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The Use of Virtual Reality in the Treatment of Posttraumatic Stress Disorder (PTSD)

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Abstract. *Background*. Interest in the treatment of PTSD is increasing with concerns about the psychological effects of war on troops. *Objective*. We performed a comprehensive literature review on virtual reality (VR) for treating combat-related PTSD. *Methods*. Canada's primary institute for scientific and technical information (NRC-CISTI) performed the initial literature search in 2008. Of 296 items which met inclusion criteria, 20 pertained to VR in the treatment of mental health.. An additional 20 more recent items were added in 2009, making a total of 40 items reviewed. Of those, 6 empirical studies involved patients with PTSD [1, 2, 3, 4, 5, 6]. *Results.* VR exposure therapy (VRET) has been successfully used to treat anxiety and phobia disorders including PTSD [7, 8]. VRET may be particularly suitable for clients with combat-related PTSD as it aids in exposure treatments for these clients whom are often unable to engage in traditional therapy [9, 10]. Future research should include randomized, controlled studies employing large samples.

Keywords: Virtual reality, Posttraumatic stress disorder, treatment

1 Introduction

Post traumatic stress disorder (PTSD) is an anxiety disorder characterized by feelings of intense horror, fear and helplessness as a result of exposure to a traumatic event when one experiences actual or threatened death or serious injury [11]. Individuals with PTSD persistently re-experience the trauma (e.g., nightmares, flashbacks), avoid stimuli that remind them of the trauma and often experience physiological hyper-arousal (e.g., sleep problems, irritability).

PTSD is a public health issue gaining prominence in Canada and many other countries. Since the start of the Canadian mission in Afghanistan, an increasing number of military personnel and veterans have been experiencing PTSD, and their families have been living with the associated stress and challenges. Assessing and treating PTSD is complex and costly. Veterans Affairs Canada – a federal government department – is mandated to provide health services to Canadian veterans. In 2002, Veterans Affairs Canada and the Department of National Defence (DND) launched a mental health initiative to support Canadian Forces members, veterans, and eligible

RCMP officers who suffer from Operational Stress Injury (OSI) as a result of their service. The OSI initiative included opening and operating six OSI clinics across the country to provide specialized assessment and treatment services for a range of associated disorders, including PTSD.

In January 2008, an OSI clinic opened in Fredericton, New Brunswick to service all four Atlantic Provinces – a large geographical area. Fulfilling this mandate will require the best possible use of information and communication technologies (ICT). The National Research Council in Fredericton partnered with the Fredericton OSI Clinic in 2008 to conduct a comprehensive literature review on how ICT could be used effectively to assess and treat OSI and PTSD. The immediate goal of the review was to provide the Fredericton OSI clinic with information to support their decisions on the best ways to use ICT for OSI assessment and treatment for clients in Atlantic Canada [12]. Drawing on that larger study, the current paper discusses the literature related to VR and PTSD.

1.1 Rise of combat-related PTSD

The unique risks of trauma associated with working in a war environment (e.g., roadside bombs, seeing comrades killed etc.) places military soldiers at risk for developing mental health problems such as PTSD. Some authors suggest that the wars in Iraq and Afghanistan - which include novel battle situations such as terrorist tactics and pervasive battlefronts - have made currently-serving military service members (SM's) more at risk for PTSD than in the past [2]. Congruently, a recent review of the Canadian DND and Canadian Forces' action on OSI [13] suggests the level and intensity of combat operations in Afghanistan has increased significantly and that, as noted by the Canadian Surgeon General in 2008, a large number of soldiers are returning home from deployments with a range of mental health issues. The Ombudsman for National Defence and the Canadian forces concluded that PTSD was a very serious problem for hundreds - if not thousands - of Canadian Forces members but that the military's current approach to the treatment of mental health injuries was inadequate. Wood [14] and others warn that in order to decrease the future burden on the healthcare system early intervention is vital.

1.2 Traditional approaches to PTSD treatment

Traditional treatment interventions for PTSD include pharmacological treatments such as antidepressant and antipsychotic medication. However, some medications that attenuate anxiety (e.g., Alprazolam) may actually undermine therapy [15] and in many cases pharmacological treatments may only provide palliative solutions as opposed to the curative or prophylactic benefits some psychological interventions provide [16].

Efficacious treatments for PTSD include stress-inoculation training, cognitive reprocessing of the event and exposure techniques [16]. Among these and other techniques, Cognitive-Behavioral Therapy (CBT) has the best empirical evidence of its therapeutic efficacy [16, 17]. CBT interventions often include an element of

exposure to anxiety provoking stimulus. For example, within the safety of the clinician's office, a person with a spider phobia may be exposed to a spider through its real (in-vivo exposure) or imagined presence (imaginal exposure). Originating from the Emotion-Processing theory [18], exposure therapy serves to reduce anxiety by activating existing maladaptive fear structures (e.g., "Being near a spider will make me have a heart attack and die") and then incorporating information that is incompatible with the fear (e.g., "I am near the spider and I am not having a heart attack"). This allows the client to process their fearful emotions and relearn new, less anxious associations with the stimulus. In the case of PTSD the feared stimulus is traumatic memories which the patient is exposed to by imagining and narrating traumatic events from their past. Treatment guidelines for PTSD recommend CBT with exposure as the first-line therapy for PTSD [19].

1.3 VR in the treatment of PTSD

Recently Virtual Reality (VR) has been introduced to exposure-based therapy of PTSD and is known as Virtual Reality Exposure Therapy or VRET [1, 4, 9]. VRET may benefit those with combat-related PTSD in its ability to present life-like scenarios via a medium which may be particularly suited to service members.

VR technology allows users to interact with a computer-simulated virtual environment (VE). In VR, input devices (e.g., head tracking devices) sense the user's motions and modify the synthetic environment accordingly, while output devices immerse the user in the VE by producing visual, auditory (through head-mounted devices with screens that project the sights and sounds of the VE), olfactory (by devices that emit scents) and haptic feed-back (e.g., vibration platforms located under the patient) sensations [9, 10, 20, 22, 23]. Currently, most VR systems include a clinical interface which displays the VE as seen by the patient [22, 23] and others also include non-invasive physiological measures both of which are displayed on a monitor allowing the clinician to observe the patient's experience and to adjust the intensity and duration of the exposure session accordingly [14].

Recent advances in VR technology have increased its therapeutic benefits. For example, Rizzo and colleagues [2, 22, 28] created a VR therapy application called *Virtual Iraq* made specifically for veterans of the Iraq war. This application features combat simulation scenarios based on the popular X-Box game *Full Spectrum Warrior*, as well as various auditory, visual and olfactory features specifically designed to replicate battle conditions in Iraq. In *Virtual Iraq*, users navigate through the VE using either a game pad controller or a replica M4 weapon with imbedded controls. The software features Middle Eastern themed city and desert road environments which include perspective shifts and realistic visual effects designed to resemble contexts that most SM's experience during deployment to Iraq. Preliminary data [2, 3] demonstrates that SM's who had recently returned from tour in Iraq found *Virtual Iraq* realistic and provided the 'feeling of being in Iraq'. This may be attributed to the iterative, user-centered design process wherein input from clinicians and SM's was continually solicited and utilized in modification of the software.

Due to its immersive nature (i.e., stimulus from the 'real world' is blocked out and only that from the VE is perceived), virtual reality exposure therapy (VRET) may potentially provide PTSD sufferers with more life-like simulations than traditional methods such as imaginal exposure. This 'presence' (i.e., the experience of an artificial stimulus as if it were real) which is an essential element of exposure therapy, contributes to the experience of anxiety and facilitates emotion processing [4, 10].

The use of VRET is relevant for clients with PTSD in particular because many are unwilling or unable to imagine or visualize traumatic events – in fact, avoidance of reminders of the trauma is a characteristic symptom of PTSD [10]. This is problematic as the inability to engage in treatment predicts worse outcomes [24]. Encouragingly, research suggests that VR may facilitate emotional engagement by augmenting patients' imaginative capacities while circumventing the natural avoidance tendency of patients with PTSD through delivering sensory cues without requiring the patient actively imagine their traumatic memories [3, 9]. This directive, multi-sensory experience helps recreate and reprocess traumatic memories and increases the engagement and efficacy of the therapeutic intervention [2, 9].

Active and veteran service members may be less likely to seek traditional talk therapies due to associated stigma [25]. In their survey, Hoge and colleagues [25] found that SM's who screened positive for a mental health disorder were two times as likely as others to report concern about stigma and barriers to mental health services. However, having previously used VR technologies in military training or recreation S.M.'s may find the virtual medium more appealing than other interventions [3]. In fact, Rizzo and colleagues [3] found that in their sample of SM's 71% were equally or more willing to use a form of technological treatment than traditional talk therapy alone. Despite its promise in the enhancement of exposure therapy, little research has been conducted assessing the efficacy of VRET specifically in the treatment of PTSD.

2 Method

The literature search was performed in 2008 by the National Research Council Canada Institute for Scientific and Technical Information (NRC-CISTI). The extensive search strategy was undertaken in five electronic databases (Inspec, El Compendex, Medline, CINAHL, and PsycInfo), using keywords including "Post Traumatic Stress Disorder" "Treat*", "Therapy", "e-therapy", "Computer Assisted Therapy", "Technolog*", "Virtual Reality" and "Software". A total of 570 potentially relevant papers were retrieved in the initial search. Among them, 296 items met inclusion criteria of being published between 2005 and present. Of those items, a final 20 articles were identified which pertained to VR in the treatment of mental health issues. In 2009, a further 20 articles were added to ensure the timeliness of this article for publication. Many of the retained articles were review articles (12) or technical papers (8). Of the empirical studies identified, 18 involved patients with specific phobias (9), social phobia (2) and PTSD (7).

3 Results

Our review of the selected articles revealed that in general, little research has been conducted involving randomized controlled trials of VRET. However, meta-anlalyses are a popular method of investigating the outcomes of VRET because they may be used to estimate effect sizes across studies while increasing statistical power. One of our main findings is that VRET has been successfully used since the mid 1990's to treat anxiety and phobia disorders and is acceptable to the majority of patients suffering from anxiety disorders [26]. Research suggests that participants with various anxiety disorders (e.g., social anxiety, specific phobias etc.) experience a reduction in anxiety symptoms after receiving VR based exposure therapy [27, 28, 29]. In fact, in a recent meta-analysis of 21 studies, [7] Parsons and Rizzo found that across anxiety disorders (i.e., social phobia, specific phobias, panic disorder with agoraphobia and PTSD) VRET resulted in clinically and statistically significant reductions in anxiety symptoms. However, the authors note that some of the studies included did not have control groups and others were not randomized, controlled trials which limits confidence in the findings. In their recent meta-analysis Powers and Emmelkamp [8] found that across 13 studies including individuals with specific phobia, social phobia, PTSD and panic disorder that VRET was significantly more effective at reducing anxiety in clients than both control and in vivo exposure conditions (although the effect size was small for the latter).

Our review also emphasized the mounting popularity of practitioners using VRET for PTSD specifically [1, 2, 29, 30, 31]. However, we were able to find few studies which examined the efficacy of VRET for PTSD specifically. Initial research conducted by Rothman and colleagues using a *Virtual Vietnam* scenario, including jungle and helicopter simulations, demonstrated the ability of VRET to reduce symptoms of PTSD in a Vietnam veteran [4]. Rothbaum's follow-up study [5] demonstrated significant reductions of PTSD in 10 Vietnam veterans although it did not utilize a control group. In their case study, Difede and Hoffman [1] found that their patient, who suffered PTSD as a result of the 9/11 attack on the World Trade Center, reported a 90% reduction rate of PTSD symptoms after completing VRET using a *Virtual World Trade Center* environment. In follow-up studies, Difede and colleagues [9, 30] also found that VRET was significantly more effective in PTSD symptom reduction than their waitlist control condition. In fact, in these methodologically rigorous studies, those in the treatment groups showed significant reductions in PTSD symptoms – seven of the ten participants no longer met criteria for PTSD following treatment [9]. Most recently, reports have shown positive preliminary support for *Virtual Iraq*. In their case study of a 29 year old SM, Gerardi and colleagues [31] documented a substantial reduction in the participant's PTSD symptoms after only a short treatment intervention (i.e., four sessions of VRET with *Virtual Iraq*) and, although the participant still met criteria for PTSD at posttreatment, he reported improved life functioning. Similarly, in their open clinical trial Rizzo and colleagues [3] used *Virtual Iraq* in their sample of 15 active duty SM's and found significant symptom reduction – twelve of the fifteen participants no longer met criteria for PTSD. Interestingly, two of the participants had mild to moderate

traumatic brain injuries (TBI's) and were still able to receive treatment benefits suggesting that VRET may be suitable for those with cognitive limitations. Rizzo and colleagues [3] have also presented preliminary findings of a case study involving an SM with PTSD who received a lower frequency treatment schedule than usual (i.e., 11 sessions over seven months) using *Virtual Iraq*. At post-treatment, the SM no longer met criteria for PTSD which suggests that VRET may be effective enough to be implemented within a flexible time-frame.

3.1 Problems with the use of VRET

The literature presents problems related to the use of VRET such as the patient's ability to use the tools and physical side effects. Gregg and Tarrier [29] suggest that the navigation of VR systems may prove problematic for clients with cognitive or motor difficulties and Rizzo [21] warns that the extra effort required to navigate the VR equipment may serve as a distraction and limit the treatment process. Also, cybersickness, a form of motion sickness, can result in a number of symptoms, including nausea and vomiting [21]. Other negative after-effects include motor disturbances, flashbacks, fatigue and drowsiness. However, some authors suggest repeated exposure could gradually reduce these side effects.

An important ethical consideration with the use of VRET is the clinician's competence with the technology. Clinicians should only employ treatments within their own area of expertise and Difede [9] suggests they should be trained in exposure therapy protocols before being trained in VRET. Further, as it is difficult to foresee how any client may respond to VRET and stress levels are difficult to predict, it is important that clinicians using this technology are well aware of potential side effects and reactions to the intervention and are prepared to respond appropriately if necessary.

3.2 Methodological considerations

Although we found support for the use of VR within therapeutic interventions, many of the studies we reviewed contained methodological weaknesses. For example, many studies used a small number of participants. Gregg and Terrier [26] claim that in order to show a treatment effect studies must employ at least 27 participants; however, many of the studies reviewed had smaller sample sizes – particularly those related to PTSD (e.g., case studies; 18 participants). Further, some studies utilized unstandardized measures and others did not clearly describe their methodology (e.g., randomization process, treatment implementation). This is particularly problematic for meta-analyses for, although these studies may correct for small sample sizes, inaccuracies of methodologically flawed studies are exaggerated when amalgamated.

Although results from uncontrolled trials and case reports are encouraging, they cannot be generalized. Our findings further underscore the fact that more well-designed research is needed to verify the effectiveness of VRET over traditional therapeutic approaches. For example, many of the studies included in the review did not have control groups or used inactive treatments as comparison groups (e.g.,

waitlist). However, the inclusion of appropriate comparison groups such as traditional therapeutic approaches (e.g., CBT, stress-inoculation training, etc.) would help to more accurately estimate the effectiveness of VRET on the reduction of PTSD symptoms relative to other, established treatments.

Another methodological consideration is for greater attention to mediator and moderator effects. Analysis of the mechanisms through which treatments exert their effect (mediation) as well as the characteristics of the patient or population which make the treatment more or less successful (moderation) would serve to advance knowledge and improve patient care. For example, recent discoveries about neural mechanisms underlying exposure therapy have allowed researchers to augment traditional exposure therapy with use of pharmacological treatments to accelerate anxiety reduction [32]. It is also important to identify factors which may differentially impact treatment outcomes in order to better identify the most favorable treatment options for individual clients to optimize therapeutic change [8].

Overall, conducting controlled studies with randomized, between-groups design and utilizing large sample sizes with consideration of possible mediator and moderator variables would help to more confidently state the efficacy of VRET and enhance future treatment of PTSD.

4 Conclusion

VRET has many benefits including the ability to facilitate emotion processing by immersing clients within the virtual world – even for those who do not respond to traditional talk therapy. VR allows exposure to be repeated, gradual and prolonged (the three main tenants of exposure therapy) which facilitates maximally effective treatment. Further, VR allows exposure to stimuli which may otherwise be expensive, difficult to arrange or beyond the constraints of the real world – all within the clinician's control.

4.1 The use of VRET in the treatment of PTSD

VRET may be particularly suitable for military service members due to its format of delivery which may be similar to military training applications and, therefore, may be less stigmatized than traditional talk therapy. In their survey of service members, Rizzo and colleagues [3] found that 20% who stated they were not willing to seek traditional psychotherapy rated their willingness to use VR-based treatment as neutral to very willing.

4.2 Future directions

In 2008, Canadian Ombudsman investigators found that the negative stigma associated with PTSD remains a real problem in military and civilian environments [13]. Mental health care providers from across Canada reported that stigma was one

of the biggest challenges still facing the Canadian Forces [13]. Thus efforts need to be made not only in clearly identifying effective treatments for PTSD but also in initiatives to reduce stigma and barriers to treatment for SM's.

Traditionally, the health system has been a very conservative environment – particularly for new innovative technology. Within the system there exists great reluctance to invest in new methods of clinical care until conclusive demonstrations of efficacy and cost-effectiveness occur. In our work with Canadian OSI clinics there was notable interest amongst clinicians of the prospect of incorporating this treatment method into extant interventions for service members. However, currently there are no plans to employ VRET, in part due to cost concerns. VR units may be extremely costly - Gregg and Terrier [26] estimate the cost is from $2,000 to $5,000 for a Head Mounted Device, and up to $200,000 for a complete system. Although Parsons and Rizzo [7] claim the price of VR systems has decreased in the past 10 years (Rizzo [3] describes a base-level system for $1,500) they are still far too costly for many clinicians – particularly those in private practice – to afford them. Further, these lower-end systems may not feature the essential stimuli (e.g., olfactory, vibrotactile) which add to the immersive nature of VR and thus, may be less effective at creating an authentic, engaging experience for patients.

We hope that future research involving methodologically-sound study designs increases confidence in the technology and stimulates the creation of more cost-effective systems which may maximize access to clinicians. However, in the meantime, clinicians in traditional health care settings have turned to lower-cost alternatives. Following Rizzo and colleagues' claim that 'simple' video tools may also aid patients who are undergoing exposure therapy [33], practitioners in England have begun experimenting with Tetris video games and others in Newfoundland, Canada have begun using games for the Nintendo Wii gaming system (which include audio, visual and vibrotactile features) to treat PTSD and traumatic stress [35, 36]. Focusing on these low-cost alternatives may also stimulate interest among administrations and clinicians to conduct trials with different technologies in treating individuals with PTSD. We look forward to the findings of future research and the application of innovative technologies in the treatment of PTSD and hope for the invention of cost-effective treatment methods which increase accessibility to these worthwhile interventions.

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5 References

1. Difede, J., Hoffman, H.G.: Virtual Reality Exposure Therapy for World Trade Center Posttraumatic Stress Disorder: A Case Report. CyberPsych. & Beh. 5, 529--535(2002)
2. Rizzo, A. A., Rothbaum, B.O., Difede, J., Mclay, R.N., Johnston, S., Reger, et al.: Clinical Results from the Virtual Iraq Exposure Therapy Application for PTSD. In: The Proceedings of the 26th Annual Army Science Conference. Orlando, Fl. (2008)
3. Rizzo, A.A., Reger, G., Gahm, G., Difede, J., Rothbaum, B.O.: Virtual Reality Exposure Therapy for Combat Related PTSD. In:Shiromani, P., Keane, T & LeDoux, J. (eds.) (in press).
4. Rothbaum, B. O., Hodges, L., Alarcon, R., Ready, D., Shahar, F., Graap, K., et al.: Virtual Reality Exposure Therapy for PTSD Vietnam Veterans: A Case Study. J. of Traum. Stress. 12, 263--271 (1999)
5. Rothbaum, B. O., Hodges, L., Ready, D., Graap, K., Alarcon, R. D.: Virtual Reality Exposure Therapy for Vietnam Veterans with Posttraumatic Stress Disorder. J. Clin. Psychiatry. 62, 617--622 (2001)
6. Rothbaum, B.O., Ruef, A.M., Litz, B.T., Han, H., Hodges, L.: Virtual Reality Exposure Therapy of Combat-Related PTSD: A Case Using Psychophysiological Indicators of Outcome. In: Taylor, S. (ed.) Advances in the Treatment of Posttraumatic Stress Disorder: Cognitive-Behavioral Perspectives. Springer, New York (2004)
7. Parsons, T. D., & Rizzo, A. A.: Affective Outcomes of Virtual Reality Exposure Therapy for Anxiety and Specific Phobias: A Meta-analysis. J. Behav. Ther. Exp. Psychiatry. 39, 250--261(2007)
8. Powers, M. B., & Emmelkamp, P. M. G. Virtual Reality Exposure Therapy for Anxiety Disorders: A Meta-analysis. J. Anx. Disord. 22, 561--569 (2007)
9. Difede, J., Cukor, J., Jayasinghe, N., Patt, I., Jedel, S., Spielman, L., et al.: Virtual Reality Exposure Therapy for the Treatment of Posttraumatic Stress Disorder Following September 11, 2001. J. Clin. Psychiatry, 68, 1639--1647 (2007)
10. Pair, J., Allen, B., Dautricoutr, M., Treskunov, A., Liewer, M., Graap, K., et al.: A Virtual Reality Exposure Therapy Application for Iraq War Post Traumatic Stress Disorder. In: Proceedings of the IEEE conference on Virtual Reality, pp. 62—72. IEEE Press, New York (2006)
11. American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders (4th, Text Revision ed.). American Psychiatric Association, Washington, DC (2000)
12. Molyneaux, H., Gibson, K., Simms, D., O'Donnell, S., Oakley, P., Kondratova, I., et al.: Information and Communication Technologies for Assessing and Treating Operational Stress Injury (OSI). Fredericton: National Research Council. ERB-1159. NRC 50740. (2009)
13. McFadyen, M.: A Long Road to Recovery: Battling Operational Stress Injuries. Second Review of the Department of National Defence and Canadian Forces' Action on Operational Stress Injuries. Special Report, Ombudsman National Defence and Canadian Forces (2008)
14. Wood, D. P., Murphy, J., Center, K., McLay, R., Reeves, D., Pyne, J., et al.: Combat-Related Post-Traumatic Stress Disorder: A Case Report Using Virtual Reality Exposure Therapy with Physiological Monitoring. In: J.D. Westwood et al. (Eds.) Studies in Health Technology and Informatics, Amsterdam, pp. 556--561. IOS Press (2007)
15. Marks, I. M., Sweinson, R.P., Basoglu, M., Kuch, K., Noshivani, H., O'Sullivan, G., et al.: Alprazolam and Exposure Alone and Combined in Panic Disorder with Agoraphobia: A Controlled Study in London and Toronto. Br. J of Psychiatry. 162, 776--787 (1993)
16. Hollon, S. D., Stewart, M. O., Strunk, D. Enduring Effects for Cognitive Behavior Therapy in the Treatment of Depression and Anxiety. Annu. Rev. Psycho. 57, 285--315 (2006)
17. Van Etten, M. L., Taylor, S.: Comparative Efficacy of Posttraumatic Stress Disorder: An Empirical Review. JAMA. 268, 633--638 (1998).

18. Foa, E. B., Kozak, M. J. Emotional Processing of Fear; Exposure to Corrective Information. Psych. Bull. 99, 20--35 (1986)
19. Foa, E.B., Davidosn, R.T. , Frances, A.: Expert Consensus Guideline Series : Treatment of Posttraumatic Stress Disorder. Am. J. of Clin. Psychiatry. 60, 5--76 (1999)
20. Spira, J.L., Pyne, J.M.: Experiential Methods in the Treatment of Combat PTSD. Combat Stress Injury: Theory, research, and Management. Routledge, New York, 205--218 (2007)
21. Gorini, A., Riva, G. Virtual Reality in Anxiety Disorders: The Past and the Future. Exp. Rev. Neurother. 8, 215--233, (2008)
22. Rizzo, A.A., Schultheis, M.T., Rothbaum, B.O.: Ethical Issues for the use of Virtual Reality in the Psychological Sciences. In: Bush, S.S., Drexler, M.L. (Eds.) Ethical Issues in Clinical Neuropsychology, 243--279, (2002)
23. Rizzo, A.A., Difede, J., Rothbaum, B.O., Johnston, S., Mclay, R.N., Reger, G., et al. VR PTSD Exposure Therapy Results with Active Duty Iraq War Combatants. In: Westwood, J.D. et al. (Eds.) Studies in Health Technology and Informatics. Amsterdam, IOS Press (in press-Jan.2009).
24. Emmelkamp, P. M. G., Krijn, M., Hulsbosch, A. M., de Vries, S., Schueme, M. J., van der Mast, C. A. P. G.: Virtual Reality Treatment Versus Exposure In Vivo: A Comparative Evaluation in Acrophobia. Beh. Res. Ther. 40, 509--516 (2002)
25. Jaycox, L. H., Foa, E. B., Morral, A. R.: Influence of Emotional Engagement and Habituation on Exposure Therapy for PTSD. J. Consult. Clin. Psych. 66, 185--192 (1998)
26. Hoge,C.W., Castro, C. A., Messer, S. C., McGurk, D., Cotting, D. I., Koffman, R. L. Combat Duty in Iraq and Afghanistan, Mental Health Problems, and Barriers to Care. N. Engl. J. Med. 351, 13--22 (2004)
27. Gregg, N., Tarrier, N.: Virtual Reality in Mental Health – A Review of the Literature. Soc. Psych. Psych. Epid. 42, 343--354 (2007)
28. Anderson, P., Rothbaum, B. O., Hodges, L.F. Virtual Reality Exposure in the Treatment of Social Anxiety. Cognitive and Behavioral Practice, 10, 240--247 (2003)
29. Garcia-Palacios, A., Botells, C., Hoffman, H., Fabregat, S. Comparing Acceptance and Refusal Rates of Virtual Reality Exposure vs. In Vivo Exposure by Patients with Specific Phobias. CyberPsych. & Beh. 10, 722--725 (2007)
30. Rothbaum, B. O., Schwartz, A. Exposure Therapy for Posttraumatic Stress Disorder. Am. J. Psychother. 56, 59--75 (2002)
31. Difede, J., Cukor, J., Patt, I., Giosan, C., Hoffman, H.: The Application of Virtual Reality to the Treatment of PTSD Following the WTC Attack. Ann. NY Acad. Sci. 1071, 500--1 (2006)
32. Gerardi, M., Rothbaum, B.O., Ressler, K., Heekin, M., Rizzo, A.A.: Virtual Reality Exposure Therapy Using a Virtual Iraq: Case Report. J. Trauma. Stress. 21, 1--5 (2008)
33. Ressler, K. J., Rothbaum, B. O., Tannenbaum, L., Anderson, P., Zimand, E., Hodges, L., Davis, M.: Facilitation of Psychotherapy with D-Cyucloserine, a Putative Cognitive Enhancer. Arch. Gen. Psych. 61, 1136--1144 (2004)
34. Rizzo, A. A., Wiederhold, M., Buckwalter, J. G.: Basic Issues In the use of Virtual Environments for Mental Health Applications. In: Riva,G., Wiederhold, B.K., Molinari, E. (Eds.) Virtual Environments in Clinical Psychology and Neuroscience. pp. 1--23. IOS Press, Amsterdam (1998)
35. BBC News, http:/news.bbc.co.uk/2/hi/health/7813637.stm
36. The Whig Standard, http://thewhig.com/ArticleDisplay.aspx?e=1347494