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A virtual reality system for the treatment of stress-related disorders: A preliminary analysis of efficacy compared to a standard cognitive behavioral program

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Abstract

This paper presents preliminary efficacy data in a controlled study of the use of a virtual reality (VR) system for treating stress-related disorders (Post-Traumatic Stress Disorder, or PTSD; Pathological Grief, or PG; and Adjustment Disorders, or AD). ''EMMA's World'' is a VR application in which patients can explore negative experiences to the degree required for their specific therapeutic needs. To accomplish therapeutic goals, a series of virtual elements is customized to be meaningful to the user; the elements contain the fundamental emotional components that the person must confront. Thirty-nine participants diagnosed with PTSD ($N=10$), PG ($N=16$), and AD ($N=13$) were randomly assigned to a standard cognitive-behavioral program (CBT) ($N=20$) or a CBT program driven by EMMA's World ($N=19$). Participants were assessed before and after treatment. Measurements related to anxiety, depression and other emotions, maladjustment and interference were applied. Results indicate that CBT with EMMA's World was as effective as the standard CBT program for the treatment of these disorders, and the statistically significant differences (depression, relaxation intensity and social area interference) were in favor of EMMA's World. We expect VR to provide a positive alternative that will draw in clients who do not seek traditional forms of treatment.

Keywords: Virtual reality; Psychological treatments; Stress-related disorders; Post-Traumatic Stress Disorder; Pathological Grief; Adjustment Disorder

1. Introduction

Stress-related disorders (SRD) are connected with a ubiquitous human behavior: reaction to adversity. Human beings have long tried to cope with adversity using many strategies. SRD occur when a person cannot cope with a stressful or traumatic event (e.g., the loss of a loved one, loss of a job, divorce, rape, etc.) and consequently develops emotional or behavioral issues. SRDs include several disorders like Post-Traumatic Stress Disorder (PTSD), Pathological Grief (PG), or Adjustment Disorders (AD). PTSD is characterized by intense feelings of fear, helplessness, or horror in response to being exposed to a traumatic event that is perceived as life-threatening (APA, 2000). Regarding PG, this syndrome comprises symptoms of separation distress (e.g., yearning, searching and preoccupation with the deceased to the point of functional

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impairment) and traumatic distress (e.g., numbness, lack of trust in others, bitterness, etc.), which can put the individual at risk for social, psychological and medical impairment (Prigerson et al., 1997, 1999). Lastly, ADs comprise debilitating reactions to an identifiable psychosocial stressor or stressors and are characterized by the development of clinically significant emotional or behavioral symptoms (APA, 2000). Fortunately, there is strong empirical support for the efficacy of certain psychological interventions for the treatment of these conditions.

In recent decades, efficacious psychological treatments have been developed for a variety of disorders; these interventions have been called "empirically supported treatments" or "evidence-based psychological practices". Cognitive-behavioral treatments (CBT) are empirically supported for many psychological disorders. In the case of SRD, the aim of CBT interventions is to evoke stressful events so that patients can learn to process them adaptively. In this approach, the "exposure technique" is a common treatment component; it involves confronting stimuli that provoke fear. In the case of anxiety disorders, the use of the exposure technique is one of the great success stories in the field of mental health treatment (Frueh et al., 1995; Olatunji et al., 2009; Tyron, 2005). Numerous studies and meta-analyses have consistently provided supportive evidence and demonstrated large effects on primary and secondary measures of psychopathology (Deacon and Abramowitz, 2004).

Despite the proven effectiveness of exposure therapy, it is surprisingly not used extensively in clinical settings. One possible reason is that it suffers from a "public relations problem", including concerns that it is cruel and at odds with some ethical considerations because it purposefully evokes distress in patients (Olatunji et al., 2009). Some practitioners hold a negative view of this treatment for this reason (Feeney et al., 2003; Prochaska and Norcross, 1999). As Olatunji et al. (2009) have pointed out, ethical concerns about the safety, tolerability, and indeed humaneness of exposure therapy are central objections against this form of treatment. A study by Becker et al. (2004) confirmed the presence of such beliefs, particularly among practitioners treating patients with PTSD. Richard and Gloster (2007) conducted a survey of professional members of the Anxiety Disorders Association of America, and found that exposure-based therapies were considered fairly aversive. Patients themselves have objected to such treatment; approximately 20–25% of people reject in vivo exposure because they consider it too aversive to confront feared situations (Marks and O'Sullivan, 1992; García-Palacios et al., 2001). This highlights the need to follow the American Psychological Association recommendations (Chambless et al., 1996, 1998; Chambless and Hollon, 1998; Nathan and Gorman, 1998, 2002), which stresses on the importance of carrying out two kinds of studies, one focused on internal validity or efficacy, and another one on clinical utility, external validity or effectiveness. New technologies, especially virtual reality (VR) could help to overcome these issues. In fact, in Richard and Gloster's (2007) survey, VR exposure therapy was viewed as more acceptable, helpful, and ethical than traditional exposure-based therapies).

VR is a new technology that comprises computer-generated simulations of reality. The essence of VR programs is that they create the illusion that users are "inside" the computer-generated environment, as if they were "there" in the virtual world. In the field of clinical psychology, VR has proven to be an effective tool for delivering exposure therapy in the treatment of phobias; recently, VR programs have been developed for the treatment of more severe problems such as panic disorder, PTSD, eating disorders and others (see, for a review, Anderson et al., 2004; Emmelkamp, 2005; Krijn et al., 2004; García-Palacios et al., 2006; Marks et al., 2007; Powers and Emmelkamp, 2008). VR therapy involves creating safe virtual worlds where the patient can explore and experience new realities; this feeling of safety is essential in therapy, so that the patient can act without feeling threatened. The virtual context allows patients to approach situations that they perceive as threatening in a gradual way, at their own pace, with complete safety and protection.

Most of the VR systems currently available in the field of psychological treatments are designed to solve specific problems. A paradigmatic example is VR systems for the treatment of PTSD. The approach has been to use VR to simulate traumatic events with high realism with the aim of exposing individuals to the feared aspects of their trauma. This perspective has resulted in the development of very targeted VR environments for individuals who have suffered specific traumas, including September 11th victims (Difede and Hoffman, 2002), Vietnam veterans (Rothbaum et al., 2001), Iraq war soldiers (Rizzo et al., 2004), and victims of motor vehicle accidents (Walshe et al., 2003). The main limitation of this approach is that such specific programs cannot be used with sufferers of other types of PTSDs (e.g., rape victims). It is costly to employ these treatments in daily clinical practice since many separate virtual environments are required to treat diverse problems (Baños et al., 2009).

In order to treat different trauma populations, it may be more efficacious to develop flexible virtual scenarios that can evoke a variety of stressful events. We propose a different approach that broadens the scope of traditional VR systems (Baños et al., 2008, 2009): instead of requiring patients to work within discrete virtual worlds, we support designing displays which are adapted to the users' needs, regardless of the type of trauma they have suffered. To this end, our group has developed a VR system called "EMMA's World" wherein patients can explore a stressful environment to the degree required for specific therapeutic needs. The system shows customized, clinically significant environments for each individual, emphasizing the meaning of the trauma or stressful event over the realism of the VR environment. Personalized components in the environments, rather than

merely realistic representations, help patients process trauma in a safe and protective environment. The ”exibility of this VR tool could be useful in treating various kinds of traumas and other SRDs such as PG and AD. The system includes emotional virtual elements that can be activated and customized. The objective is to create a relevant physical representation using virtual elements of the patient•s personal emotional associations with a traumatic or stressful event.

In a previous study (Baños et al., 2009), it has been proven the effectiveness the ••EMMA•s World••, showing that expectations and satisfaction with the treatment were high for all participants, and after completing the treatment, participants even evaluated the program higher than they did initially. Moreover, the EMMA•s World treatment program was rated by the participants as not very aversive. As we have said before, it is necessary to carry out studies that focus on ef“cacy as well as on effectiveness. Ef“cacy-focused research seeks to evaluate speci“c therapeutic protocols with the goal of achieving empirically supported therapy status. Effectiveness-focused research attempts to understand not only the ways therapy is practiced in the real world, but also to identify those factors that in”uence therapy. The aim of the present paper is to analyze ef“cacy of the ••EMMA•s World•• comparing this CBT treatment using VR and a ••traditional•• CBT treatment for SRDs. The ••EMMA•s World condition used in this work is the same used in the previous one (Baños et al., 2009), but additional measures are included and comparisons with ••traditional CBT condition•• are analyzed. So far, there are no studies comparing VR treatment for SRD with traditional treatment. To achieve this objective, general clinical variables that are common to the three SRDs included in this study (PTSD, PG, and AD) will be analyzed. This strategy is not new; Al-Kubaisy et al. (1992) used it to test the ef“cacy of a speci“c exposure-based treatment program for various anxiety disorders. It is hypothesized that both treatments will signi“cantly reduce primary symptomatology of SRDs and that the ef“cacy of the two treatment conditions will not differ signi“cantly.

2. Material and methods

2.1. Design

This study consists of a comparison design for both within-subjects (comparisons pre-post-treatment) and between-subjects (comparisons between two treatment conditions). Participants were randomly assigned to one of the two treatment conditions: ••traditional therapy•• and ••EMMA therapy••.

In ••traditional therapy••, CBT therapy was applied for each speci“c disorder (PTSD, PG, and AD). For the treatment of PTSD, an adaptation of the standardized protocol that is currently accepted as the treatment of choice for this disorder, Foa and Rothbaum•s (1998) prolonged exposure program, was used. For the treatment of PG, the guidelines stated by Neimeyer (2001) were followed. For the treatment of AD, a program designed for our group was applied (Botella et al., 2003). The main therapeutic components included in all three treatment protocols were the following: (1) educational component about the response to a traumatic or stressful event; (2) cognitive-behavioral strategies like imagery exposure to the traumatic/negative event; (3) in vivo exposure of the avoided stimuli related to the traumatic/negative event, slow breathing training; and (4) relapse prevention component.

In ••EMMA therapy•• condition, the same treatment components were used, with the addition of the tools of EMMA•s World. The main difference is that in the EMMA condition, a virtual environment was used to enhance the emotional experiences of the participants instead imagery exposure or narrative techniques that describe the negative experience.

2.2. Participants

In order to recruit the participants, announcements in the media (newspapers) were published, asking people suffering from the three selected disorders to seek help in our Emotional Disorder Clinic at Jaume I University and University of Valencia. Participants who met DSM-IV-TR (APA, 2000) criteria for PTSD, AD or PG participated in the study. The exclusion criteria included the intake of alcohol or drug abuse, having a psychotic disorder or the use of anti-psychotic medication, having a severe physical illness and being presently involved in other psychological treatment. All participants signed an informed consent form and underwent an assessment protocol consisting of two sessions.

Initially, 58 people sought help. Finally, 39 participants (12 males and 27 females) completed the treatment (19 participants in EMMA condition and 20 participants in traditional condition). Reasons for exclusion and participants ”ow through the trial described in Fig. 1. The ages of participants ranged from 18 to 50 ($M = 30.85$, $SD = 8.969$).

For PTSD patients, the traumatic experiences were abuse, crime assault and car accident. For AD patients, the stressful experiences were couple breakup, job loss, con”icts at work and family illness. All PG patients had lost a signi“cant person in their lives.

2.3. Devices

The following devices were used: two PCs, a large projection screen, two projectors, a wireless pad and a speaker system. PC#1 had the graphical outputs from its graphic card connected to two projectors (with a resolution of 1024 768 pixels and a power of 2000 lumens). They were used to project the environment onto a horizontal metacrilate screen of 4 1.5 m that was placed in the middle of the room. A wireless pad was placed on a table on the other side of the room, and the patient sat next to it.

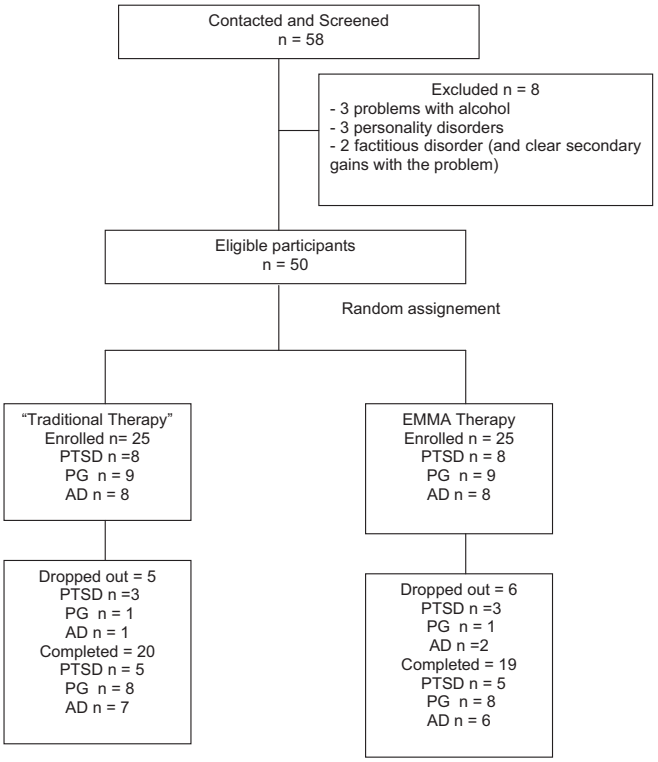

Fig. 1. Participants flow.

From this perspective, the patient could view the virtual environment, as well was interact and navigate using the wireless pad. The therapist sat next to PC#2, which was placed close to the patient. From this PC, the application and the features of the virtual environment that were shown to the patient could be controlled. In the first stages of therapy, the patient learned how to navigate and interact with the system by practicing in a neutral environment.

2.4. "EMMA's World" description

Both therapist and patient are sat in front of the screen in the room. Patients visualize a virtual environment (see Fig. 1) that offers them a special place where they can feel free to express their emotions and where the emotions have an effect on the virtual world. The therapist accompanies the patient during the session and has an important and active role in the customization of the environment. 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. A special interface has been prepared to allow the therapist to control several aspects of the appearance of the virtual environments. EMMA's World includes a circular room from which the environment outside can also be seen. Patients can navigate both inside the virtual room and outside it. A series of tools are available in this room and they are selected based on the "therapist's suggestions". One of them is the Database Screen, where a list of icons shows all the elements that patients can manipulate, including three-dimensional objects, sound, images, colored lights, movies, and texts. All these elements have been designed to help patients confront and manage their emotions and experiences that they face in their lives. These objects can be inserted in the *Object Holders* or in the *Book of Life* by selecting and dropping them in the appropriate place.

The Object Holders are distributed throughout the room. The objects that are in the inventory can be copied into these holders. The effect created is different depending on the object that is copied. If it is a three-dimensional object, it is viewed above the object holder. If it is a sound, it will be heard when the user approaches the object holder. If it is a video, it will be viewed on a small screen above the object holder when the user approaches it. If it is an image, it will be viewed in a small screen above the object holder. The Object Holders also serve as a mixing tool to combine several elements to form a new more complex element. This is achieved when different elements from different categories are copied to the same *Object Holder*; thus, it can simultaneously show a three-dimensional object, a video and an image; the associated sound can be heard when the user approaches it. Also, if a color element is copied to an *Object Holder* that already has a three-dimensional object, a colored light will be applied to the object. The size of the different elements that are shown can be also controlled by users.

Another important tool is the Book of Life, a virtual book in which patients can reflect upon feelings and experiences. It has been designed as a book to facilitate that patients would understand its use in a natural way, although it is not written only with words but also with the different kinds of materials used in the EMMA's World: three-dimensional objects, photos, icons representing music or films, etc., so users can move them, keep them in the book and recover them from the book at any moment. The aim of this tool is to represent the most important moments, people and situations in the person's life (related to the traumatic or negative experience). Anything that is meaningful for the patient can be incorporated into the system (photos, drawings, phrases, videos, etc.). Furthermore, the Book of Life is the instrument of the user to keep and put in order all the contents he/she has worked with the therapist during the therapy session in the virtual environment. In the Book of Life the user can move and modify any element from the database. This book has an index and several chapters defined by the user, and in each chapter the user describes any idea or story. The user can also change the situation of the object inside the book, and even eliminate it. The Book of Life is a flexible tool, useful to keep all those symbols with emotional meaning for the user.

"EMMA's World" also includes five different "landscapes", including beach/island, desert, meadow, dark forest, and snowscape. These environments have been designed to

correspond with different negative and positive emotions (relaxation, joy, sadness, anxiety, etc.) and can be selected by the therapist in real time. The specific application for each environment depends upon the context of the session. The therapist accompanies the patient during the session and has an important role in the customization of the environment. The therapist can manipulate the chosen scenario and graduate its intensity with elements such as rainbows, rain, snow, earthquakes, etc. Furthermore, the time of day (and the corresponding illumination) can also be changed. A special interface has been prepared to allow the therapist to control all these elements. This application runs on a different computer from the one with the virtual environment.

A more detailed description of the system can be found in Baños et al. (2008, 2009) and Rey et al. (2005) (Fig. 2).

2.5. Treatment

The total duration of the treatment was 9 weekly sessions for all PTSD and PG participants (3 for the "educational component", 5 for "imagery exposure/restructuring the loss", and 1 for "relapse prevention"). In the case of AD, the treatment consisted of 4–6 weekly sessions ($X=5.36$) (1 for the "educational component", 4 for "exposure" and 1 for "relapse prevention"). Exposure sessions took approximately between one and a half to two hours. In all cases, for ethical reasons, participants who needed more sessions could receive treatment for 3 additional weeks for PTSD and PG and 2 additional weeks for AD, until they overcame all their treatment target behaviors. However, only one AD participant received 2 additional sessions.

A total of ten therapists participated in both the assessment and treatment; all were experienced in the application of CBT programs and were either doctors or PhD students. All clinicians were trained in the delivery of the treatment protocols. To ensure treatment integrity and adherence to the treatment protocol, senior therapists supervised the treatment sessions by reviewing video recordings of some of the sessions. A total of 15% of the sessions were reviewed. Sessions to be supervised were randomly chosen with the only restriction that each therapist had at least one supervised session.

2.6. Measures

Participants filled out a complete clinical assessment protocol for their problems. In this paper, only the common measures used for all participants are included. All these measures were taken by an independent assessor, who was blind to treatment conditions.

- *Fear and Avoidance Scales*, adapted from Marks and Mathews (1979). Participants assessed their level of fear and avoidance on a scale ranging from 0 ("NO fear at all", "I never avoid") to 10 ("Severe fear", "I always avoid") for the target behaviors or situations related to the problems that they wanted to overcome with therapy. They also assessed their levels of fear and avoidance of thoughts related to their traumatic/negative events using the same 0–10 scale. Finally, the degree of belief in catastrophic or negative thoughts related to traumatic/negative events was also rated on a 0–10 scale. For this work, the two main target behaviors and thoughts, and the two main negative thoughts chosen by each participant are presented.

Fig. 2. The EMMA's World.

- *Beck Depression Inventory* (BDI; Beck et al., 1979). This is one of the most commonly used instruments for assessing depression symptoms; it includes 21 items with 4 possible answers each. Participants chose the statement that best describes their emotional state. It mainly assesses cognitive aspects of depression, as well as behavioral and physiological symptoms.
- *Positive and Negative Affect Scales* (PANAS; Watson et al., 1988). This questionnaire consists of 20 items and assesses the distinct dimensions of positive and negative affect (PA and NA, respectively). According to the authors, the dimension of PA ranges from a state of enthusiasm and activation to a state of sluggishness and lethargy (i.e., low PA), whereas the dimension of NA ranges from a state of subjective distress and aversive arousal to a state of calmness and serenity (low NA). Participants were asked to indicate on a five-point Likert-type scale the extent to which they had experienced a list of adjectives that described their emotional state over a specified time period. Separate scores for PA and NA scales were obtained by adding responses to items within each scale. Several works have reported high internal consistency and test-retest reliability of the scale (e.g., Watson et al., 1988).
- *Visual Analogic Scales* (VAS). Using these VAS scales, participants quantitatively assessed the frequency and intensity of various emotions they felt during the previous week (sadness, relaxation, joy, anxiety and anger) on a 0 (“Not at all”) to 10 (“Totally”) scale.
- *Maladjustment Scale* (MS; Echeburúa et al., 2000). This instrument assesses the level of impairment that the problem causes in different life areas (work, leisure time, social life, partner, family, and global impairment) using a scale from 0 to 8. This scale has good psychometric proprieties and is sensitive to the effects of treatment (Echeburúa et al., 2000).
- *Interference/Severity Scale assessed by the therapist*, adapted from the Anxiety Disorders Interview Schedule (ADIS-IV; Di Nardo et al., 1994). The therapist assessed the interference and global severity of the patient on a scale from 0 (“None”) to 8 (“Very severely disturbing/disabling”). This scale offers good psychometric proprieties as has been shown in several studies (Di Nardo et al., 1994).

3. Results

In order to compare the treatment conditions, several ANOVAs using one between-group factor (EMMA versus traditional) and one within-group factor (pre- and post-treatment) were applied (Bonferroni corrections were applied). Gender and therapist effect were also taken into account, including these variables as covariates, but there were no significant effects regarding these variables, and no changes were observed in the results.

Table 1 shows means, standard deviations and ANOVAs results obtained for *Fear and Avoidance Scales* regarding the two main target behaviors and thoughts, and the degree of belief in the two main negative/catastrophic thoughts. Both fear and avoidance of the two main target behaviors and thoughts and the degree of belief in the two negative thoughts were significantly lower at post-treatment (which is the time effect statistically significant for all clinical variables in both treatment conditions). However, no interaction effect group × time reached statistical significance for any of the clinical variables. Therefore, both treatment conditions showed similar changes from a statistical point of view.

Regarding *Depression and Affect Measures*, as shown in Table 2, scores by the participants obtained for the BDI after both treatment conditions were significantly lower. Moreover, participants included in the EMMA condition improved more than those in the traditional condition, since the interaction effect group × time reached statistical significance. As can be seen in Table 2, participants in the EMMA condition also showed higher scores before treatment, but they achieved lower scores after treatment. As for the data obtained for the PANAS, participants in both treatment conditions showed a significant decrease in NA and a significant increase in PA at post-treatment (see Table 2). In this case, no interaction effect was obtained.

Table 1
Means (standard deviations) and ANOVAs results obtained for fear and avoidance scales.

	EMMA		Traditional		Time		Group		Group × time	
	Pre	Post	Pre	Post	*F*	*p*	*F*	*p*	*F*	*p*
Belief negative thought 1	8.93 (1.49)	1.57 (1.98)	8.40 (3.06)	2.30 (2.00)	134.65	.001	.004	n.s.	2.19	n.s.
Belief negative thought 2	8.79 (1.63)	2.14 (2.96)	9.40 (.84)	2.50 (2.32)	133.65	.001	.527	n.s.	.04	n.s.
Avoidance target—behavior 1	9.07 (1.27)	1.29 (2.920)	9.38 (.74)	.63 (1.19)	295.01	.001	.003	n.s	.002	n.s
Avoidance target—behavior 2	9.21 (1.19)	2.00 (3.42)	8.63 (1.30)	1.38 (1.06)	102.73	.001	3.17	n.s.	.35	n.s.
Avoidance negative thought 1	8.14 (2.11)	1.50 (2.03)	8.00 (3.34)	.13 (.35)	202.47	.001	.51	n.s.	.22	n.s.
Avoidance negative thought 2	8.93 (1.73)	1.36 (2.09)	8.63 (1.77)	1.25 (1.76)	115.67	.001	.09	n.s.	.13	n.s.
Fear target—behavior 1	9.21 (.97)	1.86 (2.96)	8.75 (1.28)	1.50 (1.85)	192.41	.001	2.68	n.s.	.04	n.s.
Fear target—behavior 2	8.64 (1.74)	2.36 (3.32)	9.50 (.76)	1.88 (2.17)	123.39	.001	.56	n.s.	.28	n.s.
Fear negative thought 1	8.79 (1.58)	2.79 (3.07)	9.13 (.99)	1.75 (2.55)	123.37	.001	.01	n.s.	.11	n.s.
Fear negative thought 1	8.64 (1.55)	1.93 (2.27)	8.63 (1.77)	1.63 (2.93)	127.59	.001	.06	n.s.	.03	n.s.

Table 2
Means (standard deviations) and ANOVAS results obtained for depression and affects.

	Emma		Traditional		Time		Group		Group × time	
	Pre	Post	Pre	Post	*F*	*p*	*F*	*p*	*F*	*p*
BDI	26.28 (10.27)	6.50 (4.57)	19.74 (10.75)	7.00 (6.74)	93.530	.001	1.832	n.s.	4.386	.044
PANAS PA	17.84 (4.83)	29.26 (10.08)	19.85 (6.97)	28.90 (8.75)	36.673	.001	.190	n.s.	.492	n.s.
PANAS NA	34.05 (6.66)	20.26 (8.04)	30.35 (9.30)	17.95 (4.94)	69.852	.001	2.831	n.s.	.197	n.s.

Table 3
Means (standard deviations) and ANOVAs results obtained for emotions.

	EMMA		Traditional		Time		Group		Group × time	
	Pre	Post	Pre	Post	*F*	*p*	*F*	*p*	*F*	*p*
Frequency										
Sadness	7.00 (1.50)	2.00 (2.75)	6.94 (2.22)	2.11 (2.17)	119.425	.001	.002	n.s.	.039	n.s.
Relaxation	2.06 (1.84)	6.18 (2.66)	2.23 (2.22)	5.17 (2.94)	37.448	.001	.439	n.s.	1.051	n.s.
Joy	2.36 (2.06)	6.90 (2.80)	3.66 (2.23)	6.44 (2.50)	37.839	.001	.211	n.s.	2.205	n.s.
Anxiety	6.18 (3.10)	1.87 (2.21)	6.58 (1.93)	2.82 (2.23)	59.858	.001	1.013	n.s.	.275	n.s.
Anger	5.81 (3.05)	1.62 (2.44)	6.35 (3.16)	1.82 (2.53)	51.272	.001	.230	n.s.	.079	n.s.
Intensity										
Sadness	7.25 (1.57)	2.00 (2.75)	6.94 (2.22)	2.41 (2.15)	114.600	.001	.007	n.s.	.622	n.s.
Relaxation	2.06 (1.90)	5.66 (2.39)	2.47 (2.23)	5.00 (2.80)	30.360	.001	.045	n.s.	.344	.030
Joy	2.07 (2.17)	6.46 (2.63)	3.40 (2.11)	6.30 (2.62)	49.999	.001	.446	n.s.	2.077	n.s.
Anxiety	6.53 (3.06)	2.33 (2.35)	6.58 (1.87)	3.58 (2.67)	45.496	.001	.844	n.s.	1.264	n.s.
Anger	5.93 (3.17)	1.56 (2.44)	6.58 (3.06)	2.88 (3.29)	42.643	.001	1.344	n.s.	.292	n.s.

Table 4
Means (standard deviations) and ANOVAs results obtained for impairment and severity measures.

	Emma		Traditional		Time		Group		Goupr × time	
	PRE	POST	PRE	POST	*F*	*p*	*F*	*p*	*F*	*p*
Global	5.80 (1.57)	2.90 (1.663	4.78 (2.16)	2.89 (1.965	34.251	.001	.013	n.s.	1.420	n.s.
Family	4.00 (2.75)	2.10 (1.19)	3.78 (2.99)	2.44 (2.74)	16.835	.001	.000	n.s.	.239	n.s.
Leisure time	5.40 (2.07)	1.80 (1.32)	3.22 (2.91)	1.67 (1.59)	20.889	.001	1.253	n.s.	2.435	n.s.
Partner	6.30 (2.91)	3.20 (2.49)	3.78 (3.38)	1.89 (2.37)	24.545	.001	1.198	n.s.	2.689	n.s.
Work	4.70 (2.67)	2.30 (2.16)	3.56 (1.88)	1.44 (1.51)	32.416	.001	.438	n.s.	2.689	n.s.
Social	5.50 (1.51)	2.40 (1.43)	4.00 (2.12)	2.00 (1.87)	43.355	.001	.263	n.s.	3.110	.034
Severity therapist	4.76 (1.43)	1.47 (1.41)	4.78 (1.16)	1.61 (1.53)	107.499	.001	.047	n.s.	.042	n.s.
Interference therapist	5.18 (1.13)	1.47 (1.37)	5.11 (1.07)	1.83 (1.42)	147.900	.001	.222	n.s.	.556	n.s.
Global impairment	5.00 (1.17)	1.41 (1.37)	4.83 (.92)	1.67 (1.45)	151.984	.001	.019	n.s.	.592	n.s.

Therefore, both groups demonstrated equal improvement after treatment. EMMA condition scores in BDI and PANAS (pre- and post-treatment) correspond to those presented in a previous paper (Baños et al., 2009).

With regard to *Emotions Measures*, both the frequency and intensity of emotions such as anxiety, sadness, and anger decreased significantly after both treatment conditions; however, for emotions such as relaxation and joy, a significant increase was produced at post-treatment. As can be observed in Table 3, no interaction effect was significant except for the intensity of relaxation; the participants in the EMMA condition experienced this emotion more frequently after treatment. As for the remaining emotions, changes experienced by participants in both conditions were similar. EMMA condition scores in frequency and intensity of emotions (pre- and post-treatment) correspond to those presented in a previous paper (Baños et al., 2009).

Results obtained for *Impairment and Severity Measures* are presented in Table 4. Regarding the Maladjustment Scale, interference caused by the problem became significantly lower in all life areas for all participants. No interaction effect was

significant, except for interference in the social area; participants in the EMMA condition improved more than those in the traditional condition. Lastly, as for the *Interference/Severity Scale assessed by the therapist*, as shown in Table 4, all participants obtained significant changes in these variables after treatment, and again no interaction effect was found, which demonstrates equal improvement for both treatment conditions.

4. Discussion

Results obtained in the present work reveal that in both treatment conditions, important changes were observed after treatment. First, the degree of interference caused by the problem and the level of depression (measured by the BDI) decreased significantly. Second, levels of positive affect increased while negative affect decreased. Moreover, changes in the expected direction were also observed for the frequency and intensity of the emotions included in this study (anxiety, relaxation, sadness, joy, and anger); in other words, the positive emotions increased whereas the negative ones decreased at post-treatment. The same phenomenon occurred regarding avoidance and fear of the main target behaviors and thoughts and the degree of belief in dysfunctional thoughts; both treatment conditions produced a statistically significant reduction after treatment. As for the assessment made by the participants about the interference caused by their problem in different life areas (measured by the Maladjustment Scale) and the assessment made by the therapists regarding the interference, severity, and the global impression of the participants' clinical status, statistically significant improvements were also observed in both treatment conditions from pre- to post-treatment. In sum, results indicate that both treatments were effective and produced significant changes in the patients' clinical situations.

These data are consistent with those obtained in studies on the traditional treatment of PTSD (Ehlers et al., 2005; Foa and Meadows, 1997; Foa et al., 1989, 2000; Foa and Jaycox, 1996; Harvey et al., 2003; Orsillo and Batten, 2005), PG (Neimeyer, 2002), and AD (Andrews, 1995; Araoz and Carrese, 1996; Benton and Lynch, 2005; Strain, 1995; Van der Klink et al., 2003. With regard to the efficacy data obtained in studies that use VR to treat psychological disorders, the results obtained in the present study are consistent with the conclusions reported by the review studies that are available on this topic (Anderson et al., 2004; García-Palacios et al., 2006; Krijn et al., 2004; Pull, 2005).

Regarding the comparative efficacy of each of the experimental treatment conditions (traditional versus EMMA), results indicate very similar efficacy for both conditions; a statistically significant interaction effect was only observed for the level of depression, relaxation intensity and social area interference (those included in the EMMA condition showed greater improvement). Participants included in the EMMA condition were more severely depressed before treatment (according to the BDI); after treatment, they scored even lower in this area than the participants who received traditional treatment. Thus, although in general both treatments showed to be equally efficacious, when differences were found, they were always in favor of the "EMMA condition". It is important to emphasize that both EMMA and traditional treatments involve the same content and the same components. The only difference is in the way of delivery: in EMMA condition, a virtual environment is used to promote the emotional experiences instead of imagery exposure or narrative techniques.

These results are relevant for the field and indicate that the use of new technologies (such as VR) to support current psychological treatment programs is an alternative that should no doubt be explored. Many studies on the efficacy of VR treatment programs for various disorders have compared their efficacy with a waiting list control group or other mild alternatives (such as relaxation, in the case of flying phobia) (Mülherberg et al., 2001), a placebo condition for flying phobia (Maltby et al., 2002), or a waiting list control group in the case of spider phobia (García-Palacios et al., 2002).

Only a few studies have compared VR treatment with a more powerful treatment alternative, such as in vivo exposure in the cases of acrophobia (Emmelkamp et al., 2002), flying phobia (Rothbaum et al., 2000, 2002, 2006; Anderson et al., 2006), and panic disorder and agoraphobia (Botella et al., 2007a). So far, the present study is the first one in comparing VR treatment with traditional treatment for SRD. In this study, we used the treatment of choice as the control group from the perspective of treatments based on evidence (for PTSD); in the case of PG and AD the control group was comprised of treatment alternatives which had more empirical support and were recommended by specialized literature. Results obtained in the present work reveal that in some variables we achieved even better results than the treatment of choice (gold standard) already established in the field of psychological treatments. It is important to develop useful treatment strategies for these disorders because of its impact on quality of life and general adjustment (Oliva et al., 2008). This is especially relevant, given that the use of therapeutic tools supported by new technologies could produce rejection or resistance from patients. As it can be seen in Fig. 1, drop outs were similar in both conditions.

In this same line, it would be interesting to compare the efficacy and effectiveness of a treatment supported by "EMMA's World" and a treatment supported by VR worlds representing with a high degree of realism the stressful situation. This type of comparison would give us information about if the advantages of "EMMA's World" have to do just with using a VR world, or if it is also more advantageous using techniques focusing on the meaning of the stressful event than on the realistic representation of it. This might be because the more realistic simulations were more useful for specific types of precipitating stress events

(e.g., earthquakes, wars, etc.) and more symbolic simulations were more useful for other traumas (sexual, crimes, etc.). In any case, the possible confirmation of this, clearly depends on future research.

The present study includes some limitations that must be noted. Firstly, the sample size was small. Our future studies will increase the number of participants in order to base our conclusions on more robust data. Another shortcoming is that follow-up data are not available. These data should be obtained at least six-month and one-year follow-up periods in order to test whether the observed therapeutic gains are maintained. Furthermore, we have not included another additional control group (neither placebo nor waiting list). Lastly, given the small number of participants having each diagnosis (PTSD, PG, and AD) it was not possible to make comparisons among the different diagnostic categories. It is possible that the comparison between traditional therapy and the EMMA's World program would be different in each diagnostic group. However, the qualitative observations made by therapists suggest that there were no differences between the different diagnostic groups.

EMMA's World is different from other VR applications used in therapy thus far. As previously mentioned, it uses a virtual environment to "represent" the feared experience or situation. The aim is not to realistically simulate the physical characteristics of the aversive or traumatic event, but rather to use symbols and personalized aspects to evoke emotional reactions in patients; these in turn can help them to emotionally process negative events in the context of a protected and safe place. An important advantage of VR is the safety that it provides to the patient, as he can control the context generated by the computer at will and without risks, since it can be absolutely graded and therapists and patient can evoke the stressful experience to the degree required for therapy. Furthermore, EMMA's World also offers all of the advantages of traditional VR systems that aim to accurately simulate reality. These advantages have been highlighted in several works (e.g., Botella et al., 1998, 2004; Wiederhold and Wiederhold, 1998; Zimand et al., 2003).

In the case of PTSD, the use of a virtual environment like EMMA presents additional advantages. It can help patients overcome the shortcomings of prolonged imaginal exposure. While it is currently the treatment of choice for this problem (Foa et al., 2000), prolonged imaginal exposure is under-utilized in clinical practice (Becker, et al., 2004); several for this have been already mentioned. VR might help to overcome the reticence that some therapists demonstrate concerning the use of this exposure technique.

Another advantage of "EMMA's World" is that is very versatile, which allows treatment of a wide variety of psychological disorders wherein negative emotions are the main characteristic as in the case of PG or AD. EMMA is an open VR system that can be adapted to be a clinically meaningful environment for each person. As mentioned previously, most of the virtual environments currently available in the field of psychological treatments have been designed and developed to solve a specific problem. "EMMA's World" is demonstrating its utility in treating various problems, such as PTSD, PG or AD. Recently, EMMA has also been successfully used for the treatment of other psychological problems such as storm phobia (Botella et al., 2006) and in children (with a child who suffered from darkness phobia) (Botella et al., 2007b). However, more dissemination and translational tasks are needed in order to use VR systems in the practitioner community. In this line it must be emphasized that the software used is an experimental version, and at the moment the only possibility to obtain it is through the authors. This issue affects to the potential use of VR outside research laboratories. We expect this VR application to be soon available to the scientific and practitioner community.

It is important to highlight ethical issues regarding the use of new technologies in the delivery of psychological treatments. We think that the main issue is to test the efficacy and utility of such programs. The field of the study of the application of new technologies for the delivery of CBT treatments follows the standards of scientific rigor. The programs are being tested in controlled studies and the results published in rigorous journals (see García-Palacios et al., 2006; Powers and Emmelkamp, 2008). Another important issue is the study of the acceptability of these treatment programs by the patients. In a study already mentioned in the introduction (Richard and Gloster, 2007) a survey was conducted asking the patients' opinion about exposure therapy. VR exposure therapy was viewed as more acceptable, helpful, and ethical than traditional exposure-based therapies. García-Palacios et al. (2007) also conducted a survey among patients with a diagnosis of specific phobia. When asked to choose between in vivo exposure and VR exposure therapy for the treatment of their phobia, 76% chose VR exposure. These data offer support to the good acceptability of new technologies for the treatment of anxiety disorders. The use of VR can help patients to be willing to get involved in a psychological treatment for their problem. In a previous study (Baños et al., 2009) we analyzed the satisfaction and aversiveness of "EMMA's World". Participants rated the treatment program they were going to receive very positively before beginning. Data indicated that this VR treatment not only met the expectations of participants but even surpassed them, and after completing the treatment, participants evaluated the program even more positively than they did initially. Moreover, the EMMA'sWorld treatment program was rated by the participants as not very aversive. Although preliminary, these results are encouraging. If these data are confirmed, new technologies could increase the number of people benefiting from psychological treatments. We expect VR to provide a positive alternative that will draw in clients who do not seek traditional forms of treatment.

Finally, if we focus in the characteristics of EMMA, we also think that its flexibility can contribute to ethical

considerations. As we already mentioned, it is currently being used to treat children and the data so far support the good acceptability of EMMA by this population. Also, EMMA allows personalizing with detail the therapeutic elements, that is, the VR environment can include those aspects that are relevant for each patient. The progress in therapy can be also graded with high accuracy making EMMA a very safe and protected space where the patient progress at his/her own pace. In summary, the use of new technologies in therapy is not aimed to substitute the therapist or traditional therapy, but to improve the delivery of psychological treatments by making them more available, personalized and acceptable. In the near future, in order to enhance the VR treatment and to make EMMA more efficient, we are developing a system that allows patients to "take away" the EMMA sessions in order to practice at home the work done in therapy.

5. Conclusions

This work has presented efficacy data in a controlled study on the use of a VR adaptive display (EMMA's World) for treating SRD disorders. Results indicated that CBT augmented with EMMA's World was as effective as the treatment that so far has been more supported For some variables (depression, relaxation, social area functioning), those in the EMMA's World condition achieved even better results than those receiving the treatment already established in the field of psychological treatments. As far as we know, there has yet to be a controlled study that tests the utility of VR for the treatment of PTSD, PG, or AD. Therefore, the data obtained in the present work are promising concerning the utility of this VR application in treating these problems and are pioneering in this sense.

In recent years, several VR applications have proven useful for applying exposure techniques to the treatment of various psychological disorders. EMMA's World may be more flexible than these other virtual systems. Since the application allows customization of the environments according to the needs and preferences of users, it may be applied to a wide variety of problems.

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