CYBERPSYCHOLOGY & BEHAVIOR
Volume 6, Number 5, 2003

Anxiety and Presence during VR Immersion: A Comparative Study of the Reactions of Phobic and Non-phobic Participants in Therapeutic Virtual Environments Derived from Computer Games

GENEVIÈVE ROBILLARD, M.Sc., STÉPHANE BOUCHARD, Ph.D., THOMAS FOURNIER, Ph.D., and PATRICE RENAUD, Ph.D.

ABSTRACT

Virtual reality can be used to provide phobic clients with therapeutic exposure to phobogenic stimuli. However, purpose-built therapeutic VR hardware and software can be expensive and difficult to adapt to individual client needs. In this study, inexpensive and readily adaptable PC computer games were used to provide exposure therapy to 13 phobic participants and 13 non-phobic control participants. It was found that anxiety could be induced in phobic participants by exposing them to phobogenic stimuli in therapeutic virtual environments derived from computer games (TVEDG). Assessments were made of the impact of simulator sickness and of sense of presence on the phobogenic effectiveness of TVEDGs. Participants reported low levels of simulator sickness, and the results indicate that simulator sickness had no significant impact on either anxiety or sense of presence. Group differences, correlations, and regression analyses indicate a synergistic relationship between presence and anxiety. These results do not support Slater's[1] contention that presence and emotion are orthogonal.

INTRODUCTION

SPECIFIC PHOBIAS are very common; the lifetime prevalence in the United States is 11.3%.[2] Fortunately, it has been repeatedly demonstrated that these disorders are amenable to exposure therapy. That is, phobic anxiety is reduced by exposing the phobic client to phobogenic stimuli in a systematic manner. This exposure benefits the client by providing them with an experience that extinguishes conditioned responses to the feared stimulus, that modifies the cognitive structures that cause the pathological fear,[3] or that builds their sense of self-efficacy.[4,5]

Ideally, the exposure should be graduated, repeated, prolonged, safe, convenient, and economical. It should be graduated so that it induces a level of anxiety that is neither too low nor too high; anxiety that is too intense can distract the client and interfere with their emotional processing of the experience, and anxiety that is too low can fail to provide corrective information.[3] The exposure should also be prolonged and repeated[6] to provide enough time for the extinction of conditioned responses, and for the emotional processing of the experience. The exposure should be safe so that mishaps do not reinforce conditioned fear responses and dysfunctional beliefs. Finally, for purely practical reasons, it is important that the exposure be convenient and economical.

The provision of optimal exposure can present some serious challenges. For example, an acrophobic client may not have access to elevated sites where they are free to confront their fear repeatedly for as much as an hour at a time. Fortunately, the ex-

Psychoéducation, Université du Québec en Outaouais, Hull, Québec, Canada.

posure does not always have to be to the real stimulus. Imaginal exposure has been found to be effective,[3] but it can be difficult or impossible to elicit a suitable level anxiety just by imagining a feared stimulus.[7] In contrast, exposure to a sufficiently vivid virtual environment (VE) can evoke therapeutic levels of anxiety in a manner that is controllable, predictable, and reliable. Moreover, virtual reality (VR) exposure is safe and convenient.

Despite recent advances in three-dimensional imaging technology, however, VR exposure can be expensive. A commercially produced VE that is suitable for the treatment of only one type of phobia can cost as much as $10,000 US plus the cost of the hardware. In addition to being expensive, these environments are not readily adaptable to the needs of individual patients as it can be difficult to make small changes such as changing the color or size the phobogenic stimuli. Moreover, these environments are usually compatible with only a limited range of display and input hardware.

In contrast, the VEs used in the present study were created using map-editing programs for 3D games. These map editing programs and games retail for less than $50, and they are compatible with most off-the-shelf personal computers. The VEs created with these programs must be distributed for free, a licensing requirement imposed by the games' publishers. In some respects, despite their low cost, therapeutic VEs derived from games (TVEDG) are superior to their commercial counterparts. For example, TVEDGs can be modified by users with little computing experience. Moreover, the graphic quality of TVEDGs can be superior to that of commercial therapeutic environments because the polygonal objects in the game-based environments are finely sculpted, textured, and rendered.

The first goal of the present study is to determine if, despite their low cost and flexibility, TVEDGs can evoke anxiety in phobic clients. Previous studies have shown that exposure in therapeutic VEs can provoke high levels of anxiety in clients afflicted with acrophobia,[8–11] claustrophobia,[12–14] or arachnophobia.[15,16] Given the graphic quality of TVEDGs, and given the effectiveness of commercial therapeutic VEs, TVEDGs might prove to be effective. On the other hand, game VEs are intended to entertain, and non-phobic subjects usually find them amusing. It is necessary, therefore, to document the ability of TVEDGs to induce anxiety. To this end, the anxiety levels of phobic and non-phobic participants are compared following exposure to phobogenic stimuli in TVEDGs.

The second goal of this study is to assess the impact of parameters that may affect the phobogenic effectiveness of VR exposure. Simulator sickness is one such parameter. Simulator sickness appears to be a kind of motion sickness induced by discrepancies between visual, vestibular, and proprioceptive information.[17] For example, when a person turns their head during a simulation, their inner ear produces a sensation of movement a few milliseconds before the computer generates the corresponding visual movement, and they have almost none of the bodily sensations of movement that they would normally experience. The incoherence of these inputs can produce symptoms similar to those of car sickness or sea sickness, and these symptoms could interfere with sense of presence. The effects of simulator sickness are assessed by measuring it both in phobic and in non-phobic participants.

Another parameter that may affect the phobogenic effectiveness of VR exposure is sense of presence.[18] Sense of presence is defined as the feeling of being in an environment even if one is not physically present.[1,19] The hallmark of presence is behavior that is congruent with the subject's situation in the environment.[1]

Presence and emotions are logically distinct; it is possible coherently to discuss the one without discussing the other. Beyond this, however, the relationship between presence and emotions is poorly understood. Slater[1] suggested that presence and emotions are orthogonal. If this is true, then there should be no significant relationships between measures of presence and anxiety. If presence and emotion are not orthogonal, then it is not clear how they interact. Their relationship could be antagonistic. For example, to avoid feeling anxious, phobic subjects could block presence by attending to cues that underline the merely virtual nature of the phobogenic stimuli. Alternatively, presence and emotion could interact synergistically. This could happen if the subjects' emotions made it difficult for them to resist feeling present by interfering with information processing or with attention. Emotion could also enhance presence if the subject interpreted their emotions as evidence of the reality of their experience. The relationship between presence and emotion is addressed by comparing the sense of presence in phobic and non-phobic participants, and by determining the degree of correlation between anxiety and presence. Additionally, assessments were made of the statistical relationships between anxiety and factors that contribute to presence: propensity for immersion, and the perceived realism of the VEs.

MATERIALS AND METHODS

Sample

The sample included 13 participants (nine women and four men) between 18 and 60 years of age who had been diagnosed with specific phobias. These phobic participants were age- and gender-matched with 13 non-phobic participants. The mean ages of the phobic and non-phobic samples were 33.7 and 33.9 years, respectively. The phobic participants were afflicted with a specific phobia of either spiders, heights, or enclosed spaces, and they had no comorbid disorders such as generalized anxiety, depression, psychosis, or substance abuse. The non-phobic participants were not afflicted with any mental disorders. A semi-structured interview and questionnaires were administered to all the participants to ensure that they met these criteria. At the end of the intake interview, a questionnaire was administered to assess the participants' tendency to immerse themselves in VEs.

Procedure

Following sample selection, each of the phobic participants had three sessions of virtual exposure therapy. The present study is based on data collected from the first session; the overall results of the three-session program of therapy have been reported elsewhere.[8,14,15,20]

At the beginning of the first therapy session, the phobic participants were immersed in a VE with no phobogenic cues. The purpose of this neutral immersion was to familiarize them with the equipment and to allow the experimenter to make any required adjustments. Once the necessary adjustments were made and the participants were comfortable with the equipment, they were immersed in TVEDGs that contained phobogenic stimuli: either heights, spiders, or enclosed spaces depending on their particular phobias. Each of these immersions lasted 20 min. During these immersions, the participants were encouraged to approach the phobogenic stimuli as closely as possible. Every 5 min, they gave brief verbal reports of their levels of anxiety, sense of presence, and simulator sickness. Between the immersions, the participants removed the head mounted display (HMD) visors for approximately 5 min. At the end of the session, they gave a verbal assessment of the perceived realism of the VEs, and they were given questionnaires that measured their sense of presence and their symptoms of simulator sickness during the exposure.

The non-phobic participants had one session of VR immersion. As with the phobic participants, the session began with a 5-min immersion in a neutral VE to familiarize them with the equipment and to allow the experimenter to make adjustments. Following the familiarization immersion, the non-phobic participants had two 5-min immersions in TVEDGs. The type of TVEDG (heights, spiders, or enclosed spaces) was determined by the phobia of the phobic participant with whom each non-phobic participant was paired. The virtual locations of these immersions were determined by the phobic participants' verbal anxiety ratings. For example, the consensus among the acrophobic participants was that the most phobogenic location was on top of a construction crane, so that was the immersion site for the non-phobic participants who were paired with acrophobic participants. Like the phobic counterparts, the non-phobic participants were instructed to approach the phobogenic stimuli as closely as possible. After each of their two TVEDG immersions, the non-phobic participants gave verbal reports of their levels of anxiety, sense of presence, and simulator sickness. At the end of the session, they made a verbal assessment of the perceived realism of the VEs, and they were given questionnaires that measured their symptoms of simulator sickness and their sense of presence during the exposure.

Assessment instruments

Sample selection. Prospective candidates were screened with the Structured Clinical Interview for DSM-IV.[21] In addition, the following questionnaires were administered during the selection process to ensure that all the participants met the inclusion criteria listed above.

The *Inventaire des Objets et Situations Générateurs de Peur*[22] (FSS-II-F) is a validated French translation of Geer's[23] Fear Survey Schedule-II (FSS-II). The FSS-II-F uses a seven-point scale to measure the intensity of fear produced by 51 common phobogenic stimuli. The FSS-II-F yields a *Total* score and six subscale scores: *Shyness*, *Phobic Behavior*, *Agoraphobia*, *Blood and Wounds*, *Social Phobia*, and *Anxiety and Depression*.

The *Inventaire d'Anxiété Situationnelle et Traits d'Anxiété*[24] (STAI-Y-F) is a validated translation of Spielberger's[25] State-Trait Anxiety Inventory (Form Y; STAI-Y). The STAI-Y-F includes a 20-item state scale which measures the subject's current level of anxiety (STAI-Y-F1, state anxiety), and a 20-item trait scale that measures their habitual level of anxiety (STAI-Y-F2, trait anxiety).

The *Inventaire de Depression de Beck*[26] (BDI-F) is a validated translation of the Beck Depression Inventory[27] (BDI). The BDI-F is a 21-item questionnaire that uses a four point scale to measure depressive symptoms.

Virtual reality questionnaires. The *Questionnaire sur la Propension à l'Immersion*[28] (ITQ-F) was administered at the end of the intake interview. The ITQ-F is a validated French Canadian adaptation of the Immersive Tendencies Questionnaire[29] (ITQ). The principal differences between the two scales are that unscored items have been omitted from the ITQ-F, and it has a different factorial structure. The ITQ-F has 19 items rated on a seven-point scale (1, *never*; 7, *often*) which provide a *Total* score and four subscale scores: *Focus* (the ability to concentrate and to ignore distractions), *Involvement* (the feeling of being caught up by stories and movies), *Emotion* (the intensity of the emotions evoked by stimuli such as movies), and *Play* (the frequency of playing video games).

Every five minutes during the immersions in the TVEDGs, the experimenter asked the participants to rate verbally their anxiety ("On a scale from 1 to 100, how anxious do you feel?"), sense of presence ("On a scale from 1 tp 100, how much do feel that you really are present in the virtual environment you see?"), and simulator sickness ("On a scale from 1 to 100, how unwell is the virtual reality making you feel?"). The phobic participants' mean Verbal Anxiety, Verbal Presence, and Verbal Simulator Sickness ratings were calculated using the ratings of the first two 5-min periods during which they encountered phobogenic stimuli in the TVEDGs. The non-phobic participants' mean verbal ratings were based on their two 5-min immersions in the TVEDGs. At the end of the session, the phobic and non-phobic participants were asked to rate verbally their perceptions of the similarity between the VEs and equivalent physical environments (Verbal Perceived Realism; "In general, on a scale from 1 to 100, how realistic did the virtual environments seem?).

The *Questionnaire sur l'État de Présence*[28] (PQ-F) was administered at the end of the session. The PQ-F is a validated French Canadian adaptation of Witmer and Singer's[29] Presence Questionnaire. Just as with the ITQ-F, unscored items were omitted from the PQ-F, and it was factorially restructured. The PQ-F's 19 items are rated on a seven-point scale (1, *not at all*; 7, *completely*) that provides a *Total* score and five subscale scores: *Realism* (similarity of the VE and an equivalent natural environment), *Affordance to Act* (ability actively to explore and manipulate the VE), *Interface Quality* (delays or awkwardness related to the software or apparatus), *Affordance to Examine* (ability to approach virtual objects and to examine them from different angles), and *Self-Evaluation of Performance* (the feeling of competence to perform tasks in the VE).

The *Questionnaire sur les Cybermalaises*[30] (SSQ-F) was also administered at the end of the session. The SSQ-F is a French Canadian translation of the Simulator Sickness Questionnaire[31] (SSQ), and it shares the SSQ's factorial structure. The SSQ-F's 16 items use a four-point scale to rate symptoms of simulator sickness such as nausea, eye fatigue, and vertigo. The SSQ-F provides a *Total* score and three subscale scores: *Nausea*, *Oculo-Motor Problems*, and *Disorientation*. Although the SSQ-F is undergoing validation,[30] it is already frequently used in VR therapy research.

Virtual reality apparatus

The VEs were generated by personal computer with a Pentium III® 866 Mhz cpu, 128 megabytes of RAM, and a 64-megabyte ATI Radeon® graphics card. The environments were displayed on a two dimensional I-Glass® (i-O Display Systems) HMD with a resolution of 480 by 640 pixels. The HMD was draped with a 30 by 40 cm black cloth to block out ambient light. The HMD was also equipped with an Intertrax^{2}® tracker that sensed the movement of the participants' heads. Together, the HMD and tracker provided the participants with a view that followed their head movements as they tilted, panned and swivelled their heads to scan the VEs. The participants used a handheld Sidewinder® gamepad to control their forward and backward movements in the VEs. Ambient sounds were played on the PC's stereo speakers.

The TVEDGs were modified computer game environments. The arachnophobia environments were based on Half-Life® (1998–2000), and the acrophobia and claustrophobia environments were based on Unreal Tournament® (2000). For the arachnophobia environments, a computer graphic artist (CGA) used the Half-Life® platform to custom make environments and to populate them with animated spiders of different shapes and sizes. For the acrophobia and claustrophobia environments, the CGA selected suitable environments from among those that were provided with Unreal Tournament®. In each of the environments, irrelevant distractions such as guns, explosions, and enemies were deleted. These TVEDG's can be downloaded from UQO's Cyberpsychology laboratory website (www.uqo.ca/cyberpsy).

RESULTS

Univariate ANOVA analyses show that the phobic participants scored significantly higher on each of the screening measures: the FSS-II-F, STAI-Y-F (both state and trait), and BDI-F (Table 1). These results indicate that the phobic participants did have significantly higher levels of anxiety and depression than the non-phobic participants did.

The phobic clients also had higher overall scores on the other pre-exposure measure: the ITQ-F which measures the propensity for immersion (Table 1). Univariate ANOVA analyses show that this overall difference was due mainly to their higher scores on the *Involvement* and *Emotion* subscales (Table 2). Because of the *a priori* differences between the phobic and non-phobic participants, ANCOVA analyses were performed on the total scores and the subscale scores. These analyses showed no significant covariance effects.

All of the non-phobic participants and all but one of the phobic participants reported being comfortable with the VR equipment. The only exception was a claustrophobic participant who reported anxiety and difficulty breathing while wearing the HMD even before it was turned on. Except for this claustrophobic participant, all the participants reported low levels of anxiety when they were immersed in the TVEDGs if they were in what they considered to be a safe virtual location. The average minimum anxiety levels reported by the phobic and non-phobic participants were, respectively, 13.8 (*SD* 11.9) and 4.6 (*SD* 7.2). The claustrophobic participant´s anxiety ratings ranged from a low of 40, when they in open areas in the TVDEGs, to a high of 75 when they were in enclosed spaces in the TVEDGs.

Univariate ANOVA analyses show that at the end of the session, the phobic participants had markedly higher overall scores than their non-phobic counterparts on the PQ-F, which measures the sense of presence. This overall difference was due almost entirely to the phobic participants' considerably higher scores on the *Realism* subscale. The phobic participants had higher SSQ-F *Total* and SSQ-F *Nausea* scores. This difference was not statistically significant, but its effect size was medium.

Comparisons were made between the phobic and non-phobic participants' verbal reports . Univariate ANOVA analyses revealed some significant differences (Table 3); the phobic participants scored much higher on the mean Verbal Anxiety and mean Verbal Presence scales. The phobic participants also scored somewhat higher on the Verbal Perceived Realism scale. There were no significant differences on the mean Verbal Simulator Sickness scale; both groups reported low levels.

When the phobic and non-phobic participants' results were pooled, statistically significant correlations were found between mean Verbal Presence

TABLE 1. RESULTS OF UNIVARIATE ANOVA ANALYSES OF DIFFERENCES BETWEEN THE PHOBIC AND NON-PHOBIC GROUPS BEFORE THEY WERE IMMERSED IN THE TVEDGS

Questionnaires before exposure	*Phobic (n = 13), mean* (SD)	*Non-phobic (n=13), mean* (SD)	*ANOVA* F *(1, 24)*	*Eta Squared*	*Effect size*
FSS-II-F	132.2 (38.6)	92.5 (25.1)	9.61**	0.29	Very large
IASTA forme Y-1 (state)	37.3 (11.3)	26.0 (4.6)	11.24**	0.32	Very large
IASTA forme Y-2 (trait)	38.8 (8.1)	29.9 (4.2)	12.55**	0.34	Very large
BDI-F	3.38 (3.0)	1.00 (1.5)	6.47*	0.21	Large
ITQ-F					
Total	68.1 (11.3)	57.7 (11.0)	5.64*	0.19	Large
Focus	25.7 (4.4)	24.2 (5.3)	0.45	0.02	Small
Involvement	16.4 (5.5)	12.2 (4.8)	4.37*	0.15	Large
Emotions	14.4 (3.5)	10.8 (5.1)	4.50*	0.16	Large
Play	6.1 (2.6)	5.6 (2.1)	0.35	0.01	Very small

ANOVA, analysis of variance; FSS-II-F, French version of the Fear Schedule Survey-II; STAI-Y-F, French version of the State-Trait Anxiety Inventory Form Y; BDI-F, French version of the Beck Depression Inventory; ITQ-F, French version of the Immersion tendencies Questionnaire. *$p < 0.05$; **$p < 0.01$. Cohen's[36] qualitative criteria for effect size were used. Very small effect size = $f < 0.10$; very large effect size = $f > 0.60$.

TABLE 2. UNIVARIATE ANALYSES OF DIFFERENCES BETWEEN THE PHOBIC AND NON-PHOBIC GROUPS AFTER IMMERSION IN THE TVEDGs

Questionnaires after exposure	*Phobic (n = 13), mean* (SD)	*Non-phobic (n = 13), mean* (SD)	*ANOVA* F *(1, 24)*	*Eta squared*	*Effect size*
PQ-F—total	102.7 (9.7)	93.7 (11.2)	4.81*	0.17	Large
Realism	35.9 (5.0)	28.9 (5.5)	11.62**	0.33	Very large
Affordance to act	21.3 (2.6)	22.2 (4.6)	0.33	0.01	Small
Quality of interface	16.0 (2.6)	16.2 (3.0)	0.02	0.001	Very small
Affordance to examine	17.2 (2.6)	15.7 (2.1)	2.69	0.10	Medium
Self assessment of performance	11.4 (1.9)	11.5 (2.1)	0.40	0.002	Very small
Auditory	12.5 (5.5)	13.3 (5.5)	0.15	0.70	Very small
Haptic	5.5 (3.0)	5.8 (3.5)	0.03	0.001	Very small
SSQ-F—total	26.1 (17.7)	16.7 (17.0)	1.88	0.07	Medium
Nausea	16.9 (14.7)	8.1 (12.8)	2.66	0.10	Medium
Oculo-motor	23.3 (17.9)	16.3 (17.7)	1.00	0.04	Small
Disorientation	27.8 (29.0)	20.3 (25.2)	0.50	0.02	Small

ANOVA, analysis of variance; PQ-F, French version of the Presence Questionnaire; SSQ-F, French version of the Simulation Sickness Questionnaire. $^*p < 0.05$. $^{**}p < 0.01$. Cohen's[36] qualitative criteria for effect size were used. Very small effect size = $f < 0.10$; very large effect size = $f > 0.60$.

and eight other variables (Table 4). A linear regression was performed with mean Verbal Presence, the dependant variable, and these eight other variables; mean Verbal Anxiety was found to be the most important predictor with a part correlation coefficient of 0.33. A stepwise regression was performed with mean Verbal Presence (the dependent variable) and the eight other variables (probability of F to enter $\leq$ 0.05, probability of F to remove $\geq$ 0.10). It was found that the optimal model used only mean Verbal Anxiety to predict mean Verbal Presence (part correlation coefficient = 0.741.

Mean Verbal Anxiety was significantly correlated with 15 scales and subscales (Table 4). A regression was performed with mean Verbal Anxiety (the dependent variable) and the other 15 variables. It was found that the most powerful predictors were pre-exposure anxiety scales, particularly the FSS-II-F *Total* scale (part correlation coefficient = 0.367). Another regression was performed with mean Verbal Anxiety as the dependent variable. This time, the FSS-II-F *Total* scale was entered to represent the pre-exposure anxiety scales, and the ITQ-F scales and post-exposure scales were entered in a stepwise

TABLE 3. UNIVARIATE ANOVA ANALYSES OF DIFFERENCES BETWEEN THE PHOBIC AND NON-PHOBIC GROUPS DURING IMMERSION IN THE TVEDGs

Verbal reports (0–100)	*Phobic (n = 13), mean* (SD)	*Non-phobic (n = 13), Mean* (SD)	*ANOVA* F *(1, 24)*	*Eta squared*	*Effect size*
Mean verbal presence	71.0 (16.4)	35.9 (20.6)	23.09***	0.49	Very large
Mean anxiety	56.7 (10.6)	8.7 (10.4)	136.71***	0.85	Very large
Perceived verbal realism	64.2 (18.7)	54.6 (21.2)	1.51	0.1	Medium
Mean verbal simulator sickness	5.3 (14.0)	5.8 (13.2)	0.01	0	Very small

ANOVA, analysis of variance. $^{***}p < 0.001$. Cohen's[36] qualitative criteria for effect size were used. Very small effect size = $f < 0.10$; very large effect size = $f > 0.60$.

TABLE 4. VARIABLES THAT ARE SIGNIFICANTLY CORRELATED ($p > 0.05$) with Mean Verbal Presence and Mean Verbal Anxiety

	Mean verbal presence (r)	*Mean verbal anxiety* (r)
Pre-Immersion Scales		
STAI-Y-F State	0.44	0.46
STAI-Y-F Trait		0.42
FSS-II-F Agoraphobia		0.69
FSS-II-F Social Phobia		0.83
FSS-II-F Anxiety and Depression		0.47
FSS-II-F Total		0.42
BDI-F		0.43
ITQ-F Emotions	0.35	0.41
ITQ-F Involvement		0.41
ITQ-F Total	0.36	0.52
Post-Immersion Scales		
PQ-F Realism	0.51	0.50
PQ-F Affordance to Examine	0.49	0.41
PQ-F Total	0.43	0.40
Verbal Perceived Realism	0.43	0.40
Mean Verbal Presence		0.74
Mean Verbal Anxiety	0.74	

fashion (probability of F to enter ≤ 0.05, probability of F to remove ≥ 0.10). The optimal model produced by this procedure included three predictors: FSS-II-F *Total*, mean Verbal Presence, and ITQ-F *Total* with part correlation coefficients of 0.251, 0.506, and 0.287, respectively.

DISCUSSION

The first goal of this study is to determine if TVEDGs can induce anxiety in phobic participants. The results demonstrate that despite their low cost and flexibility, TVEDGs can be phobogenic. Moreover, virtual environments derived from games can produce the mid-range levels of anxiety that are most useful in therapy.

It is clear that it was the phobogenic stimuli in the TVEDGs rather than the VR aparatus that provoked anxiety because the participants reported low levels of anxiety when they were in what they considered to be safe areas in the TVEDGs. The only exception was the claustrophobic participant who said that the HMD made them feel anxious. Even this participant, however, reported that their level of anxiety rose from 40 to 75 as they approached enclosed areas in the TVEDGs.

These results are important because they suggest that with a total investment of less than $2500 US, a therapist can provide their clients with the benefits of VR exposure; all that is required is a PC, an HMD, a gamepad, a PC game, and a freely distributed TVEDG.

The second goal of this study is to assess the impact on phobogenic effectiveness of simulator sickness and sense of presence. Simulator sickness appeared inconsequential; although the phobic participants had somewhat elevated SSQ-F *Total* and SSQ-F *Nausea* scores, they also reported higher levels of presence and anxiety. There was also a noteworthy absence of significant correlations between the measures of simulator sickness and the mean Verbal Anxiety and Verbal Presence scores. These results indicate that with the VR equipment and programs used in this study, simulator sickness does not interfere with sense of presence or with the generation of anxiety.

In contrast, anxiety was importantly related to sense of presence. Two types of results underline the importance of this relationship: the group differences between the phobic and non-phobic participants, and the correlations and regressions based on pooled data.

The group differences show that anxiety is associated with sense of presence both before and after immersion in the TVEDGs. Before they were immersed, the phobic participants showed both a greater tendency to feel anxious (higher FSS-II-F and STAI-Y-F scores), and a greater tendency to experience presence in VEs (higher ITQ-F scores). After they were immersed, the phobic participants reported higher levels of anxiety (mean Verbal Anxiety ratings) and of presence (Verbal Perceived Realism, mean Verbal Presence, and PQ-F *Total* and *Realism* scores). High anxiety, therefore, is associated with high levels of presence.

The correlations and regressions also show that anxiety is associated with presence. Mean Verbal Anxiety is the variable that is most highly correlated with mean Verbal Presence, and it is the best predictor of mean Verbal Presence. These results indicate that it is the anxiety at the time of the VR experience which is most closely related to sense of presence. Conversely, mean Verbal Presence is highly predictive of mean Verbal Anxiety. Because these correlations are positive, the relationship between anxiety and presence appears synergistic.

The present study's results are noteworthy because they support previous studies[32,33] that found evidence of a synergistic relationship between presence and emotion. The present study's findings do not support Slater's[1] view that emotion and presence are orthogonal. Although we agree with Slater that emotion and presence are conceptually distinct, these results indicate that they are linked empirically.

In addition to this and other studies' empirical findings, there are theoretical reasons to doubt Slater's[1] orthogonality hypothesis. According to Slater, presence is orthogonal to emotion because one can feel present in situations that are unemotional. He used the example of languishing in an airport lounge to illustrate this orthogonality; he felt completely present in the lounge even though he did not feel emotional. There are two objections to this formulation. First, it has been proposed that the way we feel and act always has an emotional quality. Although we are not continuously wrought up, we are always in the grips either of what James[34] terms coarser emotions such as anger or fear, or of subtler emotions such as intellectual or aesthetic feelings. Greenberg and Paivio[35] discuss a gamut of emotional states ranging from grief to feeling on top of things. If it is true that our state of mind always has an emotional quality, then Slater was mistaken when he asserted that he felt no emotion in the airport lounge; judging from the quality of his writing, he probably felt on top of things.

The second objection to Slater's[1] formulation is that it does not jibe with common experience; normally, emotional congruence appears to be closely related to presence. For example, a person would not feel as though they really were in the presence of a dangerous predator unless they felt frightened. Similarly, a person would not feel as though they were languishing in an airport lounge unless they felt languid. In both of these examples, it is difficult to imagine how a person could feel fully present if their feelings were not congruent with their perceived situation.

Although this study has demonstrated an empirical link between emotion and presence, the underlying reason for this link remains unclear. There are at least three causal models that are consistent with this study's results. First, anxiety may increase sense of presence. Anxiety could have this effect if it interfered with the subject's ability to attend to cues that underline the merely virtual nature of the VE. Alternatively, anxiety could increase sense of presence if the participant interpreted their anxiety as evidence of the reality of the VE. Second, presence may increase anxiety; it would make sense for a person to feel more anxious if they had a greater impression of actually being in a frightening situation. Third, the causal relationship may be reciprocal. That is, increases in anxiety may enhance sense of presence, and vice versa. Further research is required to distinguish between these models. Experiments are planned in which anxiety and presence will be manipulated independently to show if either factor causes the other.

There is also an indirect causal explanation for the statistical relationship between anxiety and presence; the two factors may be closely correlated because emotional congruence is a constituent or necessary condition for sense of presence. That is, sense of presence may be determined by the congruence between the subject's emotional state and their perceived situation. This model provides an explanation for the different levels of presence reported by the phobic and non-phobic participants; the phobic participants felt present in the TVEDGs because their sense of presence was constituted in large measure of the congruence between the anxiety they experienced and the phobogenic cues they perceived in the TVEDGS. People with phobias are very sensitive to phobogenic cues (they are often frightened by photographs of phobogenic stimuli), so the representations of phobogenic stimuli in the VEs provoked anxiety in the phobic participants. The acrophobic participants, for example, felt anxious because the low resolution, two-dimensional depictions of precipices in the HMD were sufficiently realistic to make them feel anxious. Because this is how they would have felt if they really were perched atop a perilously high precipice, the virtual experience felt real. That is, the participants felt present because their emotional state was congruent with being in real rather than in merely virtual peril. The non-phobic participants, on the other hand, were less sensitive to phobogenic cues. Consequently, the HMD display did not provoke the anxiety they would feel if they really were in peril. This emotional incongruity gave their experiences in the VEs a feeling of unreality, which is to say that they experienced low levels of presence. According to this model, it was the differences in emotional congruence rather than in the emotions per se that caused the differences in sense of presence.

This study's findings are of both theoretical and practical importance. First, the synergism of anxiety and presence indicates that emotions and sense of presence are not orthogonal as some authors contend. The relationship between these factors demands further investigation. Second, the phobogenic effectiveness of the inexpensive hardware and software used in this study shows that VR technology is sufficiently advanced for VR exposure therapy to move into the clinical mainstream. Given the advantages inherent in VR exposure, it is imperative to develop and validate inexpensive clinical protocols and VE's as soon as possible.

ACKNOWLEDGMENTS

This project was supported in part by a research grant from the Fonds pour la Formation de Chercheurs et l'Aide à la Recherche awarded to the second and fourth authors. This project was also supported in part by a Canada Research Chair awarded to the second author, and by a postdoctoral grant attributed to Thomas Fournier from a Canadian Institutes of Health Research grant awarded to S.B. Portions of these results will be published in French elsewhere.[20]

REFERENCES

1. Slater, M. (2003). A note on presence terminology. *PRESENCE—Connect* [On-line]. Available: http://presence.cs.ucl.ac.uk/presenceconnect/articles/Jan2003/melslaterJan27200391557/melslaterJan27200391557.html.
2. Kessler, R.C., McGonagle, K.A., Zhao, S., et al. (1994). Lifetime and 12-month prevalence of DSM-III-R psychiatric disorders in the United States. *Archives of General Psychiatry* 51:8–19.
3. Foa, E.B., & McNally, R.J. (1996). Mechanisms of change in exposure therapy. In: Rapee, R.M. (ed.), *Current controversies in the anxiety disorders*. New York: Guilford Press, pp. 329–343.
4. Bandura, A. (1997). *Self-efficacy: the exercise of control*. New York: W.H. Freeman and Company.
5. Williams, S.L. (1996). Therapeutic changes in phobic behavior are mediated by changes in perceived self-efficacy. In: Rapee, R.M. (ed.), *Current controversies in the anxiety disorders*. New York: Guilford Press, pp. 344–368.
6. Butler, G. (1989). Phobic disorders. In: Lawton, K., Salkovskis, P.M., Kirk, J., et al. (eds.), *Cognitive behaviour therapy for psychiatric problems: a practical guide*. Oxford: Oxford University Press, pp. 97–128.
7. Wiederhold, B.K., Jang, D.P., Gevirtz, R.G., et al. (2002). The treatment of fear of flying: a controlled study of imaginal and virtual reality graded exposure therapy. *IEEE Transactions on Information Technology in Biomedicine* 6:218–223.
8. Bouchard, S., St-Jacques, J., Robillard, G., et al. (2002a). Efficacité de l'exposition virtuelle pour le traitement de l'acrophobie: une étude préliminaire (submitted).
9. Emmelkamp, P.M.G., Bruynzeel, M., Drost, L., et al. (2001). Virtual reality treatment in acrophobia: a comparison with exposure *in vivo*. *CyberPsychology & Behavior* 4:335–339.
10. Rothbaum, B.O., Hodges, L.F., Kooper, R., et al. (1995). Effectiveness of computer-generated (virtual reality) graded exposure in the treatment of acrophobia. *American Journal of Psychiatry* 152:626–628.
11. Schuemie, M.J., Bruynzeel, M., Drost, L., et al. (2000). Treatment of acrophobia in virtual reality: a pilot study. In: Broeckx, D.F., Pauwels, L. (eds.), *Conference proceeding Euromedia 2000*. Antwerp, Belgium, pp. 271–275.
12. Botella, C., Banos, R.M., Perpina, C., et al. (1998). Virtual reality treatment of claustrophobia: a case report. *Behaviour Research and Therapy* 36:239–246.
13. Botella, C., Banos, R.M., Villa, H., et al. (2000). Virtual reality in the treatment of claustrophobia: a controlled, multiple-baseline design. *Behavior Therapy* 31:583–595.
14. Bouchard, S., St-Jacques, J., Côté, S., et al. (2002c). Efficacité de l'exposition en réalité virtuelle pour le traitement de la claustrophobie: étude de cas (submitted).
15. Bouchard, S., Côté, S., Robillard, G., et al. (2002b). Effectiveness of virtual reality exposure in the treatment of arachnophobia using 3D games (submitted).
16. Carlin, A.S., Hoffman, H.G., & Weghorst, S. (1997). Virtual reality and tactile augmentation on the treatment of spider phobia: a case report. *Behaviour Research and Therapy* 35:153–158.
17. Stanney, K.M., Kennedy, R.S., & Kingdon, K. (2002). Virtual environment usage protocols. In: Stanney, D.K.M. (ed.) *Handbook of virtual environments: design, implementation, and applications*. Mahwah, NJ: IEA.
18. North, M.M., North, S.M., & Coble, J.R. (1996). *Virtual reality therapy: An innovative paradigm*. Colorado Springs: IPI Press.

19. Draper, J.V., Kaber, D.B., & Usher, J.M. (1998). Telepresence. *Human Factors* 40:354–375.
20. Robillard, G., Bouchard, S., & Renaud, P. (2002). Présence et anxiété en réalité virtuelle chez les personnes phobiques versus non-phobiques. (submitted).
21. First, M.B., Spitzer, R., Gibbon, M., et al. (1996). *Structured clinical interview for DSM-IV axis-I disorders—Patient version*. New York: Biometrics Research Department, New York State Psychiatric Institute.
22. Marchand, A. (1976). Effet de la peur, de la nature des consignes et des mesures répétées sur un comportement d'évitement chez les sujets humains volontaires [Master's thesis]. Université du Québec à Montréal, Montreal, Canada.
23. Geer, J.H. (1965). The development of a scale to measure fear. *Behavior Research and Therapy* 3:45–53.
24. Gauthier, J., & Bouchard, S. (1993). Adaptation canadienne-fran aise de la forme révisée du State-Trait Anxiety Inventory de Spielberger. *Revue Canadienne des Sciences et du Comportement* 25:559–578.
25. Spielberger, C.D. (1983). *Manual for the State-Trait Anxiety Inventory (Form Y)*. Palo Alto, CA: Consulting Psychologist Press.
26. Cottraux, J., Bouvard, M., & Légeron, P. (1985). *Méthodes et échelles d'évaluation des comportements*. Paris: Éditions EAP.
27. Beck, A.T., Steer, R., & Garbin, M. (1988). Psychometric properties of the Beck Depression Inventory: 25 years of evaluation. *Clinical Psychology Review* 8:77–180.
28. Bouchard, S., Robillard, G., Renaud, P., et al. (2002d). Validation canadienne-fran aise de deux mesures importantes en réalité virtuelle: L'Immersive Tendencies Questionnaire et le Presence Questionnaire (in preparation).
29. Witmer, B.G., & Singer, M.J. (1998). Measuring presence in virtual environments: a presence questionnaire. *Presence: Teleoperators and Virtual Environments* 7:225–240.
30. Bouchard, S., & Robillard, G. (2002e). Validation canadienne-fran aise d'une mesure sur les cybermalaises: le Simulator Sickness Questionnaire (in preparation).
31. Kennedy, R.S., Lane, N.E., Berbaum, K.S., et al. (1993). Simulator Sickness Questionnaire: an enhanced method for quantifying simulator sickness. *International Journal of Aviation Psychology* 3:203–220.
32. Regenbrecht, H.T., Schubert, T.W., & Friedman, F. (1998). Measuring the sense of presence and its relations to fear of heights in virtual environments. *International Journal of Human–Computer Interaction* 10:233–249.
33. Renaud, P., Bouchard, S., & Proulx, R. (2002). Behavioral avoidance dynamics in the presence of a virtual spider. *IEEE Transactions on Information Technology and Biomedecine* 6.
34. James, W. (1890). *The principles of psychology*. New York: Dover Publications.
35. Greenberg, L.S., & Paivio, S.C. (1997). *Working with emotions in therapy*. New York: Guilford Press.
36. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*, 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates.

Address reprint requests to:
Stéphane Bouchard, Ph.D.
Psychoéducation
Université du Québec en Outaouais
C.P. 1250 Succ "B"
Hull, Québec, Canada, J8X 3X7

E-mail: stephane.bouchard@uqo.ca