Current and Future Research Directions in Mental Health Computing

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***Abstract*—Mental illnesses have been identified as a major cause for disability and responsible for an extensive share of the global burden of diseases worldwide. Likewise psychological factors have been associated with physical health and illnesses. This motivated research into the field of mental health computing, which focuses on computer support systems for understanding, preventing, and relieving psychologically based distress or dysfunction, but also on electronic coaching of individuals to promote wellness. This paper describes past, current and future research work of the Delft Mental Health Computing Lab focusing around three research directions: (1) the recreation of relevant realities; (2) intelligent agents for health interventions; and (3) engineering methodologies for applications in the field of mental health computing.**

Keywords—mental health computing; cyberpsychology, virtual reality; ecoaching; software engineering methodolgies.

I. Introduction

Mental health illnesses are a major cause of disability with neuropsychiatric disorders filling five of the top ten causes [1]. Furthermore, unipolar depression, a mental illness, has a substantial impact to the burden of disease. Worldwide it is ranked on third place, eighth in low-income countries, but it leads the list in the middle- and high-income countries [2]. On top of that, psychological factors, for example stress, have also been associated with physical health [3, 4]. For the Netherlands, it is estimated [5] that 43% of its population is affected by a mental illness in their lifetime. Still, without adequate new policy measures, estimations are that in 2025 55 of every 145 Dutch patients will have no access to professional care, a shortfall of 40% as a consequence of demographic changes in the workforces and an increase in care demand [6]. Likewise in Europe, public health has been identified as one of the grand challenges [7, 8]. This calls for new healthcare concepts which improves the efficiency of care providers and a shift away from expensive professional care in health clinics to self-management at home. Information and communication technology (ICT) is positioned as an essential enabler to cope with these new demands, and can even reach further by providing new types of treatment and prevention strategies. In the mental healthcare sector ICT's role is therefore becoming more prominent, especially mental health computing (MHC). MHC can be seen as the intersection between computer science (including human-computer interaction), clinical and health psychology. It focuses on computer support systems for understanding, preventing, and relieving psychologically based distress or dysfunction and for mental coaching to promote health, well-being and the prevention of illness. Importantly, MHC not only focuses on mental health illness but also at computer support for psychological aspects of other type of illness and healthy living, for example supporting individuals to change their behaviour to adopt a more healthy life style.

This paper focuses on three fundamental research directions for MHC, stating scientific research questions, and giving examples of current examples in this area. The three directions are: (1) the recreation of relevant realities; (2) intelligent agents for health interventions; and (3) engineering methodologies for MHC applications. These three directions will be discussed in the context of past, current and future work conducted by the Delft Mental Health Computing (DMHC) Lab.

II. Recreation of Relevant Realities

Cognitive behavioural therapy (CBT) is a psychotherapeutic approach often used in a variety of mental conditions such as anxiety, and psychotic disorders. A key component of CBT is exposure in vivo, i.e. exposing the patient to the actual stressor in real life, e.g. a spider in the case of arachnophobia. As exposure in vivo is often difficult to arrange and to control, exposure in virtual reality (VR) has been researched as a viable alternative. Virtual reality exposure therapy (VRET) uses computer-generated environments to simulate stimuli. Already in 1992 the first experiments were conducted in this area [9]. Research on VRET has focused on various mental disorders, such as claustrophobia, fear of driving, acrophobia, fear of flying, spider phobia, social phobia, panic disorder with agoraphobia, and also post-traumatic stress disorder (PTSD) [10, 11]. An advantage of VRET seems to be that patients might be more willing to expose themselves in VR than in vivo. For example in a survey among 150 patients [12], 76% chose VR over vivo, but more importantly, refusal rate for VR exposure (3%) was far lower than that of exposure in vivo (27%). Several studies describe positive results achieved with VRET in treating anxiety disorders (e.g. [13-16]), suggesting VRET to be as effective as exposure in vivo. A fundamental research question in this area is: how effective is and in what matter can a relevant reality be recreated to evoke a specific emotional response in an individual? Recreating a relevant reality, even a non-stressful situation [17], requires a detailed analysis and understanding of a patient and his or her anxiety. Take for example a VRET system to treat patients for their fear of flying [18], several scenes might be relevant to be included in the exposure, such as the inside of an airplane, the airport, or even the train which takes the person to the airport. Furthermore, when recreating a scene in virtual reality, for example the airplane, key phobic stressors need to be identified and implemented, for example seat belt light, a vibrating chair, and the engine sound. Under the control of the therapist, these stressors make it possible to gradually expose patients to situations they fear.

A. Home-based VRET system for the treatment of Social Phobia

Although initial work successfully focused on systems for treating patients for their fear of flying or height, the DMHC lab's current focus is on social phobia with its challenge of recreating social interaction including free speech conversations and non-verbal communication, i.e. facial expression and gaze. Social phobia is one of the most commonly occurring anxiety disorders; estimated to affect 9.3 % of the Dutch population in their lifetime [5]. People with a social phobia have a strong fear of one or more social situations, such as talking in public, entering a room with other people, ordering food in a restaurant etc. The effect of this phobia on patients includes depression, substance abuse (e.g. alcoholism, drug abuse), restricted socialization, and poor employment and education performance. In the western world, social phobia leads to intensive use of (mental) health services. A virtual reality exposure therapy system specifically designed to expose patients with social phobia to various social situations has been developed using the Delft Remote VRET (DRVRET) platform [19]. This system allows exposure to various social situations such as: a job interview, a blind date, buying items in a shop, giving a presentation to an audience followed by a question and answer round. Semi-structured dialogues have been written for each of these social situations. The dialogues allow therapists at each point in the dialogue to select a reply from a set of possible replies for the virtual character, i.e. avatar, which can be more or less anxiety provoking. With the aim of transforming this system into a system that can be used at home by the patient on their own, several steps have already been undertaken. For example, work [20] towards automating the speech response shows that, although different automatic techniques such as speech detection and speech recognition have their (dis)advantages, they often did not show any significant difference compared to a therapist who controls the conversation. A VRET system with automated semi-scripted conversations might therefore be suitable for the treatment of patients with social phobia. A challenge thereby is to improve keyword recognition, for example by steering patients to use specific keywords in their answers by priming them with specific pictures in the virtual world [21]. Besides automating the conversation, the behaviour of the avatars also needs to be automatized. For example, in public speaking scenario, the behaviour of the audience should be believable, natural and adjustable to a number of outside parameters that can be set, such as attitude towards the presentation, mood, personality of the audience member [22]. As no therapist is present to set these phobic stress parameters by monitoring anxiety level, a robust automatic anxiety measurement is needed. This would ideally be a multimodal measure based on a combination of several measures, such as subjective measures, physiological measures, but also voice analysis. For automatic subjective anxiety measurement, it is essential that these questions are posed at an appropriate moment in the flow of the conversation the patient is having with the avatar as inappropriate interruptions can negatively affect individuals' ability to continue the conversation and their sense of being in the virtual world, i.e. presence [23]. Another important consideration for developing a home-based system is the potential equipment available, specifically to display the virtual world. In the clinic this is traditionally done with a head mounted display (HMD). However, for social phobia using a one-screen projection might also be sufficient as stereoscopic rendering has shown not to be of practical importance in public speaking setting [24], and a comparison between HMD and one-screen project found similarly high levels of anxiety reports during exposure to DRVRET social virtual environments [25].

Instead of indirectly supervised or unsupervised exposure system at home, an alternative research direction is an internet-delivered VRET system whereby therapists monitor a patient directly. This tele-treatment feature has already been successfully tested in a session between the Delft lab and the lab of our colleagues from Technical University of Valencia [26], and likewise the DRVRET platform support remote treatment over the internet [19]. Therapists see the patient on a camera, and they can listen and talk to the patient through an intercom, and also monitor psychological anxiety indicators such as heart rate and galvanic skin response. Using intelligent computerized assistance would reduce the workload of the therapist, creating the potential of treating multiple patients at the same time over the internet [27]. Besides these technical challenges, an important question that remains is also the efficacy of these treatment approaches for social phobia.

B. PostTraumatic Stress Disorder

PTSD is another mental health illness where exposure in virtual reality has been suggested as part of the treatment characterized by symptoms such as persistent re-experiences of the traumatic event, avoidance of stimuli associated with the trauma, numbing of general responsiveness, and symptoms of increased arousal such as irritability or outbursts of anger. PTSD is one of the most prevalent mental disorders for which psychotherapy is widely practiced [28] and depression is one of the most common comorbid disorders when PTSD is diagnosed [28]. Although reports vary, the lifetime prevalence rate for PTSD of 7.4% for the Netherlands [29] seems to be consistent with the 6.8% rate reported for the US [30]. About 20% of US soldiers who served in Iraq and Afghanistan return with psychological damage, most commonly PTSD and depression [31].

1) Treatment

Most research on PTSD VRET systems have been focusing on large scale events that have traumatized large groups, e.g. soldiers such as Virtual Vietnam [32] and Virtual Iraq [33]. This approach might only be economically viable with a sizeable patient group that has a shared traumatic experience [11]. For other cases the pursuit of an easy personalisable virtual world is needed. The Multi-Modal Memory Restructuring (3MR) system is addressing the current gap. The application focuses especially on helping patients to restructure and relearn memories about traumatic events. The system allows patients to order these and other events on a chronological life line by visualizing them using personal photos, narrative text, online geographical maps, webcam snapshots in a diary style application that also allows patients to create their own 3D virtual worlds of specific traumatic scenes. Results of a storytelling experiment found that with the 3MR system individuals told their autobiographical story in more detail, and usability was perceived as on an acceptable level [34, 35]. Initially designed for psychotherapy with war veterans, new research avenues for the 3MR system are non-combat related PTSD such as adults with childhood sexual abuse, for war-related PTSD among civilians, and for aviation related PTSD. Work is on its way to evaluate the efficacy of this type of treatment.

2) Resilience

Besides technological support for PTSD treatment, recent research is also focusing on technology that can support mental resilience training as a way to prevent PTSD. Worldwide a limited number of systems have been suggested based on various underlying prevention strategies such as stress inoculation training, CBT, and biofeedback training. These methods teach and rehearse coping and self-regulation skills. Interviews among the researchers of these systems [36] has put forward three project-limiting constraints: culture, engineering and resource related issues. An additional factor also seems to be the effectiveness measurement of these trainings and related technology. As an emerging subfield, several research questions still need to be addressed, such as the possible transfer of learning from generic virtual reality setting to a specific theatre of war setting, and whether technology can assist in improving resilience during and after deployment. Furthermore, other concepts for resilience intervention system need to be explored considering other underlying prevention strategies, for example improving self-efficacy by training sense making or (re)appraisal skills of emotionally charged events, but also improving stress coping strategies by providing individuals with bio- or cognitive feedback in a training environment of a stressful situation [37].

C. Psychosis

Most research on VRET has focussed on the treatment of anxiety disorders, far less attention has been devoted to psychosis. This is a mental condition whereby people have delusions or prominent hallucinations. Core symptoms include paranoid delusions, ideas of reference and social anxiety. Psychotic patients can experience anxiety as they believe others intend to harm them. To a lesser degree, paranoia and social anxiety also exist among the general population, and these symptoms have therefore successfully been studied in virtual reality with non-patients [38]. Key to the development of virtual reality environment which would allow for gradual exposure is the recreation of psychotic stressors in virtual reality. For example recently the density and ethnic appearance of a group of avatars has been proposed in this context [39]. Current work includes exploration of controlling the amount of arbitrary events in the virtual world which might evoke paranoid thoughts, such as overhearing snaps of conversation, news flash message on TV screens, face expression, eye gaze, and avatars that are walking around apparently searching for someone or something. Whereas the efficacy of VRET for the treatment of anxiety disorders has been examined by several studies, for psychotic disorders this is still an open question.

III. INTELLIGENT AGENTS FOR HEALTH INTERVENTIONS

The rise of facilitating technologies such as internet and mobile technology and the economic need for moving treatment out of clinics into the home explain recent interest in merging CBT with the internet [40], and the emerging interest for eCoaching as an important element for computer assisted health interventions. The challenge thereby is to understand how coaching methods, for example cognitive behavioural coaching, narrative coaching, and motivational interviewing [41], could be computerized or inspire new coaching approaches which also benefit from persuasive computing strengths [42] such as motivating patients when they most need it, having almost unlimited time to support them, providing them extensively with personalised feedback, and fitting its support to patients' daily routine. Giving the eCoach a human appearance might also benefit the alliance between the eCoach and the patient, as therapeutic alliance is a consistent predictor of therapy outcome [43]. Several intriguing reports [44] have indeed found similarity between human social responses towards a computer and towards another human. The eCoach could also provide affective feedback such as facial expression as this has shown to enhance adherence [45]. Especially as symptoms might initially intensify during psychotherapy, an eCoach task to provide psycho-education seems important. The concept of virtual coaches can not only be studied in the mental health domain, but in the health domain in general. Still, the MHC focus is on the psychological support, and educational element of the care demand, considering aspects such as trust, persuasion, personalisation, and social interaction. Self-management and remote mediate support can be expected to become an essential resource of the care system in the future. Key therefore will be the support given to patients in their home situation; empowering them in their desire of independent living. Two important roles for ICT in this context exist: 1) coaching clients directly to follow desired health behaviours, including the use of other devices or following treatment instructions; and 2) support asynchronous remote interaction between client and care provider. As accessibility, usability, persuasive and trust are all paramount aspects, natural or even anthropomorphizing of the user interface seems required. Furthermore, presenting information to patients in an appropriate format and time is also essential, thereby considering the understandability and motivational character of this information (e.g. [46]). A fundamental research question in this area is: how effective and in what manner an intelligent agent can provide psychological assistance in a health intervention? Currently within the DMHC lab, eCoaching is studied in three contexts: 1) self-management support system for renal transplant patients [47]; 2) sleep disorders [48]; and 3) home-based VRET system for the treatment of social phobia.

◄——— identified problems, opportunities and values ———

——— Technological innovations ———►

Technology Element	**Technology Intervention**	**Clinical effect**	**Field Use**
Focus on effect of technology components that affect the interactions with a user Methods include for example lab studies often with non-patients Strong involvement of technology oriented researchers	Focus on establishing usable technological health intervention Methods include both design activities and for example usability studies often with non-patients, but also with therapists Often multidisciplinary team	Focus on efficacy of treatment with technology intervention Methods include case studies, and randomised controlled trials with patients Strong involvement of mental health researchers	Focus on daily practise on technology intervention Methods include field observations, or surveys among patients and or therapists Involvement of clinicians

└——— Scope Engineering Methodology ———┘

Figure 1. Mental Health Computing Research Model [49].

IV. ENGINEERING METHODOLOGIES FOR MHC APPLICATIONS

Theoretical progresses in cognitive engineering are often highly situated. Clear understanding of the interaction between humans, the work domain, and envisioned technology, is essential for technological advances in high complex task situations. The MHC domain therefore needs an engineering approach tailored to its specific demands, values, and constraints. For example in the MHC domain applications often have multiple users, e.g. patients and care providers. The dissimilarity of knowledge makes that care providers might be responsible for selecting appropriate applications. Furthermore, stakeholders such as government and insurers may place additional demands on the application, such as privacy, patient-therapist confidentiality, but also ethics concerns about the mental health patient ability to give informed consent. These aspects are different than aspect that need to be considered in other domains. Take for example the consumer electronics domain that primary focuses on consumers and their social setting, e.g. friends and family members, but also actors such as content providers. The MHC domain therefore has its own distinctly engineering constraints. As the interview with developers of the mental resilience training systems showed [36], specific applications might also come with their own set of project-limiting constraints. A fundamental research question therefore is what makes a good MHC engineering methodology which leads to good mental health applications that can satisfactorily be used and maintained? However a first observation is that the MHC research spectrum is wider than what an engineering methodology might cover as shown by the Mental Health Computing Research Model (Figure 1). Initial research might not be related to specific health intervention, take for example research into the relationship between anxiety and cybersickness when exposed in a virtual environment [50]. Once the focus moves to a specific health intervention, more traditional human-computer interaction engineering methods can be used, e.g. scenario-based design, focus groups, task analysis, usability evaluations. Typical for mental health applications is the clinical evaluation as part of the development process, to study efficacy but also process variables, like treatment adherence. An MHC engineering methodology should also address daily operations and maintenance. Because of the sensitive nature of possible patient data storage or exchange, procedure needs to be in place to safeguard the patient privacy and avoid unauthorized access. Important is also to facilitate a learning mechanism whereby problems, opportunities and values identified in the field are fed back into the develop process, for example by conducting field studies (e.g.[51]) or surveys. One engineering methodology that has already successfully been applied in the MHC domain is the Situated Cognitive Engineering method [52]. As an initial step this approach studies relevant operational demands, human factors and values, and envisioned technology. This forms the basis for scenarios and claims leading to system requirements and identification of core functions. Finally, in iterative cycles prototypes are developed and evaluated by users and reviewed by experts, leading to revisions and validation of the requirements and claims.

V. FINAL REMARKS

The last century has seen a rise in attention for mental wellness in general, the psychological effect on physical health and illness, and the prevention and treatment of mental disorders. In this context, mental health computing is still an emerging field with some initial key successes such as VRET systems. Although in the future researchers might be specifically trained to work in this field, for now it will be essential that research and application development is conducted in a multidisciplinary team as scientific knowledge about clinical and health psychology and computers is and remains essential.

References

[1] A. D. Lopez and C. C. Murray, "The global burden of disease, 1990-2020," *Nat Med,* vol. 4, pp. 1241-3, Nov 1998.

[2] World Health Organisation, *The global burden of disease: 2004 Update*. Geneva, Switzerland: WHO Press, 2004.

[3] S. C. Segerstrom and G. E. Miller, "Psychological stress and the human immune system: A meta-analytic study of 30 years of inquiry," *Psychological Bulletin,* vol. 130, pp. 601-630, 2004.

[4] S. Cohen and T. B. Herbert, "Health Psychology: Psychological Factors and Physical Disease from the Perspective of Human Psychoneuroimmunology," vol. 47, ed, 1996, pp. 113-142.

[5] R. de Graaf, M. Ten Have, C. van Gool, and S. van Dorsselaer, "Prevalence of mental disorders and trends from 1996 to 2009. Results from the Netherlands Mental Health Survey and Incidence Study-2," *Soc Psychiatry Psychiatr Epidemiol,* Jan 1 2011.

[6] A. Goris and H. Mutsaers, *Ruimte voor arbiedsbesparende technologie om in 2025 voldoende zorg te bieden*. Zoetermeer, The Netherlands: STG/Health Management forum, 2008.

[7] European-Commission, "Horizon 2020 - The framework programme for research and innovation," 2011.

[8] (2009, 30 Sept 2012). *The Lund Declaration; Addendum*. Available: http://www.vr.se/download/18.7dac901212646d84fd38000337/1264064158065/Lund_Addendum.pdf

[9] M. M. North, S. M. North, and J. R. Coble, "Effectiveness of virtual environment desensitization in the treatment of agoraphobia," *Presence: Teleoperators and virtual environments,* vol. 5, pp. 346 - 352, 1996.

[10] M. Krijn, P. M. G. Emmelkamp, R. P. Olafsson, and R. Biemond, "Virtual reality exposure therapy of anxiety disorders: A review," *Clinical Psychology Review,* vol. 24, pp. 259-281, Jul 2004.

[11] K. Meyerbroker and P. M. G. Emmelkamp, "Virtual Reality Exposure Therapy in Anxiety Disorders: A Systematic Review of Process-and-Outcome Studies," *Depression and Anxiety,* vol. 27, pp. 933-944, Oct 2010.

[12] A. Garcia-Palacios, C. Botella, H. Hoffman, and S. Fabregat, "Comparing acceptance and refusal rates of virtual reality exposure vs. in vivo exposure by patients with specific phobias," *Cyberpsychol Behav,* vol. 10, pp. 722-4, Oct 2007.

[13] T. D. Parsons and A. A. Rizzo, "Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: a meta-analysis," *J Behav Ther Exp Psychiatry,* vol. 39, pp. 250-61, Sep 2008.

[14] M. B. Powers and P. M. Emmelkamp, "Virtual reality exposure therapy for anxiety disorders: A meta-analysis," *J Anxiety Disord,* vol. 22, pp. 561-9, 2008.

[15] L. Gregg and N. Tarrier, "Virtual reality in mental health : a review of the literature," *Soc Psychiatry Psychiatr Epidemiol,* vol. 42, pp. 343-54, May 2007.

[16] D. Opris, S. Pintea, A. Garcia-Palacios, C. Botella, S. Szamoskozi, and D. David, "Virtual reality exposure therapy in anxiety disorders: a quantitative meta-analysis," *Depression and Anxiety,* vol. 29, pp. 85-93, Feb 2012.

[17] B. Busscher, D. de Vliegher, Y. Ling, and W. P. Brinkman, "Physiological measures and self-report to evaluate neutral virtual reality worlds," *Journal of Cyber Therapy and Rehabilitation,* vol. 4, pp. 15-25, 2011.

[18] W. P. Brinkman, C. V. D. Mast, G. Sandino, L. T. Gunawan, and P. M. G. Emmelkamp, "The therapist user interface of a virtual reality exposure therapy system in the treatment of fear of flying," *Interacting with Computers,* vol. 22, pp. 299-310, 2010.

[19] W. P. Brinkman, D. Hartanto, N. Kang, D. De Vliegher, I. L. Kampmann, N. Morina, P. G. M. Emmelkamp, and M. Neerincx, "A virtual reality dialogue system for the treatment of social phobia," in *Conference on Human Factors in Computing Systems* Austin, TX, 2012, pp. 1099-1102.

[20] N. ter Heijden and W. P. Brinkman, "Design and evaluation of a virtual reality exposure therapy system with automatic free speech interaction," *Journal of Cyber Therapy and Rehabilitation,* vol. 4, pp. 41-56, 2011.

[21] C. Qu, W. P. Brinkman, P. Wiggers, and I. Heynderickx, "Visual priming to improve keyword detection in free speech dialogue," Delft, 2010, pp. 337-338.

[22] N. Kang, W. P. Brinkman, M. B. Van Riemsdijk, and M. A. Neerincx, "Internet-delivered multi-patient virtual reality exposure therapy system for the treatment of anxiety disorders," Rostock, 2011, pp. 233-236.

[23] D. Hartanto, N. Kang, W. P. Brinkman, I. L. Kampmann, N. Morina, P. G. Emmelkamp, and M. A. Neerincx, "Automatic mechanisms for measuring subjective unit of discomfort," *Stud Health Technol Inform,* vol. 181, pp. 192-6, 2012.

[24] Y. Ling, W. P. Brinkman, H. T. Nefs, C. Qu, and I. Heynderickx, "Effects of Stereoscopic Viewing on Presence, Anxiety, and Cybersickness in a Virtual Reality Environment for Public Speaking," *Presence-Teleoperators and Virtual Environments,* vol. 21, pp. 254-267, Sum 2012.

[25] N. Morina, J. Beuving, A. Deiman, I. L. Kampmann, W. P. Brinkman, D. Hartanto, and P. M. G. Emmelkamp, "Social Virtual Environments for the Treatment of Social Phobia: Using Different Virtual Reality Displays," *Journal of CyberTherapy and Rehabilitation,* vol. 5, 2012.

[26] C. van der Mast, "Technological challenges in the Delft virtual reality exposure therapy system," *International journal on disability and human development,* vol. 5, pp. 205 - 210, 2006.

[27] C. Paping, W.-P. Brinkman, and C. van der Mast, "An explorative study into tele-delivered multi-patient virtual reality exposure therapy system," in *Coping with posttraumatic stress disorder in returning troops: Wounds*

of War II, ed Amsterdam, The Netherlands: IOS press, 2010, pp. 203-219.
[28] R. C. Kessler, A. Sonnega, E. Bromet, M. Hughes, and C. B. Nelson, "Posttraumatic-Stress-Disorder in the National Comorbidity Survey," *Archives of General Psychiatry,* vol. 52, pp. 1048-1060, Dec 1995.
[29] G. J. de Vries and M. Olff, "The Lifetime Prevalence of Traumatic Events and Posttraumatic Stress Disorder in the Netherlands," *Journal of Traumatic Stress,* vol. 22, pp. 259-267, Aug 2009.
[30] R. C. Kessler, P. Berglund, O. Demler, R. Jin, K. R. Merikangas, and E. E. Walters, "Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the national comorbidity survey replication.(vol 62, pg 593, 2005)," *Archives of General Psychiatry,* vol. 62, pp. 768-768, Jul 2005.
[31] B. K. Wiederhold, "PTSD threatens global economies," *Cyberpsychol Behav Soc Netw,* vol. 13, pp. 1-2, 2010.
[32] B. O. Rothbaum, "Virtual Vietnam: virtual reality exposure therapy," in *Novel approaches to the diagnosis and treatment of posttraumatic stress disorder*, M. J. Roy, Ed., ed Amsterdam, The Netherlands: IOS Press, 2006.
[33] J. Pair, B. Allen, M. Dautricourt, A. Treskunov, M. Liewer, K. Graap, G. Reger, and A. Rizzo, "A virtual reality exposure therapy application for Iraq war Post Traumatic Stress Disorder," *IEEE Virtual Reality 2006, Proceedings,* pp. 67-+, 2006.
[34] M. van den Steen, W. P. Brinkman, E. Vermetten, and M. Neerincx, "Multi-modal memory restructuring for patients suffering from combat-related PTSD: a pilot study," *Stud Health Technol Inform,* vol. 154, pp. 208-13, 2010.
[35] W. P. Brinkman, E. Vermetten, M. van den Steen, and M. A. Neerincx, "Cognitive engineering of a military multi-modal memory restructuring system," *Journal of CyberTherapy and Rehabilitation,* vol. 4, pp. 83-99, 2011.
[36] V. Vakili, W. P. Brinkman, and M. A. Neerincx, "Lessons Learned from the Development of Technological Support for PTSD Prevention: A Review," *Stud Health Technol Inform,* vol. 181, pp. 22-6, 2012.
[37] I. Cohen, W. P. Brinkman, and M. A. Neerincx, "Creating an computational model for quick decision making during acute stress," presented at the European Conference on Cognitive Ergonomics, 2012.
[38] D. Freeman, "Studying and treating schizophrenia using virtual reality: a new paradigm," *Schizophrenia bulletin,* vol. 34, pp. 605-10, 2008.
[39] W.-P. Brinkman, W. Veling, E. Dorrestijn, G. Sandino, V. Vakili, and M. van der Gaag, "Virtual reality to study responses to social environmental stressors in individuals with and without psychosis," *Studies in health technology and informatics,* vol. 167, pp. 86-91, 2011.
[40] G. Andersson, "Using the Internet to provide cognitive behaviour therapy," *Behav Res Ther,* vol. 47, pp. 175-80, Mar 2009.
[41] S. Palmer and A. Whybrow, *Handbook of coaching psychology : a guide for practitioners*. London: Routledge, 2007.
[42] B. J. Fogg, *Persuasive technology : using computers to change what we think and do*. Amsterdam ; Boston: Morgan Kaufmann Publishers, 2003.
[43] D. J. Martin, J. P. Garske, and M. K. Davis, "Relation of the therapeutic alliance with outcome and other variables: a meta-analytic review," *Journal of Consulting and Clinical Psychology,* vol. 68, pp. 438-50, 2000.
[44] B. Reeves and C. I. Nass, *The media equation : how people treat computers, television, and new media like real people and places*. Stanford, Calif.: CSLI Publications ; Cambridge : Cambridge University Press, 1996.
[45] O. A. Blanson Henkemans, P. J. van der Boog, J. Lindenberg, C. A. van der Mast, M. A. Neerincx, and B. J. Zwetsloot-Schonk, "An online lifestyle diary with a persuasive computer assistant providing feedback on self-management," *Technol Health Care,* vol. 17, pp. 253-67, 2009.
[46] W. Wang, W. P. Brinkman, T. J. M. Rovenkamp, P. J. M. van der Boog, L. Alpay, and M. Neerincx, "Feedback to renal transplant patients in a self-managment support system," presented at the European Conference on Cognitive Ergomics, Edinburgh, UK, 2012.
[47] W. Wang, T. J. M. Rövekamp, W. P. Brinkman, L. Alpay, P. J. M. van der Boog, and M. A. Neerincx, "Designing and Evaluating a Self-Management Support System for Renal Transplant Patients: the First Step," presented at the European Conference on Cognitive Ergonomics 2012.
[48] C. H. G. Horsch, W. P. Brinkman, R. Eijk, and M. A. Neerincx, "Towards the usage of persuasive strategies in a virtual sleep coach," in *UKHCI 2012 Workshop on People, Computers & Psychotherapy*, 2012.
[49] W. P. Brinkman, "Guest editorial - Cognitive engineering in mental health computing," *CyberTherapy and Rehabilitation,* vol. 4, pp. 9 - 13, 2011.
[50] Y. Ling, W. P. Brinkman, H. T. Nefs, C. Qu, and I. Heynderickx, "Cybersickness and anxiety in virtual environments," *VTT Symposium (Valtion Teknillinen Tutkimuskeskus),* pp. 80-82, 2011.
[51] W. P. Brinkman, G. Sandino, and C. Van Der Mast, "Field observations of therapists conducting virtual reality exposure treatment for the fear of flying," *VTT Symposium (Valtion Teknillinen Tutkimuskeskus),* pp. 169-176, 2009.
[52] W. P. Brinkman and M. A. Neerincx, "Applying situated cognitive engineering to mental health computing," presented at the CHI2012 workshop: Interaction Design and Emotional Wellbeing, Austin, TX, 2012.

Brinkman, W.P. (2013). Current and future research directions in mental health computing. *Proceedings of International conference on computation and communication advancement.* pp.xvii-xxi.