
Sense of Presence in Virtual Reality Exposures Therapy

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Abstract

Virtual Reality Exposure is already considered as a valid technique in Cognitive Behavioral Therapy. It is an interesting approach to the question of Presence in Virtual Reality. The Sense of Presence (feeling of being in the Virtual Environment) is a complex mental mechanism that, as we expose here, is strongly linked to our emotional reasoning abilities. What we verify in our experiments is the importance of the psychological vulnerability of the patient and the strong impact of symbols in the perception of a virtual world. Psychiatric diagnostic and patient's reactions during exposure could also be considered as important elements in the evaluation of the Sense of presence.

Keywords

Sense of presence, Virtual Reality Exposure, Cognitive Behavioral Therapy, Social Phobia.

1 Introduction

Virtual Reality (VR) could be described as a multimedia process which creates synthetic sensations that make the user feel in another reality. This action is called Immersion and can be described objectively. Nevertheless, this concept should be distinguished from the Sense of presence (SoP) which is the subjective sensation of “being there”. The concept of presence is not restricted to VR: reading a book, watching TV, and talking on the phone can all engender some level of presence. This is why there is currently no single agreed upon way to appreciate its quality.

Even so, this is not an obstacle to the extension of VR which finds effective applications in many different fields where simulation training is preferable to real training (aviation, surgery, etc). But for art, games, and (recently) psychiatry, VR is not only used for its qualities of simulation, but as a specific platform for entering mental areas. In the case of treating people with VR technologies, immersion is used to expose patients suffering from an anxiety disorder in the fearful situation and to provoke some reactions. The therapist could help the patients to understand, accept, and control those sensations in order to fight their phobias (cognitive therapy). So, it seems that presence is one of the key factors in the exposure success.

In addition, therapists are used to evaluate the effect of exposure on their patients as they need to have a control over the therapy. If we could make the link between the effect of VR Exposure (known) and the impact of this immersion, we could get an interesting evaluation tool of presence.

This paper is organized follows. First, we define more precisely presence and different existing approaches of its evaluation. Second, we focus on exposure in the context of Cognitive Behavioral Therapy (CBT) and on the possible means of psychological measurements. Then, we introduce some correlations we found between the two concepts. Before we can conclude, a case study on a Virtual Reality Exposure system for the treatment of Social Anxiety Disorder (SAD) will give us a concrete application of those ideas.

2 Presence evaluation

2.1 Definitions

Barfield *et al.* [1] define presence as “the participant’s sense of ‘being there’ in the virtual environment”. This concept is however still confusing as its definition itself

Variable	Contribution	
Form Variables This group includes the more objective parameters		
Sensory outputs	Number of sensory outputs	Positive (for higher numbers)
	Consistency of sensory outputs	Positive (when consistent)
	Visual outputs have various dimensions	Strong <i>see dimensions below</i>
	- Display size	Positive (for larger proportion)
	- Viewing distance	Positive (for larger proportion)
	- Quality of image	Positive (for high quality)
	- Depth cues	Positive
	- Camera techniques	Positive
	Audible outputs also has different dimensions	Strong
	Other sensory outputs (smells, touch etc)	Less strong than audio or visual
	Body movement and force feedback	Positive when done well
	Interactivity of medium	Positive
	Visibility/obtrusiveness of medium	Negative
	Interference from real world	Negative
	Human contact	Positive
Content Variables Can be both objective and subjective		
	Characters and storylines	Positive and negative
	Media conventions	Usually negative
	Nature of representation	Positive and negative
Media user variables These are highly subjective and depend directly on the individual		
	Willingness to suspend disbelief	Positive
	Previous experience	Positive or negative

Table 1: Possible Causes of presence(from Kalawsky [3])

is relative to the understanding of the words 'sense' and 'being'. To avoid this problem, Lombard & Ditton [2] propose to interpret presence as "a perceptual illusion of non-mediation"; presence is what happens when the participant 'forgets' that his perceptions are mediated by technologies. This media-oriented approach allows to analyze the causes of presence with objective variables: number and consistency of sensory outputs, visual display characteristics, aural presentation characteristics, interactivity, obtrusiveness of medium, and number of people involved. Kalawsky [3] recently made a large review of the literature and proposes a synthetic table of "the possible causes of presence" (see table 1).

Rita Lauria [4] propose to enlighten the problem with psychological knowledge and philosophic analysis: "psychology is the physics of VR in the sense that the virtual environment is manufactured towards creating a cognitive state". In this perspective, she extends the metaphysical approach of VR (as in 'Beyond the metaphysics of Virtual Reality' of R.Pettifer [5]) by centering the SoP on the user's abstraction capacities. This is why psychiatry may help in the understanding of the Sense of presence.

2.2 The problem of presence evaluation

As it is already difficult to know precisely what is presence, it is even more complex to evaluate it. However, for each comprehension of the concept, researchers tried to propose a way to interpret observable immersive information into a valuable representation of the presence.

According to the first definition, presence is at its maximum in real situation, while on the contrary Virtual Reality is supported by an undefined artificial SoP. So, it seems appropriate at first sight to assess presence with direct questions: "If your level of presence in the real world is '100' and your level of presence is '1' if you have no presence, rate your level of presence in this virtual world" [6].

Following the idea that presence has to do with 'being in' a virtual environment, Prothero *et al.* [7] orient their research by defining 'being' as the sense of position and orientation in space. Even if this approach allows for an objective quantification of presence by observation of human behaviors in spatially disturbing situations, it limits SoP to the sense of immersion.

According to the 'non-mediation' definition of presence, Witmer and Singer [8] propose two questionnaires based on a large list of contributing factors to presence (similar to table 1). The presence Questionnaire (PQ) and the Immersive Tendencies Questionnaire (ITQ) rely exclusively on self-report informations. PQ and ITQ together count more than 60 questions, oriented on the VR experience and on the general user habits.

As a counterexamples, Usoh *et al.* [9] tested two different presence Questionnaires in Reality (Witmer & Singer and their own). They carried out a between-group experiment to assess whether we could distinguish between real and virtual experiences. It appears that no significant difference were found in the questionnaire results! They conclude that evaluation of presence can be consistent only when all subjects experience the same type of immersion, and that 'cross-environment' comparisons must be done using another approach. The authors speculate that the subjects 'relativised' their responses to the domain of their given experimentation.

Frank Biocca presents in his 'Cyborg Dilemma' [10] an important question on the 'relative' naturalness of technology: "The more natural the interface the more 'human' it is, the more it adapts to the human body and mind. The more the interface adapts to the human body and mind, the more the body and mind adapts to the non-human interface. Therefore, the more natural the interface, the more we become 'unnatural', the more we become cyborgs". Both new technologies -in particular VR immersive devices- and human beings tend to adapt to each other in order to get the maximum benefits (technologies die if they are not used, humans want technologies to be easy). This corrupts the human estimation of artificial presence as we progressively appropriate technological interfaces and become less and less critical on mediated stimulations. But paradoxically -and happily- this also leads us to feel more and more comfortable with VR technologies and improves the Sense of Presence.

However, Lessiter *et al.* propose "A Cross-Media presence Questionnaire" [11] in order to enable a comparison for video, cinema, computer game and VR (and intermediate multimedia technologies). One of the main interesting conclusion we can take out from their experiments is that for each factor (Sense of Physical Space, Engagement, Ecological Validity, Negative Effects), each media has a strong point and a weak point. It seems not possible to conclude on the presence efficiency of a system independently of the application.

Finally, according to the third approach of SoP, an evaluation of the system itself is not sufficient and we should take advantage on the observation of its effect on the user. Dillon *et al.* [12] aim to observe the "psychophysiology of presence" by monitoring the arousal during immersion. Physiological measures like electrodermal activity (EDA) or electrocardiograms (ECG) could, although it has not been enough experimented yet, be considered as objective indications of humans reactions to immersion.

3 Exposure in Cognitive Behavioral Therapy

3.1 Definitions

In the medical field of anxiety disorders therapy, two main approaches are possible. First, the pharmacological treatment has good results, but its positive effects ends soon after the end of the treatment. Then, the Cognitive Behavioral Therapy have slower but persistent effects on the pathology. CBT commonly includes prolonged exposures of the patient into the feared situation (within the therapy session and as homework assignments). The exposure has a direct effect of habituation, and is the starting point of a cognitive treatment in order to adjust the patient's perception of himself in his

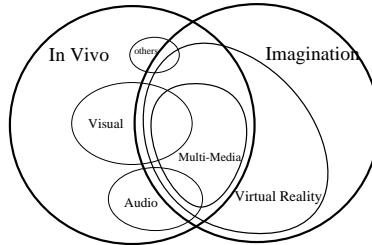


Figure 1: Exposures techniques recovery

<i>Exposures</i>	In Vivo	Imagination	Single Media	Multi Media	Virtual Reality
Covers every sensibilities?	yes	yes	no	more/less	more/less
Focus on stimuli?	no	no	yes	more/less	yes
Active exposure?	yes	no	no	no	yes
Applicable to any phobia?	yes	yes	yes	no	no

Table 2: Summary of advantages/disadvantages of the different exposure solutions

environment and to correct some disfunction of his behaviors. In the example of Social Phobia (section 5), cognitive therapy attempts to restructure maladjusted beliefs about social situations and other persons' opinions with social skill training.

Virtual Reality entered the mental health field some years ago to determine if Virtual Reality Exposure (VRE) may be an alternative to standard in vivo exposure for wide phobias: agoraphobia, fear of spider or fear of flying. First, VRE gets full benefits of the VR flexibility as it can be entirely modeled and controlled by software. Also, VRE covers a less restrictive area of possible exposure technics than stimulus-specific exposure (figure 1).

From a therapeutic point of view, we can compare VRE and other exposure techniques. First, in-vivo exposure is not always the best solution; the main advantage of covering perfectly every sense makes it difficult to focus on one particular stimuli. Indeed, psychiatrists need to isolate input factors in order to reduce the number of variables that influence their diagnostic. To reach this goal, they use isolated media exposure with pictures, sounds or touch. But in this case, the sensitivity of the patient to one or the other stimuli limits the exposure's effect. With multimedia technologies (like video), this issue is improved. But as for the imaginary exposure, we can't be sure of the patient's implication during the exposure. According to all those problems, Virtual Reality offers a good compromise: it can focus artificially on one stimuli, it covers many media, and it ensures that the patient is active (table 2).

1	Can the same objective be accomplished using a simpler approach?
2	How well do the current attributes of a VE fit the needs of the psychological approach of target ?
3	How does a VE approach match the characteristics of the target clinical population?
4	What is the optimal level of presence necessary for the application?
5	Will the target users be able to learn to navigate in and interact with the environment in an effective manner ?
6	What is the potential for side-effects (cybersickness and aftereffects) in light of the characteristics of different clinical groups?
7	Will assessment results and treatment effects generalize to the "real world"?
8	How should VE studies be designed and how will the data be analyzed?

Table 3: Basic VE Cost/Benefit Issues for Mental Health Applications (from Rizzo *et al.* [13])

Of course, VR immersion and interaction technologies have some limits that determine the target therapies and how they should be applied. Rizzo *et al.* [13] determined eight major issues for the selection and the eventual elaboration of Virtual Environments (VE) for Mental Health (MH) applications (table 3). They particularly discuss on the relationship between the level of presence and the medical requirements (fifth point in table 3) and conclude on the importance of such information in the design and development of effective MH VE's.

3.2 Survey of Virtual Reality Exposure experiments

Since 1996, medical and computer science researchers tend to evaluate the effectiveness of low-cost Virtual Reality Exposure (headphone, Head Mounted Display, etc) in patients suffering from phobias ([14], [15], [16]). VRE was found to be as effective as in vivo exposure on anxiety and behavioral avoidance. This section presents a panel of experiences for different phobias.

The case study of Rothbaum *et al.* [17] in 1997 already supported the efficacy of VR exposure therapy for the fear of flying, a typically difficult situation to reproduce in vivo. In 1999, Rothbaum and Hodges [18] published a successful experience in reducing the fear of heights with the aid of Virtual Reality therapy (assessed on measures of anxiety, avoidance, attitudes, and distress). More recently, the same team presented a description of the immersive properties of VR and its importance for clinical purposes: Anderson [19] reviews the current clinical applications where VR has been used (treatment of specific phobias, post-traumatic stress disorder, eating disorders, and pain management).

Bullinger's team from the mental health research facility in Basel provides an overview of the of the VR technology in the development of MH applications [20]. They also demonstrate the use of VR in two applications for use with claustrophobic and acrophobic patients.

Garcia-Palacios *et al.* [21] propose a large surveys, assessed on 162 students high in fear of spiders, to propose VRE in stead of in vivo exposure. Indeed, while usually only few phobic (less than 15-20%) ever seek in-vivo treatment, VR seems to be more attractive as for this study, more than 80% chose the VR treatment.

Pertraub *et al.* [22] recently experimented VRE for the public speaking anxiety in various audiences. The 40 persons sample was divided in two groups by the immersive technology selection (desktop and HMD) and each group was exposed to three different virtual audiences. The subjects were asked to make a speech in front of a static audience (seminar room populated with height male Virtual Humans (VH) sitting and not animated), a positive audience (same situation but the VH simulate an interest to the speech), and a negative one (VH are bored, lean backward, go away...). The somatic self-evaluation questionnaire and the subjective performance self-rating used to evaluate the patient's revealed that the liveness of the scene was an important factor of the impact of the exposure on the subjects, with a maximum for the negative audience. They conclude on the evident possible use of VRE for the treatment of Social Anxiety Disorder.

3.3 Patient's reactions evaluation

The psychological impact of an exposure is not directly readable. The therapists have to interpret every signs (conscious or unconscious), and use many different aids to observe their patient's state. We propose to classify them into tree main classes;

Overt Behaviors: They regroup the external manifestations that can be directly observed on the patient attitudes (avoidance and reassurance behaviors: he escapes or tends to hide his disturbances, hands in the pocket, drink something, gaze..., and conditioning: behavioral stimuli-reaction habituation).

Cognitive responses. This is the patient's interpretation of what he experiences. The therapist can obtain information on how he feels the situation and how he perceives himself in this situation (through spontaneous reports: free (or slightly guided) written description and observations, or interviews and questionnaires: list of prepared questions with score).

Emotional states. Emotions are observed through the physical and involuntary reactions of the patient ((i) subjective emotional assessment: self evaluation of the patient on an emotional scale (must be non-verbal description), (ii) arousal: physiological measures of pulse (ECG), skin-conductivity (EDA), breath, and others, and (iii) brain observation: actual knowledge of the brain activity can give an emotional interpretation of the excitement of some cortical areas and some located neural networks).

However, as the sets of data are heterogenous, it is difficult to elaborate a global evaluation system. It is also hard to give a sense to measures on one individual, and only a comparison in a population allows for an interpretation. So, either the experiments have to be based on a group, either the exposure has to be done in comparison with some existing reference of 'standard' human reactions.

4 Sense of presence evaluation in the Virtual Reality Exposure context

As shown in the previous sections (2 and 3), the concepts of presence and exposure are very close together. While SoP expresses the sensation of being immersed, exposure is the act of being in an immersive situation. The link is so thin that it is even difficult to determine how they mutually influence each other.

4.1 Exposure is based on the Sense of presence

The principle of exposure is to bring the patient into his phobic situation. In the case of non-vivo exposure, the situation is artificially projected in the subject mind by mediated stimulations (speech, video, VR). The subject's feeling of 'being there' is the only cue of the exposure success.

For a better understanding of this mechanism, we must introduce a well-known psychological theory: Neo-Behaviorism. This approach to psychology explains behaviors in terms of Stimulus- Organism- Response chains (SOR chains). In this model, presence is the ensemble of elements that surround the Organism during exposure (see figure 2). Within this scope, presence can be both considered as the fruit of a mediation chain and as a psychological mechanism. However, the psychiatrists have no other evaluation means of the patient (O) than the observable effects (R) to exposure stimulations (S). As Blake *et al.* [23] propose, an evaluation of presence itself would be useful in a better understanding of mind mechanisms and human behaviors.

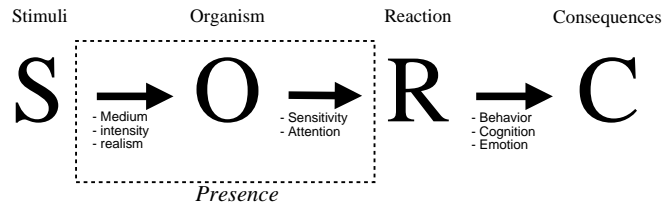
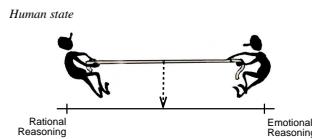


Figure 2: SOR chain : where does presence take place?

4.2 Human psychology as a factor of Sense of presence

In order to understand how the SoP is elaborated in the human mind, we will use another scheme of mental mechanisms. We (human beings) are mainly directed by two major forces: the rational reasoning and the emotional reasoning. Our mental equilibrium can be represented as the balance of this forces as we are always torn between the two.



The main work of the therapist who aims to create an exposure situation is to artificially bring his patient into favorable emotional-reasoning conditions for a mental representation of the fearful situation. Indeed, if the patient remained in a rational state of mind, he would not take off from the reality (being there in the consulting room). In short, the SoP is strongly linked with the patient's ability to enter into an emotional reasoning state. The mechanism of exposure can be described as an evolution of the patient's state from a rational observation of his presence in the real world to a virtual presence in an imaginary world.

As well, Huang and Alessi [24] already supposed that SoP and emotions are strongly linked: "Like emotions, presence is continuously changing and dynamic". The figure 3 proposes an hypothetical representation of human reasoning state and SoP during an exposure: it is probable that they will evolve together in the same way. This is why we introduce the possibility to locate the Sense of Presence in a bidirectional scale between *Realism* and *Imagination* (in stead of a numerical scale up to 100%). This of course could not measure the SoP global quality, but would give continuous and instantaneous indications during the immersion.

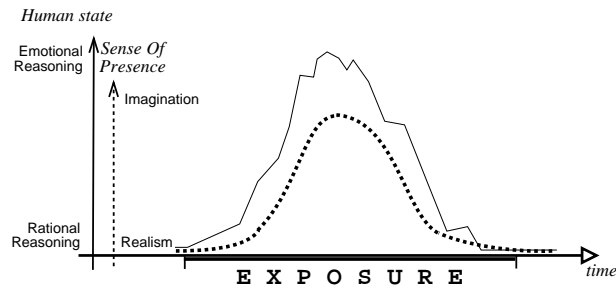


Figure 3: Human state and SoP supposed co-evolution during exposure

4.3 What Cognitive Behavioral Therapy can bring to Sense of presence knowledge

We propose two major limitations in the definition of presence. First, the SoP is highly dependent on the user's ability to control an emotional reasoning state: strong resistances or high emotional instabilities could entirely change the impact of the VR experience. In the case of MH rehabilitation, the psychological vulnerability of the patient (known with a pathological diagnostic) must be taken into consideration for the use of VRE in a therapy. In the general case, a knowledge on the subject's history may be necessary in order to ensure a good evaluation of the SoP: experience with technologies, past problems in the situation, cybersickness, etc.

Then, it appears that the presence sensation is obtained by a successful arousal of the emotional reasoning of the human brain. For example, Pertraub [22] observes that patients feel more involved in a 'negative audience' situation than in the other 'neutral' or 'positive' audiences. As the media system itself was the same in every cases, we think that this is only due to a higher social exposure with stronger psychological stimuli. In short, we would say that the mediation itself is not the key of presence, but rather the stimulation efficiency of the content.

Nevertheless, we do not underestimate the role of the immersive technologies. Their function is to provide favorable conditions for the rising of the SoP. For instance, kids are very fast in taking off from reality when telling stories, whereas adults - and all the more patients who reject a fearful situation- need to be more stimulated. There is, indeed, an essential need for appropriate mediations of the stimuli to enter an artificial presence state. What is more, the media accessibility has to be fast and easy so people do as less efforts as possible (compare book to television). This is why VR technologies tends to be as natural as possible and graphics rendering so realistic.

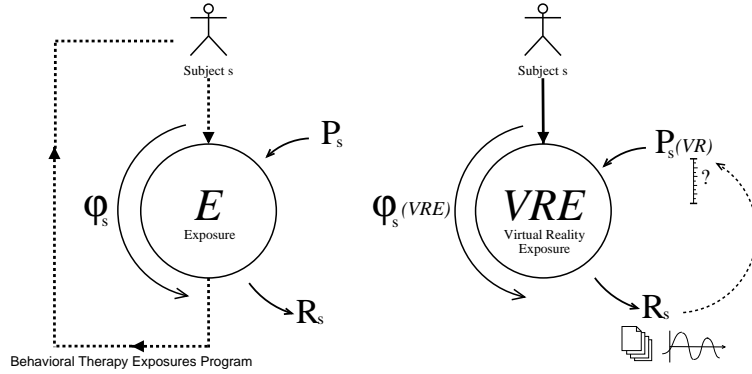


Figure 4: The exposure process: taking advantage of the subject's reactions to evaluate the SoP (φ_s is the psychological impact of exposure on the subject s , R_s is the Reaction of s , and P_s is the Sense of presence)

4.4 Sense of presence evaluation

As observed in section 3.3, the only valuable data on the psychological impact of an exposure are given in the subject's reactions (Behavioral, Cognitive and Emotional). We also previously noticed in section 4.1 that the human reactions depends on the SoP. This is what we want to focus on in this part.

Hypothesis:

For a given subject s , the reaction R_s to an exposure VRE depends on the Sense of Presence P_s in this exposure.

Proposition:

For a given subject s , the Sense of Presence P_s in an exposure VRE depends on the reaction R_s to this exposure.

In other words, if we consider we can have some valuation of R_s for an exposure, how can we airt this information (usually dedicated to the progression of the therapeutic program) into an expression of presence (figure 4)? First, it is important to notice that if P_s depends on R_s , it must have the same dependencies on B , C , and E , the three components of the human reactions (Behavior, Cognition and Emotion). This was already verified in section 2.2 when we described that presence can be evaluated

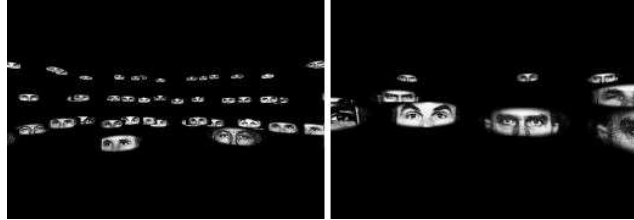


Figure 5: Snapshots of the 'Phobia' symbolic Virtual Environment: a large and a normal assembly.

through notification of the human actions (B), questionnaires of the subjects (C) or monitoring of the arousal (E). Moreover, the Behavioral Therapy would offer a consistent way to integrate them together. The way those data can be used to determine the SoP of the patient during an exposure is not evident and still has to be discussed individually, depending on their nature (assessment scale, questionnaire score, hardware measure, time occurrences, etc) and on their concern (see the case study in section 5). However, it is clear that positive reactions to stimulus have a positive effect on SoP evaluation.

In addition, we saw in section 4.2 that the value set of P_s could take place in a scale between *Realism* and *Imagination*. Section 4.3 also suggests that we could preferably imagine a range between *Realism* and *Symbolism*. How could we use a such scale? Let say that the user entering a virtual Environment would start at a SoP close to *Realism* (as he is in the reality). Then, he may slightly raise a SoP level enabling a perceptual reconstruction of the virtual world. When his SoP is close enough to *Symbolism*, he may forget about reality and feel present in the VE.

5 A case study on Social Anxiety Disorder

5.1 Experiments and results

In the experimentations we made in collaboration with the Adult Psychiatry University Department of Lausanne[25], ten subjects were exposed to a public speaking situation through the immersion in a specific VE. The 'Phobia' exposure environment is a symbolic virtual environment that places the subject at the center of a virtual audience (figure 5 shows the circular repartition of many expressive eyes photographs).

Before the experiments, the subjects filled the Liebowitz self-assessment questionnaire (subjective appreciation of their anxiety in many usual social situations). According to the answers, the therapist can compute a score to determine the social phobia severity. In our sample, we distinguished two tendencies: the group A was determined as *SAD inclined*, whereas the group B represent the non anxious subjects in social situations.

Two assessment tools were also used to evaluate the degree of anxiety during the simulation: at each stage the patients could express their subjective anxiety on an analogical scale, and continuously, the two main physiological parameters of anxiety were recorded (pulse (ECG) and skin conductivity (EDA)). We could observe a significant increase of subjective anxiety and pulse during the exposure to the virtual audience. Furthermore, we noticed important differences between the groups. For example, whereas in group B the subjective anxiety slightly appears just before the speech, the SAD inclined subjects were already stressed when exposed to the audience. This group also has a higher pulse variation at the same time. It was concluded that this kind of virtual exposure could be effective in a social phobia therapy.

5.2 Interpretation in terms of presence

In spite of the limited size of the sample, we could verify that the psychological vulnerability of the patients influences their perception of the situation. The subjects anxious in social situations were already stressed by the immersion in the virtual audience, whereas non anxious subjects only showed a normal stress during the speech. Here, the sensibility of the patients to the social stimuli clearly influence their feeling of being in a stressful situation. In other words, the sensitivity to the contents is a significant factor of the Sense of Presence. Moreover, the judicious selection of a specific social stimuli (gaze) is able to provoke some stress when used as the evocation of human presence. With this conditions, the circular repartition used as a symbolic auditorium is enough to model a public speaking situation. This confirms the possibility to simulate presence by the only mean of a specific arousal.

Finally, we saw how the measures of human reactions (generated stress) were used to assess the effectiveness of the presence, but we did not give a way to evaluate the SoP itself. We could however interpret the answers to the question “how much do you feel stressed?” into a subjective evaluation of the SoP to the question “how much do you feel present?”. This correlation offers a tool for the evaluation of SoP with the advantage to avoid direct references to ‘presence’ and ‘immersion’. Even then, this essentially depends on the context of the experimentation (i.e. stress of public speaking).

6 Conclusion

First, we want to insist on the possible misunderstandings about such concepts as Sense of Presence, presence, and immersion. We tried to clarify their meaning by a survey of the literature and a comparison to Mental Health VR applications. According to our experiences, the particular case of Virtual Reality Exposure offered an appropriate experimental platform for the psychological impact of VR. We could define two additional and important cues for the understanding of SoP mechanisms. First, the psychological vulnerability of the patients influences their SoP for a situation (depending on their sensibility). Then, the psychological impact of the content itself seems to be at the heart of the imaginary presence process. As a side effect, we consider that the mediation (VR devices and rendering) can be forgotten only if the content is *strong* enough. Also, 'strong' does not mean 'realistic' but 'emotionally effective' (symbolic).

However, it is still a complex task to evaluate presence in an objective way. We can only obtain a representation of the exposure consequences via the observation of the subject's reactions. In order to have a SoP scale, we could compare it with the Beaufort's wind scale; given the observation of its effects on land, one can appreciate the wind strength. In our case, the idea would be to elaborate an approximative SoP scale on the observation of humans reactions. This of course would require much more experiments and various observation tools for the behavioral, cognitive and emotional human reactions.

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