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EDITORIAL

Treating anxiety disorders with virtual reality exposure therapy☆

Tratamiento de los trastornos de ansiedad con terapia de exposición a realidad virtual

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Anxiety disorders and exposure therapy

Anxiety disorders characterised by avoidance are among the most prevalent mental disorders.[1] Exposure therapy is one of the key components in cognitive-behavioural treatment (CBT) for these problems. The essence of exposure therapy consists of the patients confronting the feared situation repetitively, gradually and systematically, until their anxiety is reduced. Foa and Kozak[2] used the concept of emotional processing to explain the fear reduction that occurs in exposure therapy. They suggested that exposure to feared stimuli allows the fear structure to be activated and the resulting anxiety reduction provides corrective information that is incompatible with the pathological elements of the fear structure.

Exposure can be applied traditionally *in vivo* (through the confrontation with real situations, for example, presenting the patient with a real spider to treat arachnophobia) or by employing the imagination (for example, the memory of a traumatic event in treating post-traumatic stress disorder or PTSD). A more recent form of applying exposure therapy is the use of virtual reality.

Virtual reality exposure

The immersion systems of virtual reality (VR) allow the user to interact with the computerised environment that they are seeing, like a videogame, but with a sensation of presence in that environment. The form most used in this therapy is to have the user wear a head-mounted display system (HMD) with binocular screens, stereo sound and a movement-tracking method to follow the shifting VR environment and the user's head movements. In many cases, the user can move with a manual controller when appropriate, feel vibrations though a platform and be presented with olfactory stimuli through a scent machine that uses compressed air to diffuse scented substances. In virtual reality exposure (VRE) therapy, this sensation of presence is used to evoke emotions and facilitate the processing of associated fears in a controlled exposure environment.[3]

Research in evaluating the efficiency of VRE in treating anxiety disorders began in the early 90s. Rothbaum et al.[4] published the first study in which significant evidence was obtained indicating that VRE was an effective form of reducing anxiety associated with acrophobia. In later years, VRE applications were broadened to the treatment of

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cognitive, emotional, psychological and physical disorders.[5] VRE turned out to be especially effective in treating anxiety disorders like the phobia of flying[6] or spiders.[7] The efficiency of VRE goes beyond simpler anxiety disorders, given that studies performed with panic disorder, agoraphobia and social anxiety disorders have also shown VRE to be effective.[4] In a meta-analysis of 13 studies in which VRE was compared with *in vivo* treatments, the magnitude of effect with VRE was greater in the control groups ($d = 1.1$, $P < .05$) and lower with the use of *in vivo* methods ($d = .35$, $P < .05$).[8] In addition, Parsons and Rizzo[9] arrived at the conclusion that the efficiency of VR therapy is backed by data from examining more than 300 patients treated in 21 studies.

In addition to the effective use of VRE, technological innovations have allowed us to advance a step further by supporting a variation of VR, called augmented reality (AR). This uses computer graphics combined with the real world in real time. The user sees the real world ''augmented'' by virtual elements. Botella et al.[10,11] described the effective use of an AR system in treating the phobia of spoons, and they have recently introduced the concept of ''serious game'' in this field. In a unique case study, results indicated that the use of mobile games before a session of AR exposure treatment reduced the level of fear and avoidance.

Another line of research is the combination of VRE with **D-cycloserine** (DCS; brand name, Seromycin). Ressler et al.[12] observed that DCS—an antibiotic employed in the past to treat tuberculosis—facilitated the extinction of fear through a reaction with the neuronal receptor N-methyl-D-aspartate (NMDA) for glutamate. In the first trial in which DCS was combined with exposure therapy in humans—a double-blind study comparing DCS and a placebo, both combined with VRE—it was observed that DCS significantly strengthened the favourable effect in treating participants with acrophobia.[12]

VRE for post-traumatic stress disorder (PTSD)

The first use of VRE for PTSD was in 1997 with veterans of the Vietnam War, by using *Virtual Vietnam*, and the results were promising, for the veterans and for the general treatment of PTSD.[13] Other groups have used VR environments to facilitate the treatment of PTSD in civilians. For example, a virtual World Trade Centre was used to treat the survivors of the terrorist attacks in New York City on 11 September 2001.[14,15] Josman et al.[16] are currently applying a PTSD treatment scenario called *BusWorld* for civilians who have survived terrorist attacks in Israel. In response to the growing number of veterans who return with PTSD from Iraqi and Enduring Freedom operations, the University of Southern California initiated the development of a scenario called *Virtual Iraq* in 2005.[17] It is currently the object of research at Emory University and in other clinical centers.[18,19]

Virtual Iraq is a very flexible virtual environment platform that uses the most innovative technology. Its environment includes 2 general scenarios: a Middle Eastern city and a multipurpose military vehicle with 4-wheel drive (Humvee) that circulates alone, or as part of a convoy, on a motorway in the desert. All the characteristics of the scenario are adjustable, such as the time of day or night, degree of illumination and weather conditions. The current environment includes different triggering stimuli:

- Auditory (e.g., gun shots, explosions, vehicle noise, human voices, helicopter flying overhead).
- Static visuals (e.g., destroyed vehicles).
- Dynamic visuals (e.g., distant images of vehicle movement).
- Dynamic audiovisuals (e.g., nearby movement of humans and vehicles, explosions, insurgent attacks).

Olfactory and tactile stimuli can also be applied, such as the following:

- Burnt rubber.
- Cordite.
- Garbage.
- Body odour.
- Smoke.
- Diesel fuel.
- Iraqi spices.
- Gunpowder.

In *Virtual Iraq*, using a vibrating platform is a key element to produce the sensation of being present.

According to the data from 20 patients who completed an open clinical trial on a military base in active service, the use of VRE (specifically *Virtual Iraq*) in treating PTSD produced statistically significant improvements. Of the 20 participants who completed the study, 16 no longer satisfied the DSM criteria for PTSD.[19] In addition, a descriptive case study published by Gerardi et al.[18] showed a 56% reduction in scores on the Clinician-Administered PTSD Scale (CAPS) for the first patient treated with the use of *Virtual Iraq*.

Even though no randomised clinical trial has yet to be published comparing VRE with prolonged exposure (PE) in treating PTSD, VRE has been studied in comparison with *in vivo* exposure. Emmelkamp et al.[20] did that in the case of acrophobia and observed that the beneficial effects of treatment were equivalent and continued to be evident 6 months after its application. In addition, 2 studies were performed to compare VRE with *in vivo* exposure in patients with a phobia of flying.[6,21] Both treatments produced significant and equivalent improvements, in comparison to the control situation, an effect that was maintained 6 months after the treatment[21] and even 12 months after.[22]

Advantages and disadvantages of VRE

VRE has many advantages over more traditional exposure therapy. Firstly, VRE offers the possibility for the

patient and therapist to share the exposure experience. Secondly, with VR the option of applying exposure and of control over the stimuli becomes available; with other methods, this would be extremely difficult, if not impossible, to carry out in real life. For example, the virtual airplane should be mentioned, in which the therapist can manipulate various aspects, such as waiting time, flight conditions (calm or turbulent weather), take off and landing, as well as repeated exposure, all within the setting of a consultation visit. Thirdly, VR allows the therapist to individualise the exposure for each patient. Fourthly, VRE facilitates the evoking of memories that may be difficult for the patient to relive by complementing those mental images with sensory cues. Fifthly, VRE is especially attractive for the current generation geared towards digital technology.

Like any treatment, VRE also has certain limitations. Firstly, the development of computer programs and the necessary computer equipment are costly. Secondly, as a characteristic of technology, the possibility of a system failure is always present and could interrupt a therapy session. In addition, the therapist has to be trained to use a VR system. Thirdly, the VR concept itself may distract patients; if the stimulation is not appropriate, it can be used as a way of avoiding emotions associated with a traumatic event. In addition, the amount of sensory stimulation that can be used in VR is limited by current existing technology.

Even though its inception is relatively recent, VRE continues to show significant evidence that it is an effective method for treating many anxiety disorders, including PTSD. VR is a treatment experience with some totally unique characteristics, with a surprising degree of detail and malleability. Clinical trials have repeatedly revealed that its effects persist after treatment and that it constitutes a valid alternative, or useful addition, to traditional exposure therapy. With the increasing prevalence of mental health assistance and the constant evolution of technology, the future possibilities for VR seem practically limitless.

Conflict of interest

Dr. Rothbaum and Emory University have stock in Virtually Better, Inc., which develops products related to virtual reality research described in this article, and Dr. Rothbaum is a consultant of Virtually Better, Inc. The terms of this agreement have been examined and approved by Emory University in relation to its conflict of interest policy.

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