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Monographic Article

Virtual reality for the treatment of emotional disorders: a review

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Summary:

At this moment a great expansion of Information and Communications Technologies such as Virtual Reality and Augmented Reality is taking place in several fields, including the psychological treatments field. These technologies help the patient both to confront his/her problems in a meaningful yet controlled and safe setting. Further, they open the possibility of experiencing his/her life in another, more satisfactory, way. There are already data on the effectiveness of these procedures for the treatment of different psychological disorders. In the present work a review of the different studies made in this field for emotional disorders is presented. Besides, the advantages and disadvantages of VR, and the future lines of work concerning these technologies are also analysed.

Keywords: Virtual Reality, Emotional Disorders, Psychological Treatments, Clinical Psychology

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Introduction

The psychology treatments field has advanced notably in the last years. Since the beginning of the movement of psychology based on evidence we have already a high number of treatments protocol that have proved to be effective and efficient. In this sense, it should be highlighted the role played by the Information and Communication Technologies (ICTs). It is generally assumed that technology assists individuals in improving their quality of life; but, to ensure appropriate development and use of these technologies, clinicians must have a clear understanding of the opportunities and challenges they will provide to professional practice. Our team has developed and validated several applications based on different ICTs, such as: Virtual Reality (VR), Augmented Reality (AR), the Internet or mobile devices. In this work some advantages and limitations of ICTs for this field are discussed; also some of these applications using VR for the treatment of emotional disorders are presented, and finally, some future perspectives are analysed.

Advantages of Virtual Reality for the psychological treatments field

Research over the past three decades has shown that the "in vivo exposure" technique is quite effective in treating several psychological problems, especially anxiety disorders. For these disorders, avoidance of feared situations is an element that contributes to maintenance of the problem. The clearest form of avoidance is not facing the situation; for instance, not using elevators, not staying in places where the windows are closed, etc. This kind of behaviour provides relief in the short term, but causes important problems in the long term. Consequently, one of the main aims of treatment consists of coping with feared situations. This is achieved by "exposure", a treatment technique that is used precisely to activate pathological fear structures in order to disconfirm sufferers' beliefs and teach them to cope with phobic situations. In fact, most studies stress that the most effective treatment for many psychological disorders is in vivo exposure to the feared situations (Harris, Robinson & Menzies, 1999; Marks, 1987; Öst, 1987).

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In short, exposure procedures involve presenting a person with anxiety-provoking material (situation, objects, etc.) for a long enough time to decrease the intensity of their emotional reaction. Usually, in vivo exposure is presented in a graded or graduated way; that is, the patient is exposed to the feared situation in a gradual manner. However, in vivo exposure has a number of limitations and VR has been considered a viable alternative to this technique. Generally, the works devoted to analyzing the contribution of VR to the field of psychological treatments highlight the following advantages that VR has over traditional exposure therapies (Botella, Baños, Perpiñá, & Ballester, 1998a; Botella, Baños, Perpiñá, Alcañiz, Villa, & Rey, 1998b; Botella, Quero, Baños, Perpiñá, García-Palacios, & Riva, 2004; Riva, 1997; Riva, Botella, Legéron, Optale, 2004; Wiederhold, & Wiederhold, 1998; Zimand, Rothbaum, Tannenbaum, Ferrer, & Hodges, 2003):

Firstly, in vivo exposure is costly, as it usually requires the therapist to go to the feared place. Exposure interventions "without a therapist" are still not very frequent and patients are often reluctant to participate in this type of treatment. In addition, the feared place is not always easily accessible, and imaginal exposure (that is, exposure to imagined situations) in these cases is less effective. The additional difficulty of individual differences in imaginative ability must also be taken into account. VR technology can help overcome these difficulties by generating different settings that would not otherwise be readily available without leaving the office

VR exposure allows almost total control of everything occurring in the situation experienced by the person in the virtual world. If a patient fears being trapped in an elevator, or turbulence and bad weather during a flight, we can assure him/her that these threats are not going to occur until he/she feels prepared to cope with them and, in fact, he/she accepts them to happen in the virtual world. The same can be said for numerous elements that are present in the situation which can make it more or less threatening. For instance, number of feared persons, animals or objects, size and degree of closing/opening of virtual spaces, the height of the spaces, the presence of protecting elements, duration of a determined situation, etc. This makes a personalized construction of the exposure hierarchy possible by enabling the user to cope with the feared situation or context at his/her own pace. A VR system can generate as many audiences and social situations as the person requires, and such situations can be at his/her disposal when needed and as many times as the person desires. The only mission of the avatars and the whole virtual world is to be there in order to help. Therefore, VR provides valuable opportunities regarding training and self-training. A person with fear of driving following a motor vehicle accident can practice different feared elements (overtaking a track, driving with rain, entering a tunnel, or passing over a bridge) as many times as needed in the virtual world. This possibility of continuous practice in many diverse contexts may help to generalize the therapeutic achievements to the real world.

VR helps the person feel present and judge a situation as real. In fact, a central element of VR is that it provides the person a place where he/she can be placed and live the experience (Baños, Botella, Guerrero, Liaño, Alcañiz, & Rey, 2005). VR contributes an important benefit to treatment because it affords a feeling of presence that can rarely be achieved with imaginal exposure. This aspect is fundamental, since exposure therapy is intended to facilitate emotional processing of fear memories. Furthermore, the therapist is able to know what is always happening in the situation, what elements are being faced by the patient and by what is disturbing him/her. Obviously, this also contributes to the control of the situation and the protection of the patient.

VR makes going beyond reality possible. In therapy, (and also in the real world) one can witness the importance of certain situations considered extreme in order to definitively overcome a problem. There are different thresholds of difficulty/threat; once a very high threshold is overcome, it is much easier to cope with the remaining ones. Virtual worlds allow creating situations or elements so "difficult or threatening" that they would not be expected to happen in the real world. For instance, in our claustrophobia application one of the walls can be displaced (producing a loud noise) reducing the room to a very small space. The first patient who was treated with this application indicated precisely this: "If I am able to cope with that wall I can confront everything" (Botella, et al 1998b). The same can be created in other virtual worlds; a person with phobia of spiders unexpectedly has to cope with thousands of spiders, or spiders whose size increase so much that they turn into monsters.

VR is an important source of personal efficacy (Botella, et al. 1998a; 2004). According to Bandura (1977), from all possible sources of personal efficacy, performance achievements are especially useful. VR is an excellent source of information on personal efficacy. VR allows the construction of "virtual adventures" in which the person experiences him/herself as competent and efficacious. VR is flexible enough to permit the design of different scenarios in which the patient can develop personal efficacy expectations of the highest magnitude (including from easy performances to very difficult ones) generalization (referred to very different domains) and strength (difficult to extinguish, and to achieve the patient perseveres regardless of difficulties). The goal is for the person to discover that the obstacles and feared situations can be overcome through confrontation and effort.

A problem posed by in vivo exposure treatment is that patients are sometimes so afraid of facing what they fear that they either refuse this type of program or drop out after beginning (Marks & O'Sullivan, 1992). This treatment can also be very aversive for patients who do accept them and can make them feel very insecure, as there is no assurance that something will not go wrong (e.g., the elevator stopping, technical problems on the plane, etc.). Safety is an important advantage of VR. Patients can control the context and the computer-generated setting with the therapist as they wish and with no risk involved. Indeed, the "virtuality" of the setting is precisely what makes patients feel safe (they can act, experiment and explore the feared setting "as if" it were real). This provides the important intermediate step between the therapist's office (where patients feel safe and sheltered) and the real world (which may seem so threatening that patients decide they cannot cope with it). Furthermore, VR allows the feared object to be graded very precisely according to individual differences. This means that treatments can be "custom-made" for each patient and each problem. Moreover, patients usually accept the use of VR very well. A study conducted by Garcia-Palacios and colleagues compared the acceptance of one-session and multisession in vivo exposure vs. multisession VR exposure therapy (Garcia-Palacios et al., 2001). More than 80% of the sample preferred VR to in vivo exposure.

VR offers privacy and confidentiality. The possibility offered by VR of confronting many fears inside the consulting room, without the necessity of in-vivo exposure, represents a significant advantage.

Besides these advantages of VR over the traditional exposure technique VR offers other advantages from a more general treatment perspective. On one hand, VR becomes a new sense that is incorporated in our "perceiving apparatus", using Popper's (1962) and Lorenz's (1973) terminology. The virtual worlds allow us to access more information about both ourselves and the world. By watching him/herself confronting different feared agoraphobic situations, an agoraphobic changes the perception he/she has of him/herself (perhaps I am not so weak) and about the world (perhaps it is no so dangerous). The magic of virtual worlds and its importance regarding treatment lies precisely there. They are "safe" contexts, the "safe base" that therapy offers to the patient (Bowlby, 1973). In these protected contexts, people can freely explore, experience, feel, live, revive feelings and/or thoughts whether they are current or past. Nothing prevents them from knowing the world and their selves. Assuming this new perspective provides an enormous sensation of freedom. It is possible to be aware of the world and the self, which were considered absolutely given and finished; in fact, they are just an interpretation, a simulation, which (at least to a certain extent) can be changed. The patient can construct a new reality about him/herself and the world ("I have been an agoraphobic until today, but starting now there is no need to keep doing it"). Therefore, the goal of VR is not necessarily to "recreate" reality, but rather to achieve virtual environments that are relevant and significant to the person (Hoorn, Konijn, & Van der Veer, 2003).

The first study using VR for the treatment of a psychological disorder was focused on acrophobia and exposed the user to virtual anxiety-provoking environments instead of real anxious situations. Since then, there have been significant advances in the number of problems studied, as well as their complexity. A review of the main results obtained with VR therapy for emotional disorders is presented below.

Virtual Reality based applications for emotional disorders

1 Phobias

1.1 Acrophobia

The first experience aimed at testing the utility of VR for the treatment of acrophobia, fear of heights, was carried out by the Kaiser-Permanente Medical Group of California. A system wherein the patient had to pass through a deep gully crossing over a suspension bridge and a narrow board was developed (Lamson, 1994). The use of the system with 32 patients obtained a 90 percent success rate.

Apart from this first experience, six case studies and four controlled studies have been reported to date. The first case studies were carried out by Rothbaum and North's groups at the University of Clark Atlanta (North, North & Coble, 1996a,b,c; Rothbaum, Hodges, Kooper, Opdyke, Williford, & North, 1995). Furthermore, Choi, Jang, Ku, Shin & Kim (2001), and Jang, Ku, Choi, Wiederhold, Nam, Kim & Kim (2002) also demonstrated that VR exposure technique is effective in the treatment of acrophobia. Nevertheless, in a single case study, Kamphuis, Emmelkamp and Krijn (2002) did not find a clinically significant improvement. However, in other work published one year later, Bouchard, St-Jacques, Robillard, Coté and Renaurd (2003) found statistically significant improvement in fear of heights in a series of 7 patients (five females and 2 male). Moreover, the gains were maintained at 6-month follow-up.

The first controlled study on the effectiveness of VR exposure for the treatment of acrophobia was carried out by Rothbaum, Hodges, Kooper, Opdyke, Williford & North (1995). Students with fear of heights were randomly allocated to one of two experimental conditions: a VR exposure group (N=12) versus a no-treatment control group (N=8). The results showed significant differences between the students who completed the VR treatment and those on the waiting list.

The remaining three controlled studies made with clinical populations were conducted by Emmelkamp's research group. In the first one, Emmelkamp, Bruynzeel, Drost & van der Mast (2001) evaluated the effectiveness of a low-budget virtual reality exposure versus exposure in vivo in a within-group design. Although VR exposure was as effective as in vivo exposure, firm conclusions could not be drawn due to the limitation of a potential order effect influencing the results. In the second study (Emmelkamp, Krijn, Hulsbosch, de Vries, Schuemie & van der Mast, 2002), participants were also randomly allocated to either VR exposure treatment or in vivo exposure. VR exposure was shown to be as effective as in vivo exposure for all measures (including a "Behavioral Avoidance Test" consisting of climbing open stairs) and improvement was maintained at 6-month follow-up. Finally, another study developed by this group (Krijn, Emmelkamp, Biemond, de Wilde de Ligny, Schuemie & van der Mast, 2004) was aimed at examining two different conditions of VR exposure treatment, varying in their degrees of immersion by using either a head-mounted display (HMD) for low immersion, or a computer automatic virtual environment (CAVE) for high immersion. To control the effect of time, a no-treatment control group was added. Thirty seven patients took part in the study, and they were assigned randomly to one of the three conditions. Results showed that VR exposure was more effective than no treatment, with no differences found between the two presence conditions (HMD versus CAVE). Gains were maintained at 6-month follow-up. All studies used visual and audio stimuli and some form of tactile stimuli)such as a platform or a railing that the participant could hold on to), thus increasing the sense of presence.

In conclusion, it appears that VR exposure has proven to be effective for the treatment of fear of heights. The four controlled studies and most of the case studies show that VR exposure is effective in treating fear of heights.

1.2 Claustrophobia

Positive results about the effectiveness of VR exposure for the treatment of claustrophobia, fear of enclosed or confined spaces, have been reported in the three studies carried out by Botella's research group. The first study (Botella, Baños, Perpiñá, Villa, Alcañiz & Rey, 1998a) consisted of a case report. The participant was a 43-year-old woman who received 8 VR exposure sessions. All fear measures were reduced after treatment and were maintained at one-month follow-up. In the second work (Botella, Villa, Baños, Perpiñá & García-Palacios, 1999) the same VR exposure therapy was applied to a patient with a diagnosis of two specific phobias (claustrophobia and storms), panic disorder and agoraphobia. Results showed an important change in all measures after treatment. In addition, a generalization of improvement to other phobic and agoraphobic situations not specifically treated was observed. Furthermore, changes were maintained at 3-month follow-up. In another study, Botella, Baños, Villa, Perpiñá & García-Palacios (2000) tested the effectiveness of VR exposure therapy following a controlled design. Results again supported the effectiveness of VR exposure. An improvement was observed in all measures (including a Behavioral Avoidance Test consisting of keeping the person in a closet) and gains were maintained at 3-month follow-up.

In short, although results obtained in the aforementioned studies are promising, additional studies with larger samples, using group designs including control groups, are still needed in order to draw firmer conclusions.

1.3 Small animal phobia

The group at the University of Nottingham and the Institute of Psychiatry developed the first VR system for the treatment of arachnophobia (Grimsdale, 1995). Through an HMD, participants viewed a spider whose realism gradually increased until the patient's tolerance allowed him/her to face the spider. In addition, Hoffman's research group has reported three studies examining the effectiveness of VR exposure for the treatment of phobia of spiders: a case report and two controlled studies. The case report (Carlin, Hoffman & Weghorst, 1997) showed the efficacy of immersive computer-generated virtual reality and mixed reality (consisting of touching real objects which patients also saw in VR) in a 37-year old female with severe and incapacitating fear of spiders.

Later, this promising result was supported by two controlled studies. In the first one, García-Palacios, Hoffman, Carlin, Furness & Botella (2002) compared VR exposure therapy with a waiting list condition in a between group design with 23 participants who received an average of four one-hour exposure sessions. Results showed that 83% of patients in the VR treatment group improved in a clinically significant way (including a Behavioral Avoidance Test, consisting of exposure to real spiders) compared with 0% in the waiting list no treatment condition. The second work (Hoffman, García-Palacios, Carlin & Botella, 2003) explored whether treatment effectiveness was increased by providing the patient the illusion of physically touching the virtual spider. Results showed that the participants in the tactile augmentation group showed the greatest progress on behavioral assessment as observed in the Behavioral Avoidance Test at post-treatment. Therefore, we can conclude that the effectiveness of VR exposure for the treatment of arachnophobia is well established, since it has been proven that is more effective than non treatment. However, its effectiveness compared with in vivo exposure still remains unknown.

1.4 Flying Phobia

Several case studies have been reported, all of them providing results favoring the utility of VR therapy for the treatment of fear of flying (Baños, Botella, Perpiñá & Quero, 2001; Klein, 1999; North, North & Coble, 1997; Rothbaum, Hodges, Watson, Kessler & Opdyke, 1996; Wiederhold, Gervitz & Wiederhold, 1998).

On the other hand, another seven studies, which differ in the degree of methodological control achieved, also provide support for the effectiveness of VR for the treatment of flying phobia. Wiederhold (1999) compared VR exposure therapy with "Imaginal exposure therapy" (that is, exposure treatment done through imagination). Three groups were included in the study: VR with no physiological feedback (wherein users did not receive information about their physiological state) (N=10), VR with physiological feedback (wherein users received information about their physiological state) (N=10) and imaginal exposure with no physiological feedback (N=10). Contrary to what was expected, there were no differences between groups after treatment. However, statistically significant differences between groups at three-month follow-up were found: 80% of the VR Exposure with no physiological feedback group, 100% of the VR Exposure with physiological feedback group, and 10% of the imaginal exposure group could fly without medication or alcohol at follow-up. Kahan, Tanzer, Darvin & Borer (2000) investigated the effects of anxiety management training (techniques focused on coping anxiety symptoms) and VR exposure therapy; the results showed that 21 out of 31 patients flew after treatment. However, as Krijn, Emmelkamp, Olafsson & Biemond. (2004) point out, no conclusion about the effectiveness of VR exposure can be drawn due to several methodological shortcomings (e.g., the design consisted of a package rather than pure VR exposure, and the number of sessions differed across patients).

In the study carried out by Mühlberger, Herrmann, Wiedemann, Ellgring & Pauli (2001), thirty patients were randomly assigned to either VR exposure condition or relaxation condition. Results showed that fear of flying improved in both treatment groups. VR exposure was found to be more effective than relaxation on specific fear of flying questionnaires. In a more controlled study, Rothbaum, Hodges, Smith, Lee & Price (2000), three experimental conditions were used to compare VR exposure therapy (four sessions of VR exposure and four sessions of anxiety management therapy) with in vivo exposure therapy (two sessions of traditional in vivo exposure and four sessions of anxiety management therapy) and a waiting list (that is, no treatment). Forty-five patients were randomly allocated to one of these conditions. Both treatment conditions were more effective than a waiting list period, with no differences between treatments, neither after treatment nor at 12-month follow-up (Rothbaum, Hodges, Anderson, Price & Smith, 2002).

A second, more controlled study was carried out by Maltby, Kirsch, Mayers & Allen (2002). Using a between group design they compared VR exposure therapy (psycho-education and graded exposure) with an attention-placebo condition (education about the safety of a flight and mechanisms of airplanes). The VR exposure group showed a better outcome on most measures at post-treatment; however this superiority of the VR exposure group disappeared at 6-month follow-up. In another randomized controlled work, Mühlberger, Wiedemann & Pauli (2003), compared three experimental treatment conditions: 1) cognitive treatment and VR exposure therapy with motion simulation; 2) cognitive treatment and VR exposure therapy with no motion simulation; and, 3) cognitive treatment alone. A non-random waiting list group was also used. Only participants who received VR exposure (with or without motion simulation) showed reductions in their fear of flying measured by questionnaires at post-treatment. Furthermore, motion simulation did not enhance treatment effectiveness.

Finally, Botella, Osma, García-Palacios, Quero & Baños (2004) carried out a multiple baseline design controlled study where the use of VR exposure was the only therapeutic component (consisting of 6 exposure sessions). Nine participants took part in the study, and results showed that VR produced a decrease of the fear, avoidance and belief in catastrophic thoughts; all participants flew after treatment. Moreover, these results were maintained at 1-year follow-up.

In short, results obtained thus far suggest the utility of VR for the treatment of flying phobia. However, more controlled studies are needed with larger samples and comparable treatment conditions with regard to number of sessions and length of sessions in order to draw firmer conclusions.

1.5 Driving Phobia

Wald & Taylor (2000) carried out the first case report examining the efficacy of VR exposure therapy for treating the fear of driving. A decrease in anxiety and avoidance was produced, with gains maintained at 7-month follow-up. In a second controlled work, Wald (2004) presented efficacy data from a multiple baseline across-subjects design that included five participants who followed a VR exposure treatment with eight weekly sessions. There were significant reductions in fear and avoidance symptoms in three out of five participants that were maintained at one-year follow-up, as measured by self-monitoring (in a driving diary) and interviews *(SCID-IV*, First et al., 1996; *Driving History Interview*, Ehlers, 1990). However, VR exposure did not result in an increase in actual driving frequency for any of the participants. Given these limited results, the author concluded that VR exposure might be most useful as a preparatory intervention or as an adjunct for *in vivo* exposure rather than as a stand-alone intervention.

Finally, Walshe, Lewis, Kim, O'Sullivan & Wiederhold (2003) have reported an open study aimed to investigate the effectiveness of the combined use of computer generated environments involving driving games and a VR driving environment for the treatment of driving phobia. Fourteen subjects who met DSM-IV criteria for Specific Phobia after a motor vehicle accident participated in the study. Participants who experienced "immersion" in one of the driving simulations (7 out of 14) completed the exposure program. Significant reductions for all measures were produced at post-treatment supporting the utility of VR and computer games in the treatment of driving phobia even when co-morbid conditions such as post-traumatic stress disorder and depression were present.

In conclusion, studies on the use of VR exposure therapy are still contradictory and preliminary for this specific phobia. The open trial by Walshe et al (2003) offered promising findings. However, the study by Wald (2004) offers very limited results regarding the use of VR in the treatment of driving phobia. The literature on *in vivo* exposure therapy for driving phobia is also very scarce (Towned & Grant, 2006) and there are no available controlled studies with a group design. Controlled studies are needed in order to investigate if this phobia has a differential response to exposure therapy.

1.6 Public Speaking Fear/Social Phobia

Anderson, Rothbaum & Hodges (2003) reported two case studies using anxiety management treatment, in vivo exposure and VR exposure. Results showed a decrease in specific anxiety symptoms at post-treatment. The authors also informed that the results for these two cases were similar to the effectiveness of "traditional" treatment (cognitive behavior therapy). Légeron's group has also designed (Roy, Klinger, Légeron, Lauer, Chemin & Nugues, 2003) and recently tested (Klinger, Bouchard, Légeron, et al., 2005) a VR-based protocol to treat social phobia. This last work is a preliminary controlled study in which a VR exposure therapy group was compared with a cognitive behavior therapy group (control condition). The virtual environments used recreated four situations related to social anxiety: performance, intimacy, scrutiny, and assertiveness. The results showed that both groups improved significantly.

Slater and colleagues (Slater, Pertaud & Steed, 1999) have been working on software designed for fear of public speaking and its validation (Pertaub, Slater & Baker, 2002). In this last work, Pertaub et al. studied the anxiety response of 40 individuals with fear of public speaking in a virtual reality environment. Participants had to give a 5-minute presentation to a neutral, positive, or negative audience that consisted of eight avatars. Results confirmed that all three virtual environments could generate anxiety in participants. Harris, Kemmerling and North (2002) reported a study with a subclinical population. Two conditions were contemplated: VR exposure therapy and a waiting list control group. VR exposure therapy included four exposure sessions of 15 minutes each. Participants in the VR condition showed an improvement on several questionnaires after treatment.

In summary, preliminary results suggest that VR may be a useful tool for the treatment of fear of public speaking. However, there is only one controlled study in the literature (Harris et al., 2002) and it has been carried out with a subclinical sample. In the near future more controlled studies will likely be conducted. Fear-provoking virtual environments are already available and results, although preliminary, are in favor of the efficacy of VR exposure for the treatment of social anxiety.

2. Panic disorder and agoraphobia.

Panic disorder and agoraphobia (PDA) is a highly incapacitating psychological disorder. PDA is an anxiety disorder characterized by attacks of anxiety or terror, often (but not always) occurring unexpectedly and without reason. These attacks are associated with somatic symptoms such as dyspnea, palpitations, dizziness, vertigo, faintness, or shakiness and with psychological symptoms such as feelings of unreality (depersonalization or derealization) or fears of dying, going crazy, or losing control; there is usually chronic nervousness and tension between attacks. Agoraphobia is the fear of having a panic attack in general in any place whether it be the grocery store, at work or in the privacy of one's own home.

Virtual environments for the treatment of PDA are available (Botella, Villa, García-Palacios, Baños, Perpiñá & Alcañiz, 2004; Moore, Wiederhold, Wiederhold & Riva, 2002; Vincelli, Choi, Molinari, Wiederhold & Riva, 2000). Due to the complexity of PDA compared to specific phobias, studies carried out to test the effectiveness of VR exposure therapy for the treatment of this disorder have included the exposure to anxiety-provoking virtual environments as a part of a cognitive behavioral treatment program. This program also includes other techniques such as breathing retraining, relaxation, cognitive restructuring (that is, techniques focused on replacing irrational beliefs with more accurate and beneficial ones), and education (that is, information about the problem and how to manage it).

VR treatment efficacy for PDA has been demonstrated in several controlled studies with clinical samples that use VR for situational exposure. Vincelli et al. (2003) tested the efficacy of a CBT program in which exposure to agoraphobic situations was applied using a clinical intervention protocol called Experiential Cognitive Therapy (ECT) for the treatment of PDA that included VR environments designed three years prior by Vincelli, Choi, Molinari and Riva (2000). Eighteen participants with PDA were assigned to three experimental conditions: 1) the ECT group, 2) the traditional CBT group and, 3) a waiting list control group. Both treatment groups were equally effective, and each was more effective than the control group. However, this study had some limitations. Firstly, the sample size was small. Secondly, participants were given self-exposure assignments between sessions, which made it difficult to determine if the improvement was due to the ECT or to in vivo exposure. Thirdly, the treatment groups received different numbers of sessions: 8 for the ECT group and 12 for the CBT one. Finally, relevant measures for PDA such as the Panic Disorder Severity Scale and the Anxiety Sensitivity Index were not included. In a later study, Choi et al. (2005) compared two experimental treatment conditions: one group received the traditional Panic Control Program developed by Barlow and Craske (1994) consisting of 12 sessions, while the other group received the aforementioned ECT with 4 sessions. Forty people with PDA participated in the study. Results again showed an improvement in both treatment conditions with no differences between them at post-treatment. However, at 6-month follow-up, the ECT group's results were inferior to those of the Panic Control Program. Again, though, the treatment groups received different number of sessions (the ECT group was smaller). Finally, a recent study by Peñate, Pitti, Bethencourt, De La Fuente and García (2008) compared two treatment conditions: CBT with VR exposure to agoraphobic situations and CBT with in vivo exposure to agoraphobic situations. The authors observed a slight amelioration of symptoms in the group that received VR exposure compared with the in vivo exposure group. However, analyses did not reach statistical significance between groups neither at post-treatment nor at three-month follow-up.

All of the aforementioned studies show the efficacy of VR exposure to agoraphobic situations for the treatment of PDA. However, all of them apply the Interoceptive Exposure (IE) component in the traditional manner (in vivo), so the efficacy of IE using VR was not explored. The VR program for PDA developed by Botella et al. (2004) enables therapists to simultaneously use virtual reality interoceptive exposure to present bodily sensations (including rapid audible heartbeats and panting as well as visual effects) while patients are immersed in various VR environments (e.g. a bus or a mall) in the consultation room. In a previous controlled study (Botella et al., 2007), we compared three experimental conditions: In vivo exposure (wherein both exposure to agoraphobic situations and IE were conducted in vivo), VR exposure (wherein exposure to agoraphobic situations was conducted using virtual scenarios and IE was conducted using the effects offered by the VR program as well as traditional exercises), and a waiting list control. Results revealed that both treatment conditions showed similar efficacy, and that each was more effective than the control group. In spite of the efficacy and acceptability of VR exposure reported by the participants in this study (Botella et al., 2007), the VR condition did not use the IE VR component in a controlled manner. For this reason, in a recent study (Perez-Ara et al., 2010), the effects of using VR IE and traditional methods for IE were compared. We did this by comparing the efficacy of a single CBT program in two applications: one in which VR was used for both the situational exposure and IE components, and another in which VR was used for situational exposure, but the IE component was applied in the traditional manner. Results showed that both treatment conditions significantly reduced the main clinical variables at post-treatment. These results were maintained or even improved for both conditions in six of the outcome variables at three-month follow-up. However no significant differences were found between the two treatment conditions, so it seems that provoking physical sensations with VR effects was as powerful as evoking them with traditional exercises (such as hyperventilation, climbing or descending stairs, spinning in a chair, etc.) traditionally used in IE (Barlow, Craske, Cerny & Klosko, 1989). These promising findings support the utility of the Panic-Agoraphobia program (Botella et al., 2004) in applying both VRE to agoraphobic situations and VR-IE.

Despite the few studies available and the limitations of the studies that have been presented, VR exposure could be useful for the treatment of PDA. However, most of the work in this field remains to be done. For instance, it is necessary to replicate these in larger clinical samples, including follow-up assessments, and to validate the virtual interoceptive exposure component.

3. Stress-related disorders

3.1. Post-traumatic stress disorder

Post-traumatic Stress Disorder (PTSD) is a psychological disorder that can occur following the experience or witnessing of life-threatening events such as military combat, natural disasters, terrorist incidents, serious accidents, or violent personal assaults such as rape. People who suffer from PTSD often relive the experience through nightmares and flashbacks, have difficulty sleeping, and feel detached or estranged, and these symptoms can be severe and long enough to significantly impair the person's daily life. The use of cognitive behavioral programs that include exposure-based techniques is currently the treatment of choice for PTSD. The treatment program for PTSD with the most empirical support is Prolonged Exposure, developed by Foa & Rothbaum (1998), which involves imaginal exposure to the traumatic experience.

Rothbaum et al. (1999) published the first case study in the use of VR exposure in the treatment of PTSD. Since then, an increasing number of studies are showing the utility of VR exposure for PTSD, resulting in a significant reduction of patients' symptoms related to the traumatic event they have experienced. Most of these works have been centered on war victims (war veterans or active military personnel) and a minority has been conducted with terrorist attack victims and motor vehicle accidents victims. For instance, Rothbaum's team has reported clinical situation improvements in Vietnam war veterans in several case studies (Rothbaum et al., 1999; Rothbaum, Hodges, Ready, Graap y Alarcon, 2001; Rothbaum, Ruef, Litz, Han y Hodges, 2004) and in an open clinical trial (Rothbaum, Ruef, Litz, Han y Hodges, 2004). However, preliminary results obtained in a controlled study conducted by Gamito el al. (2009) did not find significant differences from pre to post-treatment (fifth session) in the participants who were exposed to the virtual environment. In any case, this is still a study in progress in where only data referred to half of treatment sessions were analysed. Finally, in a more recent clinical pilot study Gamito et al. (2010) assigned 10 participants to 3 groups: VR exposure therapy, prolonged exposure and waiting list control group. Participants were Portuguese was veterans who fight in African colonial wars more than 30 years ago. Patients who received VR exoposure condition showed a significant reduction of symptoms related to PTSD (anxiety and depression). These results, although no conclusive, show that VR can be effective to treat elderly war veterans.

On the other hand, in the last 4 years numerous studies with active soldiers using Irak and Afganistan wars VR environments for the treatment of this problem have been published: four case studies (Gerardi, Rothbaum, Ressler y Heekin, 2008; Reger y Gahm, 2008; Tworus, Szymanska y Illnicki, 2010; Wood, Wiederhold y Spira, 2010); a case series study (McLay, McBrien, Wiederhold y Wiederhold, 2010); three open clinical trials with 20 or more participants participantes (Reger et al., 2011; Rizzo et al., 2009; Rizzo et al., 2010); and a small random controlled study which compared VR exposure versus treatment as usual (McLay et al., 2011). The positive results obtained in all these works point out the utility of VR for the treatment of combat-related PTSD in active soldiers.

Thirdly, regarding terrorism victims, VR has showed its utility in the treatment of survivors of the September 11th attack in New York (Difede & Hoffman, 2002) and positive preliminary results have been also found in a small control study which compared VR exposure versus a wainting list control group (Difede et al., 2007). Finally, there exist preliminary data on the use of VR for the treatment of terrorist bulldozer attack victims in a case study (Freedman et al., 2010).

Preliminary data are also available on the use of VR for the treatment of motor vehicle accidents PTSD victims in two case series studies (Beck, Palyo, Winer, Schwagler y Ang, 2007; Walshe, Lewis, Kim, O'Sullivan y Wiederhold, 2003).

In general, results obtained in all these aforementioned studies are very promising regarding the utility of VR for the treatment of PTSD: Furthermore, we should highlight that in the study conducted by Difede and Hoffman (2002), the VR treatment was more effective that traditional treatment, resulting in success when the treatment of choice currently for PTSD (imaginal prolonged exposure) had failed. However, it is also important to notice that most of these studies are uncontrolled ones (case studies, case series, clinical open trials), thereby is necessary to replicate the results in controlled studies with bigger samples in order to draw firmer conclusions regarding the efficacy and effectiveness of VR in the treatment of PTSD.

Finally, another approach is proposed by Botella et al. (2006a). In the previously mentioned studies, the approach is to simulate traumatic events with high realism with the aim of exposing the participants to the feared aspects of the trauma. Botella's design follows a different approach. The aim is to design clinically significant environments for each participant, while attending to the meaning of the trauma for the individual, rather than to simulating the physical characteristics of the traumatic event with high realism. The aim is not realism, but using customized symbols and aspects which provoke and evoke an emotional reaction in the participant. This can help to achieve the emotional processing of the trauma, while creating a safe and protective environment. In the EMMA research project funded by the European Union (Engaging Media for Mental Health Applications, IST-2001-39192) we have developed a virtual environment 'EMMA's World' that acts as an adaptive display to treat emotional disorders. We have obtained data about the efficacy of the 'EMMA's World' (Botella et al., 2006b; Botella et al., 2010; Baños et al., 2009, 2011).

In summary, VR technology may provide a useful means to treat PTSD. The results thus far are preliminary but encouraging. It remains to be seen, however, what the appropriate applications of the technology will be, whether or not there is a significant advantage to using this technology compared to other strategies that are currently available, and what factors may contribute to its effects.

3.2 Adjustment disorders and pathological grief

As noted, 'EMMA's World' was designed to treat PTSD. However, the treatment of PTSD shares strategies and components that may also be useful in treating other stress-related problems, such as Adjustment Disorders or Pathological Grief. In these cases are people who have suffered an adverse life event and they could not overcome it. 'EMMA's World' permits customization of the environments according to the needs and preferences of patients. For these reason, we thought that the system could be applied to different disorders. The therapist is free to tune the patient experience according to the specific therapeutic needs. In fact, it allows real-time modifications of the virtual scenarios (a beach, a field, a desert, a solitary and snow-covered place); the use of different realistic natural effects (fog, rain, change from night to day, earthquake, rainbow); the use of objects and significant symbols (from 3D objects to real photographs of something/someone significant to the person) to anchor the virtual experience to the personal history. All this is thought to help to catalyse, potentate and facilitate the process of change.

In brief, in 'EMMA's world' the focus has been on designing an application to elicit emotions with the goal to reduce or modify them, and on designing affectively significant environments, including those elements with the potential of activating emotions. To do that, "EMMA' World" has proved that it is not necessary to copy physical reality exactly as it is. A patient can experience virtual presence in the traumatic or stressful situation he/she suffered even when the virtual environment does not represent completely or with total precision the real world. In this way, the therapist can use the system to provide meaningful experiences able to induce a deep and permanent change in their patients.

The systematic application of "The World of Emma" to patients suffering different disorders has shown that it is a highly versatile VR application and this has allowed its use in the case of other psychological disorders in which emotions play an important role, such as Adjustment Disorders and Complicated Grief. In fact, we have already obtained promising preliminary results in all of them (Andreu-Mateu et al., 2012; Baños, Botella et al., 2008; Botella, Osma et al., 2008).

Limitations of Virtual Reality

As we have seen, there has been a steady growth in the use of VR in mental health due to the advances in information technology and the decline in costs (Riva, 2002). However, several barriers still remain:

The first is the lack of standardization in VR devices and software. The PC-based systems, while inexpensive and easy-to-use, still suffer from a lack of flexibility and capabilities necessary to individualize environments for each patient (Riva, 1997). To date, very few of the various VR systems available are interoperable. This makes their use in contexts other than those in which they were developed difficult.

The second is the lack of standardized protocols that can be shared by the community of researchers. In the two clinical databases – Medline and PsycInfo - there are only five published clinical protocols: for the treatment of eating disorders (Riva *et al.*, 2001b), fear of flying (Klein, 1999; Rothbaum *et al.*, 1999), and panic disorders (Vincelli *et al.*, 2001).

The third is the costs required for the set-up trials. As we have just seen, the lack of interoperable systems added to the lack of clinical protocols forces most researchers to spend a lot of time and money in designing and developing their own VR application: many of them can be considered "one-off" creations tied to proprietary hardware and software, which have been tuned by a process of trial and error. According to the European funded project VEPSY Updated (Riva *et al.*, 2001a) the cost required for designing a clinical VR application from scratch and testing it on clinical patients using controlled trials may range between 150000 and 200000 €. The costs of technological applications decrease very rapidly as they become commercial products that can be used by many users.

Finally, the introduction of patients and clinicians to VEs raises certain safety and ethical issues (Durlach & Mavor, 1995). In fact, despite developments in VR technology, some users still experience health and safety problems associated with VR use. However, for a large proportion of VR users, these effects are mild and subside quickly (Nichols & Patel, 2002).

Conclusions and future perspectives

VR has helped the ICTs field to find a significant space in mental health treatment. In particular, VR helps the patient to confront his/her problems in a meaningful yet controlled and safe setting. Furthermore, it opens the possibility of experiencing his/her life in a more satisfying way. In fact, as previously was stated, therapists can use VR to provide meaningful experiences capable of inducing deep and permanent change in their patients (Watzlawick, Weakland, & Fisch, 1974).

However, some efforts are still required to move VR into commercial success and therefore routine clinical use: the more a complex and costly a technology is, the less the user is likely to accept it. Therefore, a critical challenge for the future is the development of easy-to-use and customizable virtual environments that may be adapted in real time to the patient's needs. An example of this approach comes from the possibility of using in different ways the VR application 'EMMA's World'.

A second challenge for the future is the evolution of a typical VR experience. Currently, most of the existing VR applications for mental health are based on single PCs located in the office of a therapist. However, the technological scenario is changing quickly. According to the recent "ISTAG SCENARIOS FOR AMBIENT INTELLIGENCE 2010" (Ducatel *et al.*, 2000) the evolutionary technology scenarios in support of the Knowledge Society of the 2000s will be rooted within three dominant trends:

Pervasive diffusion of intelligence in the space around us, through the development of network technologies and intelligent sensors towards the objective of so-called "Ambient Intelligence" (AmI) (Riva, 2003);

Increasingly relevant role of mobility, through the development of mobile communications, moving from the Universal Mobile Telecommunications System (UMTS) "Beyond 3rd Generation" (B3G) (Laxminarayan & Istepanian, 2000);

Increase of the range, accessibility and comprehensiveness of communications, through the development of multi-channel multimedia technologies (IJsselsteijn & Riva, 2003).

To exploit the full potential of this evolving situation the development of future ICTs based applications will require multidisciplinary teams of engineers, computer programmers, and therapists working in concert to treat specific clinical problems. In particular, ICT must be made available to the health care community experts in a format that is easy-to-understand and which invites participation.

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