presence within VRT

As pointed out by several authors [Held and Durlach 1992, Sheridan 1999, Slater 2002, Slater and Steed 2000], we have not yet developed a scientific body of knowledge or theory delineating the factors underlying the phenomenon of virtual presence. There is, however, an emerging general consensus within the virtual reality and teleoperations community on several issues that are important to the development and scientific use of the concept of virtual presence. Based on the literature and our own extensive experience, there are many open questions concerning virtual presence in virtual reality situations. The authors introduce a few of these questions here and attempt to answer them empirically either individually or collectively:

- *Is there a sufficiently useful operational and quantitative definition of virtual presence?*
- *What are the factors that create virtual presence?*
- *How can virtual presence be quantified?*
- *What are the factors that create virtual presence?*
- *Is there any relationship between virtual presence and subject performance?*
- *What is the difference between virtual presence and physical presence, and is there a relationship between the two?*

On the following pages, the authors attempt to provide some limited answers to these questions. Based on the collected data from the VRT experiments and our observations of subjects' behavior, we make several assertions concerning the sense of virtual presence:

- *A person's experience of a situation in a virtual reality may evoke the same reactions and emotions as an experience in a similar real-world situation.*
-

All of our research studies of psychological treatment categories demonstrated that people who are agoraphobic in the real world are also agoraphobic in a virtual world. When subjected to virtual phobic-invoking situations, our subjects exhibited the same types of responses as would be exhibited in a real-world situation. These responses included anxiety, avoidance, and physical symptoms.

As a measure of anxiety, subjects were repeatedly asked to rate their current level of anxiety on a Subjective Unit of Distress Scale (SUDS) scale. The relatively high SUDS scores at the beginning of each treatment session indicated that the subjects' fear structures were invoked and the SUDS scores (and thus fear levels) gradually decreased as subjects remained in the virtual scene.

A second measure of anxiety was subject behavior and verbalization. Examples of common subject behavior included tightly gripping the rails and displaying reluctance to let go of the rails. These are some of the verbal expressions we recorded: "The higher I get, the more worried I get." "I am really there!" "It feels like being in a real helicopter." "I am afraid to fall down!" "I do not like this at all!" "I am scared!" "I feel like I am actually on the fiftieth floor!" Physical symptoms reported by subjects included shakiness in the knees, heart palpitations, tenseness, sweaty palms, and dizziness.

- *A person may experience a sense of virtual presence similar to the real world even when the virtual reality does not accurately or completely represent the real-world situation.*

Remarkably, subject reactions consistent with phobic stimuli were experienced in spite of the fact that their virtual experience did not correspond to the real-world experience in several ways. All visual environments were much less detailed than a real scene would have been, and some environments included much simpler auditory and tactile cues, such as the engine sound and vibration designed to approximate the Apache AH64 helicopter in a fear of flying study.

As stated previously, the subjects reported a number of physical and emotional

anxiety-related symptoms such as dizziness, sweaty palms, and heart palpitations. These feelings would not have been reported by the subjects if they had not perceived that they were experiencing a realistic situation, even though the virtual environments were far from being exact copies of real world scenes.

- *Each person brings her own background into a virtual reality experience.*

It is important to recognize that perception is in many ways just as much a product of our previous experiences as of current stimulation. Each subject is a unique, special individual with an independent experience of reality that is unique and different from the objective world, or the so-called world of reality. The implication for virtual environments is that the sense of virtual presence is dependent not only on the physical qualities (resolution, realism, interactivity, lag time, etc.) of the experience provided by the virtual environment, but also upon what the participant psychologically brings to the environment. The very nature of perception causes each person to react differently to the same real or virtual experience.

This was evidenced by SUDS and the verbal comments of the subjects. Just as various individuals may react differently to a real world experience, our subjects exhibited different reactions to the same virtual world experience. This point was clearly demonstrated by the variety of responses among subjects to the same phobic stimuli in the virtual scene. Several subjects went through several levels of phobic situations without reporting any significant anxiety. On the other hand, many subjects reported differing amounts of anxiety at different levels of the virtual scene. There was major variation in the amount of time subjects spent in each level of the virtual scenes.

- *Experience with a virtual reality increases the participant's sense of virtual presence.*

The idea that a sense of virtual presence may increase with experience has been suggested by several researchers [Naiman 1992, Loomis 1992, Held and Durlach 1992, Heeter 1992]. Our experiments verified this hypothesis, in that the longer subjects stayed in the virtual scene, the deeper they were pulled into the virtual world and the greater their sense of virtual presence.

Based on SUDS and verbal comments during the experiments, most subjects initially felt some level of virtual presence in the phobic situation, and their sense of virtual presence increased over time, or at least was maintained, during all of the sessions.

- *The sense of presence in virtual and physical environments is constant. Subjects have to give up the sense of presence in a physical environment in order to achieve a stronger sense of presence in the virtual one.*

This assertion is based on the data drawn from SPSVP (Sense of Presence Scale in Virtual and Physical environments) and SUDS questionnaires. The SPSVP was designed to assess one's sense of presence in the virtual and physical environments, sense of interactivity with the virtual environment system, and perception of the real

world as reflected in the virtual environment.

The subjective measures of sense of presence in the virtual environment increased gradually during each session. The subjective measures of sense of presence of the physical environment while in the virtual environment decreased gradually within and between sessions. These results led to the conclusion that the longer subjects remained in the virtual environment, the higher the experienced sense of presence in the virtual environment (even when using very minimal stimuli), and the lower the experienced sense of presence of the physical environment. This supports a theory that the total sense of presence is constant, and subjects have to divide their overall sense of presence between the virtual and real worlds.

- *Subject concentration increases significantly in the virtual world as compared to the physical world when the subject has enough interaction to develop a strong sense of virtual presence.*

Each subject's interest level in the learning study was determined by a ten-point scale instrument administered at the end of each experiment. The scores ranged from very weak to very strong. The interest level and sense of control level in the virtual world were always higher than the scores in the physical world.

Based on the data and observation, it was obvious that each subject was excited, enthusiastic, and eager to be in the virtual environment rather than the physical environment. The main conclusion of this research was that memory span increased significantly in the virtual environment as compared to the span in the physical environment, and that the learner's motivation and interest levels may be maintained longer in the virtual environment. We hypothesize that at least a part of this effect may be due to the simplicity of the virtual environment, providing less distraction to the learner.

- *A person's perceptions of real-world situations and behavior in the real-world may be modified based on her experiences within a virtual world.*

Most applications of virtual reality are intended to augment human intelligence by either increasing or modifying a person's *intellectual understanding* of the structure or nature of objects or tasks [Bajura at al. 1992]. A virtual environment can also modify users' perceptions of real-world situations and thus their behavior in those situations.

This conclusion is based on the reports of subjects who exposed themselves to real-world phobic situations after receiving VRT treatment. What was learned and experienced in the virtual reality was transferred to real-world perception and behavior.

## 6 Conclusion and Discussion

We now return to our list of open questions concerning *virtual presence.* Our purpose is not to completely resolve the questions but to suggest some answers and intellectually excite other researchers to conduct experiments in order to more systematically analyze and study this most important factor of virtual reality, the

sense of virtual presence.

- *Is there a sufficiently useful operational and quantitative definition of virtual presence?*

The answer to this question is mixed. Useful? Yes. Operational? No. Quantitative? Yes, with some qualification.

A number of definitions of presence have been offered in the literature. The definition that we introduce is a variation of the definition offered by Sheridan [6].

> *Virtual Presence is* ***the perception of being physically present*** *in a computer generated or remote environment.*

Our basic assertion in this definition is in agreement with that of Loomis (1993) that "the phenomenology of synthetic experience is continuous with that of ordinary experience." While this assertion may at first appear rather trivial, it is, in fact, of extreme importance. Those subjects who appear to become the most immersed in virtual environments (and who often benefit the most from such exposures) frequently are heard to make comments such as "This is just like the real thing," or "I'm really getting up there now." With a strong sense of virtual presence, the subject is not merely being entertained by a nice computer game, but has instead entered an alternate world, which is assumed to operate under the same set of rules as the real world.

Unfortunately, the acceptance of such a definition recognizes sense of virtual presence as a perception, a private experience that cannot be readily defined in operational terms. This does not, however, mean that sense of virtual presence cannot be quantified. Self-report scales, while always subject to question, can certainly yield quantitative data, and our experience has been that these reports show significant reliability and validity.

- *What are the factors that create virtual presence?*

In the spirit of previous models by Zeltzer [Zeltzer 1992] and Sheridan [Sheridan 2000, Sheridan 1999], we present our own three-axis taxonomy of a *sense of virtual presence*. A participant's sense of virtual presence in an environment may be represented by three primary determinants:

1. *Fidelity and extent of sensory information.* This axis corresponds closely to the "sensory information" axis proposed by Sheridan [Sheridan 1999] or the "presence" axis proposed by Zeltzer [Zeltzer 1992] and can be measured with respect to the quality and quantity of information that is available to a person experiencing a virtual environment.

2. *Participant's interaction.* This axis corresponds to the interaction between a participant and the environment. On a basic level, it would include the ability of a

participant to modify his point of view through head movement, or to interact with objects (or other participants) in the environment.

3. *Previous life experience of the participant.* This axis represents the existential world (or personal reality) which the participant brings to the virtual environment, in the sense that a person's perception is not merely a reaction to the present sensory environment, but also an interpretation of that environment in light of all the individual's previous experiences.

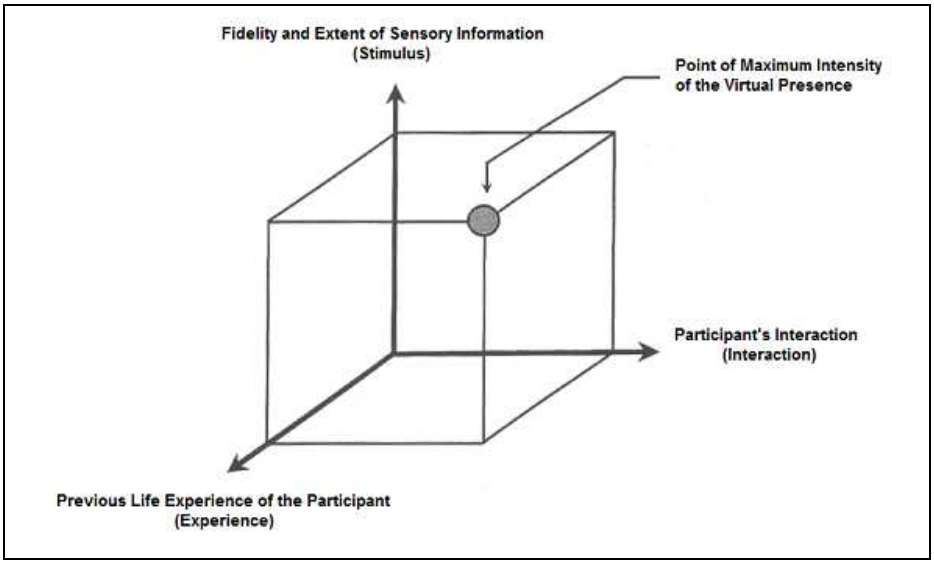


*Figure 1: Stimulus, Interaction and Experience (SIE) Cube*

Figure 1 illustrates these three determinants of virtual presence as orthogonal axes of a Stimulus, Interaction and Experience (SIE) cube. We postulate that a sense of virtual presence may be associated with every point inside the cube. The intensity or vigor of the sense of virtual presence would, in general, increase as we move along each axis. Our understanding of virtual presence differs from previous models in several respects. Previous taxonomies have ignored the notion of experience as a primary determinant of the nature and intensity of a user's sense of virtual presence for a given situation or task. Our work with agoraphobic subjects and other subjects has clearly illustrated that what the user psychologically brings to the environment is important to her perception of the environment and cannot be ignored.

- *How can virtual presence be quantified?*

At first glance, this would appear to be a difficult task, since virtual presence is a subjective experience. It has been our experience, however, that subjective measures of virtual presence are highly reliable and valid, a conclusion supported by Thyer et al [Thyer at al. 1984]. Their study showed a high correlation between subjective

measures and physiological measures of arousal.

- *Is there any relationship between virtual presence and subject performance?*

This is an area that needs more extensive exploration, but the question can be answered with a reasonably strong "yes." While quantitative data is limited, we have gained the strong impression in a variety of situations that subjects with the greatest virtual presence also tend to perform best and improve most in the virtual environments.

- *What is the difference between virtual presence and physical presence, and is there a relationship between the two?*

As mentioned above, we have explored this question directly, finding that there is a strong negative correlation between virtual presence and physical presence. Our current hypothesis is that there is basically a fixed total amount of presence, which can either be devoted totally to the physical world, devoted totally to the virtual world, or split between the two. Such a hypothesis seems consistent with our common experience with standard media, where serious immersion in a book or movie is often accompanied by decreased awareness of physical stimuli from the real world.

In conclusion, while there is certainly much work to be done in exploring the phenomenon of virtual presence, we are well on our way to answering many of the most basic questions in this area. With the strong resemblance between virtual presence and physical presence, it appears certain that virtual reality will soon move far beyond the arcade, because many forms of learning, training, and therapy can be performed much more quickly, easily, economically, and/or safely in the virtual world than in the real world.

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## Appendix A

Virtual Reality Therapy (VRT) is an innovative new modality of therapy using technology that allows clients to enter a computer-generated environment and confront what troubles them. In our VRT experiments, a set of fear- or anxiety-provoking scenes were created for each type of disorder. Standard screening tests were conducted to determine the severity of client disorders. Only the clients who met DSM (Diagnostic and Statistical Manual of Mental Disorders) criteria were invited to participate in the VRT experiments. After the clients became familiar with the VRT system, clients were exposed to eight to ten weekly sessions, each lasting 15 to 20 minutes. The VRT sessions began with the least fearful scene and progressed to more fear-provoking scenes as the clients felt comfortable to encounter them. Discomfort was measured every few minutes with the Subjective Units of Disturbance (SUD) scale. Clients rated their discomfort on a scale of 0 to 10. They progressed systematically through each level of discomfort and then were exposed to the next fearful scene. In some cases, a heart-monitoring Device and/or EEG/EMG was employed to monitor physical reactions of the clients. Over the past two decades, approximately 253 clients (72% male, 28% female, ranging from 18 to 46 years old) have participated in the VRT experiments conducted by the authors. A majority of the clients showed statistically significant improvement toward facing their fears in the real-world situation after completing the VRT experiments. Details of each individual VRT experiment can be found in the references [North et al. 1995, North and North 1996, North and North 1994, North et al. 1996, North et al. 1997].