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New Directions in Virtual Reality-Based Therapy for Anxiety Disorders

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This article critically discusses the new trends in virtual reality-based (psycho) therapy for anxiety disorders. After an initial brief presentation of anxiety disorders and their current traditional evidence-based treatments (e.g., cognitive-behavioral therapies; CBTs), current models of virtual reality-based therapy are presented and examined. The paper emphasizes that virtual reality-based therapy is not a new form of therapy, but a technological development in the current evidence-based therapies (e.g., virtual reality-based CBTs). New trends in virtual reality-based therapy are also presented. To date, research supports the efficacy of virtual reality-based CBTs for anxiety disorders. The paper also discusses advantages of virtual reality (VR) technologies in (1) clarifying theory/mechanisms of change; (2) potentially reducing costs and increasing access and (3) stimulating more ecological research in the CBT. The need for further studies using VR is also highlighted.

The last two decades have witnessed an increasing effort to integrate technological developments into the research and practice of clinical psychology and psychotherapy. Today, new approaches integrating technological components such as computer-assisted therapy, internet-based intervention, cognitive bias modification, and virtual reality exposure therapy, have become more widely used in mental

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health. This interest could be explained in part by the fact that access to evidence-based treatments is limited. Epidemiological studies show that the prevalence of mental disorders is extremely high across the globe (World Health Organization, 2001). Moreover, and what is perhaps more concerning, is the fact that despite numerous existing treatments for various mental disorders, more than half of those in need of specialized mental health services don't access it and/or do not have access to these treatments (Alonso et al., 2004c; Kohn, Saxena, Levav, & Saraceno, 2004; Wang et al., 2005). Thus, developing new psychological treatments that are more efficient and/or increasing accessibility to existing psychological treatments are key goals in mental health.

New technologies (e.g., virtual reality) may potentially help increase the efficacy (i.e., how they work in controlled conditions) and effectiveness (e.g., how they work in real clinical practice) of traditional psychotherapy [e.g., for anxiety disorders, cognitive behavioral interventions (CBT) are typically considered as the standard evidence-based psychological treatments]. They may also be more practical, as well as potentially improve the efficiency, access, and palatability of these standard treatments. Furthermore, using new technologies may help clarify the mechanisms of change involved in various evidence-based psychological treatments and thereby improve the efficacy of existing psychological treatments. Finally, new technologies such as virtual reality therapy may lower the cost of current psychological treatments (i.e., cost-effectiveness) and may stimulate ecological clinical research.

ANXIETY DISORDERS

Anxiety disorders are among the mental health problems with the highest prevalence. In the United States, the life time prevalence of any adult anxiety disorder is estimated to 28.8%, with specific phobia (12.5%) and social phobia (12.1%) having the highest rates (Kessler, Berglund et al., 2005). The 12-month prevalence for anxiety disorders is estimated to 18.1%, with specific phobia (8.7%) and social phobia (6.8%) again being the most common among them (Kessler, Chiu, Demler, Merikangas, & Walters, 2005; for a combined analysis on both adolescent and adult populations see Kessler, Petukhova, Sampson, Zaslavsky, & Wittchen, 2012). Results show somewhat lower frequencies in Europe, with the lifetime prevalence of anxiety disorders estimated at 13.6% with specific phobia being the most common condition among the ones assessed (7.7%), followed by generalized anxiety disorder (GAD; 2.8%). Twelve-month prevalence for any anxiety disorder is 6.4%, with specific phobia being the most frequent (3.5%), followed by social phobia (1.2%; Alonso et al., 2004b). A recent review of the epidemiological data estimated the one-year prevalence of anxiety disorders at 11.6% across the globe, with higher rates for the more developed regions. The rate of anxiety disorders was 8.6% for emerging countries, 7.8% for developed countries, and 5.4% in the developing regions (Baxter, Scott, Vos, & Whiteford, 2012).

In addition to being highly prevalent, anxiety disorders have a higher degree of impact on impairment and disability than chronic medical disorders (Druss et al., 2009). Some of the anxiety disorders (i.e., panic disorder, posttraumatic stress disorder-PTSD, specific phobia, social phobia, and agoraphobia) are among the conditions with the highest impact on work capability and quality of life (Alonso et al., 2004a). Given the high prevalence of anxiety disorders along with associated costs to patients, their families and society, the goal of increasing access to affordable evidence-based treatments (i.e., cognitive-behavioral therapy, as a standard treatment of anxiety disorders) becomes critical.

COGNITIVE BEHAVIORAL THERAPY FOR ANXIETY DISORDERS: A GENERAL FRAMEWORK AND EMPIRICAL SUPPORT

The general framework of CBT conceptualizes anxiety as a syndrome that has subjective (e.g., anxious feelings), behavioral (e.g., avoidance behavior), cognitive (e.g., awfulizing/catastrophizing thinking), and psychophysiological (e.g., arousal) components. These components can be manifested differently across the specific anxiety disorders (see Clark & Beck, 2009 for examples). The general CBT framework is based on the classic stress-diathesis model, but it can be particularized in specific CBT theories/models for specific anxiety disorders (see Clark & Beck, 2009). Within this general model, the cognitive components, in the form of dysfunctional/irrational beliefs, are seen as cognitive vulnerability factors (Beck, 1995; Ellis, 1962). More precisely, dysfunctional/irrational beliefs are not necessarily associated with anxious symptoms or signs; they become associated with anxiety only when primed by various more or less specific activating events.

Functional/rational and dysfunctional/irrational beliefs can be analyzed from a variety of points of view, for details see the work of Wessler (1982) and its new derivative work by David & Szentagotai (2006). Three points of view are key in this analysis and tend to guide CBT interventions (see also David, in press; David, Lynn, & Ellis, 2010; Lazarus & Folkman, 1984).

First, there is a distinction between descriptive and inferential (cold cognitions) versus evaluative cognitions/appraisal (hot cognitions). The following sequence of information processing provides an illustrative example: (1) descriptive cognitions (e.g., I am in front of a crowded auditorium to present a paper); (2) inferential cognitions (e.g., I will fail to present my paper properly and they will laugh at me); (3) evaluative cognitions/appraisal (e.g., I must have a perfect presentation and it will be awful if they laugh at me). While descriptive and inferential cognitions mainly generate behaviors (i.e., they can be modeled as production rules: If X than Y), evaluative cognitions (i.e., appraisal) are more related to feelings (see David, 2003). The relations between cold (e.g., descriptions/inferences) and hot cognitions (e.g., rational and irrational beliefs; see Ellis, 1962) seem to be bidirectional. Indeed, rational and irrational beliefs seem to influence the function-

ality of descriptions/inferences (see David, 2003). However, if cold cognitions are not further appraised by rational and/or irrational beliefs in terms of motivational relevance, they do not generate feelings (see David, 2003; Lazarus & Folkman, 1984).

Second, there is a distinction between (1) core beliefs (often tacit and general), (2) cognitive biases, and (3) automatic thoughts (for details see Beck, 1995). Core beliefs are represented in our mind as schemas (see Beck, 1995) or other types of mental representation (e.g., propositional networks, production rules; see David, 2003). During various activating events, core beliefs (e.g., I am inferior) bias our informational processing of the activating events, generating specific beliefs in the form of automatic thoughts (e.g., I will fail to present properly and/or It is awful). They are called automatic thoughts (i.e., be they hot and/or cold cognitions) because they come to our mind unintentionally; once generated, these automatic thoughts reinforce their underlying core beliefs.

Third, some cognitions (i.e., information processing) generating anxious symptoms/sings may be implicit (i.e., unconscious information processing/cognitive unconscious). Implicit information processing may be structurally unconscious—it cannot be conscious and always functions unconsciously (e.g., classical conditioning, implicit associations/expectancies)—and/or functionally unconscious—it may be conscious, but often functions unconsciously (e.g., automatization of conscious beliefs). In the case of mental disorders that have underlying mechanisms which are structurally unconscious information processing, classic conscious dysfunctional/irrational beliefs do not immediately mediate the impact of the activating events on anxious symptoms (i.e., stress-diathesis model). However, these conscious beliefs can amplify, through further appraisal, anxious symptoms/signs generated by unconscious information processing (see also David, in press; David, 2003).

The general CBT framework of anxiety disorders can be summarized as in Figure 1 (see also, Beck, 1995; Ellis, 1962). Based on this model, cognitive behavioral treatments (CBT) use a large variety of techniques (see David, in press, for details). To deal with stress—in the stress-diathesis model—CBT therapies use a large spectrum of "practical problem solving techniques" such as assertiveness training, social skills training, behavioral modifications, decision making, conflict resolution, specific problem solving techniques, etc. To deal directly with anxious symptoms/signs, CBT treatments use a large spectrum of symptomatic techniques, such as relaxation, meditation, behavioral modifications, and other coping strategies that aim to change the anxious symptoms without explicitly targeting their underling cognitions. To achieve etiopathogenetic changes in anxious symptoms/signs, CBT therapies use cognitive restructuring (e.g., disputation, reframing) techniques aiming to turn dysfunctional/irrational beliefs into functional/rational beliefs. A special type of cognitive restructuring (e.g., by mindfulness, acceptance, cognitive defusion) aims to change the function of our beliefs (see for details, Hayes, 2004) and not the content. If the information processing is implicit (mainly structurally and it cannot be conscious), then various behavioral techniques are employed (e.g., exposure, reinforcement modifications).

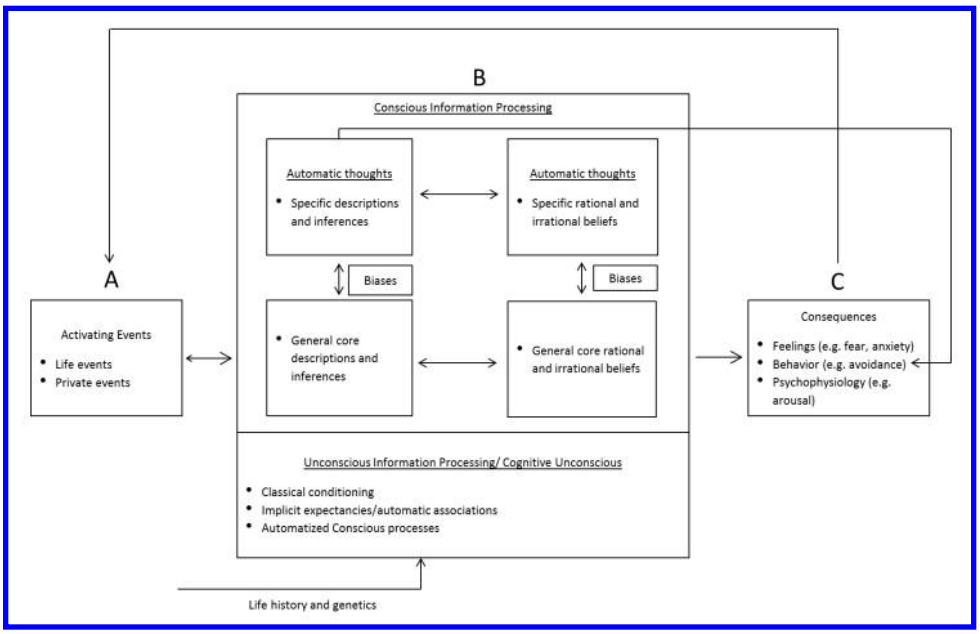

FIGURE 1. A CBTs general framework for anxiety disorders (first published in David, in press).

In general, CBT treatments are currently considered the golden standard of evidence-based psychological interventions (David & Montgomery, 2011). They are seen as an evidenced-based approach to mental health and have consistent evidence of their efficacy/effectiveness in the case of many mental disorders, including anxiety disorders (Deacon & Abramowitz, 2004). A review of meta-analytic studies conducted by Butler and his colleagues (Butler, Chapman, Forman, & Beck, 2006) showed that CBT therapies have large effect sizes in the treatment of GAD, panic disorder, social phobia, PTSD, and childhood anxiety disorders. CBT treatments also have good support for their theories and the proposed mechanisms of change targeted in the psychological interventions (see for example Smits, Powers, Cho, & Telch, 2004, for panic disorders). A valid theoretical model allows for a cumulative development of the field, wherein fundamental research informs clinical practice by enabling the identified mechanisms of psychopathology to be specifically targeted in new methods and techniques (e.g., see Hoffman, 2007, in the case of social anxiety disorder). We have recently introduced a new framework for the classification of evidence-based psychological interventions that takes into account not only the efficacy of an intervention protocol, but also the empirical support for the theory upon which it relies (see for details David & Montgomery, 2011).

Even though traditional CBT treatments are extremely effective in treating most of the anxiety disorders, there are some patients that do not respond to treatment. Moreover, given the high prevalence of these disorders and the lack of accessibility and/or willingness to access these treatments as discussed above, it becomes easier to understand the interest in developing new approaches that would

allow for better dissemination, accessibility, efficacy/effectiveness, and lower costs of mental health services. One of these approaches is the integration of virtual reality technology into psychological treatment protocols. In the next section we describe how this technology is integrated and outline its benefits/advantages over traditional psychological treatments.

VIRTUAL REALITY IN PSYCHOTHERAPY

Virtual reality (VR) can be conceptualized with a large or a narrow meaning. In a large meaning it refers to any artificial reality generated by digital technology (e.g., internet). In a narrow meaning, used here, VR is a multi-sensory computer generated environment that is experienced by the subject throughout a series of technological devices, such as a head mounted display (HMD) or an audio-visual experience in an automatic virtual environment (CAVE; Cruz-Neira, Sandin, DeFanti, Kenyon, & Hart, 1992). Depending on the technology used, the VR environment may be two-dimensional (2D) or, more often, three-dimensional (3D), and the subject may interact with it using a joystick, a haptic device, or a tracking system, so that the environment can adapt itself to the user's behavior. An important characteristic that distinguishes VR from other types of human-computer interaction (Riva, 2005), is the phenomena of presence and immersion experienced by the user, meaning that the environment is perceived as being real and non-mediated, even though the user knows that is computer-generated (Lee, 2004; Lombard & Ditton, 1997). Although presence is related to the level of anxiety experienced by the patients during exposure sessions for the treatment of phobias using VR environments, there is little support for its relation to treatment outcome (Alsina-Jurnet et al., 2011; Price & Anderson, 2007; Price, Mehta, Tone, & Anderson, 2011).

For more details regarding virtual reality see our "Robotherapy and Virtual Reality-Based Psychotherapy Platform" (http://www.psytech.ro), a world-class research facility directed by the first author (DD).

Several authors have pointed out the advantages that VR brings to clinical psychology and psychotherapy (Glanz, Rizzo, & Graap, 2003; Riva, 2003; Szentagotai, Opriş, & David, 2011). VR offers the potential to immerse the patient in a highly controlled yet ecological environment, to match this environment to patient's needs, and to approach problems in a manner that otherwise would be expensive and/or possibly less effective. As an example, the classical exposure treatment for a patient with fear of flying could be limited by the cost (e.g., plane tickets) and the real-life practical challenges (e.g., a panic attack that could affect all the passengers and even the flight plan) of an in vivo exposure session, or by the patient's ability to realistically imagine an anxious provoking flight experience. The combination of virtual reality with exposure therapy (i.e., virtual reality exposure therapy) has the potential to help overcome these disadvantages by gradually immersing the patient in a virtual plane, and going through different moments of the flight, from take-off to landing, on sunny or stormy weather. All these expo-

sure sessions can be done in the therapist's office, while teaching the patient how to handle an eventual panic attack (see Matu, Opriş, & David, 2012; Riva, 2003). What is fundamental here is the fact that what is learned in VR can be generalized to real life and this fact is a strong argument for using VR to enhance classical psychotherapy (Opriş et al., 2012). Going beyond clinical applications, the high control over the presented stimuli while keeping their ecological validity makes VR a powerful tool for research. VR has been successfully used to clarify some of the mechanism involved in the etiology of mental disorders. For example, Coelho and his colleagues (Coelho, Silva, Santos, Tichon, & Wallis, 2008; Coelho, Waters, Hine, & Wallis, 2009) showed that height itself might not be the only trigger that generates the anxious response in fear of heights. Their research showed that the combination of perceived height and vestibular sensations of movement may be responsible for the experienced fear and associated reactions.

VIRTUAL REALITY-BASED CBT IN THE TREATMENT OF ANXIETY DISORDERS: CURRENT MODELS

Given that cognitive behavior treatments have clear, valid models and empirically supported therapeutical packages for various mental disorders is one of the possible reasons why VR technology has been easily assimilated into this therapeutic paradigm. Having flexible manualized psychological treatment packages and knowing the mechanisms that have to be altered to reduce symptoms have permitted researchers and practitioners to more easily incorporate VR into CBT. Few studies have investigated VR in other therapeutical modalities and even those conducted are often case studies, rather than rigorous experimental studies and/or controlled clinical trials (e.g., Wiederhold, Gavshon, & Wiederhold, 2010).

Currently, there are major VR applications and interventions that target several key mental disorders using CBT: anxiety disorders (e.g., specific and social phobia, PTSD), addictions, and eating disorders (Clough & Casey, 2011; Glanz et al., 2003). To date, most of the available models and studies using VR have been conducted using CBT for anxiety disorders in adult populations with only a few studies examining the use of this technology with child populations.

Based on the general framework of CBT (see Figure 1), virtual realities may be used in CBT therapies in various ways. VR may be used to generate specific activating events, thus helping clinicians to implement techniques more ecologically: (1) various practical problem solving techniques (e.g., social skills training while the patient is immersed in the relevant environments); (2) cognitive restructuring techniques targeting conscious/explicit and/or unconscious/implicit information processing (e.g., while the patient is exposed to critical activating events generated by virtual reality); and/or (3) symptomatic techniques (e.g., coping strategies while the patient is facing relevant activating events generated by virtual reality).

Indeed, as mentioned earlier, one of the advantages of VR is the fact that it allows the generation of realistic environments in a controlled manner. The most elaborated VR application in the clinical field is related to virtual reality exposure

therapy (occasionally using a basic cognitive restructuring component during exposure). The VR technology exposes patients to a realistic simulation of the stimuli they fear and helps them develop more adaptive responses to situations they face in their natural environments. Given that exposure is an important component in the treatment of anxiety disorders, virtual reality exposure therapy (VRET) has been widely used in the treatment of some of the anxiety disorders (i.e., specific phobias, social anxiety disorder/fear of public speaking, panic disorder, and PTSD). VRET brings to the clinician's office the benefits of in vivo exposure, at the costs of in vitro exposure; for some expensive in vivo exposure situations (e.g., plane flights) this strategy could be a cost-effective alternative. Moreover, VRET allows a careful control of the exposure and the customization of the environment, based on patient's needs. VRET is a tool/technique that permits clinicians to conduct an ecological behavioral analysis of the problem and achieve reductions in anxious responses by exposing patients to relevant phobic stimuli.

Also, following a cognitive formulation of the emotional reactions, immersion in VR may also be used to get real-time access to patient's negative automatic thoughts and irrational/dysfunctional core beliefs in order to challenge and restructure them while the patient is immersed in the virtual environment and confronted with the phobic stimulus (Szentagotai et al., 2011). However, as compared to VRET, the use of VR in conjunction with practical problems solving techniques, symptomatic techniques, and/or classical cognitive restructuring techniques (i.e., restructuring conscious beliefs), is still very incipient.

At this point, it is important to keep in mind the fact that using VRET or other VR components in CBTs does not imply new treatment principles and/or theories. The same principles of CBTs are extended and used in an immersive VR environment. VR therapies also target the same mechanisms of change and have all the limitations of the current psychotherapeutic models of anxiety disorders. Therefore, in order to clarify that VR therapy is not a new school of psychotherapy, we strongly propose that the term virtual reality-based (psycho)therapy (or virtual reality-enhanced therapy) be used instead of the term virtual reality (psycho)therapy.

THE CURRENT STATUS OF VR-BASED CBT IN THE TREATMENT OF ANXIETY DISORDERS

Several literature reviews that describe the progress made by VR-based interventions in mental health and rehabilitation psychology have been recently published (e.g., Gregg & Tarrier, 2007; Meyerbröeker & Emmelkamp, 2010; Pull, 2005; Riva, 2005; Rizzo, 2006; Rose, Brooks, & Rizzo, 2005). Moreover, three meta-analytical studies have synthesized available data on the efficacy of VRET for anxiety disorders. All three meta-analyses show a positive effect of this tool although there are some important methodological differences between them. Indeed, as we mentioned before, VRET is the main development in the field of VR-based therapy (i.e., VR-based CBTs) and has received a lot of attention in rigorously

conducted clinical experimental studies. As follows, we will shortly analyze the differences between the meta-analytical studies and their specific results.

A meta-analysis conducted by Parsons and Rizzo (2008) included 21 studies with a total of 300 subjects (clinical and nonclinical). Some of the selected studies compared VRET with various types of control groups or other treatments (e.g., in vivo exposure, relaxation) while others studies used a pre- post-treatment design. However, the analysis was based solely on the data before and after the VRET intervention. Parsons and Rizzo found a large mean overall effect size (Cohen's d = 0.95) and large effect sizes for all the categories of symptoms taken into account. The largest effect size was found in the case of panic disorder with agoraphobia (d = 1.79), followed by aviophobia (d = 1.59), social phobia (d = 0.96), acrophobia (d = 0.93), arachnophobia (d = 0.92), and PTSD (d = 0.87).

Powers and Emmelkamp also conducted a meta-analysis on the efficacy of VRET for anxiety disorders (Powers & Emmelkamp, 2008). They included 13 randomized or matched controls studies with a total number of 397 clinical subjects. In their analysis, Powers and Emmelkamp compared VRET to control group (e.g., waitlist, no treatment, attention control) and also to in vivo exposure. They found a large mean overall effect size (g = 1.01) for VRET when compared to a control groups and a small, but significant, positive effect size when compared with in vivo standard exposure treatment (g = 0.34). Across domains of diagnostic measures used, they found medium to large effect sizes for all type of symptomatology, when comparing VRET with control conditions: g = 0.95 for specific phobia; g = 0.73 for social phobia; g = 1.59 for panic disorder; and g = 0.72 for PTSD. Also, they found medium to large effect sizes for general treatment outcomes (e.g., g = 0.50 for level of distress) when VRET was compared to control conditions. Of note, investigators also found a trend for dose-response relationship in the sense that a larger number of treatment sessions were associated with better outcomes, even though this association reached only marginal significance.

Our research group (coordinator DD) also conducted a meta-analysis to examine the efficacy of VRET (Opriş et al., 2012). What differentiates our approach from previously described meta-analyses is the fact that our focus was on comparing the efficacy of VRET with traditional evidence-based interventions for each specific diagnostic category. We selected these comparison interventions from the list of evidence-based treatments published by the Society of Clinical Psychology, Division 12 of American Psychological Association (APA; American Psychological Association, 2006). We were also interested in the degree of generalization of the results to real life situations (e.g., avoidance at behavioral level), the dose-response relationship, and the long-term impact of treatment. We selected only studies that compared VRET with a standard/classic evidence-based treatment or waiting list that randomly allocated the subjects to study conditions. Twenty-three studies with a total of 608 subjects from clinical populations met our inclusion criteria. Across all diagnostic categories, we obtained a large overall effect of VRET, when compared to waitlist (d = 1.12), but no effect in comparison to standard evidence-based treatments (d = 0.16 NS). We did not find any difference between VRET and evidence-based treatments at 3 to 6 months follow-up (d = -0.2 NS) or at one

year or more follow-up (d = -0.11 NS). The comparisons between VRET and traditional evidence-based treatments yielded nonsignificant effect sizes for all diagnostic categories at post-treatment and follow-ups. Based on the available data, we found a large effect size for social phobia (d = 1.01), and a medium effect size in the case of fear of flying (d = 0.53), at post-treatment, when comparing VRET with waitlist. With the exception of a small, but significant, positive effect size for VRET in the case of fear of flying (d = 0.33), we did not found any difference in efficacy between VRET and classic evidence-based treatments, suggesting that the generalization of treatment responses to real life is similar or with a very small differences between the two treatments. With respect to dose-response relationship, we found a significant association between number of exposure sessions and the efficacy of VRET. Finally, we did not find any difference in dropout rates between VRET and traditional CBT treatments.

Taken together, the results of these meta-analyses suggest that VRET for anxiety disorder is more effective than no treatment and other control groups, with VRET showing medium to large effect sizes. Moreover, data supports the idea that VRET has at least a similar efficacy to traditional exposure therapy (sometimes even higher, but in the low range of effect sizes), both at post-treatment and follow-up, and the similar efficacy is relatively constant among all the investigated anxiety disorders (e.g., simple phobias, panic disorders/agoraphobia, social phobia, PTSD). Although few studies have been conducted to date, results so far suggest that VRET and traditional CBT treatments are similar (or have very small differences) in effect with regard to generalization of treatment results to real life contexts. The degree to which this generalization occurs is not clear in the meta-analysis conducted by Opriş et al. (2012), given that there was no comparison with a control group with respect to generalization. Data tends to support the idea that there is a relationship between the number of exposure sessions and treatment outcome (i.e., the higher the number of sessions the higher the clinical effect), but to date, there is no estimation of an appropriate number of sessions or a guideline to estimate such a number based on the specific disorder and its severity.

Although these results seem to be promising, it is important to keep in mind that the conclusions of a meta-analysis ultimately depends on the validity of the studies included in the analysis (Parsons & Rizzo, 2008). After performing a critical analysis of clinical studies on the efficacy of VRET for anxiety disorders, Meyerbröker and Emmelkamp (2010) cautioned against prematurely concluding that VRET is an effective treatment for some of the anxiety disorders (such is the case of PTSD), given that few valid studies have been conducted to date. Further, since VRET has demonstrated similar rates of efficacy (Opriş et al., 2012), and/or show only a marginal advantage (Powers & Emmelkamp, 2008) compared to standard CBT treatments, the value of further investing in this technological development may be questionable. However, some important information could come from studies that show a higher preference among patients for VR-based exposure treatments as compared with traditional treatments (Garcia-Palacios, Botella, Hoffman, & Fabregat, 2007). Also, some authors (Difede et al., 2007) have shown that patients with PTSD, who didn't respond to classical treatments,

benefited from VRET. However, in the meta-analysis conducted by our group we found a similar drop-out rate for VRET and standard treatment, but there were several important limitations in our study with regard to this issue (see Opriş et al., 2012). Further studies are needed to see if VR-based intervention may have an advantage in terms of lower dropout rates and higher adherence.

VR-BASED CBT IN CHILDREN

Researchers have also begun to use VR-based interventions in children suffering from anxiety disorders. Although preliminary results have been positive, few studies to date have examined the efficacy of VR-based therapies in this population. In one such study, thirty-six children (between 10 and 15 years old) presenting with high scores on school phobia were allocated to an active treatment or to a waiting list (Maldonado, Magallón-Neri, Rus-Calafell, & Peñaloza-Salazar, 2009). The active treatment was a combination of relaxation and imaginal exposure in the first two sessions and VRET in the three subsequent sessions. The active intervention reduced fear of school symptoms in comparison to the waiting list, but it had the same efficacy as the waiting list in reducing general childhood fears. The virtual reality environment consisted of a virtual school and a classroom populated by virtual peers, all delivered on a computer screen. Another study using thirty-one arachnophobic children (between 8 to 15 years old) compared a treatment comprising of five sessions of classic exposure with a combination of four sessions of VRET and one session of classic exposure (St-Jacques, Bouchard, & Bélanger, 2010). The virtual environment was accessed through a head mounted display. Even though investigators did not find support for an increased motivation for treatment in the group that received the combination including the VRET component, they found that both treatments were efficacious and comparable in reducing spider phobia at post-treatment and at six months follow-up. Similar to the findings observed with adult populations, the preliminary studies conducted with children suggest that VRET therapy is better than waitlist and has a similar efficacy with classic in vivo exposure. However, more studies are needed before we can arrive at a definitive conclusion.

NEW TRENDS IN VR THERAPY FOR ANXIETY DISORDER

As mentioned above, virtual reality-based (psycho) therapy is not a new form of therapy, but a technological development within the current psychotherapeutic approaches (i.e., in particularly CBT) that allows clinicians to tackle the known mechanisms of change in a more ecological and cost-effective manner. Yet, the relation between virtual reality-based therapy and traditional (psycho) therapies is not just unidirectional, with VR being used solely as an instrument to apply classical treatment strategies. The relationship is rather bidirectional, meaning that

virtual reality-based therapy can stimulate the organization and development of the research, theory, and practice of CBT for anxiety disorders.

PSYCHOLOGICAL ASSESSMENT OF ANXIETY DISORDERS: EVIDENCE-BASED VIRTUAL REALITY ASSESSMENT (EB-VRA)

In the last years, efforts have been made at building guidelines to evaluate the validity of current psychological assessment instruments for anxiety and anxiety disorders. The paradigm of evidence-based assessment has set the standard and researchers have begun identifying the instruments that have the greatest empirical support (Antony & Rowa, 2005; Hunsley & Mash, 2005; Tulbure, Szentagotai, Dobrean, & David, 2012). However, despite the fact that evidence-based assessment instruments have good psychometric properties and clinical utility, they often lack strong ecological validity. Indeed, filling a psychological questionnaire and/or answering the questions (open/semi-structured/structured) in an interview can provide us with decisive clinical information, but these assessment tools might lack specific and important information from the patient's ecological context. For example, a retrospective evaluation of the level of anxiety while relating the story of a plane flight or a battle field (as in war-related PTSD) in a psychotherapy office—even if the patient tries to imagine these situations—might be different than the evaluation of the level of anxiety during a real plane flight and/or a battle field (i.e., simulated in VR). The disadvantages of assessing anxiety in real life situations as those described above are easy to understand. Therefore, a new paradigm of evidence-based virtual reality assessment tools (EB-VRA) may complement standard psychological instruments by obtaining more ecologically valid information about anxious clients. This paradigm is in its infancy, but some assessment tools have already been developed in the case of executive functions (i.e., attention, memory; Elkind, Rubin, Rosenthal, Skoff, & Prather, 2001; Matheis et al., 2007; McGeorge et al., 2001; Parsons, Silva, Pair, & Rizzo, 2008; Rizzo et al., 2000), eating disorders (Ferrer-Garcia & Gutierrez-Maldonado, 2012; Riva, 1998) and also in the case of anxiety disorders. For example, in the case of spider phobia, researchers using VR behavioral avoidance test have pointed out that there are discrepancies between self-report, behavioral, and physiological measures assessed in a virtual confrontation with the phobic stimuli. However, further research is needed to clarify how these different components of anxiety relate in predicting clinical status and treatment outcome (Muhlberger, Sperber, Wieser, & Pauli, 2008).

PSYCHOLOGICAL INTERVENTIONS: EVIDENCE-BASED VIRTUAL REALITY-BASED THERAPY (EB-VRBT)

Outcome Studies. As described above, meta-analytical studies demonstrate that current virtual reality-based therapy (i.e., VR-based CBTs) have (1) similar (and

in some cases even a small advantage) rates of efficacy/effectiveness to traditional CBT treatments both at post-test and follow-up; and (2) exhibit similar rates of generalization to real-life settings (Opriş et al., 2012; Powers & Emmelkamp, 2008). However, this impact is mainly related to the use of exposure techniques (with no or just little cognitive restructuring procedures). More research is needed on using practical problem solving techniques, cognitive restructuring techniques, and symptomatic techniques in VR. Also, VRBT should be (1) compared to other technological based therapies (e.g., computer-based therapy; e.g., Tortella-Feliu et al., 2011) and (2) in comparison to or as an adjunct to pharmacotherapy (e.g., Meyerbroeker et al., 2012). In the event that future studies show that VRBT does not have greater clinical benefits in comparison to standard CBT treatments, researchers will have to demonstrate that VRBT is more cost-effective and/or bring additional advantages (e.g., efficiency, palatability, access, practicality, satisfaction/interest) to justify its use. While the additional benefits have been discussed above, there are only few studies that have assessed VRBT's cost-effectiveness (e.g., Wood et al., 2009) and those conducted are non-systematic. Finally, it is possible that with further technological developments in the field, newer, less expensive and more realistic VR environments will allow us to use more flexible and individualized treatments strategies so that future treatments will become more personalized, and will have a stronger and/or generalized impact.

Mechanisms/Theory of Change. As mentioned above, we (see for details David & Montgomery, 2011) have recently introduced a new framework for the classification of evidence-based psychological interventions that takes into account not only the efficacy of an intervention protocol, but also the empirical support for the theory (i.e., mechanisms of change) upon which it relies. A valid theoretical model and clear mechanisms of change help us to improve the current psychological interventions by developing new methods and techniques. Thus we consider this line of research a fundamental one. Studies on the mechanism of EB-VRBT have brought to the surface some discrepancies between theoretical models and empirical data (see also Meyerbröker & Emmelkamp, 2010). For example, outcome expectancies seem to similarly predict the results of treatment in both VR-based CBTs and classical forms of delivering CBTs for social anxiety disorder (Price & Anderson, 2012). Additionally, VRBT reduced self-reported anxious symptomatology and behavioral avoidance in arachnophobia, as well as cardiac response and information processing (asset with an emotional Stroop task; Cote & Bouchard, 2005). There was also a high correlation between self-report measures and behavioral avoidance. However, consistent with other results in the literature, no correlation was observed with the other psychophysiological and cognitive processing measures. Their results seemed to be in accordance with Foa and Kozack (1986) theory on emotional processing and with the results of traditional CBT interventions. However, other authors have found contrasting evidence. Wilhelm et al. (2005) replicated previous findings in which VRBT for phobias had an impact on skin conductance measures, but not on cardiac responses, as would be expected in the case of classic in vivo exposure. Yet, in another study, heart rate responses were reduced over repeated exposure of phobic subjects in a VR environment

while skin conductance initially increased and later decreased between sessions (Mühlberger, Herrmann, Wiedemann, Ellgring, & Pauli, 2001). Wilhelm and his colleagues (Wilhelm et al., 2005) build on Gray's (1975) theory of animal learning and motivation and suggest that VRBT—especially those VRs based on more static head-mounted displays, rather than more flexible CAVE systems—may activate the behavioral inhibition system (a system that inhibits appetitive behaviors in situations where these behaviors might be punished), as contrasted with the behavioral activation system (responsible for initiating approach behaviors and active avoidance), which is activated in classic *in vivo* exposure (alongside behavioral inhibition). Such differences in comparison to traditional CBT interventions need further documentation, but it is possible that VRBT's efficacy will be explained through slightly different mechanisms. This is probably another future direction for research in EB-VRBT and highlights the importance of a valid theoretical conceptualization in an evidence-based paradigm.

Quality and Affordability of Virtual Reality. The use of VR in psychotherapy is dependent on the quality of VR environments (e.g., to mirror the physical reality) and on their cost (affordability). The use of VR in mental health has evolved with the development of new virtual environments that have been tailored to the idiosyncratic treatment needs of patients with specific disorders. Initially developed for simple phobias (like acrophobia, claustrophobia, fear of flying), the development of virtual environments for anxiety disorders has continued with social phobia, PTSD, and panic disorder with agoraphobia (Glanz et al., 2003). New emerging VR applications for war-related PTSD resemble real-life war environments (e.g., Virtual Iraq/Afghanistan; Rizzo et al., 2005) and the preliminary results using these environments seem to be promising (Rizzo et al., 2011b). We present a short example of another mental health application to be used in the same field of military service, with the aim of introducing three ideas (i.e., virtual human avatars, online delivery, and augmented reality) that we think could have a major impact on the future development of VRBT research and practice.

SimCoach is a project developed by Rizzo and his colleagues (Rizzo et al., 2011a) for the U.S. Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury that aims to provide information and guidance to military personnel, veterans and their families in accessing mental health services. What distinguishes this application is the fact that it uses expressive and interactive virtual human avatars to offer guidance and support in the client's decision to attend professional help. Moreover, the accessibility of this service is enhanced by the fact that is delivered online, and is a combination of two technological developments in the field of clinical psychology and psychotherapy: (1) VR and (2) internet-based intervention (even though this application does not deliver the treatment itself, but offers primary guidance in accessing treatment). However, the use of interactive human avatars in mental health is still in the incipient phase and even the application described above has major limitations in the level of interactivity it offers. The technological developments coming from computational models of human behavior and emotional expression (Liu, 2011) will probably allow virtual avatars to become real instruments in mental health treatment delivery in the fu-

ture. In our opinion, one of the major trends in VRBT for mental disorders in the following years will be the development and use of more realistic environments, including interactive virtual human avatars, to better simulate the reality that the clients confront. On the other side, the augmentation of real situations by computer generated inputs—augmented reality—is a complementary approach to be developed [e.g., to project controllable virtual human and/or animal avatars (e.g., for various animal phobias) in clients' real environment]. Practically, the combination between several technological developments (e.g., VR, internet-based therapy, augmented reality) that bring together the advantages of each one (e.g., ecological validity, dissemination, safety, accessibility, and/or flexibility) will be a direction that will attract the efforts of researchers and clinicians in the future.

Indeed, such a project is already ongoing in the case of depressive disorder (where our university/group is part of an international team). The aim of Help-4Mood project (http://www.help4mood.info/site/default.aspx), financed by the European Commission, is to develop a technologically enhanced CBT tool to help patients with depressive disorder to recover in their own home. The patients have daily interactions at home with a virtual agent that has various functions: (1) assessment (e.g., mood, activity, sleep, motor skills); (2) coping skills (e.g., based on CBTs principles); and (3) clinical decision-making (e.g., planning sessions). All the data can be remotely accessed, monitored, and adapted by a professional clinician. This paradigm could be easily extended and applied to chronic and severe anxiety disorders.

Finally, the costs of acquiring the necessary technology for using VR in mental health promotion have dramatically decreased, while the quality of virtual environments has continuously increased (Glanz et al., 2003). Hopefully, this trend will continue in the future, or at least more realistic environments will be available at similar costs, which will allow for a better dissemination of this tool in clinical field.

VIRTUAL REALITY AND BASIC RESEARCH IN ANXIETY DISORDERS

Various experimental clinical paradigms have started to rigorously investigate anxiety disorders. By engaging more experimental paradigms we can hopefully learn more about the (1) mechanism of various anxiety disorders; and (2) components of therapeutic packages used in clinical practice and research (e.g., in randomized clinical trials). However, a serious concern is that these experimental paradigms could generate findings that are artifacts rather than real clinical knowledge. It is likely that the integration of VR tools in these fields of research might help shed some light on the true nature of the observed results. Let us examine two of these new-trend paradigms to see how VR could help overcome some of the main limitations in these paradigms.

Emotion Regulation Paradigm. Some of the research coming from the field of emotion regulation (Gross, 1998b) tries to investigate the role of various regu-

latory strategies (e.g., situation selection or modification, cognitive reappraisal, suppression) in the etiology of psychopathology. This type of research is not new (see for example Cramer & Fong, 1991; Lazarus & Folkman, 1984), but it was recently resurrected under a new name—emotional regulation paradigm—that attracted a lot of attention. The main assumption of this approach is that mental disorders are caused by the lack of functional emotion regulation strategies or by the long-term use of dysfunctional ones (Werner & Gross, 2009). Moreover, some theorists have argued that the major current approaches to psychotherapy (i.e., CBTs), that have been shown to be effective in several mental disorders (see the Society of Clinical Psychology, Division 12 of American Psychological Association; APA; American Psychological Association, 2006), work because they promote adaptive emotion regulation strategies (e.g., cognitive reappraisal; acceptance; see Hofmann & Asmundson, 2008). Two main types of data have been provided by the studies conducted in this paradigm. First, cross-sectional studies have shown that certain dysfunctional dispositional emotion regulation strategies (e.g., rumination, avoidance, suppression) have a strong link to certain forms of psychopathology (e.g., depression and anxiety disorders; Aldao, Nolen-Hoeksema, & Schweizer, 2010). Second, experimental laboratory studies have shown that certain emotion regulation strategies (e.g., cognitive reappraisal) are better than others (e.g., suppression) at regulating negative emotions (Gross, 1998a; Hofmann, Heering, Sawyer, & Asnaani, 2009). A common design for this second type of studies involves two groups of participants going through a negative emotion induction task after each group has received a specific instruction (to be used just for several minutes) on how to regulate their emotion; typically, these instructions contain self-statements relating and/or countering our automatic thoughts (see Figure 1). It is possible that the experimental nature of these designs might generate a series of findings that are artifacts rather than results that illuminate the true nature of emotion regulation. Indeed, the tasks used to induce various emotions are often laboratory tasks (e.g., various film clips or pictures). Additionally, very often the regulatory strategies are subject to demand characteristics so that the participants can anticipate the expected effect (e.g., some suggestive evidence was found in a recent review of emotion regulation studies, showing that effects sizes are higher when a within subjects study design is used, which is more prone to demand characteristics, as compared with a between subject design; Webb, Miles, & Sheeran, 2012) and/or are artificial (e.g., asking the subjects to reappraise a negative situation so that they feel no emotion and/or feels a positive emotion; Denson, Grisham, & Moulds, 2011; Gross, 1998a; Richards, Butler, & Gross, 2003); thus they have little to no implication for real clinical practice. Indeed, in the real clinical practice reappraisal is not employed with the aim to change anxiety relating a negative threatening situation for example, to no emotion and/or to positive emotions! On the contrary, typically, in real clinical work, the aim of reappraisal in a potentially negative situation is to change a dysfunctional anxious state in to a more functional one (e.g., concern; see Cristea, Szentagotai, Nagy, & David, 2012, for a more detailed critical analysis). Thus, it is possible that ex-

perimental studies in this paradigm might sometimes artificially induce various emotions and then use various artificial (i.e., demand characteristics) instructions to regulate them (see also Kappas, 2011, and Mesquita & Frijda, 2011, for similar and other critical points of view on this issue). Therefore, it is possible that some of the results and conclusions derived from these studies are misleading artifacts (especially those based on self-report data).

Some researchers using VR environments to study social anxiety (Cornwell, Johnson, Berardi, & Grillon, 2006) have shown that these environments might have a good potential to induce more realistic state anxiety and associated responses (e.g., psychophysiological reactivity, negative automatic thoughts). What is perhaps more relevant in this context is the fact that the VR environment have been shown to have a specific effect on clinical subjects (i.e., those that had a social anxiety disorder diagnosis) as compared to healthy controls. In a recent study, subjects with social anxiety showed higher overall state anxiety during the entire procedure (entering VR environment, performing a speech and existing the environment) and higher startle responses in the anticipation phase in which the virtual audience turned towards the subjects (Cornwell, Heller, Biggs, Pine, & Grillon, 2011). Given these findings, we believe that the use of VR could overcome potential limitations of the emotion regulation paradigm. Using emotional regulation strategies during VR exposure to regulate VR-induced emotions (that are more similar to those generated in real life) would considerably increase the validity of the observed results (e.g., to reduce anxious symptoms after using—just for several minutes—an emotional regulation strategy—as reappraisal and/or acceptance).

Cognitive Biases Modification (CBM). CBM is a computer-delivered technique aimed at reducing clinical symptomatology by changing the biases induced by various maladaptive schemas. These cognitive biases, at the levels of attention, interpretation, and/or memory processes, are modified by systematically practicing an alternative way of processing information (Koster, Fox, & MacLeod, 2009). In a classical procedure on the attentional bias, participants are shown two stimuli simultaneously for a short time interval (e.g., 500ms). The two stimuli, one neutral and one with a negative valence, are displayed each on one side of a computer monitor. After this, both stimuli disappear and one of the two stimuli are replaced by a probe (e.g., a letter from the keyboard) and the participants are asked to indicate as fast as possible which of the two words was replaced by the probe. In the assessment procedure for attention bias, the probes replace with equal probability each of the neutral and negative words. The presence of the attentional bias is indicated by faster reactions time for the trials in which the replaced word had a negative valence as compared with the trials where the words had a neutral one (MacLeod, Mathews, & Tata, 1986). To modify attentional bias toward positive stimuli, the researcher increases the probability (up to 100%) that the probes replace the words with a neutral valence. Many variations of this task have been developed and words have been replaced with other type of stimuli, like pictures or human faces expressing different emotions (Beard, 2011). Looking through the

general framework of CBT therapies (see Figure 1), the CBM approach to anxious symptomatology changes cognitive biases (i.e., an important pathogenetic mechanism) induced by the schema (i.e., a core etiological mechanism), instead of changing the automatic thought (i.e., a surface pathogenetic mechanisms) and/or schema. By changing the biases, the schema is posited to not generate negative automatic thought and thus, have reduced anxious symptomatology; on a long term, by changing the biases, the maladaptive schema will not be reinforced by automatic thoughts and therefore, it will be changed and/or inactive. On the other side, in classical CBT, we change automatic thoughts and/or schema by cognitive restructuring, understanding that the change of core schema has a direct impact on changing cognitive biases; however, these inter-relations need more research to be fully understood (see also Mobini & Grant, 2007). At present, the efficacy/effectiveness of cognitive biases modification is still under scientific scrutiny with some meta-analyses showing a strong effect (Hakamata et al., 2010) while others being more cautious in their conclusions (Hallion & Ruscio, 2011). We think that adopting VR technologies into this paradigm could bring more ecological validity to these studies by enhancing the stimuli used to assess and modify the biases. Current computer analog designs that are artificial to some extent could be replaced by immersive and realistic environments/stimuli that could generate robust effects which generalize to real life situations.

CONCLUSIONS AND FUTURE DIRECTIONS

Anxiety disorders are prevalent clinical conditions that have a strong impact on personal, family, and social levels. Cognitive behavioral treatments are the standard evidence-based psychological treatments for anxiety disorders. The present paper hypothesized that virtual reality could (1) enhance the efficacy and/or effectiveness of standard psychological treatments (e.g., VR-based CBTs) as well as improve efficiency, practicality, access, satisfaction, and palatability of these treatments; (2) clarify the mechanisms involved in various anxiety disorders and evidence-based psychological treatments; and (3) lower the cost of psychological treatments (i.e., cost-effectiveness).

The available rigorous research in experimental and/or randomized clinical trials is related mostly to VR-based CBTs for adults with anxiety disorders. Few studies have focused on other therapeutical approaches and/or populations (e.g., children). Current research suggests that the efficacy/effectiveness of VR-based CBTs is as good as (or slightly better in some cases) than traditional CBT treatments, but new models are still under scientific scrutiny. However, even if VR-based CBTs are as efficient as the traditional CBT therapies, it brings new and important benefits: (1) some CBT techniques may be delivered in a more palatable environment; (2) patients who do not respond to standard psychological treatments may respond to VRBT; (3) in some cases (e.g., complex exposure) the cost of the intervention could be reduced; and (4) VR could provide an excellent

research tool for CBTs, revealing new, more ecological mechanisms that could then be tested for their efficacy and effectiveness in real clinical practice. Thus, VR offers the possibility to immerse the patient in a highly controlled yet ecological environment, to match the environment to patient's needs, and to approach problems that otherwise would be impractical, expensive, and/or less effective to treat using traditional approaches. The few studies investigating VR-based CBTs for children with anxiety disorders support similar conclusions (e.g., St-Jacques et al., 2010).

The research on using VR to determine mechanisms of change is still in an incipient phase. Some research data (Cote & Bouchard, 2005) suggests that the mechanisms of change are similar in CBTs and VR-based CBTs, while other data (Wilhelm et al., 2005) suggest that they might be different. Future research is needed to identify specific mechanisms of change involved in a specific psychological intervention in order to: (1) improve that intervention and/or (2) to develop other, independent, complementary, and/or adjunctive interventions, based on different mechanisms. Indeed, David & Montgomery (2011) proposed the validity of the mechanisms of change as a key ingredient in establishing a treatment as an evidence-based treatment.

The costs of acquiring the necessary technology for using VR in mental health treatments has dramatically decreased while the quality of virtual environments have continued to increase (Glanz et al., 2003). As stated above, this trend will hopefully continue in the future, or at least more realistic environments will be available at the same costs, which will allow for a better dissemination of this tool in the clinical field. However, at this time there are few cost effectiveness analyses for anxiety disorders comparing virtual reality-based CBT to standard treatment using rigorous clinical designs.

In conclusion, VR-related research holds promise in the treatment of anxiety disorders. Even if VR-based (psycho) therapy (e.g., VR-based CBTs) may involve some different mechanisms of change as compared to traditional treatments (e.g., CBT), it is not a new school of therapy, but a technological development in traditional CBT. At present, results on the efficacy and effectiveness of VR-based CBTs for anxiety disorders are promising; however, VR-based CBT is mainly related to exposure techniques (with no or just little cognitive restructuring) and therefore, more research is needed on the application of VR using practical problems solving techniques, cognitive restructuring techniques, and symptomatic techniques. Also, we have new insights in relationships to the mechanisms of change, cost-effectiveness, and the way in which VR could stimulate more ecological research in CBT. However, these insights should still be under scientific scrutiny and future studies are needed to clarify how VR could enhance clinical research and practice in relation to these aspects.

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