Technological challenges in the use of Virtual Reality Exposure Therapy

Charles VAN DER MAST [a,1], Sinisa POPOVIC [b], Dave LAM [c],
Gianluca CASTELNUOVO [d], Pavel KRAL [e], Zeljka MIHAJLOVIC [b]
[a] Delft University of Technology, the Netherlands
[b] University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia
[c] U.S. Army Telemedicine and Advanced Technology Research Center, Ft. Detrick Maryland, and University of Maryland School of Medicine, National Study Center for Trauma and EMS, Baltimore Maryland, USA
[d] ATN-P Lab, Instituto Auxologico Italiano, Milan, Italy; Clinical Psychology Lab, Instituto Auxologico Italiano, Verbania, Italy and Department of Psychology, Catholic University, Milan, Italy
[e] Central Medical Psychology Department, Central Military Hospital, Prague, Czech Republic

Abstract. This paper describes the result of a discussion in a working group and a plenary discussion at the NATO Advanced Research Workshop on Novel approaches to the diagnosis and treatment of posttraumatic stress disorder. Several technological challenges are presented for the basic functions of a VRET system. Most challenges are demand driven and focussing on better ways to support the therapist, for better and more efficient treatment. Tele-care is one of the most promising but difficult challenges. The results give directions for both fundamental and practical research.

Keywords. Virtual reality exposure therapy, agent technology, tele-care, human-computer interaction., PTSD, Post Traumatic Stress Disorder

1. Introduction

Virtual reality exposure therapy (VRET) is the result of a close collaboration between researchers and practitioners of significantly different disciplines, among others, psychiatry, clinical psychology, psychotherapy, computer science, graphics design, human-computer interaction, and engineering. The traditional cognitive behavioural therapy (CBT) treatment process between therapist and patient has been taken as the main paradigm to be supported

[1] Corresponding Author: C. van der Mast, Delft University of Technology, Mekelweg 4, 2628 CD Delft, The Netherlands; E-mail: c.a.p.g.vandermast@ewi.tudelft.nl.

by technology in different ways, not least of all by providing interactive immersive worlds to "play" the treatment process in virtual reality instead of *in vivo*, as in the behavioural approach or by imagination, as in the cognitive framework. It has proved to be the case that patients are very sensitive to specific multimodal features in the virtual world and the appropriately accompanying sounds [12]. Medium-level resolution and graphics quality has proven sufficient in many cases to trigger the specific phobia-related reactions that are essential in exposure therapy. The effect of locomotion technique on fear is studied in [20]. In one study [11], treatment using a standard head-mounted display (HMD) -gave the same results for the treatment of acrophobia as an advanced CAVE system providing advanced virtual reality systems. Of course this substitutability may be dependent on the specific type of disorder to be treated. It is proven in many studies that VRET can achieve the same results as traditional CBT, but will not outperform it [8]. But there are more aspects of CBT which are important besides exposure. Technology can also support the therapist in changing in real time to other synthetic worlds to be exposed to the patient, or in recording and replaying sessions in the virtual world for later analysis and planning the following session [2].

Current VRET systems are mostly developed and used in laboratories where technical support is available. A few systems are available on the market, but evaluation of practical use on a larger scale has not yet been reported. To provide full support in the clinical roles, it is essential that VRET systems be usable in the clinic by several therapists of a team and without strong and expensive technical support. This usability is important to enhance the performance of the treatments on the one hand, and on the other hand we may expect benefits from other support functions beside the VR exposure technique itself [7]. Interesting new technologies are available to extend a VRET system with new functions in order to measure and analyze details of the treatment process for better understanding of diagnosis and treatment and for improving the efficiency of the therapist's work [16].

In this paper we present the results of a structured brainstorming session on technological challenges which might assist in enriching and improving all aspects and functions of VRET we can imagine now. Three of the authors have a technical background in VRET technology and three have a background in clinical treatment. First we present an overview of the essential technical and functional components of VRET systems. Second we present, explain and structure the challenges we found. Finally we will discuss these and give some final conclusions.

2. Essential components of VRET systems

Most current VRET systems consist of typical functions and components as summarized below. The system is usually located in one room where both therapist and patient are together so they can *communicate* by natural means. If for some reason they are not in the same room an audiovisual intercom facility should be provided. See Figure 1 for a typical VRET system in one room with direct communication between therapist and patient.

This system is equipped for treating fear of flying. The main functions are the following. First a device is needed to present the world *visually* (in stereo or mono) to the patient [1].

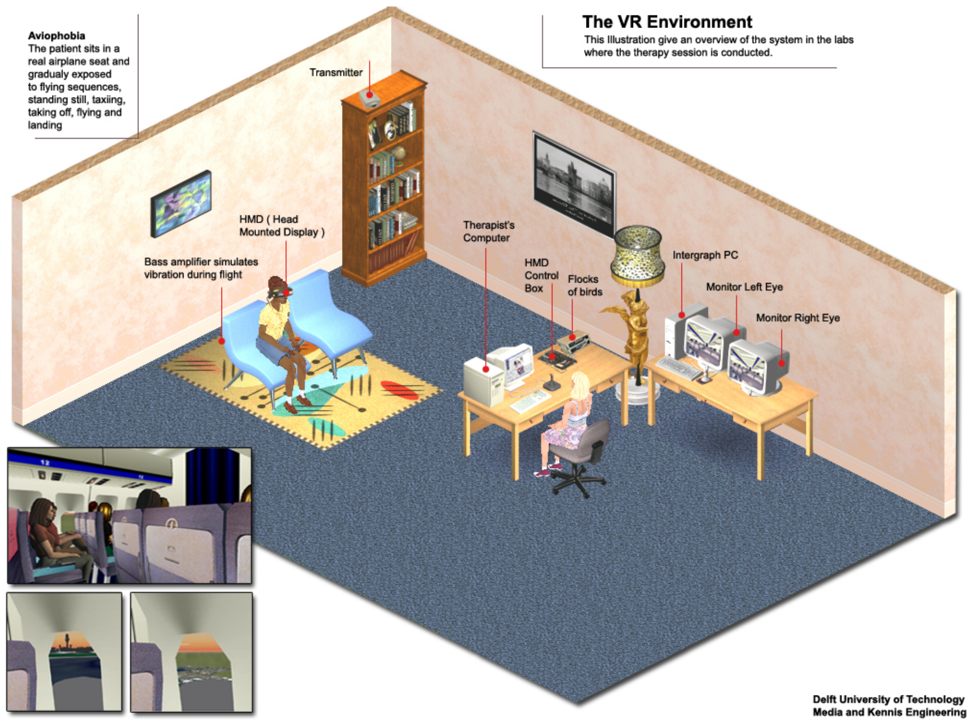


Figure 1. Overview of a typical VRET system in one clinical room [7] and [19].

This computer-generated synthetic world can be presented in an immersive way by a head-mounted device or it can be projected on one or more screens. However, some intermediate forms are possible. Augmented reality can be used to superimpose artificial objects, e.g. animals, on the real world you can see through the HMD. Patients should be able to *look around*. If immersive worlds are being presented a tracker system is needed with a sensor on the patient's head built in the HMD. Another function is that the patient should be able to *navigate* in the virtual world, although it may be to prefer that the therapist takes the navigation task over from the patient in some situations [20]. For navigation some other input device is necessary to start and stop navigation in some direction. Sometimes the patient should be able to initiate *actions* or events or choices within the virtual world, e.g. as part of tasks to do selections of virtual objects to improve presence. Then we need stereo *sound* as an important resource to improve the sense of presence [14] in the virtual environment. This sound may be dependent on the distance and the direction between the source of sound and the patient. Another output channel may be servo-controlled *mechanical* devices, e.g. to move the aircraft chair to simulate air turbulence during the flight.

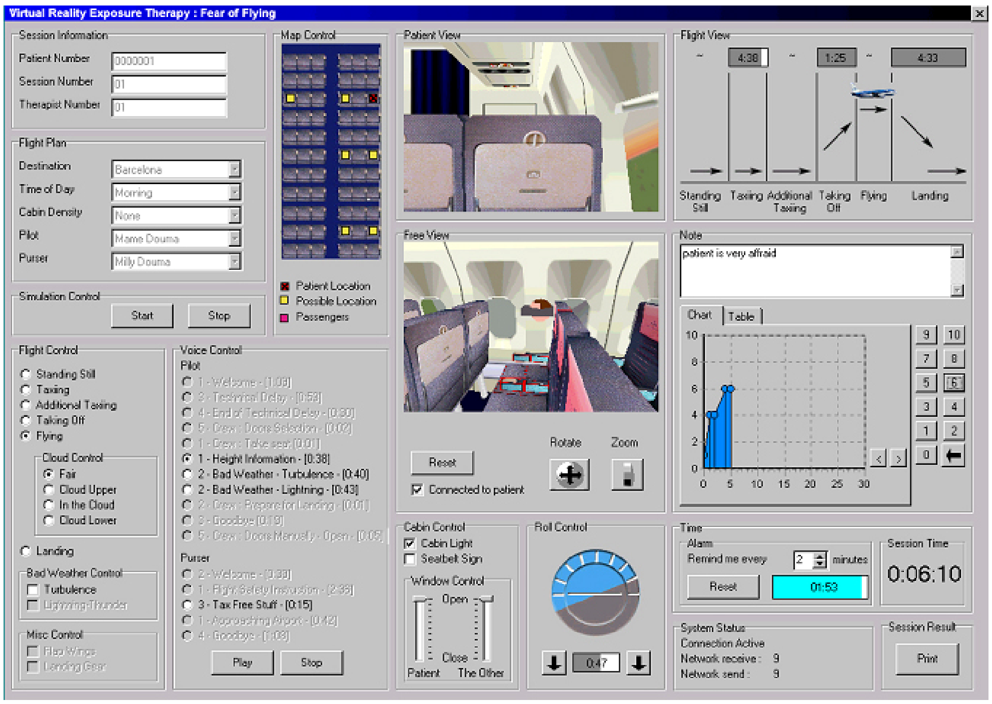


Figure 2. Example of a therapist user interface of a system for treating fear of flying [7].

This may improve the presence, e.g. for treating fear of flying significantly. Last but not least we need a *user interface for the therapist* to control what may or should happen in the world [7], e.g. lighting condition in the world, the occurrence of turbulence in the aircraft, the change of crowds in worlds for agoraphobia, see figure 2. We can summarize all these functions in Figure 3.

<insert Figure 3 about here>

Figure 3. Basic communication functions in a VRET system. ------See below on last page: Figure should be moved. I do not succeed in moving! [Charles]

3. Challenges

The following challenges were formulated in the workgroup by the authors, and discussed during a plenary meeting with all the participants of the NATO workshop. We decided that it is not reasonable to give a priority to these challenges, as work in many of these areas is currently ongoing simultaneously in different venues, and any or all of these developments may be useful, no matter in which order technological advances are made.

3.1. Personalizing the system

A VRET system may be used by many different colleagues from a clinic. Additionally, each therapist may change over time his or her preferences about using the system for some specific phobias. This gives a rationale for implementation of the possibility to personalize the user interface and a part of the main functions of the treatment process by the individual therapist and to store the applicable parameters. It is conceivable that this personalization could be extended to prepare for each patient an individual treatment procedure off-line, including some changes in the worlds, specific for each patient to be treated. This kind of personalization is an important research goal sometimes referred to as “adaptive” user interfaces [22]. The possibility of the therapists to “tailor” different versions of the same virtual environment according to the patient’s needs has been underlined by Castelnuovo [5].

3.2. Automated support for the therapist

This challenge was emphasized most highly by the workgroup. The first function of a VRET system is to offer an interactive virtual environment for the patient to experience the feelings that have to be worked on. But beyond that, the most promising challenge is to develop support functions for the therapist [2]. By analyzing the treatment process and composing task models one can recognize and specify steps and modes in the treatment ,see Figure 4. This is an example of a task model. New models have to be developed describing the task in terms of treatment steps and specific aspects and levels of the disorder.

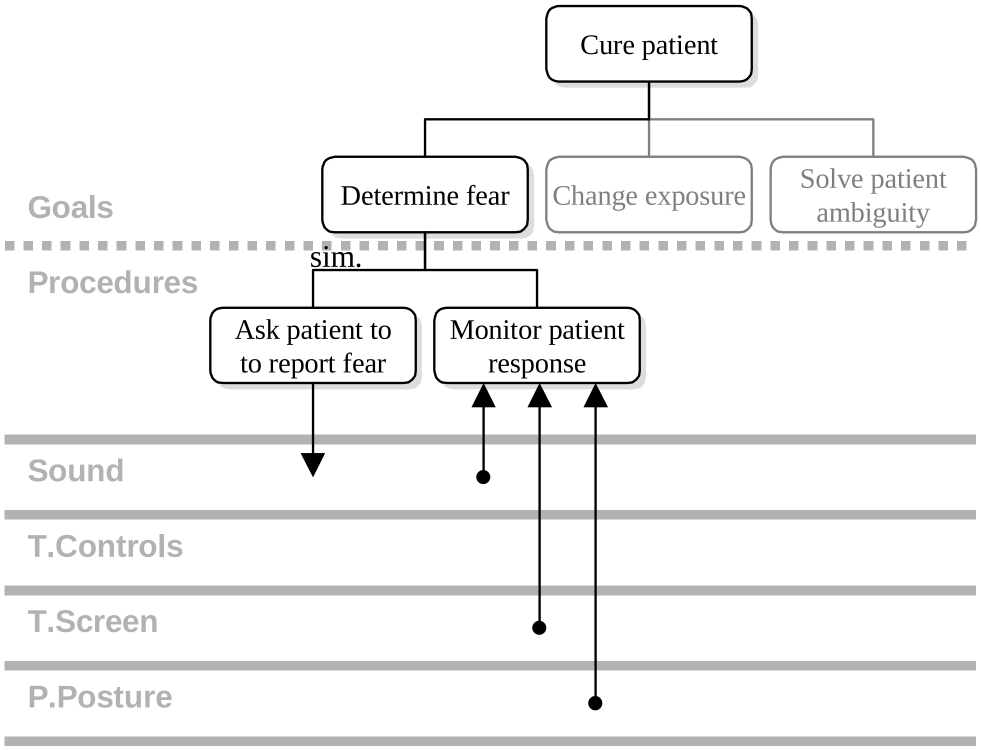


Figure 4. ‘Determine fear’ goal decomposition (see [21] for decomposition and explanation of more details).

If it is possible to describe a treatment session in terms of steps to be taken under supervision by the therapist it may be possible to develop an electronic agent which provides advice including some rationales to the therapist about the following step(s) in the actual context of the treatment. It would also seem interesting to provide a planning mode to the therapist to specify some sequential steps for a session just before it starts. The general goal is to provide extra explicit knowledge to the therapist about the progress of the treatment. The agent can obtain its information from built-in procedures which may be adjusted by the therapist and by measurements of the patient’s physiological condition, e.g. heart rate and skin conductance. It would be most useful to construct a learning electronic agent which could learn from an experienced therapist. A junior therapist could use this “smart” agent to give better treatment in non-critical sessions, under the responsibility and supervision of an experienced therapist. It would be possible to teach such agents to give good advice by analyzing individual treatment patterns in specific clinical cases. The advice might propose the next procedure step or the next navigation or modification of the virtual world to control the level of fear. Even more measurements can be done by face recognition [15], [25] and voice recognition since these can indicate levels of stress, fear, and other emotions [18], [24].

As an additional form of support may be considered procedures of computer-supported self-treatment by the patient. The therapist should be able to specify the procedures and constraints of these modules for self-treatment. Related to section 3.1, easy-to-use tools oriented toward non programmers could be useful for providing greater flexibility and individualization in defining VR scenarios. The therapist could thus individualize homework scenarios for the patients without the need that the programmer hardcodes each scenario. Individualization of virtual environments is addressed within a currently ongoing EMMA project [3]. Envisioned VR scenarios driven by the patient's physiology [23] could also be useful for patient's self-treatment during homework sessions.

3.3. Computer-based training

A completely different challenge is the construction of a VRET system for computer-based training of junior therapists. This could be done using simulated or real patients or recorded sessions. The learner could be trained how to use the system and how to treat different types of disorders. Simulated patients could include a combination of computer-generated patients and normal people requested to simulate. Computer-generated patients could model non-visible changes happening in real patients (e.g. physiological changes), and normal people could manifest patients' visible responses.

3.4. Tele-Care

It is both a technical and an organizational challenge to develop a system for tele-treatment of mental disorders using VRET over the internet. The most serious challenge is to have a ratio of therapist : patient of more than 1:1. It should be possible to develop a system and a therapist's user interface to allow the provision of treatments to more than one patient at the same time, in different rooms in the same clinic or in different clinics. If one senior and one junior therapist could treat more than two patients simultaneously, the ratio will improve. Some experience with tele-treatment of agoraphobia without VR has previously been reported [13]. In a more general project on tele-care the possibilities of agent support for tele-care at home has been investigated [8], [17].

3.5. Eye tracking

A challenge that was discussed a lot during the plenary session was the use of eye tracking to study how the focus of the patient is oriented during VRET sessions. It is expected that this may give better insight in what triggers the emotions during the sessions. This information may be used to adjust the session procedure or the characteristics of the virtual world online. It was noted that the development of such a capability which would not require time-consuming and difficult alignment or standardization for each new patient might be very difficult, but that lessons may be learned from the work previously done in aviation technology with Heads-Up-Displays and helmet-mounted visual devices.

3.6. VRET experience with the MRI/CT scanner

The most futuristic challenge is to implement a mechanism to allow the use of MRI or CT scans of the brain during a VRET session. Early steps in this direction have been taken by devising a fiberoptic magnet-friendly high-resolution wide-field-of-view image delivery system [9]. Initial tests with functional MRI (fMRI) offer promising results, showing that the display does not interfere with the brain scans, and that the users can feel the sense of presence in the virtual environment while being inside the scanner [10]. With state-of-the-art technology it therefore seems possible to present images of virtual environments to a person who is within a scanner. Further VRET-fMRI research could address brain patterns occurring in patients during VR baseline and exposure sessions, compare brain activities of patients and controls, and so on. This challenge is aiming at research on understanding optimal treatment schedules, not at standard scanner-mediated treatment in the clinic.

4. Discussion

Most of these challenges were discussed during the plenary workshop without detailed knowledge about what is going on in other domains. In aviation training and development, interesting progress is being made which should be looked into, especially with regard to heads-up displays and helmet-mounted visual instruments. New visualization techniques in cockpit design using mixed reality may give interesting concepts for improving VRET. But in any case we need to separate the requirements of basic research from those of clinical therapy – they have different requirements, goals, and rationales. In general we need the best clinical feedback during treatment. The goal is to provide the therapist information and feedback on the changes occurred, so as to allow him to provide the most effective treatment. So tools to detect changes in physiological parameters by external measurement are necessary. Some participants in the plenary session stated that tele-treatment could be dangerous because these patients are difficult and fragile, but others reported that tele-care without VR of agoraphobia and PTSD [13] works - is currently being used and is both safe and effective. It may prove to be that tele-treatment of PTSD or other psychiatric disorders is only usable in some stages (diagnosis and initial therapy) of the treatment plan. Obviously, all of these alternative potentials require much more research and development in both the clinical and technological realms to determine their feasibility and benefits.

5. Conclusion

We have seen that several interesting technological challenges are on the horizon. But we must remain aware that we need fundamental research on how new technologies can improve the very personal treatment process supervised by the therapist. This research must be demand driven by the therapists, and not pushed by technology—The technical ability to do something does not imply that it is either safe or desirable from a clinical standpoint. We are just in the early stages of some very interesting developments. They will both improve our insight in how treatment can be given in the most effective way and how treatment can be deployed on a large scale more efficiently than with the current means. VRET may play an important role in these developments.

In our view, an emerging scenario could characterize the future clinical setting: old (and functional) practices could be integrated and enhanced through new (and promising) media such as VR. This framework aims at matching "techno" and "psycho" for clinical purposes [4].

References

[1] M. Alcaniz, J.A. Lozano & B. Rey, Technical Background of VR, in G. Riva et al. (Eds.) *Cybertherapy*, IOS Press Studies in health technology and informatics Vol 99, 2004, 199-214.

[2] C. Botella, S. Quero, R.M. Banos, C. Perpina, A. Garcia Palacios & G. Riva, Virtual reality and psychotherapy, in G. Riva et al. (Eds.) *Cybertherapy*, IOS Press Studies in health technology and informatics Vol 99, 2004, 37-54.

[3] C. Botella, Clinical issues in the application of virtual reality to treatment of PTSD. *NATO ARW Novel Approaches to the Diagnosis and Treatment of Posttraumatic Stress Disorder*, Cavtat-Dubrovnik, Croatia, 2005 **THIS VOLUME!!!**

[4] G. Castelnuovo, C. Buselli, R. De Ferrari, A. Gaggioli, F. Mantovani, E. Molinari, M. Villamira, and G. Riva, New tools in cybertherapy: the VEPSY web site, Stud Health Technol Inform 99 (2004) 15-35.

[5] G. Castelnuovo, G. Cesa, A. Gaggioli, F. Mantovani, E. Molinari, G. Riva, A new generation of virtual environments for the treatment and rehabilitation of eating disorders, *Book of Abstracts, SPR 2005*, Ulm: Ulmer Textbank, 2005, 176.

[6] A.H.M. Cremers & M.A. Neerincx. Personalization Meets Accessibility: Towards the Design of Individual User Interfaces for All. In: *User-Centered Interaction Paradigms for Universal Access in the Information Society*. *Lecture Notes in Computer Science*. Berlin etc.: Springer, 2004, 119-124.

[7] L. T. Gunawan, C. van der Mast, M. A. Neerincx, P. Emmelkamp, M. Krijn, Usability of Therapist's User Interface in Virtual Reality Exposure Therapy for Fear of Flying in: Jeanne Schreurs & Rachel Moreau, *Proceedings of the Euromedia 2004 Conference*, April 19-21 2004, Hasselt, Belgium, 2004, 125-132.

[8] G. de Haan., C.A.P.G. van der Mast, O.A. Blanson Henkemans and M.A. Neerincx, SUPERASSIST: Personal Assistants for Cooperative Healthcare Treatment, *Proceedings Euromedia 2005*, ISBN 90-77381-17-1, EUROSIS publication, April 2005, 2005, 125-128.

[9] H. G. Hoffman, T. L. Richards, J. Magula, E. J. Seibel, C. Hayes, M. Mathis, S. R. Sharar and K. Maravilla, A magnet-friendly virtual reality fiberoptic image delivery system, *CyberPsychology & Behavior* 2003 Dec;6(6):645-648

[10] H. G. Hoffman, T. Richards, B. Coda, A. Richards and S. R. Sharar, The illusion of presence in immersive virtual reality during an fMRI brain scan, *Cyberpsychology & Behavior* 2003;6(2):127-131

[11] M. Krijn, P. M. G. Emmelkamp, R. Biemond, C. de Wilde de Ligny, M. J. Schuemie and C. A.P.G. van der Mast, Treatment of acrophobia in Virtual Reality; the role of immersion and presence *Behaviour Research and Therapy*, 2004 Feb; 42(2):229-239.

[12] M. Krijn, P. M. G. Emmelkamp, R.P. Olafsson, R. Biemond, Virtual reality exposure therapy of anxiety disorders: A review, *Clinical Psychology Review* 24 (2004) 259-281.

[13] A. Lange, Schrieken, B.A.L., Ven, J.-P.Q.R. van de., Bredeweg, B., & Emmelkamp, P.M.G., Kolk, J. van der., Lysdottir, L., Massaro, M., & Reuvers, A. INTHERAPY: The effects of a short protocolled treatment of post-traumatic stress and pathological grief through the internet. *Behavioral* & *Cognitive Psychotherapy, 28,* 2, 2000, 103-120.

[14] K. Nowak, Conceptualizing, Differentiating and Measuring Copresence and Social Presence, *4th Annual International Workshop PRESENCE 2001*, Temple University, Philadelphia, PA, USA, 2001.

[15] M. Pantic and L.J.M. Rothkrantz, "Machine understanding of facial expression of pain", *Int'l Journal of Behavioral and Brain Sciences*, vol. 25, no. 4, pp. 469-470, August 2002.

[16] B. Rey, M. Alcaniz & J.A. Lozano, New technologies for providing remote psychological treatments, in G. Riva et al. (Eds.) *Cybertherapy*, IOS Press Studies in health technology and informatics Vol 99, 2004, 181-197

[17] G. Riva, F. Morganti & M. Villamira, Immersive virtual Telepresence: virtual reality meets eHealth, in G. Riva et al. (Eds.) *Cybertherapy*, IOS Press Studies in health technology and informatics Vol 99, 2004, 255-270.

[18] L.J.M. Rothkrantz, P.Wiggers, J.W.A. van Wees, R.J. van Vark, *Voice stress analysis, Proceedings of Text, Speech and Dialogues 2004*, 2004.

[19] M. Schuemie and C. Van der Mast, VR testbed configuration for phobia treatment research, in: M.E. Domingo, J.C.G. Cebollada & C.P. Salvador (Eds.), *Proceedings of the Euromedia 2001 conference*, April 18-20 2001, Valencia, Spain, pp. 200-204.

[20] M.J. Schuemie, B. Abel, C.A.P.G. van der Mast, M.Krijn and P.M.G. Emmelkamp, The effect of locomotion technique on presence, fear and usability in a virtual environment in: Marwan Al-Akaidi & Leon Rothkrantz (Eds.) *Proceedings of Euromedia 2005 Conference*, April 11-13, 2005, Toulouse France, 2005, 129-135.

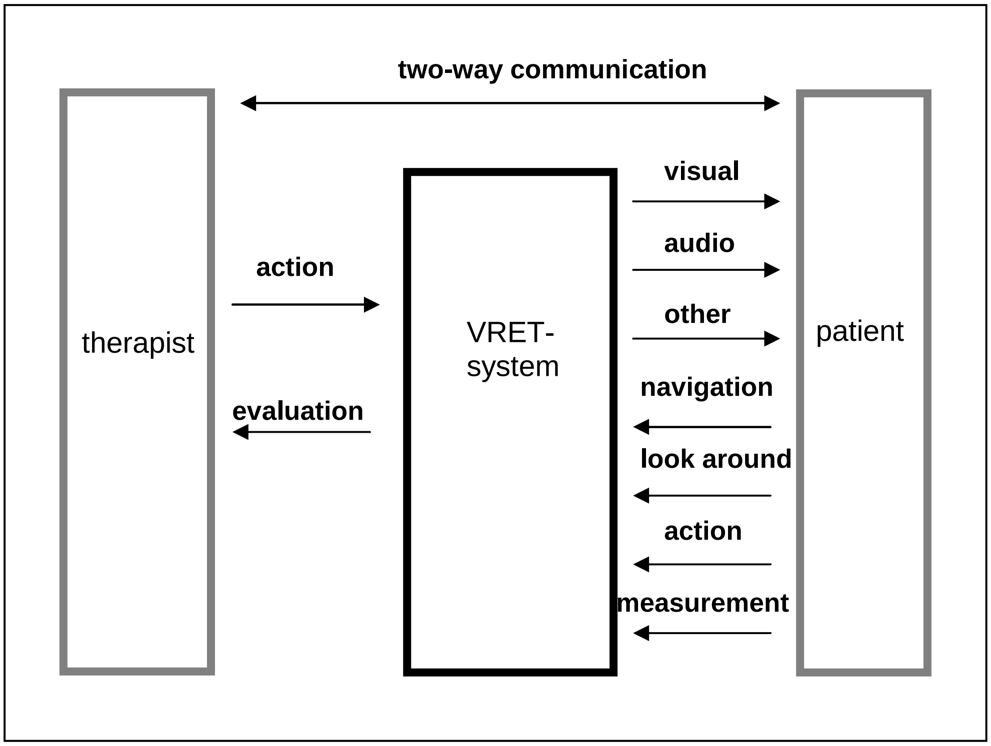
[21] M.J. Schuemie (2003). *Human-Computer Interaction and Presence in Virtual Reality Exposure Therapy*. PhD Dissertation, Delft University of Technology. (available at http://mmi.tudelft.nl/~vrphobia under publications)

[22] C. Stephanidis, (2001). Adaptive techniques for universal access. *User modeling and user-adapted interaction*, 11, 159-179 (20).

[23] B. K. Wiederhold and M. D. Wiederhold, The future of Cybertherapy: improved options with advanced technologies, in G. Riva, C. Botella, P. Légeron, G. Optale (Eds.), *Cybertherapy: Internet and Virtual Reality as Assessment and Rehabilitation Tools for Clinical Psychology and Neuroscience*, Amsterdam: Ios Press, 2004, 263-270.

[24] P. Wiggers, L.J.M. Rothkrantz, Integration of speech recognition and automatic lip-reading, *Proceedings of Text, Speech and Dialogues 2002*, September 2002, 203-212.

[25] A. Wojdel, J.C. Wojdel and Leon J.M. Rothkrantz, Dual-view Recognition of Emotional Facial Expressions, *Proceedings of 5th annual conference of the Advanced School for Computing and Imaging ASCI'99*, pp. 191-198, Heijen, The Netherlands, June 15-17 1999, 191-198.



.

(Figure 3) [Patricia: please move this to the position within the text. I do not succeed in doing this-Charles.]