Sense of Presence and Metacognition Enhancement in Virtual Reality Exposure Therapy in the Treatment of Social Phobias and the Fear of Flying

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Abstract. The aim of this research effort is to identify feeling-of-presence and metacognitive amplifiers over existing well-established VRET treatment methods. Patient real time projection in virtual environments during stimuli exposure and electroencephalography (EEG) report sharing are among the techniques, which have been used to achieve the desired result. Initialized from theoretical inferences, is moving towards a proof-of-concept prototype, which has been developed as a realization of the proposed method. The evaluation of the prototype made possible with an expert team of 28 therapists testing the fear of public speaking and fear of flying case studies.

Keywords: Virtual Reality Exposure Therapy, Anxiety Disorders, Sense of Presence, Metacognition, Fear of Public Speech, Fear of Flying.

1 Introduction

Virtual Reality Exposure Therapy (VRET) is a technique that uses Virtual Reality technology in behavioral therapy for anxiety disorders treatment. Having many people suffering from disorders, as such as social phobia, etc., VRET therapies that rely on Computer Based Treatment (CBT) principles for a diagnosis and evaluation establishment of the patient's progress, constitute a promising method. VR interfaces enable the development of real world models to interact with. In other than phobia therapy application areas, like cultural and scientific visualization, education and infotainment, this aims at altering the model in such ways that the user can navigate in the artificially created environment in an immersive manner. Using VR environments, people can immerse themselves in models ranging from microscopic to universal scale, e.g. from molecules to planets. In phobias treatment there is an antistrophe to this rule and the concept is to change the behavior of the user after exposure to visual and auditory stimuli in a simulated experience.

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1.1 Past Projects and Short History of VRET

VR in service of cognitive-behavior therapies (CBT) has offered a lot over the past decades projecting several advantages including the generation of stimuli on multiple senses, active participation and applicability to most frequent phobias. Today, it is considered very effective from a psychotherapeutic standpoint, especially in carefully selected patients [23]. For example, Social Anxiety Disorder, the most common anxiety disorder [28], can be treated using VRET systems [17] [13] [4]. There is a great variety of VRET systems related to a specific phobias, like fear of flying [2] [19], cockroach phobia [3] and dog-phobia [9], to name a few. More information can be found on the extensive list (300 studies) of the meta-analysis of Parson & Rizzo [23].

1.2 Facts about Phobias

Over 2.2% of the adult populations of European citizens suffer from Social Phobias [31]. Although anxiety disorders can be treated in most cases, only one third of the sufferers receives treatment and even the specific phobia is not the primary reason to seek treatment [14] [5]. Actually, only the 26% of mental disorder sufferers have made a contact with formal health services [1]. Similarly, the US National Institute of Mental Health (NIMH) indicates that 6.8% of the US adult population suffer from 12-month prevalence Social Phobia, while the 29.9% of those (e.g. 2.0% of adult population) suffer from lifetime prevalence Social Phobia [16]. The rates for teenagers (13 to 18 years old) include 5.5% of the population, with a lifetime prevalence of severe disorder affecting 1.3% of the population [21]. On the other hand, in Greece, the prevalence of all Phobias is 2.79% (2.33 M, 3.26 F) [25].

1.3 Structure of the Paper

This paper is organized as follows: After the introduction, Section 2 (Requirements of a new approach) identifies main areas of VRET adaptation on exposure therapies. The therapeutic aims and the functional requirements of the new approach are presented in section 3 (A more flexible approach). The use cases of the pilot studies and the content development are discussed on Section 4 (Performance situations and content development). The evaluation section (Section 5) presents the results of the prototype evaluation by a group of experts. Finally, an overview of the novel approach as well as future plans are discussed in the last section (Section 6: Conclusions).

2 Requirements of a New Approach

The lack of widely accepted standards for the use of VR to treat specific phobias forces research and clinical use in vertical solutions in most cases. What if a new approach could load new content on demand and be programmable by the therapist to adapt to specific cases and parameters of each patient?

In order to design a VRET system to help therapists achieve a permanent change in patient's behavior, contemporary efforts should take into account current technological trends, updated psychological research results and certain limitations. For example, haptics are not required in social phobias, and/or fear of internal states (e.g. fear of vomit) against stimuli is difficult to be replicated in VR.

After a thorough research on existing solutions, we identified three main areas of adaptation: A) adaptation to the requirements of the therapists, including special conditions of the clinical use and the trends of exposure therapy (e.g. portability, reusability, reliability, effectiveness) and B) adaptation to the specific phobia or anxiety disorder as a matter of content and functional automation (virtual world, scenarios, avatars, stimuli) and C) adaptation to the needs of individuals (phobia history, level of anxiety, human factors). The following sections discuss certain aspects of adaptation.

2.1 Adaptability in Performance Situations

Social anxiety disorder refers to a wide range of social situations, so adaptability of a VRET system can be extremely difficult. Instead of creating and using a highly adaptive VRET system with moderate or poor quality of immersion and presence, a targeted solution would be more appropriate, especially in performance situations.

2.2 Self-awareness

As Hood and Antony note, phobia sufferers 'exhibit biased information processing related to specific threads, while their attention and interpretation are biased' [14]. The mechanism behind that, as well as the result itself stays invisible to the sufferer even if most individuals understand that they overreact. The difficult point seems to be around error estimation, because patients are not able to see themselves and the outcome of their overreaction during stimuli.

2.3 Feeling of Presence

According to Eichenberg [10], VR is experienced as realistic under the conditions of '*immersion*' (virtual world perceived as objective and stimulating) and '*presence*' (the subjective experience of 'being there'). The feeling of presence, or Sense of Presence (SoP), and the Immersion are logically separable, with the former considered as 'a response to a system of a certain level of immersion' [26]. It is believed that, in order a projected word model to be therapeutically useful, it requires a strong SoP [18] [6].

2.4 User Profiling and Monitoring

Not all people respond in the same way given the same stimuli [20] and thus, some patients do not respond to typical cognitive-behavior therapy in VR. Regarding human responses, Behavioral Activation System (BAS) activity is reflected to changes in heart rate, while electrodermal responses resound the behavioral inhibition system

(BIS) activity [11]. Having a reliable activation of BAS and BIS on a real world exposure with the fear-provoking stimulus [29], phobic individuals have a weak BAS activity in contrast to overactive BIS [15]. Similarly, it was found that VR exposure activates the BIS alone [30]. Thus, heart rate and EEG data could be collected by the VRET system to fulfil the patient's profile and monitor the progress achieved in a systematic way. Served with a detailed, after-VRET-session reports could offer an objective variable quantification basis for discussion and trigger metacognition.

2.5 Customization and Personalization

It is not uncommon that therapists would like to change the VRET scenario according to their personal intuition about the problem and the needs of their patients. VRET is by no means a one-size-fits-all tool to treat all phobic populations in a uniform way, because such an assumption could cancel its fundamental psychotherapeutic principles. Therapists need full control over the stimuli, the duration of the exposure and the simulated world itself. Moreover, variations of the same virtual environment could serve in avoiding the memorization of the simulated world and the way stimuli are affecting patient's responses (memory effect). Thus, adaptation tools should be made available to therapist's rather than VRET developers.

3 A More Flexible Approach

The proposed approach is a set of extensions to be applied over the well-established VRET methods and practices to maximize benefits. Figure 1 presents in a flowchart the main components of the proposed VRET system and the way patient's response regulation is achieved, as an evolution to the schema used by Moussaoui et al. [22].

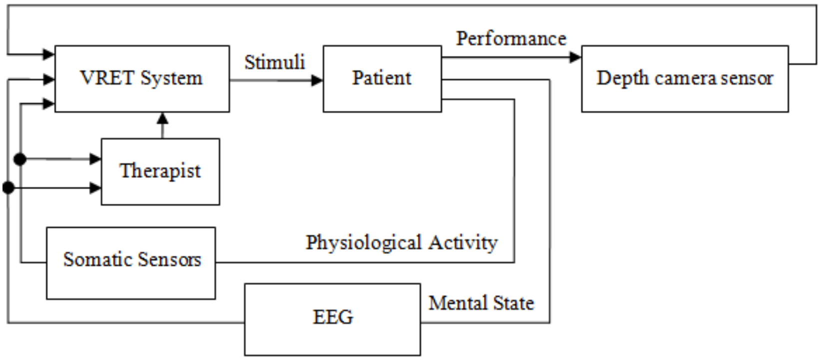

Fig. 1. A basic schema of the proposed treatment rule

The sufferer performs in front of a depth camera which previously had taken a picture of the room (background) as a reference of non-moving objects. Keeping the rule of not moving the depth camera during a session, the system can isolate the figure of the moving actor (patient) from the static background and transfer that figure to the virtual world. At the same time, the patient can navigate in a small area around initial position. Full body movements are transferred in real time (~20fps) in the virtual world to let the body language be directly observed (usually being seen from the back).

Therapists use the keyboard to control the VR, the quality and intensity of the stimulus, like a film director. In the *fear of flying* scenario for example, the therapist can create turbulence to trigger the patient's catastrophic thoughts and the overreaction. The VRET alarm subsystem is flashing when somatic sensors exceed predefined thresholds based on the patient's profile. Those are used to monitor the flow of emotional responses during a session. Currently, there are sockets for heart rate sensors and Electroencephalography (EEG), transmitted wirelessly to PC (via Bluetooth).

3.1 Therapeutic Aims and Functional Requirements

The extension key-points of the therapeutic aims and the functional requirements of the prototype can be summarized as follows: A) To truly disconnect the VRET supportive system from the performed scenarios and the kind of phobia (highly structured), B) Extensive reporting and monitoring of somatic symptoms via physical sensors (feedback), C) Enhance the feeling of presence and metacognition having in mind its importance on the treatment success, D) Be adaptable to the needs of specific scenarios to treat heterogeneous set of phobias in individuals (personalization).

3.2 Feeling of Presence and Metacognition Amplifiers

After a period of practical experimentation (Nov. 2012-May 2013), we finally achieved VRET-scenario disconnection, sensor data reporting and personalization using client profiles. Table 1 briefly presents the followed approach for each encountered challenge, based on the factors influencing the SoP as Bouchard [7] adapted from Sadowski & Stanney [24] together with which, novel methods were used to achieve scenario-specific or mode-specific adaptation.

Table 1. Factors and methods used in the prototype

Factors	Challenge	Approach	Limitations
System related factors	Large field of view to make the system transparent Convincing level of realism	Head movement tracking when HMD is in use. Stereoscopic display in 3DTV when Kinect is used Build-in virtual laptop presentations	LCD Screen sizes Delays in HMD fast movements The virtual laptop plugin is capable of loading ppt files only
Ease of interaction	Highly synchronous Interactions	Self-video VR projection in LCD mode using Kinect Intuitive orientation and short distance navigation	Narrow area navigation when use Kinect Self-projection in VR not appropriate for body shape concerns

Table 1. (*Continued*)

Factors	Challenge	Approach	Limitations
User initiated control	Direct user initiated control Indirect by the therapist initiated control	The system responses to sensor's input, based on zones of accepted values Interruptions allowed by the therapist (having the highest priority)	Lack of previously captured physical and EEG input during the first session
Objective Realism	High quality of stimuli	Immersive prioritized stimuli (continuity, consistency, connectedness and meaningfulness)	Known VR technology limitations
Social factors	Interaction with other avatars Observation of other's reactions when exposed to the same stimuli	Acknowledge the existence of other passengers / audience Restrained reaction of passengers and crew during turbulence in flight scenarios Crowd reactions as a result of the collective identity	Limited artificial intelligence
Duration of immersion	Avoid unnecessarily prolonged immersion Familiarization with the system	Time slots with quantized duration depending on the performed scenario Demo or introduction mode which implements VR exposure without the stimuli (easy flight or idle audience)	Lack of familiarization [or] Too much familiarization with the system
Internal factors	Individuals' characteristics	Create user profiles for accepted ranges of sensor (physical and EEG data) input based on the first session	Noisy user profiles (low accuracy, narrow testing periods, human factors)
Side effects	Eliminate motion sickness, to avoid dizziness on returning participants	Immobilized virtual camera for the public speaking scenario Eliminate motion sickness by eliminating camera rotations during flight scenario	If the fear is caused by the fear of dizziness (not the turbulence), then the stimuli cannot be realistically reproduced

4 Performance Situations and Content Development

Using VRET to treat phobias is a stepped procedure regarding elimination of the distance between the desired sufferer's response and the actual one. The concept is partially programed *a priori* by the therapist during the scenario preparation. This is made possible through a simple additional software tool, which generates scenario files to be used later by the VRET. Scenario files follow a simple XML schema to describe elements and attributes of the VRET execution over specific virtual scenes.

4.1 Scenario Preparation and Execution

In Figure 2, the interface of the scenario preparation tool is demonstrated. The therapist can chain a series of short independent incidents to create a whole session. The therapist can modify the session duration and level of difficulty, while he/she can also intervene during the session's execution and modify the computer-controlled avatars and certain parameters in real-time. The following two scenario-chains were initiated as working demonstration content, while in later phases they were used as case studies in pilot tests. Both were carefully designed by experienced psychiatric staff with long route in Clinical Psychiatry (members of the General Hospital Psychiatric Society, Greece). The model development was based on the detailed scenarios provided by the psychiatric staff and was performed by experienced computer scientists/artists.

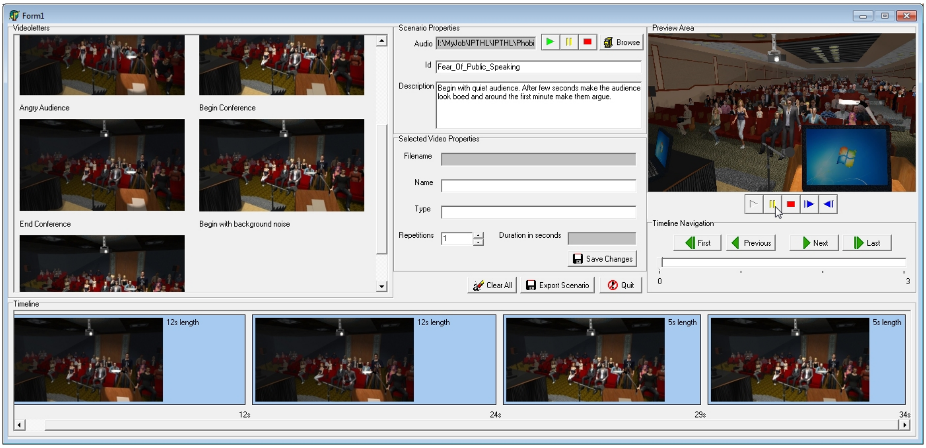

Fig. 2. The VRET scenario maker, used by therapists to prepare automated scenario sessions

4.2 The Fear of Public Speaking Scenario

Figure 3 is a view of the virtual conference room used in the *fear of public speech*. A virtual laptop is available for running the client's custom presentation (especially useful when HMD is in use) and to strengthen the feeling of presence by providing enhanced presentation-flow realism. The computer-controlled avatars behavior is defined by the scenario, but affected to some degree by their position (distance to the speaker). Virtual characters sitting in front of the speaker exhibit more detailed behavior and appearance. As one moves towards the far end of the conference room, there are three zones: A) 3D models with skeletal animation, bone facial expressions and lip synchronization, B) virtual persons who participate as 2D animations and C) in the far away, there were only static figures who can perform idle or imperceptible horizontal movements. The intelligence of the avatars follows the axis of detailed visual representation having the front seated ones to be more smartly interactive than ones seating further back. Currently the idle, silent, normal, look bored, noisy and aggressive modes are available for the audience.

4.3 The Fear of Flying (Turbulence) Scenario

Figure 4 depicts what the patient is viewing from own perspective (in stereo mode). This scenario was created for people who fear flights and believe in catastrophic consequences of turbulence. During the flight, other passengers look and behave naturally, while the crew is offering beverages. The therapist can select whether to create discomfort at any time. In auto-mode, the intensity and quality of the stimuli can be raised or lowered by the artificial intelligence of the VRET system.

Fig. 3. The conference room captured at a time audience express disapproval (aggressive mode)

Fig. 4. The flight scenario viewed in stereo from patient's perspective

4.4 Tools Used for Content Development, Rendering and Projection

The content development of the supported case studies, mainly 3D objects and avatars, was made with SketchUp 8.0 and iClone 5.0. Scenes were imported into Unity Game Engine (version 4) in order to be projected through the HMD (Virtual Research v.8) in a very good realistic representation. The depth camera used in pilot studies was Microsoft Kinect and the OpenNI SDK was used for the 3D sensing middleware interface development. The patient's body moves sensing functionality, engineered in Visual Studio, was exported as a dynamic link library (dll file) to the front-end application. The scenario development tool and the front-end application for stereoscopic projection on 3DTVs were developed with Delphi.

5 The Evaluation

Given the feature and functionality extension to existing VRET approaches, the evaluation of the first working demonstrator aims at evaluating the proposed approach. The prototype was evaluated by a body of twenty eight professionals (N=28) from which 18 of which were women and 10 men. Their mean age was 47.73 (SD=13.16). Eleven of them were Psychiatrists (medical doctors) while the rest were clinical and counseling psychologists, including a 14.28% of students. The prototype used in the pilot study was a mature version which supported the two scenarios descried earlier, the depth camera and both the 3DTV and HMD versions in a dual graphics output. The output was rendered in full HD, in 16:9 aspect ratio. In the 3DTV version, it was viewed by a distance of 1.5 m (indicated by a colored area in the demo room floor).

Table 2. Responses on the elements of the questionnaire (Likert scale: 1-5)

#	Question	Mean	SD
B1	How familiar are you with Virtual Reality technology?	2,25	1.11
B2	How often have you used similar applications in the context of your professional obligations, research or your studies?	1,57	0.92
Q1	Are the stated aims and goals of the modules obvious and intuitive?	3,85	0.77
Q2	Is the workflow of loading and control of new modules intuitional and without problems?	3,13	1.45
Q3	Did the modules you have tested so far covered your expectations on Virtual Reality Exposure Therapies?	3,48	1.92
Q4	Did the overall system worked as expected?	3,6	1.10
Q5	Are you satisfied from the quality of content (graphics, realism)?	3,85	1.24
Q6	Using the VR tools, do you think your effectiveness as a therapist will be increased?	3,79	1.94

After 5-10 minutes experimentation with the VRET system, participants were asked to fill up a questionnaire, the results of which are presented in Table 2. Responders were familiar with the VRET, but the lack of personal experience gave a 2.25 mean to the B1 question (SD=1.11) and 1.57 in B2 (SD=0.92). From Q1 it was made clear that of the VRET prototype was perceived as obvious and intuitive. The means of 3.85 (SD=0.77) was the highest in the questionnaire. In Q2, participants found the workflow of loading and using modules to be intuitive and free of problems (M=3.13, SD=1.45). Also, in Q3, good expectations from the system was reported (M=3.48, SD=1.92). The prototype worked as expected (Q4, M=3.6, SD=1.10) and the level of satisfaction was very encouraging (M=3.85, SD=1.24). Based on their demonstration experience, testers believe that the proposed VRET system could increase their effectiveness as therapists (Q6, M=3.79, SD=1.94).

The last open-questions aimed to capture missing functionality (Q7: In your opinion, what features or functionality are missing from the system or its modules?) and take feedback on the time and effort it would be necessary to learn how to use the system (Q8: Make a comment on the time & effort needed to learn the tools). Apart from the fact that the head tracking mechanism of the HMD was not available during the demonstration, most therapists did not find missing features. Two therapists mentioned that using VRET systems cannot reveal much about the etiology of a specific phobia. However, some believe that knowing the reasons behind the onset of the phobia is not necessary to complete the treatment [14]. In Q8, most therapists implied that the VRET prototype was rather easy or very easy to learn (80%). A good learning curve and the low price -they said-would be necessary for a future investment.

6 Conclusions

VRET is used in phobias treatment as a tool to treat anxiety disorders which cause great impairment of patient's socialization, professional activity and quality of life. Given the long distance VRET has covered during the last decades, an extension to well-known approaches is proposed in order to enhance the Sense of Presence (SoP), disconnect content from VRET functionality by adopting the idea of scenario preparation by therapists themselves and support multiple sensors to serve as objective measures of anxiety levels. It is not a therapist-free solution like Virtually Free developed by Green, Flower and Fonseca [12] which uses mobile technology.

A novel addition to the overall architecture is personalization (user profiles) and depth camera sensors which can project in real time the patient into the simulated world and leverage higher mental processes like social self-awareness and metacognition to amplify VR benefits as a therapeutic modality. Realism was given attention, but not to the extreme that could raise the development cost, as a VRET system can be effective even at low representational level [27]. It is expected that therapists will use such VRET sessions before real life situation exposure.

It is believed that the proposed approach is suitable for certain types of specific phobias, standardized over existing Diagnostic Classification systems like the Diagnostic & Statistical Manual of Mental Disorders of the American Psychiatric

Association [8]. Although the target audience of this study was the therapists, as users of the VRET system, a future clinical use with people who suffer from phobias would be necessary to confirm the usability of the prototype and the findings of the literature regarding the therapeutic use of the VRET.

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