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E-virtual reality exposure therapy in acrophobia: A pilot study

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Abstract

Virtual reality therapy is already used for anxiety disorders as an alternative *to* in vivo and in imagino exposure. To our knowledge, however, no one has yet proposed using *remote* virtual reality (e-virtual reality). The aim of the present study was to assess e-virtual reality in an acrophobic population. Six individuals with acrophobia each underwent six sessions (two sessions per week) of virtual reality exposure therapy. The first three were remote sessions, while the last three were traditional sessions in the physical presence of the therapist. Anxiety (STAI form Y-A, visual analog scale, heart rate), presence, technical difficulties and therapeutic alliance (Working Alliance Inventory) were measured. In order to control the conditions in which these measures were made, all the sessions were conducted in hospital. None of the participants dropped out. The remote sessions were well accepted. None of the participants verbalized reluctance. No major technical problems were reported. None of the sessions were cancelled or interrupted because of software incidents. Measures (anxiety, presence, therapeutic alliance) were comparable across the two conditions. e-Virtual reality can therefore be used to treat acrophobic disorders. However, control studies are needed to assess online feasibility, therapeutic effects and the mechanisms behind online presence.

Keywords

Virtual reality therapy, telemedicine, acrophobia, online therapy, e-health, e-mental health

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Introduction

In recent years, e-mental health care in the form of email, videoconferencing, chat technology or any combination of the above, has gradually become part of mainstream medicine, as a means of improving psychiatric care. There is growing evidence to suggest that the provision of mental health services over the Internet is both clinically efficient and cost effective.[1] E-mental health is just as efficient as face-to-face consultations when it comes to the diagnosis and treatment (e.g. cognitive behavioural therapy)[2] of mental disorders such as depression[3,4] and anxiety disorders.[5] Furthermore, several studies have reported a high level of satisfaction with e-mental health care,[6,7] with no difference in comparison with traditional consultations.[5,8] Reviews indicate that e-therapy is at least equivalent to face-to-face therapy in terms of therapeutic alliance.[1,9]

One example of how technological advances are finding applications in medicine is virtual reality, which is already being used in psychiatry. This involves the creation of an interactive, computer-generated, three-dimensional environment.[10] Here, the user is no longer simply an external observer of images on a computer screen, but an active participant in a virtual world[11] that changes in a natural way to keep pace with his or her head and body motion.[12] Virtual reality is used in the treatment of a variety of mental disorders, including eating disorders,[13] drug addiction[14] and schizophrenia.[16] There is a growing body of literature on the different uses of virtual reality to treat psychosis–to improve social cognition,[17,18] for instance, or carry out assessments.[19] Virtual reality is also used for anxiety disorders as an alternative to the in vivo and in imagino exposure provided in cognitive behavioural therapy – the gold standard psychotherapeutic treatment for this pathology. According to recent meta-analyses,[20–23] its efficiency is at least equivalent to that of in vivo exposure in anxiety disorders. The anxiety disorders assessed so far range from specific phobias,[24] fear of flying[15,25–30] and acrophobia[31,32] to panic disorder with agoraphobia,[33–35] social phobia[24] and post-traumatic stress disorder.[36–38] Virtual reality exposure is well accepted.[24]

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A fundamental feature of the virtual reality experience is *presence*, which is commonly defined as the mental experience of *being there* in the virtual world.[39–43] Three presence components are usually described: immersion, realness and physical presence.[44,45] Some authors also consider a fourth dimension, namely the negative effects induced by virtual reality navigation.[46]

To our knowledge, no one has so far tested remote virtual reality exposure therapy (e-VRET). In this condition, it is crucial to assess the occurrence of presence and its modalities. The aim of the present study was therefore to examine e-VRET in an acrophobic population.

Materials and methods

Participants

Participants were individuals with acrophobia who had sought treatment from a hospital consultant. To take part in this project, patients had to meet the current criteria for acrophobia laid down in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV).[46] Acrophobia had to be the main complaint. We included patients aged 18–65 years. Patients with a current depressive episode were excluded to avoid hindering their ability to deal with the computerized procedure and the efficiency of the therapy.

Measures and procedure

The participants were informed about the exposure procedures and their informed consent was obtained. Sessions were free of charge.

Before receiving the virtual reality therapy, participants underwent a nonstructured clinical interview screening for the main diagnoses of the DSM-IV, such as anxiety and mood disorders. They then completed four questionnaires: Beck Depression Inventory (BDI), Spielberger State-Trait Anxiety Inventory (state anxiety: STAI form Y-A; trait anxiety: STAI form Y-B), Attitude Toward Height Questionnaire (ATHQ) and Acrophobia Questionnaire (AQ).

Each of the participants met the therapist for a training session. During this session, the virtual reality procedure was explained and participants were trained to use the equipment. They were then immersed in a neutral virtual world for a trial run.

Six sessions (two sessions per week) of virtual reality exposure were scheduled. The first three were e-VRET sessions, which took place without any contact with hospital staff, while the last three were traditional sessions in the physical presence of the therapist (p-VRET). To avoid having to lend equipment and control the conditions in which the measures were made, the e-VRET sessions took place at the hospital, but without any direct contact between therapist and patient. For the first three sessions, a non-health care worker greeted participants, seated them in front of the computer, then left. The therapist and the participant sat in two separate rooms and communicated via videoconferencing. After an initial interview, the therapist took control of the participant's computer and opened the virtual reality software. The same therapist conducted all the sessions. The order of the three virtual worlds was randomized across participants in both the e-VRET and p-VRET conditions.

Before each virtual exposure, participants completed the STAI form Y-A, and rated their anxiety on a visual analog scale (VAS) ranging from 0 (none) to 10 (maximum). After each exposure, participants rated presence and anxiety on VASs and filled out a questionnaire on technical difficulties (computer, head-mounted display and wireless mouse). Presence was rated on five VASs ranging from 0 (none) to 10 (maximum). Four of these scales concerned factors that have previously been described:[47] immersion, realness, physical space and negative effects (cybersickness with dizziness, nausea). The fifth one was added to measure the therapist's assessment of the participant's presence. Therapeutic alliance was assessed with the short version (12 items) of the Working Alliance Inventory (WAI)[48] after the third and sixth sessions. One questionnaire was for the patient and one for the therapist. Heart rate was continuously recorded with a Mio Alpha wristband, from the waiting room (five minutes at rest) to the end of the consultation.

Virtual reality exposure

A powerful laptop (DELL Precision M6700 - Intel Core i7-3740QM) and an Nvidia Quadro K5000 card with 4 GB of dedicated memory were used to display the virtual worlds in high-resolution stereoscopic mode (3D, 1280x720) on a Sony HMZ-T1 head-mounted display. A 3D orientation sensor (OS3D; Inertial Labs) was built into the helmet to measure head and body motion during navigation. A directional microphone placed on the ceiling was used for oral communication between the therapist and the patient. A webcam allowed the therapist to monitor the patient's behaviour during immersion in the virtual world.

The remote control software was TeamViewer 6. The virtual worlds (subway stations, 24-storey tower block) were created with Blender version 2.67 open-access software (Figure 1).

Statistical analyses

Nonparametric testing (Wilcoxon) were used to compare results between the e-VRET and p-VRET sessions. We calculated the before and after differences in anxiety VAS ratings and heart rate to assess the amount of anxiety induced by exposure.

Results

Six participants were included: two men and four women. The population's baseline characteristics are set out in Table 1.

Figure 1. Virtual world (office building).

Table 1. Participants' mean (standard deviation) baseline characteristics.

Age, years	44.5 (14.2)
BDI	10.7 (10.0)
STAI-Y-A	33.9 (10.0)
STAI-Y-B	43.4 (10.4)
AQ	
Avoidance	19.9 (7.1)
Anxiety	74.0 (12.5)
ATHQ	45.6 (9.9)

AQ: Acrophobia Questionnaire; ATHQ: Attitude Toward Height Questionnaire; BDI: Beck Depression Inventory; STAI: Spielberger State-Trait Anxiety Inventory (state anxiety: STAI form Y-A; trait anxiety: STAI form Y-B).

None of the participants dropped out. The e-VRET sessions were well accepted. None of the participants verbalized reluctance. No major technical problems were reported. None of the sessions had to be canceled or interrupted because of software incidents. No cybersickness (dizziness and nausea) was encountered during the sessions, as attested by the fourth presence VAS (negative effects). No adverse events occurred.

No significant difference was found between e-VRET and p-VRET on the pre-exposure STAI form Y-A scores or the before-and-after difference in anxiety VAS ratings (Wilcoxon; $p = 0.216$ for STAI and $p = 0.256$ for anxiety VAS). Only one of the six participants' STAI form Y-A questionnaires was missing for the first three sessions (none for the last three). No data were missing for the anxiety VAS ratings.

Table 2. Comparison of mean (standard deviation) results for remote virtual reality exposure therapy (e-VRET) and virtual reality exposure therapy in therapist's physical presence (p-VRET).

	e-VRET		*p*-VRET		*p*
STAI-Y-A	34.00	(8.75)	32.83	(7.40)	*0.216*
Difference in anxiety VAS ratings	0.99	(1.80)	1.59	(2.50)	*0.256*
Presence					
Immersion	5.23	(3.55)	5.71	(3.05)	*0.615*
Realness	5.29	(3.23)	5.77	(3.35)	*0.363*
Physical presence	5.95	(3.16)	6.00	(3.19)	*0.532*
Negative effects	2.14	(3.22)	2.18	(3.29)	*0.552*
Therapist's evaluation	4.96	(2.48)	5.65	(3.06)	*0.266*
WAI					
Participant's evaluation	74.2	(5.60)	73.67	(7.37)	*0.786*
Therapist's evaluation	59.83	(4.49)	6.67	(7.37)	*0.168*
Heart rate difference	−1.57	(6.97)	0.31	(6.53)	*0.381*

STAI: Spielberger State-Trait Anxiety Inventory (state anxiety: STAI form Y-A); VAS: visual analogue scale; WAI: Working Alliance Inventory.
Values of *p* based on Wilcoxon test.

No significant difference between e-VRET and p-VRET was found on heart rate (Wilcoxon $p = 0.381$).

No significant difference was found between e-VRET and p-VRET on any of the five dimensions of the presence VAS (Wilcoxon; immersion, $p = 0.615$; realness, $p = 0.363$; physical presence, $p = 0.532$, negative effects, $p = 0.552$; therapist's assessment, $p = 0.266$).

No significant difference was found between the patients' assessment and therapist's WAI ratings (Wilcoxon $p = 0.786$ and $p = 0.168$). One participant's questionnaire was missing for the e-VRET sessions.

Results are set out in Table 2. In conclusion, no significant differences were found between the e-VRET and p-VRET sessions on anxiety, heart rate, presence or therapeutic alliance.

Discussion

To our knowledge, this is the first time that data have been published on exposure on e-virtual reality. The aim of the present study was to examine the feasibility of e-virtual reality exposure. It yielded three main findings. First, e-VRET is possible. No major technical incidents occurred and all the sessions were successfully completed. Furthermore, the e-sessions were well accepted. None of the participants verbalized any reluctance. Second, participants were able to handle the computer without any problems from the very outset, even though the first sessions were remote and the therapist was not physically present, and even though not all participants had experience of computers (one of them had never had unrestricted

access to computers). Moreover, the procedure was designed so that the therapist was in charge of starting the computer and managing the virtual worlds. This means that e-VRET sessions can even be used with patients who are not computer literate. Third, no significant differences were found between the e-VRET and p-VRET sessions on any of the anxiety, presence or therapeutic alliance measures. We studied two anxiety dimensions. Exposure anticipation was measured with the STAI form Y-A, while the difference in ratings on the anxiety VAS before and after exposure and the difference in heart rate between rest and exposure assessed the anxiety triggered by the exposure itself. Results for these measures were comparable across the two conditions. We can therefore conclude that e-VRET induces the same exposure anticipation and the same anxiety during exposure as traditional virtual reality therapy. Presence during virtual reality exposure did not differ between the conditions without and with the therapist's physical presence. It is therefore possible to induce presence even in e-VRET sessions. Distance does not lessen the therapeutic alliance.

Techniques using the Internet to conduct virtual reality therapy in the patient's home now seem feasible. However, several important issues need to be addressed. First, a powerful computer with a powerful graphics card (gamer card) is needed to implement virtual reality. If this therapy is to be extended, dedicated computers may have to be lent by the hospital, as the patient's own personal computer may not be sufficiently powerful. In addition to the risk of damage, there is the problem of ensuring the return of the personal computer at the end of therapy. Moreover, if the software has been installed on the patient's own personal computer, he/she may continue the exposure unsupervised. If this exposure is not properly undertaken (e.g. nonhierarchical exposure or insufficient decrease in anxiety), the disorder may worsen or the therapy may be less efficient. The patient might also allow other people access to the software without any prior medical assessment or monitoring (possibly inappropriate treatment). Second, a fast Internet connection must be available in the patient's home. In our study, the therapist could directly control and view the virtual reality sessions on his computer. If the Internet bandwidth at home was insufficient, the data would have to be filtered, so as to transmit just the information required by the therapist to monitor the patient's progress in the virtual world. Third, there were some missing data, as it was not possible for the therapist to check that the participants had filled out the questionnaires during the e-sessions. This issue could easily be resolved through the use of online questionnaires, which have been shown to be useful for tracking patients' progress.

Cost considerations have hitherto proscribed the spread of VRET. However, helmet prices have declined substantially, from €10,000–20,000 to just €300 today. Free open-source software, such as the Blender software used in this study, is also now available. VRET is therefore now financially feasible.

This study had several limitations, the most obvious one being the small number of participants. Second, to avoid the loan of equipment, all the e-sessions took place in hospital. Even though no major problems occurred, feasibility in the home could not be assessed. This study was a simulation of what can be done over the Internet. However, as all the sessions were conducted in the same environment (hospital), we could control the conditions in which the measurements (anxiety, presence, heart rate) were made. Third, we only used one physiological measure of anxiety: heart rate. Skin conductance reactivity could have been added, in order to achieve a more accurate assessment. Fourth and last, although we found no significant difference, this is not the same as non-inferiority. As the absence of a significant difference may have been due to a lack of power, we cannot strictly speaking conclude that e-VRET and p-VRET are equivalent. Future research will need to consider using non-inferiority statistical testing to assess equivalence between e-VRET and p-VRET.

In conclusion, e-virtual reality can be used to treat phobic disorders. VRET is finally on the verge of becoming technologically and financially feasible. e-VRET can therefore be made available to a larger number of patients, however computer literate or illiterate they are and no matter where they live, with only minimal equipment (computer with Intel Core i7-3740, GTX470 graphics card (1000 GFLOPS), Internet connectivity of at least of 2.5 Mb/s). Further studies will be needed to assess e-VRET in the home using the Internet. Its therapeutic effects and the online presence mechanisms must also to be identified.

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Declaration of Conflicting Interest

None declared.

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