Virtual Reality Exposure Therapy: 150-Degree Screen to Desktop PC

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ABSTRACT

Virtual reality exposure therapy (VRET) developed using immersive or semi-immersive virtual environments present a usability problem for practitioners. To meet practitioner requirements for lower cost and portability VRET programs must often be ported onto desktop environments such as the personal computer (PC). However, success of VRET has been shown to be linked to presence, and the environment’s ability to evoke the same reactions and emotions as a real experience. It is generally accepted that high-end virtual environments (VEs) are more immersive than desktop PCs, but level of immersion does not always predict level of presence. This paper reports on the impact on presence of porting a therapeutic VR application for Schizophrenia from the initial research environment of a semi-immersive curved screen to PC. Presence in these two environments is measured both introspectively and across a number of causal factors thought to underlie the experience of presence. Results show that the VR exposure program successfully made users feel they were “present” in both platforms. While the desktop PC achieved higher scores on presence across causal factors participants reported they felt more present in the curved screen environment. While comparison of the two groups was statistically significant for the PQ but not for the IPQ, subjective reports of experiences in the environments should be considered in future research as the success of VRET relies heavily on the emotional response of patients to the therapeutic program.

INTRODUCTION

While making a diagnosis of schizophrenia is relatively straightforward, understanding and empathizing with how hallucinations make a patient feel can be very difficult. The hallucinations experienced in schizophrenia are difficult for patients to describe, which makes it hard to imagine the sensations experienced by these patients. Therapists can have difficulties learning about the exact nature of schizophrenia, as they have no personal experience of it.³ A number of virtual environments have been developed to model the experience of schizophrenia, recreating audio and visual hallucinations, to educate psychiatrists and other mental health workers.³-⁴ These environments, allow professionals to gain first hand knowledge of what it is like to experience psychotic hallucinations. These programs have been shown to result in increased empathy of psychiatry students with people who have schizophrenia, potentially leading to reduced stress and alienation of their patients and better patient outcomes.⁵

Virtual environments (VEs) have been used to assist people with schizophrenia to recreate their experiences, not only so therapists can better

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understand them but also to facilitate medical investigations of the disorder, including into functioning of the hippocampus. Virtual reality (VR) has also been proposed by a number of researchers as a new medium of cognitive behavior therapy for patients with schizophrenia. Exposure therapy or cognitive behavior therapy allows a patient with schizophrenia to realize the control they have over their symptoms and to understand that the symptoms are not life-threatening. Through the processes of habituation and extinction, in which feared hallucinations cease to elicit the same extremes of behavioural and psychological response, their meaning ultimately becomes less threatening to the patient with schizophrenia.

**Virtual reality exposure therapy and presence**

Immersive virtual reality exposure therapy (VRET) is proving invaluable to patients suffering from a range of mental illnesses including many phobias such as fear of heights, flight, and spiders, especially those who do not respond to traditional exposure therapies. It is the illusion of being in a different place that is essential for the effectiveness of these applications. To denote this illusion, the term “presence” is used.

Psychologically, a successful virtual experience will make the user become involved in the world to the point where he or she experiences a sense of presence in the virtual world or of “really being there.” Presence has also been described “as the subjective experience of being in one place or environment, even when one is physically situated in another.”

Sense of presence has been widely researched as a key construct facilitating the effectiveness of VR in therapy. In these studies it mostly assumed that the higher the level of immersion the higher the sense of presence. Thus, it is assumed the more inclusive, extensive, surrounding, and vivid the VE the higher the sense of presence. Presence in VRET ensures the anxiety-evoking situation recreated will evoke a similar emotional response to *in vivo* therapy. The advantages of VRET compared to exposure *in vivo* include, no loss of patient confidentiality since the treatment sessions can be performed in the therapist’s office and increased safety as VRET can be terminated by the patient must first learn how to manipulate the software with the mouse and keyboard before gaining confidence with the environment. For this reason, it has been suggested that the desktop VE might be perceived as less immersive. Using physiological measures of presence; however, Weiderhold et al. found that changes to heart rate did not differentiate between HMD and PC interfaces for participants accessing simulated flight plans. Despite this, users did report feeling more immersed in the HMD environment.

A study by Banos et al. compared three immersive systems (a PC monitor, a rear projected video
wall, and a HMD). Their aim was to test the role of immersion and media content on the sense of presence and to determine if presence could be enhanced in less immersive VE s by using emotional content. They found presence could be enhanced in less immersive virtual environments by using emotional content. Therefore, while both immersion and affective content have an impact on presence, immersion was more relevant for non-emotional versus emotional environments.

Already, much research has been devoted to finding what factors can contribute to a sense of presence in VR. Several researchers have constructed categorizations of these factors: however, prior studies have all approached presence in a variety of ways with a variety of definitions. Banos et al. approached Presence as being determined by media characteristics and user characteristics. Pauch et al. demonstrated a range of other variables that impact a user’s sense of presence, for example, displays, motion, and control devices. A large number of presence measures use a factorial approach to measurement in which the factors have been shown to be causes of presence. A widely accepted set of presence causal factors that have been developed over many years by Witmer and Singer include measures of control, sensory, distraction, and realism factors.

As alternatives to causal factorial approaches to presence measurement another approach is to ask users to retrospectively introspect on their experiences in the VE. The main criticisms of introspection are related to the need for subjectivity in responses. Slater claims self-report is not appropriate for measuring presence because the measurement becomes inexplicably tied to personal aspects of the user. For example, Nisbett and Wilson argue that introspective reports do not function as memories of mental process, but rather they are a process of the subject constructing an explanation of their behaviour based on personal theories of behaviour. Even if VE participants have the same experience, therefore, it is unlikely they would report the identical experience. However, the measurements of causal factors of presence also rely on self-report. In utilizing any self-report measure of presence, it must be considered that results can be tied to the personal aspects of the user.

The current study measures presence in a VRET program for schizophrenia that was created and developed using the 150-degree semi-immersive environment. The program takes the user for a walk through a hospital psychiatric ward during which a number of audio and visual hallucinations appear, disappear, and reappear repeatedly. The VE was designed to recreate the experiences described by patients with schizophrenia. The VRET has been previously experienced by students of psychology and psychiatry, and while presence was not measured, the program did elicit emotional responses which were reported to have increased understanding and empathy for patients with schizophrenia. The software was created however to provide an advanced option for delivering exposure therapy thereby adding to the range of tools currently available with which to treat schizophrenia. Use of a 150-degree semi-immersive curved screen in therapy, however, presents a usability problem for practitioners. To meet practitioner requirements for lower cost and portability, the schizophrenia VRET has been ported to desktop PC. This is likely to have impacted the presence of the program and may have important implications given the need for any VRET program to evoke the same reactions and emotions as a real experience.

The primary research goal is to determine how presence of the VRET for schizophrenia in its initial research environment of 150-degree semi-immersive curved screen compares to presence of VRET for schizophrenia after it is ported to PC.

METHODS

In order to study the effect on presence of porting the schizophrenia VRET software to a PC, a two-condition design was used. The first group experienced the schizophrenia software via a non-immersive desktop PC. The second group experienced the software via a semi-immersive environment consisting of a curved screen of 2.5-m radius, affording 150 degrees field of view.

Participants

Twenty-four participants were recruited for the study from the University of Queensland. They were 18 females and six males. Participants were recruited from both the Information Technology and Psychology Departments. None had any prior involvement in the research project. Most of the participants were students (16 undergraduates and two Ph.D. students). There were six members of staff, which comprised three academics and three administrative workers. The mean age was 28.6 (SD = 13.2 years), with a range of 18–57. Two groups of 12 participants were randomly allocated to one of the two experimental conditions. Participants volunteered to take part in the study, and informed consent was gained.
Measures

Causal factors. Measures of causal factors rely on self-report, but are not classed as introspective, as they do not require participants to report on their subjective feelings but rather gauge their perceptions of various factors or variables that have been demonstrated to influence the experience of presence. While many questionnaires and surveys are available to attempt to measure presence via causal factors only a small number of these have gained widespread use.\cite{34} The Presence Questionnaire (PQ), developed by Witmer and Singer, is one survey that has gained a significant level of acceptance and has been tested across a number of studies.\cite{35,36} For these reasons it was selected for this study. The PQ is comprised of 30 items each of which is of the semantic differential type. No items directly query the subject about the experience of presence. All four factors measure participant’s perception of display system features. They are as follows:

1. Control works on the hypothesis that in general the more control a person has over the VR task environment the greater the experience of presence will be. For example if they are able to anticipate or predict what will happen next in the VE and if they are able to modify physical objects and thereby their control over the VE the more presence should be experienced.

2. Distraction measures factors which act to make the user feel isolated from the real environment such as natural interfaces and reduction of ambient noise which allow the user to fully concentrate on the VE. The more a user is facilitated to focus on the VE and able to ignore external distractions the higher their experience of presence will be.

3. Sensory factors are included because any information presented via other sensory channels in addition to vision also enhances the ability of a user to become more fully immersed in a VE. The hypothesis being that an environment which conveys little information to the senses will decrease sense of presence.

4. Realism factors refer to those that measure meaningfulness of the experience to the user such as consistency of the information with what the user knows of the real world.

Because the content of the software is conveying hallucinations and cannot, therefore be understood or made sense of with reference to the real-world this last factor of realism was not measured in the current study. Only the first three factors of control, sensory, and distraction were included in a version of the Witmer and Singer\cite{13} survey in which modifications were restricted to removing the realism factor items.

Introspective measure. As introspective measures of presence have also gained significant acceptance as an alternative measure of presence the introspective Igroup Presence Questionnaire (IPQ) was also used.\cite{29} The IPQ consists of 13 items, which are aimed at measuring spatial presence (the sense that a VE is a real place) through asking participants to report on their own individual experience through questions such as, “How real did the virtual world seem to you?” Several research projects have investigated the reliability and validity of the IPQ’s psychometric properties.\cite{29} While some of the IPQ items are not introspective the majority are and in light of its prior testing and subsequent widespread use it was selected for this study to add to the factorial measures of Presence provided by the Witmer and Singer PQ.

Virtual environment

Software

The virtual environment consisted of a psychiatric ward in which users could experience simulated visual and auditory hallucinations. Structures comprising the virtual environment such as the ward building and furniture were built using a 3D modeling package. The software loaded and positioned these structures, and coordinated the audio track and the movements of objects in the scene.\cite{33} The software was written in C++, and used the OpenSceneGraph library (<www.openscenegraph.org>) for scene management. The cross platform nature of this library allowed the software to be developed on a Windows-based PC platform and then ported to the IRIX platform used in the immersive environment.

Hardware

Desktop PC. The PC platform used consisted of a 1.8-GHz Pentium-4 laptop running Windows. The PC had a 15-inch screen and 64 M of graphics memory.

Curved screen. The semi-immersive environment was located at the Visualisation and Advanced Computing (VISAC) laboratory at the University of Queensland. These facilities include a
curved screen of 2.5-m radius, providing 150-degree field-of-view. Three Barco projectors, separated by 50 degrees, were used to project the images onto the curved screen. The system is driven by an SGI Onyx Infinite Reality 3 comprised of four processors, 2-Gb memory, 256-Mb texture memory, and 1Graphics Pipeline.

Procedure

Participants had been provided with a research information sheet that described the purpose of developing the software and the aims of the present study. In both conditions participants experienced the psychiatric ward in the same sequence. That sequence commenced outside the hospital entering through the main front doors, proceeding down a hall and entering the ward at the central nurse’s station. From there participants proceeded to the common lounge area, passed through this into a far hall and entered finally into a twin bed room.

While travelling through this sequence of rooms, at predetermined points, subjects would encounter a frightening visual hallucination (in this case a representation of an abusive Virgin Mary) and move closer to it. When the subject approached the hallucination closely it would disappear and re-appear in a different position. Successful completion of the task involved travelling the sequence of rooms and experiencing the hallucination a set number of times in predetermined positions. This kept the experience standard across participants.

In the semi-immersive condition participants sat on a chair and passively watched the sequence on a curved screen 5 m in diameter and 2 m high, providing 150-degree field-of-view. They were immersed in the psychiatric ward for approximately 5 min. Immediately following the experience, they were taken to an adjoining room to complete the questionnaires.

In the non-immersive condition participants sat in front of a desktop PC and navigated themselves through the virtual ward with the keyboard and mouse. For the purposes of this research, the software, initially written for the curved screen, was modified so that hallucinations occurred only at certain predefined locations, instead of randomly. This was to ensure that participants in this experiment, who all traveled the same path through the scene, would all experience the same sequence of events. Participants were given one-on-one training in the virtual environment for approximately 5 min without the audio component of the experience and without the hallucinations. The purpose was to allow participants to become comfortable with the control device without pre-experiencing the VE. During this training time the software author explained how to self-navigate through the program and the sequence of rooms to traverse was outlined. They were then required to practice navigating through the virtual psychiatric ward moving through the sequence of rooms once. On conclusion of the practice run participants could ask questions or discuss any difficulties associated with self-navigation in the VE. Finally, the participants were left alone to be immersed in the psychiatric ward. Completion of the task took approximately 5 min. As with the semi-immersive condition, immediately following the experience they were taken to the adjoining room to fill out the presence questionnaires.

Statistical analysis

Data were subjected to multiple independent t-tests.

RESULTS

Means, standard deviations, and results of independent t-tests for each presence questionnaire and the PQ sub-factors can be found in Table 1. The questions were designed so that larger response values indicated greater presence in the VE. Responses were analyzed separately for each question; also, the responses across the items of IPQ, the PQ, and the questions for each of the PQ sub-factors of control, sensory, and distraction were pooled separately for further analysis. A Kolmogorov-Smirnov test revealed the IPQ data (desktop, \(p = 0.57\); semiimmersive screen, \(p = 0.81\)) and the PQ data (desktop, \(p = 1.00\); semi-immersive screen, \(p = 0.28\)) was consistent with a normal distribution. Due to the two group design multiple independent t-tests were used to calculate the statistical significance of group differences over each of the presence measures and across sub-factors. The small sample size does increase risk of Type 1 errors however analysis of variance is not recommended for study designs in which less than three groups are being compared. The choice of independent t-tests was therefore evaluated as the more appropriate option.

Comparison of means show that the semi-immersive screen users scored their experience of
presence higher on the IPQ than the desktop users. However this difference was not significant, $t = 0.778$ $p = 0.445$. A statically significant difference did exist between the mean scores for the two groups for the PQ, $t = 2.78$, $p = 0.011$, with the desktop users reporting increased experience of presence. However, across the sub-factors of the PQ, only the control factor had a significant effect on presence, $t = -6.28$, $p = 0.0001$. Across the two groups neither the distraction nor the sensory factors revealed any significant effect on the experience of presence.

The analysis indicates that IPQ items measuring presence introspectively are experienced more positively by the semi-immersive screen group but not significantly so. PQ items measuring the casual factors of distraction and sensory had comparatively equal influence on the experience of presence across both groups. The causal factor of control however was experienced as significantly of more effect in the desktop group.

### DISCUSSION

The aim of this study was to determine the impact on presence of porting a virtual exposure therapy environment from the research environment of a 150-degree semi-immersive screen to a more portable and cost-efficient desktop environment. Based on some prior research on the immersive properties of the higher-end VR interfaces it could have been expected that the desktop may score lower on presence than the semi-immersive screen. While a stronger sense of presence was reported from the 150 degree screen group over introspective measures this difference was not significant. In contrast, the desktop group did report significantly higher levels of presence via a causal factor measure of presence; however, this result appears to have been achieved solely through the one sub-factor of control. As the desktop environment did not score more highly than the semi-immersive screen across any of the other sub-factors, this result should be interpreted with caution.

The factor of control differed across the test environments in the following ways. Those participants interacting with the large screen had no navigation control, while in the PC condition navigation was controlled through a mouse. Presence is usually enhanced when the user can exert a greater level of control over the task environment or has an increased ability to interact in the environment. Having navigation control in the desktop environment meant user actions taken to modify the environment such as the opening of doors within the psychiatric ward were under full control of the user. In contrast the experience for participants in the semi-immersive screen group included the automatic opening of doors as they approached them. To some extent both groups would have learned that they could safely anticipate the reaction of doors to their approach however desktop users had more direct ability to modify the position of doors. This held for other physical objects in the ward. If immersive screen users had been given a control device such as a wand they would most likely have also, to an increased extent, anticipated that the environment would react to their directions given via the control device. In addition, although not in the full virtual experience as some visual and all auditory simulations were withheld, users in the PC group did receive some prior training giving them

### TABLE 1. MEAN SCORES AND T-TEST RESULTS FOR THE DESKTOP AND 150-DEGREE SEMI-IMMERSIVE SCREEN GROUPS FOR THE IPQ AND PQ PRESENCE MEASURES

<table>
<thead>
<tr>
<th>Presence measures</th>
<th>Desktop group (n = 12), mean (SD)</th>
<th>Semi-immersive group (n = 12), mean (SD)</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPQ</td>
<td>48.75 (10.6)</td>
<td>52.25 (11.4)</td>
<td>0.778</td>
<td>0.445</td>
</tr>
<tr>
<td>PQ</td>
<td>86.66 (10.7)</td>
<td>73.50 (12.4)</td>
<td>2.78</td>
<td>0.011</td>
</tr>
<tr>
<td>PQ factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>29.50 (5.33)</td>
<td>15.16 (5.83)</td>
<td>-6.28</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Distraction</td>
<td>29.08 (5.53)</td>
<td>32.08 (5.53)</td>
<td>1.33</td>
<td>0.20</td>
</tr>
<tr>
<td>Sensory</td>
<td>27.25 (3.14)</td>
<td>26.25 (6.24)</td>
<td>-0.496</td>
<td>0.62</td>
</tr>
</tbody>
</table>

$p < 0.05.$
further advantages in terms of anticipation. Taking these conditions into consideration, the resultant differences between groups over the control factor could have been predicted.

Other results within the sub-factor of control were less predictable. While users in the semi-immersive group did not have a direct control device, they still reported in some questions an experience of control equal to that in the desktop group. For example, participants where asked, “How natural did your interactions with the environment seem?” Lack of a control device did not appear to interfere with the experience of moving through the ward feeling natural to users. In fact, having to use a mouse in the desktop group could have been predicted to decrease the experience of presence, but this was not reported.

For the sub-factor of sensory, information presented to sensory channels was restricted to visual and audio in both conditions. The software was the same in both conditions so the environments convey the same information to those senses. The multimodal variable was also held constant as widescreen users were not given any locomotion devices and were required to sit in a specified position for viewing the ward. The similar experience reported from both groups across this sub-factor of sensory supported prior research on this causal factor.

In the distraction factor the experience of isolation differed across conditions. This was of particular interest as it was difficult to determine prior to the experiment which device would isolate users from their actual physical environment and thereby increase presence—unlike control in which it was highly likely that PC would score higher. Though the curved screen did not provide a device which allowed users to interact with the environment it also, on the other hand, was not negatively affected by an unnatural or clumsy device. The mouse in the PC condition may have felt less natural than a walking device, for example, yet the curved screen was more likely to induce simulator sickness.

In the desktop environment users wore earphones which effectively eliminated noises external to the VE such as ambient room sounds. In the semi-immersive screen condition, users wore no earphones making external noises audible. It could have been predicted then that users may have felt less isolated from the real world under these circumstances however this result was not found. Similarly, predictions could have been made as to the impact of interface device awareness on presence. The 150-degree screen group would have had significantly decreased awareness of the interface equipment and its associated control devices as they did not have to concern themselves with understanding how these worked or how to control them. In addition the PC group would have been more likely to have remained aware of their interface device even if practiced with such devices and the control of them. However, results did not reveal a difference in the causal effect of the sensory factor. It may be that in both conditions aspects of the environments which impacted the sensory factor negatively were counterbalanced by those conditions which impacted it positively.

Although not questioned directly on simulator sickness several participants in the semi-immersive screen condition volunteered the information that they had experienced a degree of sickness. Simulator sickness is a form of motion sickness induced by discrepancies between visual, vestibular and proprioceptive information in a VE. The existence of simulator sickness raises the concern that attention is diverted from the psychiatric ward to concern over the unpleasant physical symptoms. Without further investigation of this variable it cannot be clearly determined. However, in a study of PC-based computer games used to provide exposure therapy for anxiety, simulator sickness was found to have no significant impact on either anxiety or presence.

Though this study has demonstrated that porting a virtual exposure therapy environment from a semi-immersive interface to desktop PC does not significantly impact presence, these results need to be considered with caution. The small sample size and differences across some key aspects of the two conditions such as use/non-use of participant control devices mean further investigations are necessary. The study’s findings are of practical importance however. With practitioners’ requirements of affordability and accessibility to be met if the benefits of therapeutic VR exposure programs are to be made more widespread, further investigations of the impact on presence of different VR interfaces need to be made. Therapeutic VR applications require emotional engagement from participants so while the relationship between causal factors and presence need to be further understood subjective reports of users are of equal importance. Future work needs to attempt to make a closer match across causal factors between groups and then retest on subjective measures. Although not significant in this study, the introspective experience of presence reported as higher in the semi-immersive environment needs to be further investigated. It is important to determine more
conclusively if subjective presence is or is not detrimentally impacted by porting to lower-end VR interfaces for therapeutic purposes.

REFERENCES


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