PERGAMON

Behaviour Research and Therapy 36 (1998) 239–246

BEHAVIOUR RESEARCH AND THERAPY

Short Communication

Virtual reality treatment of claustrophobia: a case report

C. Botella[a,*], R. M. Baños[b], C. Perpiñá[b], H. Villa[a], M. Alcañiz[c], A. Rey[c]

[a]*Departamento de Psicología Básica, Clínica y Psicobiología, Universidad Jaume I, Carretera de Borriol, s/n, 12080-Castellón, Spain*

[b]*Department of Personality, Universidad de Valencia, Spain*

[c]*Design & Image Development, Universidad Politécnica de Valencia, Spain*

Received 22 July 1997

Abstract

The efficacy of a treatment for claustrophobia using only Virtual Reality (VR) exposure was examined. The subject was a 43-year-old female who suffered from clinically significant distress and impairment and sought psychological therapy. Eight individual VR graded exposure sessions were conducted. All self-report measures were reduced following VR exposure and were maintained at one month follow-up. The necessity of a theoretical framework for this new medium for exposure therapy is discussed.

1. Introduction

The term "Virtual reality" (VR) was coined in 1989 by Jaron Lanier, although Sutherland (1965, 1968) is usually considered to be the father of this new technology. The potential of VR is such that practically all the clinical disciplines will be able to benefit from this man-computer interface (Greenleaf, 1995).

Although the future is promising, VR applications to the field of the psychological treatments are scarce. The first application was Schneider's study (1982), in which the effectiveness of a very rudimentary initial tool was tested (special lenses which altered the

* Author for correspondence.

This article was partially sponsored by Conselleria de Cultura Educacío i Ciència (Generalitat Valenciana) [GV-D-ES-17-123-96] and Instituto de la Mediana y Pequeña Industria de la Generalitat Valenciana (IMPIVA) [971801003559].

0005-7967/98/$19.00
PII: S0005-7967(97)10006-7

perception of depth and which were used to magnify the sensation of height during the process of *in vivo* exposure). Advances since then include the work by the group of the University of Nottingham, where a VR system has been developed for the spider phobia treatment, and the works of the Kaiser-Permanent Medical Group of California, where a set of tests has been developed to assess the utility of VR in the acrophobia treatment (Vince, 1995). The group of Rothbaum in Clark Atlanta University has published the first reports about the utility of softwares designed for acrophobia treatment (North and North, 1994 and 1996; Rothbaum et al., 1995a,b) and for the fear of flying (Rothbaum et al., 1996). The first book of treatment by means of VR has been recently published: *Virtual Reality Therapy: An Innovative Paradigm* (North et al., 1997).

In short, there is evidence for the utility of VR for the treatment of specific phobias. The present work seeks to advance this field and focuses on the treatment of claustrophobia by means of VR.

The choice of claustrophobia is justified by the special characteristics of this phobia. It is similar to agoraphobia with a more constricted range of avoidance (Barlow, 1988; Booth and Rachman, 1992; Öst, 1987); moreover, claustrophobia can be incapacitating and disturbing, since closed places are common in daily life (elevators, aeroplanes, tunnels, booths, etc.). In some circumstances, this phobia can be especially impairing, for example, when certain tests for medical diagnosis/therapy are necessary (Computed Tomography Scan -CTS-, Magnetic Resonance Imaging -MRI-, Hyperbaric Oxygen Treatment, etc.) (Katz et al., 1994; Kilborn and Labbe, 1990; Hillard, 1990).

Exposure therapy is an effective way to treat specific phobias (Marks, 1987; Öst, 1989; Warwick and Marks, 1988) including claustrophobia (Frankel, 1970; Gatchel, 1977; Koulak et al., 1976; Leitenberg et al., 1968, 1970, 1971; Öst et al., 1982; Speltz and Bernstein, 1979). However, exposure therapy has limitations. Firstly, it does not benefit all people who suffer from phobias, since many patients (around 25%) are afraid of facing the threatening object or context and, therefore, they refuse to participate in an exposure program or they drop-out (Marks, 1992). One of the advantages of VR is that the context generated by the computer can be completely controlled by the therapist and by the patient. Another element that provides safety to the patient is the "virtuality" of the environment. Therefore, VR can be a key intermediate step between the therapist's consulting room, completely protected, and the threatening real environment. However, the frightening situation is not always easily accessible (an aeroplane, a cave, a tunnel). In these instances imagery exposure is usually used, but this treatment is less effective and there are individual differences in imaginative ability. Another problem of exposure treatments is that patients continue manifesting "residual fears" in the scaring situations. As VR can go beyond what a "real" situation would allow, a great control of the phobic setting is possible and therefore the residual fears may disappear.

Besides the possible advantages of VR, this special kind of exposure may also contribute to other important aspects of the therapy. Firstly, therapy may be considered like a special, protected environment in which the patient can start to explore and to act (that is, to cope with what he/she fears). The virtual situation is a safe base at the patient's service where nothing of what he/she fears can "actually" happen. VR also allows one to grade the situation in such a way that the patient can progress from the easiest performances until the most

difficult ones at his/her own pace. That is, the virtual treatment can be designed so that it fits each patient. Some of the previous tests of VR used VR exposure as the only therapeutic intervention (North and North, 1996; Rothbaum et al. 1995a,b), but other studies combined VR exposure and anxiety management techniques (Rothbaum et al., 1996) or *in vivo* exposure (Carlin et al., 1997).

The purpose of the present work was to examine the efficacy of a treatment for claustrophobia using *only* VR exposure, in a person who suffered from clinically significant distress and impairment and sought psychological therapy.

2. Method

2.1. Subject

The patient was a 43-year-old widow. She was referred by the Mental Health Services because of her strong fear, anxiety and inability to undergo a CTS to detect a possible lesion in the spinal column that may have been contributing to her back pain for three years. The CTS was the last neurological test she had to complete but her great fear of this kind of exploration prevented her from carrying it out. She reported she had been afraid of closed places since she was a child (e.g. elevators, aeroplanes, putting her head into water, having the windows closed during sleep).

3. Measures

3.0.1. Fear and avoidance scales (FAS)

A Spanish adaptation of the Marks and Mathews' scales (1979). The target behaviour (CTS) is evaluated according to the degree of fear and avoidance, from 0 to 10, where 0 is "I Never avoid it"/"No fear" and 10 is "I Always avoid it"/"Extreme Fear".

3.0.2. Fear of closed spaces measure (FCSM)

One item was included to assess the degree of fear of closed spaces, from 0 to 10, where 0 is "No fear" and 10 is "Extreme Fear".

3.0.3. Problem-related impairment questionnaire (PRIQ)

(Echeburúa and De Corral, 1987, in Borda and Echeburúa, 1991) It consists of rating scales from 0 to 10 (from "Not at all", to "Very much"), assessing the overall functional impairment caused by the problem.

3.0.4. Subjective units of discomfort scale (SUDS)

(Wolpe, 1969)The subject rated her maximum level of anxiety on ten-point scale in the present situation.

3.0.5. Self-efficacy towards the target behaviour measure (SETBM)

One item was included to assess the degree of self-efficacy related to the target problem (CTS).

3.0.6. The attitude towards CTS measure (TAM)

Consists of one item assessing attitudes towards CTS, including the following dimensions rated on a 0 to 10 semantic differential scale: good/bad; awful/wonderful; quiet/oppressive; dangerous/safe; threatening/unthreatening; wide/narrow, and pleasant/unpleasant.

4. Apparatus

Hardware to create virtual environments (VE) consisted of a Silicon Graphics Indigo High Impact computer graphics workstation, a high quality head-mounted display (FS5 from Virtual Research) and an electromagnetic sensor that was used to track the head and right hand (Fastrak system from Polhemus). Modelling was made using Autocad v.13 software (Autodesk, Inc). In order to obtain realistic virtual environments, a special technique of texture-mapping generation was used. VE was rendered with radiosity techniques using Lightscape v.3.0 software (Lightscape Technologies). Once calculated radiosity solutions of VE, the Dvise v.3.0 (Division Inc) was used to create VE from the models. On this model, the texture generated from radiosity solutions was mapped on the geometry models thus obtaining a highly realistic VE.

5. Procedure

A total of eight VR sessions were carried out in a three-week period. After the sixth session, the patient received a call from the Health Services to inform her about the appointment for the CTS. She decided to go, and had slight distress while the CTS was being carried out, but managed it very well. We decided to go on with two additional VR sessions in order to achieve overlearning. The same self-report scales fulfilled at the beginning of treatment were applied again immediately after the last VR exposure session (post-treatment assessment) and one month after she had finished the VR treatment (follow-up assessment).

6. Treatment

VR graded exposure sessions were conducted for approximately 35–45 minutes by CB and HV. The therapists simultaneously viewed on a video monitor all the virtual environments to which the patient was exposed and commented appropriately. The therapist's comments were similar to those used in conventional *in vivo* exposure. The patient was encouraged to interact with the environments long enough for her anxiety to decrease. Her anxiety level (SUDS) was assessed every 5 minutes during VR exposure sessions.

Table 1
Self-report scale pre-, pos-treatment and follow-up

	Pre-	Post-	Follow-up
PRIQ	2	0	0
FAS (fear of TCS)	10	2	2
FAS (avoidance of TCS)	10	0	0
TAM	57	32	31
SETBM	4	10	9
FCSM	8	4	3

PRIQ: Problem-Related Impairment Questionnaire.
FAS: Fear and Avoidance Scale.
TAM: The Attitude towards CTS Measure.
SETBM: Self-Efficacy towards Target Behaviour Measure.
FCSM: Fear of Closed Spaces Measure.

In the software design, special attention has been paid to the different elements that could facilitate the immersive effect of VR and the "real" interaction of the patient with the virtual setting. To grade the levels of difficulty of the claustrophobic environment, three environments were created with increasing degrees of difficulty: *Setting 0*: A balcony or small garden of 2×5 m.; *Room 1*: A 4×5 m. room which communicated with the balcony; this room has doors and a big window that could be opened and closed in three tracts; *Room 2*: A 3×3 m. room which communicated with the previous one; this room did not have any furniture or windows and the ceiling and the floor were darker, with wooden texture to give a sensation of greater enclosure. Once the door was closed, the patient could lock it. There was also a wall that could move as the patient's will making a great noise with four possibilities for advancing toward the patient leaving her locked up in a space of 1 m^2 of width.

7. Results

As can be seen in Table 1 all the measures were reduced following VR exposure and were maintained at follow-up. Fear and avoidance measures dramatically decreased, providing evidence for the efficacy of the therapy.

Table 2
SUDS rating in VR sessions

1st Ses		2nd Ses		3rd Ses		4th Ses		5th Ses		6th Ses		7th Ses		8th Ses	
R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
O		C		C		C	C	C	C	C	C	C	C	C	C
6		5		7		6	9	7	10	0	6	0	1	0	0

Ses = Session; R1 = Room 1; R2 = Room 2; O = Open environment; C = Closed environment.

Table 2 shows the highest SUDS during each session. The SUDS ratings were higher as the patient was exposed to a more threatening environment (Room 2; sessions 4 and 5) and decreased in the following sessions. Some of her comments were: "I don't like the wall at all, this room is so awful—this wall is disgusting; I hate this wall more than CTS."

The patient was asked to rate the contribution of VR to her progress in a 0 to 10 scale and she assessed it as 8. But what is more important: the clearest indication of VR effectiveness is that the patient was able to undergo CTS.

8. Discussion

The exposure by VR treatment was effective since the patient's anxiety for closed spaces decreased, as can be observed from the measures taken before and after the treatment. Initially, the virtual software produced an anxiety response in the patient, and the virtual exposure reduced this anxiety.

These results are consistent with those of North and North (1996); Rothbaum et al. (1995a, b), and Carlin et al. (1997) showing the effectiveness of VR for the treatment of specific phobias. Our study is the first report of VR to treat claustrophobia in a patient. Moreover, in the present study VR was used alone, without the combination of any other treatment technique, and the patient's achievements persisted for at least one month after the treatment.

During the VR sessions, the patient reported several times that "the wall produces even more fear in me than the CTS does". This statement suggests two reflections. Firstly, as mentioned above, VR allows one to go "beyond" reality because this technology may create a more frightening and flexible reality, i.e., a "reality" more useful in a therapeutic context. In fact, we were able to alter the environment in such a way that the person was faced by a virtual situation even more feared than one which could happen in "actual reality". This VR characteristic might improve self-efficacy and promote generalizability of the results, as the patient claimed: "If I can do it here, I'll do it anywhere". Secondly, the extreme anxiety produced by the sliding wall which moves closer to the patient and the noise points out the importance of certain variables to make judgements of reality and to feel "immersed" in the virtual environment, a central issue in this field. According to Brickman (1978) attributing reality depends on two elements: (a) the achievement of a high *internal correspondence* of the behaviour with the emotion; and (b) the achievement of a high *external correspondence* of the behaviour with the consequences in the environment. Our virtual setting contained elements that allowed to grade the claustrophobic threat. Particularly, in Room 2 we achieved a high internal correspondence, since the patient felt and reported a high anxiety level when she faced the claustrophobic environment.

Regarding the external correspondence, the software included elements that facilitated the manipulation of the environment (to open and close windows and doors; to walk around the room, i.e., the patient acted). All these elements allowed the patient to experience the consequences that her actions had in the virtual environment. Her verbal reports about "the wall" and its noise suggested a high degree of realism and immersion.

However, there are some limitations to VR treatment. First, it is necessary to continue enlarging the field of applications of VR and to check their effectiveness for other

psychological disorders. Second, controlled group studies with clinical patients and longer follow-up periods are needed. Obviously, due to the novelty of the topic, the published studies only offer pre-treatment vs. post-treatment data and they do not inform one about the stability of the improvement, post-therapy progresses, relapses, etc. Third, the most important gap is the absence of comparisons between the VR effectiveness and the "traditional" exposure treatments and also short follow-up periods. Last, but not least, it is necessary to provide a psychological model that serves as a theoretical framework to organize the results and guide future research. Carlin et al. (1997) were already concerned with these topics and identified the importance of the *S*s' sense of presence, the immersive effect, the absorption, and the individual differences involved as issues for future research. We believe that Brickman's model can be a useful first step in the foundation of a theoretical framework.

References

Barlow, D. H. (1988). *Anxiety and its disorders: The nature and treatment of anxiety and panic.* Guilford Press, New York.

Borda, M., & Echeburúa, E. (1991). La autoexposición como tratamiento psicológico en un caso de agorafobia. *Análisis y* Modificacionn de Conducta, *17,* 993–1012.

Booth, R., & Rachman, S. (1992). The reduction of claustrophobia-1. *Behaviour Research and Therapy, 30,* 207–221.

Brickman, P. (1978). Is it real?. In J. H. Harvey, W. Ickes & R. F. Kidd (Eds.), *New directions in Attribution Research, Vol. 2.* Academic Press, NY.

Carlin, A. S., Hoffman, H. G., & Weghorst, S. (1997). Virtual reality and tactile augmentation in the treatment of spider phobia: a case report. *Behaviour Research and Therapy, 35,* 153–158.

Frankel, A. S. (1970). Treatment of a multisymptomatic phobic by a self-directed self-reinforced imagery technique: a case study. *Journal of Abnormal Psychology, 76,* 496–499.

Gatchel, R. J. (1977). Therapeutic effectiveness of voluntary heart rate control in reducing anxiety. *Journal of Consulting of Clinical Psychology, 45,* 689–691.

Greenleaf, W. (1995). Rehabilitation, Ergonomics and disability solutions using virtual reality technology. In Morgan & Satava (Eds.), *Interactive technology and the new paradigm for healthcare* (pp. 415–422). IOS Press, Washington.

Hillard, J. R. (1990). Severe claustrophobia in a patient requiring Hyperbaric Oxygen Treatment. *Psychosomatics, 31,* 107–108.

Katz, R. C., Wilson, L., & Frazer, N. (1994). Anxiety and its determinants in patients undergoing Magnetic Resonance Imaging. *Journal of Behavior Therapy and Experimental Psychiatry, 25,* 131–134.

Kilborn, L. C., & Labbe, E. E. (1990). Magnetic Resonance Imaging Scanning Procedures: Development of phobic response during scan and at one-month follow-up. *Journal of Behavioral Medicine, 13,* 391–401.

Koulak, D., LeBow, M. D., & Church, M. (1976). The effect of desensitization on the sleep and dreams of a phobic subject. *Canadian Journal of Behavioral Sciences, 8,* 418–421.

Leitenberg, H., Agras, W. S., Thomson, L. E., & Wright, D. E. (1968). Feedback in behavior modification: an experimental analysis in two phobic cases. *Journal of Applied Behavior Analysis, 1,* 131–137.

Leitenberg, H., Agras, S., Edwards, J. A., Thomson, L. E., & Wincze, J. (1970). Practice as a psychotherapeutic variable: an experimental analysis within single cases. *Journal of Psychiatric Research, 7,* 225–225.

Leitenberg, H., Agras, S., Butz, R., & Wincze, J. (1971). Relationship between heart rate and behavioral change during the treatment of phobias. *Journal of Abnormal Psychology, 78,* 59–68.

Marks, I. M. (1987). *Fears, phobias and rituals.* Oxford University Press, Oxford.

Marks, I. M. (1992). Tratamiento de exposición en la agorafobia y el pánico. In E. Echeburúa (Eds.), *Avances en el tratamiento psicológico* de los trastornos de ansiedad (pp. 35–55). Pirámide, Madrid.

Marks, I. M., & Mathews, A. M. (1979). Brief standards self-rating for phobic patients. *Behaviour Research and Therapy, 17,* 263–267.

North, M. M. & North, S. M. 1994. Virtual environments and psychological disorders. Electronic Journal of Virtual Culture. 2(4) ?? .

North, M. M., & North, S. M. (1996). Virtual reality psychotherapy. *The Journal of Medicine and Virtual Reality, 1,* 28–32.

North, M. M., North, S. M. & Coble, J. A. (1997). *Virtual Reality Therapy: An Innovative Paradigm.* IPI Press, Ann Arbor.

Öst, L. G. (1987). Age of onset in different phobias. *Jornal of Abnormal Psychology, 96,* 223–229.

Öst, L. G. (1989). One-session treatment for specific phobias. *Behaviour Research and Therapy, 27,* 1–7.

Öst, L. G., Johansson, J., & Jerrelmalm, A. (1982). Individual response patterns and the effects of different behavioral methods in the treatment of claustrophobia. *Behaviour Research and Therapy, 20,* 445–460.

Rothbaum, B., Hodges, L., Kooper, R., Opdyke, D., Williford, M., & North, M. (1995a). Effectiveness of computer-generated (Virtual Reality) graded exposure in the treatment of acrophobia. *American Journal of Psychiatry, 152,* 626–628.

Rothbaum, B., Hodges, L., Kooper, R., Opdyke, D., Williford, M., & North, M. (1995b). Virtual reality graded exposure in the treatment of acrophobia: A case report. *Behavior Therapy, 26,* 547–554.

Rothbaum, B., Hodges, L., Watson, B., Kessler, G., & Opdyke, D. (1996). Virtual reality exposure therapy in the treatment of fear of flying: A case report. *Behaviour Research and Therapy, 34,* 477–481.

Schneider, J. W. (1982). Lens-assisted *in vivo* desensitization to heights. *Journal of Behavior Therapy and Experimental Psychiatry, 13,* 333–336.

Speltz, M. L., & Bernstein, D. A. (1979). The use of participant modeling for claustrophobia. *Journal of Behavior Therapy and Experimental Psychiatry, 10,* 251–255.

Sutherland, I. (1965). The ultimate display. *Proceedings of the International Federation of Information Processing Congress, 2,* 506–508.

Sutherland, I. (1968). A head-mounted three dimensional display. *FJCC, 33,* 757–764.

Vince, J. (1995). *Virtual reality systems.* ACM Press, Cambridge.

Warwick, H., & Marks, I. M. (1988). Behavioral treatment of illness phobia and hypochondriasis: A pilot study of 17 cases. *Brithis Journal of Psychiatry, 152,* 239–241.

Wolpe, J. (1969). *The Practice of Behavior Therapy.* Pergamon, New York.