Chapter 2

Virtual Realities in the Treatment of Mental Disorders: A Review of the Current State of Research

Christiane Eichenberg and Carolin Wolters

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/50094

1. Introduction

In the past decade, *virtual reality* (VR) technologies have been discussed as promising supplements in psychotherapy. Virtual realities enable users to interact in real time with computer-generated environments in three dimensions [1]. The fact that VR applications simulate real experiences and trigger anxiety, including physiological symptoms such as sweating or nausea, emphasizes their potential to replace conventional exposure therapy.

If users are to experience virtual environments as real, two conditions are required: immersion and presence. *Immersion* describes a state of consciousness in which the user's awareness of the physical self declines due to an increasing involvement in the virtual environment. A sensation of immersion can be achieved by creating realistic visual, auditory or tactile stimulation. Additionally, the usage of specific output devices (e.g. data-goggles and monitors) and input devices (e.g. data gloves, voice recognition and eye tracking software) may facilitate the user's perception of immersion. The feeling of being physically immersed can result in a sense of *presence*, that includes a perception of the environment as being real, shutting out real-life stimuli and performing involuntary, objectively meaningless body movements such as ducking to avoid an object displayed in VR. Moreover, persons seem to experience a strong sense of control in VR. A study [2] showed that persons who were told to have control over the movements of an elevator but actually did not, rated their perceived control as high as those who in fact had control over the elevator.

Another technology that has been developed in the past years is referred to as *Augmented Reality* (AR). AR describes the superimposition of virtual elements into the real world. Persons therefore see a visualization of the real world and virtual elements at the same time [3].

Advantages of AR in comparison to VR may include an enhanced feeling of presence and reality, since the environment is in fact real. Additionally, AR might be less expensive, because the real world environment can be used as a scheme. Thus, the setting does not need to be entirely developed.

Research on the usage of VR and AR technologies in psychotherapy has mainly focused on behavioral therapy and was proven to be effective particularly in the treatment of specific phobias [4]. According to well-established behavior therapy theories, clients have to be exposed to fear inducing situations in order to treat phobias, because avoidance of fearful stimuli might stabilize the assumption that they are dangerous. Corrective experiences would thus be prevented. Two kinds of exposure can be implemented in therapy. While in-vivo exposure involves the immediate exposure to a fear-enhancing situation or object in reality, in-sensu exposure describes the mere imagination of the exposure to fearful stimuli. In terms of a graduated exposure, stimuli that trigger low levels of anxiety are usually presented first, increasing up to the client's most extreme fear, which is called "flooding" (in-vivo exposure) or "implosion" (in-sensu exposure).

2. Benefits and costs of applying VR in psychotherapy

As already mentioned, exposure therapy supported by VR technologies exceeds imaginative exposure by adding a sense of presence. Moreover, including VR applications in psychotherapy offers a series of advantages. These include the possibility of adjusting virtual environments to each client's specific needs and controlling what is presented to the client. In addition, VR enables the therapist to expose the client to conditions that might be unsafe or only accessible at high cost in the outside world, and to improve confidentiality by avoiding spectators [5]. Furthermore, therapists seem to consider VR exposure to be less aversive than in-vivo therapy [6]. Presumably, the same applies to patients. For instance, García-Palacios et al. [7] showed that only 3% of 150 participants suffering from specific phobia refused VR exposure, while 27% refused in vivo therapy.

Nevertheless, the usage of VR entails considerable costs. First of all, despite recent findings, some groups might be reluctant to the use of VR technologies and might therefore be excluded from treatment. Furthermore, the handling of VR applications requires a certain amount of training for therapists. Besides, therapists are tied to the position of VR equipment, since it is usually too unhandy to transport [1]. Additionally, equipment acquisition is rather expensive, even though costs have sunk dramatically in the past ten years [5]. Finally, clients might experience dizziness and nausea while undergoing a VR application, a syndrome referred to as simulation sickness [4]. But even though the cited costs have to be taken into account, a recent study [1] indicated that therapists perceive the benefits of VR supported psychotherapy to be outweighing potential costs.

Self-evidently, those costs should only be accepted on condition that VR applications are able to effectively treat mental disorders. The present article aims to outline recent findings in order to examine the effectiveness of usage of VR technologies in psychotherapy.

3. Current state of research

Previous studies have mainly focused on the use of VR applications in the treatment of anxiety disorders and particularly specific phobias, such as fear of heights, fear of flying, fear of animals or social phobia. However, research has recently started to focus on the usage of VR in the treatment of other disorders as well, including eating disorders and sexual dysfunctions. In the following, an overview of the current state of research will be given. After briefly describing the search strategy, two meta-analyses that are concerned with the application of VR in the treatment of anxiety disorders will be presented. Subsequently, exemplary studies evaluating the effectiveness of VR-assisted psychotherapy of different specific disorders are summarized.

3.1. Method

In order to identify eligible studies, a search on the databases PsychInfo, PsychArticles and Pubmed was conducted. The search words *Virtual/ Augmented Reality*, *Exposure Therapy* and *effectiveness/ efficacy/ metaanalysis* were entered alone and in combination with *mental disorder* and derivatives of the different terms for disorders, particularly *acrophobia/ fear of heights/ aviophobia/ fear of flying/ arachnophobia/ fear of spiders/ social phobia/ fear of public speaking/ panic disorder/ posttraumatic stress disorder.* To ensure the currentness of the findings presented here, we focused on studies that were published within the past ten years, even though studies conducted before were not excluded if they contributed significantly to the current state of research.

3.2. Meta-analyses

Two current meta-analyses have been reported concerning the effectiveness of VR in the treatment of anxiety disorders. Parsons and Rizzo [8] analyzed N= 21 studies that used pre-post measurements but not necessarily a controlled study design. The authors found an average effect size of d= .95 (SD= .02) for the reduction of symptoms in VR-assisted therapy. The treatment of fear of flying (d= 1.5; SD= .05), and panic disorder with agoraphobia (d= 1.79; SD= .02) using VR applications accounted for the largest effect sizes concerning symptom reduction. They were followed by treatment of social phobia (d= .96; SD= .10), acrophobia (d= .93; SD= .06) and arachnophobia (d= .92; SD= .12), while the treatment of posttraumatic stress disorder (PTSD) by means of VR obtained the smallest effect size of d= .87 (SD= .01). In addition, a series of determining factors were assumed. These include the degree of immersion and presence, duration of disease and socio-demographic variables. However, due to a lack of data within the examined study, the authors were unable to make a valid statement about potential moderators.

Powers and Emmelkamp [9] examined N= 13 controlled studies, reverting to a more rigid design that excluded studies involving case reports, multiple components of treatment conditions, and an unequal amount of treatment sessions in the conditions compared. In general, effect sizes of VR exposure therapy were found to be large to very large, ranging from *d*= .85 to *d*= 1.67. A smaller effect size of *d*= .35 favored treatment with the aid of VR to in-vivo exposure and therefore demonstrates the superiority of VR in comparison to in-vivo treatment. Admittedly, studies considering therapy of specific phobias predominated.

Nevertheless, overall results prove that VR applications are highly effective in the treatment of anxiety disorders. However, difficulties common to the realization of meta-analyses, for instance a publication bias that favors publication of studies implying significant results, have to be taken into account. Moreover, small sample sizes as well as missing data about the point of time of follow-up ratings and therefore questionable lastingness of treatment effects, limit the meaningfulness of findings. Future research should include varied levels of immersion and ensure controlled study designs.

3.3. Exemplary studies of various syndromes

The meta-analyses presented here mainly focused on the effectiveness of VR as a supplement of behavior therapy for patients with anxiety disorders, some of the most frequently diagnosed psychological disorders. Nearly one out of five adults in the USA suffers from an anxiety disorder, whereat women are more often affected than men [10]. Therefore, the continuing development and evaluation of effective treatment methods seems crucial.

Anxiety disorders present the first syndrome category for which the use of modern media such as the Internet or VR technology as a setting for interventions was scientifically evaluated. They are usually assigned to the field of *behavior therapy*. Since anxiety disorders are frequently treated with the aid of exposure, they are suitable for VR settings. In contrast, *psychodynamic therapy* concentrates more on relationship aspects. However, there are conceptual considerations about how to integrate VR in psychodynamic therapy [11], and a few studies have already been conducted to examine the use of VR within the psychodynamic approach (e.g. [12]).

Anxiety disorders are classified differently within the two major diagnostic classification systems. While the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) [13] sorts them within a separate chapter, the International Classification of Diseases (ICD-10) [14] includes them in the chapter „Neurotic, Stress and Somatoform Disorders". The latter distinguishes between the subgroups of phobic disorders (agoraphobia, social anxiety disorder, specific phobias) and other anxiety disorders (panic disorder, generalized anxiety disorders). In both classification systems, posttraumatic stress disorder is discussed along with anxiety disorders. In the following, the effectiveness of VR-assisted treatment of various syndromes is presented.

3.3.1. Fear of heights

Acrophobia, classified as a specific phobia of the naturalistic type, describes an extreme fear of heights. It involves the avoidance of various height-related situations, such as stairs, terraces, high buildings, bridges, or elevators. The fear of heights is widely spread: In a survey of more than 8000 adults, 20% stated that they had already experienced an exaggerated fear of heights in the past, which did not meet the criteria for acrophobia [15]. In the aforesaid study, the prevalence of acrophobia amounted to 5.3% and therefore closely followed the prevalence of fear of animals. While women usually tend to develop specific phobias substantially more often than men [12], merely 55 to 70% of acrophobic persons are female.

The first successful application of VR in the treatment of acrophobia was presented in a case study of an acrophobic student who was successfully treated using graded VR exposure [16]. A more extensive study including a sample of 20 students furnished further evidence for the effectiveness of VR-assisted treatment [17]. However, due to study limitations such as the absence of a control group, the further conclusions can only be drawn under reserve.

The first clinical trial of the effectiveness of VR in the treating acrophobia was conducted by Emmelkamp and collaborators [18]. In a within group design, ten patients were treated with two sessions of VR, followed by two sessions of exposure in-vivo. Acrophobic symptoms were measured before treatment, after VR treatment and after in-vivo exposure. Results showed that after being treated by the means of VR, exposure to real situations did not lead to any significant improvement on the Acrophobia Questionnaire (AQ) or the Attitudes Towards Heights Questionnaire (ATHQ). Unexpectedly, the research design had created a ceiling effect, insofar as the VR treatment effects left little space for improvement during exposure in-vivo.

In a randomized controlled trial (RCT) conducted by the same research group, effectiveness of exposure by the means of VR and in vivo were compared [19]. The places used in the exposure in vivo were reproduced in a virtual environment. Exposure was affected in a real or virtual shopping mall in Amsterdam, a fire escape, and a roof garden. *N*= 33 acrophobic persons underwent three weekly sessions of one hour each. Anxiety levels were reported on the Subjective Units of Disturbance-Scale (SUDS). Results demonstrated that both kinds of treatment were equally effective and improvements were maintained at a six months follow-up.

Krijn et al. [20] examined the effectiveness of different VR systems. *N*= 37 acrophobic subjects were treated either with three VR sessions administered by a head-mounted display (HMD) or by a computer animated virtual environment (CAVE) or were assigned to the waitlist control group. Results showed no differences in effectiveness between the different VR systems. The higher degree of presence that was experienced in the CAVE condition did not affect outcome measures. In a following study [21] the same research group analyzed the role of cognitive self-statements in VR exposure therapy. In a crossover design, *N*= 26 acrophobic persons were randomly assigned to two sessions of VR treatment followed by two sessions of VR treatment plus self-statements or vice versa. Results indicated that VR-assisted treatment reduced symptoms of fear of heights as well as behavioral avoidance and improved attitudes towards heights. However, cognitive self-statements did not additionally enhance effectiveness of VR.

Another study series concentrating on treatment of acrophobia with the aid of VR was conducted by Coelho and collaborators [22, 23]. Initially, the authors compared effects of treatment in a VR (*N*= 10) and a real environment (*N*= 5). Both groups showed equally large improvements on the Behavioral Avoidance Test (BAT), the ATHQ, and the AQ, even though treatment time was substantially lower in the VR condition. A following study with eight persons suffering from fear of heights revealed that movement during VR exposure enhances anxiety. One of the virtual settings used in these studies can be seen in Figure 1.

However, VR-assisted treatment of acrophobia is not only effective and time efficient, but additionally represents a series of advantages. Anxiety inducing situations such as being on bridges or high buildings can be experienced without any great logistic efforts. Therefore, difficulties of accessing the actual place and potential disturbances by pedestrians can be avoided.

Figure 1. View from the real world (left) and the virtual reality system (right). Adapted from "Contrasting the Effectiveness and Efficiency of Virtual and Real Environments in the Treatment of Acrophobia" by C.M. Coelho, C.F. Silva, J.A. Santos, J. Tichon and G. Wallis, 2008, *PsychNology*, *6*(2), p. 206. Copyright 2008 by PsychNology Journal. Adapted with permission.

3.4. Example case

Choi and collaborators [24] described the case of a 61-year old patient, who had been suffering from acrophobia for the past 40 years. He was not able to go up higher than the third floor of any apartment and therefore lived on the third floor on his 18-story building. In order to treat his acrophobia, the authors planned eight sessions of VR therapy that were supposed to take place three times a week and took about 30 minutes each.

The virtual environment was comprised of a steel tower which involved a lift within a steel frame structure that was open to all four sides. To enhance the sense of reality, sounds of wind and a moving lift were included, and the patient was isolated in a dark room in order to increase immersion. Prior to VR treatment, the patient received four sessions of relaxation training, including abdominal breathing and progressive muscle relaxation training, to be able to cope with body sensations during the VR sessions. Pretreatment assessment was completed and the patient accomplished a demo program to get used to VR.

In the first session, the patient stayed on the floor of the virtual lift to get accustomed to the environment. He was free to decide whether to go up on a higher floor or stay where he was. In this session, the patient went up to the fourth floor, experiencing dizziness and sweating and reporting 70 to 90 subjective units of disturbance (SUD). SUD was evaluated every two to five minutes. Whenever the patient stated to experience intense fear, he was instructed to relax. In the second and third session, the patient went up to the eighth floor, but still experienced high levels of SUD, breathlessness, and the sensation of falling down. After these sessions, the patient was already able to walk up to the eighth floor of his building for the first time in ten years. According to the patient, the virtual lift scared him more than going up his building in the real world. In the fourth session, the patient went up to 18th floor of the virtual tower, and then to the 25th floor, the top of the tower, in the fifth session. Even while looking down, the patient did not experience any particular symptoms and reported SUD scores below 30. After the sixth session, the patient claimed that he did not need VR anymore. The authors therefore changed treatment plans and assigned the patient to go up to the observatory of a mountain by cable car. Going up to and looking down from the observatory, the patient showed neither symptoms of anxiety nor avoidance. Subsequently, he suggested going up the highest building of Seoul. Looking outside from the elevator of this building, the patient expressed only little fear. Six months after the treatment, the patient stated that he did not have any fear of heights.

3.4.1. Fear of flying

Fear of flying, or *aviophobia*, is characterized by an intense fear of flying that often results in flight avoidance or experiencing substantial distress while flying. Acrophobia affects 10-20% of the general population and 20% of airline passengers consume alcohol or sedatives to deal with their fear of flying [25]. Most persons suffering from acrophobia fear a plane crash, while some fear being closed in and therefore often meet the DSM-IV criteria for claustrophobia. Further fears concern experiencing a panic attack and not being able to escape the situation or get medical attention, complying with the concept of panic disorder with agoraphobia, or a general fear of heights. Therefore, comorbidity with other anxiety disorders occurs very frequently.

The use of VR applications in the treatment of aviophobia could be advantageous to an exposure in-vivo because financial and logistical expenses are essentially lower. Furthermore, the privacy and confidentiality of a VR exposure in contrast to a regular flight should be emphasized.

The first RCT investigating the effectiveness of VR treatment of aviophobia was presented by Rothbaum et al. [26]. *N*= 49 participants were randomly assigned to VR exposure therapy, exposure in-vivo, or a waitlist control group. Both treatment groups received four sessions of anxiety management and four further sessions consisting of exposure to an airplane, either in reality or VR. The latter involved acoustic and visual simulations with the aid of a HMD, as well as vibration simulation. Exposure in vivo included preparation training at an airport as well as visualization of takeoff, flight and landing inside of an airplane. Both treatment groups showed significant symptom reduction on several standardized scales, while no improvements were observed for the control group. Effects remained stable after six and twelve months follow-up. However, flight situations differed between conditions, because an actual flight was not part of the exposure in-vivo. Moreover, both treatments were combined with anxiety management training with the result that treatment effects were not completely distinguishable. The findings were replicated in another sample of N= 75 aviophobic persons [27].

Another study compared VR exposure therapy with and without physiological feedback measures to self-visualization in N= 30 persons suffering from fear of flying [28]. Results showed significant improvements in flying behavior, physiological measures of anxiety, and standardized self-report measures of anxiety in the VR condition in contrast to imaginative exposure. Furthermore, the combination of VR treatment and biofeedback was more effective than VR treatment alone. The authors reported that after eight weeks of therapy, 20% of the patients in the imaginative condition, 80% of those in the VR condition and 100% of patients who received both VR treatment and biofeedback were able to fly again. In a follow-up study three years later, treatment effects were maintained [29].

Mühlberger et al. [30, 31] proved the effectiveness of VR-assisted treatment of aviophobia in a series of studies. N= 30 participants were randomly assigned to a VR treatment condition or a relaxation training group. While both treatment conditions resulted in significant symptom improvement, several outcome measures, including physiological fear responses, indicated larger effects of VR exposure therapy than self-visualization. In a following study, the research group demonstrated that one session of VR exposure therapy in combination with cognitive behavior therapy (CBT) achieved better results than CBT only and a control group (N= 45) [31]. Results remained stable at six months follow-up. Limitations of the study include the time spent with the therapist, which was much longer for the combined treatment than for CBT only. In addition, group assignment was not randomized. Nevertheless, the elucidated study demonstrates that VR-supported exposure can show persistent effects even after one single session. Furthermore, Mühlberger et al. [32] revealed that the completion of graduation flights might be important for long-term treatment effectiveness, but that the presence of a therapist is not necessarily required.

Comparing five sessions of VR exposure therapy to an attention placebo group, Maltby et al. [33] obtained mixed results. While the VR treatment condition was superior to the placebo condition on self-report instruments, BAT scores did not reveal any significant differences. Moreover, VR exposure was more effective on only one self-report measure at six months follow-up.

Furthermore, Krijn and collaborators [34] compared four sessions of VR exposure with four sessions of CBT and with five weeks of bibliotherapy, that involved reading a psycho-educative book about aviophobia. Results indicated that both VR treatment and CBT were effective and did not differ in symptom reduction. However, after undergoing an additional CBT program, including an exposure in-vivo, CBT group was superior to VR treatment group.

Finally, the efficacy of VR and computer-aided psychotherapy in the treatment of aviophobia was examined by Tortella-Feliu et al. [35]. *N*= 60 participants were randomly assigned to the following conditions: VR exposure, computer-aided exposure with a therapist's assistance, and self-administered computer-assisted exposure. Results demonstrated that all three conditions were equally effective in reducing flying phobia, even after one year. The findings indicate that therapist involvement might be reduced in VR and computer-aided treatment.

3.4.2. Fear of spiders

According to the ICD-10 [15], *arachnophobia* is categorized within the group of zoophobias and is characterized by a persistent fear of spiders, an immediate anxiety response to exposure to a spider, and avoidance of spiders. The category of "bugs, mice, snakes or bats", which includes spiders, accounts for about 40% of specific phobias [36]. Approximately 3.5 to 6.1% of the general population suffers from arachnophobia, whereof the majority is constituted by women. Even though most arachnophobic persons recognize that their fear is unreasonable, daily life can be restrained. For instance, persons suffering from fear of spiders might depend on the help of others when confronted with a spider, or be restricted in choosing an apartment.

VR applications seem to represent a potential treatment method for arachnophobia. Rinck et al. [37] examined spider fearful persons' attention and motor reactions to spiders on a VR. The authors demonstrated that spider fearfuls show increased state anxiety, spend more time looking at spiders, and exhibit behavioral avoidance of spiders.

A first single case report examining the effectiveness of treating arachnophobia with the aid of VR was conducted by Carlin et al. [38]. They used VR as well as mixed reality, which involved touching real objects that can be seen in VR, to treat a 37-year old female suffering severe fear of spiders. After twelve weekly sessions of one hour each, measures of anxiety, avoidance, and behavior towards real spiders improved significantly.

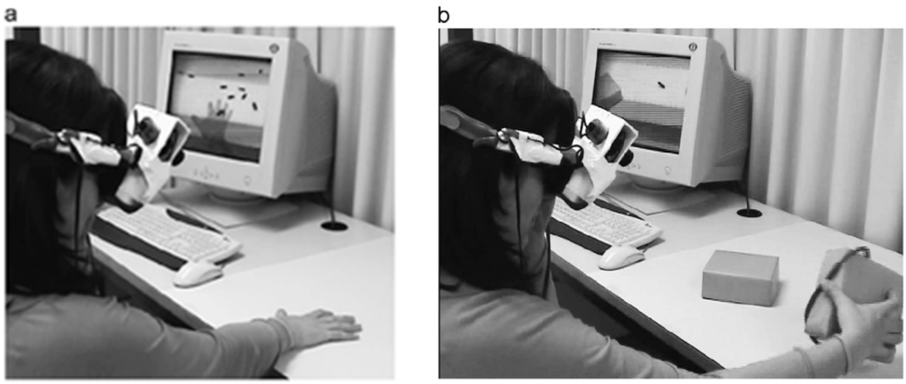
In 2002, a RCT was conducted that compared VR exposure therapy group and a waitlist group of altogether *N*= 23 participants [36]. The VR treatment group received four one-hour sessions on average. Effects were assessed by the Fear of Spiders Questionnaire (FSQ), a BAT, and severity ratings effected by clinicians. Results demonstrated that 83% of participants who received VR treatment showed clinically significant improvement compared with 0% in the waitlist control group.

In a following study with *N*= 36 participants, it was demonstrated that VR combined with touching an object that resembles a spider was more effective than only VR exposure [39]. *N*= 36 phobic students were randomly assigned to one of three conditions: No treatment, VR exposure without any tactile stimulation, and VR exposure including tactile stimulation.

After three sessions of VR exposure, the treatment groups showed less avoidance and lower levels of anxiety than the control group; and VR including tactile simulation was superior to VR without any tactile clues.

Michaliszyn et al. [40] found similar results comparing the effectiveness of VR treatment and in-vivo exposure to a waitlist condition. A total of *N*= 43 persons suffering arachnophobia were randomly assigned to the three conditions. Treatment groups received eight therapy sessions of one and a half hour each. Outcome measures included the Fear of Spiders Questionnaire, the Spider Phobia Beliefs Questionnaire (SBQ), a BAT, and the Structured Interview for DSM-IV (SKID). Both treatment groups showed clinically significant improvements in comparison to the waitlist control group, whereat in-vivo exposure was superior to VR treatment on the SBQ-F.

Furthermore, a study demonstrated that modified 3D computer games instead of actual VR software can be effective in the treatment of arachnophobia [41]. Modification of computer games could therefore represent a less expensive alternative to VR equipment.



(a) (b)

Figure 2. (a) Participant putting her hand on the table and the cock- roaches crossing over it. (b) Participant searching for hidden cockroaches. Adapted from "A comparative study of the sense of presence and anxiety in an invisible marker versus a marker augmented reality system for the treatment of phobia towards small animals" by M.C. Juan and D. Joele, 2011, *International Journal of Human-Computer Studies 69*(6), p. 445. Copyright 2011 by Elsevier. Adapted with permission.

Research has also focused on the use of AR in treating phobia towards small animals. In doing so, virtual spiders or cockroaches are blended into the real world. In a first case study, a participant suffering from cockroach phobia showed significant decreases in fear and avoidance levels, being capable of approaching, interacting with, and killing real cockroaches following AR exposure and one month later [3]. In a following study evaluating the effectiveness of AR, nine participants with either spider or cockroach phobia were treated in a single session [42]. Firstly, progressively more virtual spiders or cockroaches were presented in the therapist's hand. Participants were asked to bring their hand closer to the animals. Subsequently, a box appeared which the participants had to pick up to see if there was an animal underneath. Finally, virtual animals had to be killed with an insecticide, flyswatter or dustpan and put into a box. After completion of the session, participants were asked to approach, interact and kill real spiders or cockroaches. All of the participants succeeded in doing so, showing considerable less avoidant behavior. A validation of the system used in these first studies demonstrated that all elements of the AR environment were highly fear inducing in *N*= 6 female participants with cockroach phobia. In addition, ratings of presence, reality and immersion obtained high scores [43]. In this AR system, visible markers were used to identify insecticide, flyswatter or dustpan approaching a virtual animal. To avoid this warning, a second version in which the markers were invisible was compared to the first one [44]. For an example of the AR setting, see Figure 2. Results indicated that the invisible marker-tracking system induced a similar or higher sense of presence and levels of anxiety and seems therefore superior to the visible marker-tracking system. In this context, it should me mentioned that we consider the killing of animals within the studies as ethically questionable.

3.4.3. Social phobia

Social phobia is defined as an unreasonable or excessive fear of social situations and the interaction with other people that automatically brings on feelings of self-consciousness, judgment, evaluation or inferiority [14]. Symptoms of social phobia include intense fear, blushing, sweating, a dry mouth, trembling, a racing heart and shortness of breath. There are two subtypes of social phobia: specific social phobia, that is limited to a small number of fear inducing situations, and generalized social phobia, that involves almost all social situations. Situations that may evoke fear include speaking in public, establishing contacts, protecting one's interests and being under scrutiny. Usually, persons suffering from social phobia are worried that their fear is being noticed by others. Social phobia is one of the most commonly observed mental disorders, showing a life-time prevalence of 13%, according to the USA National Comorbidity Survey [45].

Roy et al. [46] presented a clinical protocol to assess the effectiveness of VR treatment of social phobia, describing the study structure, assessment tools, and content of the therapy sessions. Four virtual environments were used to reproduce situations inducing high levels of anxiety in social phobics: Performance, intimacy, scrutiny, and assertiveness. In a preliminary study, the effectiveness of VR treatment was demonstrated in *N*= 10 persons suffering from social phobia in a between-subjects design. In a following study conducted by the same research group [47], the same virtual environments were used to examine the effectiveness of VR exposure in *N*= 36 social phobics. Participants were assigned to either VR treatment or cognitive-behavioral group therapy (CBGT). After twelve weeks of therapy, both treatment groups showed clinically and statistically significant improvement. In a more recent RCT, the effectiveness of VR treatment, a combination of CBT and VR exposure and a waitlist control condition were compared in *N*= 45 participants diagnosed with social phobia [48]. Results indicated a significant reduction of anxiety on all questionnaires for both treatment groups in contrast to the waitlist control group.

Furthermore, a few studies have focused specifically on the effectiveness of virtual environments in treating *public speaking anxiety*. Harris et al. [49] showed that four VR treatment sessions of 15 minutes each (see table 1) reduced self-reported anxiety as well as physiological reactions significantly in eight students suffering from public speaking anxiety in comparison to six students in a waitlist control group. In an open clinical trial, the effectiveness of four sessions of anxiety management and four subsequent therapy sessions was examined, using a virtual audience in *N*= 10 participants diagnosed with social phobia [50]. As a result, self-report measures indicated lower levels of public speaking anxiety at post treatment and three months follow-up. However, participation rates of giving a free speech to an actual audience did not differ before and after the treatment. A larger sample size of *N*= 88 persons with public speaking anxiety was used in a RCT that compared the effectiveness of CBT, VR and CBT combined, and a waitlist control condition [51]. Results demonstrated significant improvements of both treatment groups on self-rated anxiety during a behavioral task and four out of five anxiety measures in contrast to the control group. At one year follow-up, results remained stable.

Other studies have concentrated on specific aspects of treating social phobia with the aid of VR. For instance, Ter Heijden and Brinkmann [52] evaluated speech detection and recognition techniques in comparison to a human control condition in a VR surrounding. Interactions were observed in two phobic and 24 healthy persons. Results indicated that automatic speech techniques often did not show any significant differences compared to manual speech. Therapist workload of entering speech content might therefore be minimized in VR treatment.

Initial interview	Besides self-report instruments measuring social anxiety, a voice test sample was recorded while the participants answered a question and read a paragraph. The heart rate was measured during the speaking test and a brief relaxation exercise.
Session 1	Participants stood at a podium with a microphone, looking around a virtual empty auditorium to get accustomed to the environment. Subsequently, participants were asked to talk about their public speaking anxiety.
Session 2	Participants were asked to say the American Pledge of Allegiance. The auditorium was gradually filled with people, and applause was used to encourage participants. The pledge was repeated, with the virtual audience applauding at the end of the recitation.
Session 3	Participants were asked to deliver a 2-min speech with a small light on the clipboard. The room was gradually filled with audience, people were speaking to each other, laughing, asking the speaker to speak louder, and applauding at the end of the speech. Afterwards, the speech was repeated.
Session 4	Participants were asked to give the same or another speech. Manipulations of the scenario were made as in session 3.

Table 1. Procedure of VR treatment for public speaking anxiety [49]

Another study brought the aspect of presence within VR exposure into focus [53]. The relationship of three components of presence (spatial presence, involvement, and realness), fear ratings during VR, and treatment effectiveness were evaluated in *N*= 41 participants suffering from social phobia. The authors found an association between total presence as well as realness subscale scores and fear-ratings during treatment, while only scores on the involvement subscale were able to significantly predict treatment outcome.

VR environments may also facilitate research on specific aspects of social phobia. For example, Cornwell et al. [54] used a VR setting to examine physiological reaction of persons diagnosed with social anxiety disorder in social-evaluative threat situations. Participants were asked to deliver a short speech in front of a virtual audience. In this way, no actual audience has to be recruited in order to realize study designs of that kind.

3.4.4. Panic disorder

Around 5% of the US Americans suffer from *panic disorder* in their lifespan [55]. Panic disorder is diagnosed if a panic attack, including symptoms such as sweating, palpitations, trembling, nausea, derealization and depersonalization, results in consistent concern about having additional attacks, worries about its consequences or behavioral changes. Persons suffering from panic disorder frequently develop agoraphobic avoidance behaviors. Agoraphobia refers to anxiety about being in places or situations from which escape might be difficult or in which help may not be available in case of having an unexpected panic attack, such as being in a crowd, on a bridge, train or the like. Therefore, agoraphobia often has to be included in the treatment of panic disorder as well.

Vincelli et al. [56] presented a treatment protocol called Experiental Cognitive Therapy (ECT), which integrates VR in order to treat panic disorder and agoraphobia. Its effectiveness was demonstrated in *N*= 12 patients, who were randomly assigned to an ETC group and therefore undergoing VR exposure, a CBT group or a waitlist control group. Results indicated that eight sessions of ECT and twelve sessions of CBT equally reduced the number of panic attacks, the level of depression and state and trait anxiety.

In a following study examining the effectiveness of VR in the treatment of panic disorder, *N*= 40 participants received either four sessions of cognitive therapy including VR exposure, or twelve sessions of a panic control program [57]. Results indicated that both treatments were equally effective. However, findings did not remain stable at six months follow-up, where participants of the panic disorder program showed higher overall functioning. Botella et al. [58] used a more rigid study design in order to compare *N*= 37 persons receiving nine sessions of either CBT with VR exposure or CBT with in-vivo exposure and a waitlist control group. Both treatment groups obtained equal symptom reductions in comparison to the waiting list, and results were maintained at twelve months follow-up. A following study using a between-subjects design compared eleven sessions of CBT including exposure in-vivo with CBT and VR exposure in *N*= 28 participants diagnosed with panic disorder [59]. All participants additionally received antidepressant medication, and a BAT was applied to assess treatment effects. Results revealed that both treatments were equally effective, and results remained stable after three months. Findings were replicated in a RCT by the same research group in *N*= 27 participants with panic disorder and agoraphobia [60].

A later study evaluated effectiveness of interoceptive exposure in a virtual environment, simulating physical sensations through audible stimulation such as rapid heartbeat and panting, and visual stimulations such as blurry or tunnel vision [61]. Results indicated that both IE using VR and traditional IE significantly reduced symptoms of panic disorder, and that results were maintained or even improved at three months follow-up. Finally, Meyerbröker et al. [62] showed that varied levels of presence by using either a CAVE or a HMD did not influence effects of VR treatment of panic disorder.

3.4.5. Obsessive-compulsive disorder

Obsessive-compulsive disorder (OCD) is a debilitating mental disorder that is characterized by either obsessions, compulsions, or both. According to the DSM-IV, obsessions are defined as recurrent and persistent thoughts, impulses, or images that may cause anxiety, including the obsession of contamination, need for symmetry or aggression [13]. Compulsions refer to repetitive behaviors, such as hand washing, ordering, and checking, or mental acts such as praying, counting, or repeating words silently, that are performed to respond to an obsession or to rules in order to reduce distress. Lifetime prevalence rates are estimated about 2% worldwide.

While the benefits of computer-based assessment and treatment of OCD has already been demonstrated [63], only preliminary data concerning the use of VR in the treatment of OCD is available. A South Korean research group presented first results of VR exposure therapy of OCD [63]. *N*= 33 participants with OCD and *n= 30* healthy controls navigated through a virtual environment, consisting of a training, distraction, and main task phase. Anxiety rates as well as decreased ratio of anxiety during the main task were significantly higher in participants with OCD than healthy controls. VR may therefore function as anxiety-provoking and a potential treatment tool for OCD. The same virtual environment was used to examine its potential efficacy in assessing OCD in *n*= 30 patients with OCD and *n*= 27 matched healthy controls [64]. Results indicated that OCD patients had significantly greater difficulties with compulsive checking than controls, and that task performance was positively correlated with self-reported symptoms as well as interviewer-rated measures of OCD. Another study by the same research group demonstrated that anxiety levels of *N*= 24 healthy participants decreased as a result of performing virtual arrangement tasks three times with three-day intervals [65]. However, the amount of anxiety reduction depended on the type of task, and only the Symmetry, Ordering and Arrangement Questionnaire (SOAQ) showed significant correlation with anxiety. Nevertheless, VR seems to be a potential device for the assessment and treatment of persons with symptoms of arranging compulsion.

3.4.6. Posttraumatic stress disorder

Posttraumatic stress disorder (PTSD) is a serious condition that persons experiencing a traumatic event may suffer from. According to the ICD-10, the traumatic event needs to be exceptionally threatening or catastrophic and would distress most people. Such disasters can be either manmade, as it is the case in war, torture, or sexual abuse, or they can be natural disasters, such as earthquakes, accidents, or life-threatening diseases. Criteria for PTSD include intrusions such as flashbacks and repeating dreams, avoidance of situations similar to the traumatic event, loss of memory about certain aspects of the event, and symptoms of hyperarousal. Experiencing psychological distress right up to PTSD is common among military members who are constantly confronted with threatening situations. Approximately 18% of warfighters returning from Iraq and 11% returning from Afghanistan were screened positive for PTSD.

Some authors suggest the application of new treatment approaches such as VR exposure, reasoning that conventional therapy approaches may be rejected by war veterans due to stigmatization and that in-vivo exposure is not possible. In fact, situations that caused the traumatization are difficult to frequent, but according to traumatherapy, this is neither necessary nor indicated [66]. On the contrary, exposure to virtual settings that are reconstructing traumatizing situations is ethically questionable, which is demonstrating by the following scenarios.

A case report describes the first application of VR for a Vietnam veteran suffering from PTSD [67]. As a result of VR treatment, he significantly improved on all PTSD measures and those gains remained stable at six months follow-up. A following open clinical trial demonstrated the effectiveness of VR in ten male Vietnam veterans diagnosed with PTSD [68]. They underwent eight to 16 sessions of VR exposure in two virtual environments: a virtual helicopter flying over Vietnam, and a clearing surrounded by jungle. Participants showed significant PTSD symptom reductions on the Clinician Administered PTSD Scale (CAPS) at six months follow-up, declaring symptom reductions ranging from 15 to 67% in an interview. Self-reported intrusion symptoms as measured by the Impact of Event Scale were significantly lower at three months follow-up in comparison to baseline, but not at six months follow-up. Another open trial of VR in the treatment of N= 21 Vietnam veterans was conducted by Ready and collaborators [69], simulating virtual environments in response to participants' memories. Participants showed significant symptom reductions at three and six-months follow-up, even though two participants experienced an increase in symptoms during VR exposure. A RCT using a small sample size was presented by the same research group [70]. Eleven Vietnam veterans were assigned to either ten sessions of VR exposure or present-centered therapy, utilizing a problem-solving approach. Results indicated no significant differences between treatment groups at posttreatment and six months follow-up.

Furthermore, several studies examined the use of a virtual environment to treat veterans returning from "Operation Iraqi Freedom" who suffered from PTSD. The "Virtual Iraq/ Afghanistan" environment was adapted from the Microsoft® X-box game "Full Spectrum Warrior". Scenarios include a Middle Eastern city and a Humvee driving down a desert highway. Auditory, visual, olfactory and vibrotactile stimulation such as gunfire, weather conditions, the smell of burnt rubber and the sensation of a moving car can be adjusted. Some examples of Virtual Iraq/Afghanistan are shown in Figure 3.

Several case reports were conducted [e.g. 71, 72]. The first clinical trial assessing the effectiveness of exposure using "Virtual Iraq" indicated clinically and statistically significant symptom reduction in N= 20 participants [73]. In addition, McLay and collaborators [74] presented a RCT comparing the efficacy of VR exposure therapy and usual CBT in a sample of N= 19 Iraq veterans diagnosed with PTSD. Within the VR condition, seven out of ten participants improved at least 30% on the CAPS, while only one out of nine within the CBT condition showed similar improvement. The effectiveness of "Virtual Iraq" was also supported by Reger et al. [75] in 24 Iraq and Afghanistan veterans. Moreover, a pilot study focusing on the combination of VR exposure and cognitive enhancing medication has shown promising results [76].

Another VR environment was created to treat Portuguese survivors of the 1961-1974 wars in Africa. Subsequently to a case study [77], Gamito and colleagues [78] examined the effectiveness of a VR war environment to imaginal exposure and a waiting list condition. Participants in the VR condition showed significant reduction of depressive and anxiety symptoms.

An increased incidence of PTSD was also detected among the survivors of the attacks of September 11, 2001. Consequently, Difede and Hoffman developed a virtual environment simulating jets crashing into the World Trade Center, people jumping to their deaths from the buildings, and towers collapsing. A study revealed that participants in a VR condition (n= 9) showed significantly greater improvement on CAPS scores than the waitlist control group (n= 8) [79]. Findings were replicated in a following study [80].

In a further study, a VR surrounding was developed in order to treat victims of a terrorist bus bombing in Israel. The potential effectiveness of "BusWorld" was demonstrated in a study examining 30 asymptomatic participants, who showed significantly higher mean subjective units of discomfort scores (SUDS) with increasingly distressful scenarios. Treatment of a 29-year-old victim of a bus bombing using VR resulted in significant reduction of PTSD symptoms as measured by the CAPS [81].

Another field of application in the treatment of PTSD by the means of VR exposure is made up by motor vehicle accident survivors. Saraiva et al. [82] presented a case study describing positive outcomes of VR exposure of a 42-year-old female in the aftermath of a serious vehicle accident. Findings were confirmed by Beck et al. [83], who demonstrated significant reductions of re-experiencing, avoidance, and emotional numbing in six persons reporting subsyndromal PTSD after completing ten sessions of VR treatment.

A new approach of treating PTSD was introduced by Fidopiastis et al. [84]: As aforementioned, AR, referred to as Mixed Realities (MR) by the authors, are supposed to blend virtual content into the real world, which means that computer-generated objects can be superimposed on the real-world environment. In a pilot study, first promising effects of MR in the assessment of PTSD by capturing the patient's interaction with the simulated environment were demonstrated. Riva et al. [85] further advanced the approach of MR by presenting the paradigm of Interreality, which is supposed to bridge the virtual and real world by using activity sensors, personal digital assistants or mobile phones.

However, even though treatment of persons suffering PTSD is crucial, study designs using VR seem questionable with regard to ethical concerns. Exposing war veterans or victims of terror attacks to simulated war scenarios is contra-indicated according to current research on trauma therapy. Certain phases of traumatherapy such as stabilization and development of a therapeutic relationship have to precede the processing of the traumatic experience [86]. In the studies presented here, none of these phases were considered so that VR exposure bore the risk of retraumatization. Besides, if the virtual setting does not in detail project the traumatic event, renewed traumatisation is risked. To date, long-term effects of exposing persons with PTSD to virtual environments are mostly unknown, because efficacy studies rarely collect follow-up data. Therefore, even though the use of VR technology seems feasible in the treatment of PTSD, ethical concerns and aspects with regard to therapy indication always need to be considered.

Figure 3. Virtual Iraq/ Afghanistan scenarios. Courtesy of Virtually Better Inc. and University of Southern California, Institute for Creative Technologies.

3.4.7. Other applications

Virtual environments have also been applied in the assessment, treatment and research of other mental disorders such as eating disorders, sexual dysfunctions, schizophrenia, attention deficit disorder, and addictions. In the following, a cursory overview of VR treatment approaches in those clinical pictures will be provided.

The first use of VR in treating *eating disorders* was accomplished by an Italian research group [87]. VR programs focused on the improvement of body image, body satisfaction and physical acceptance in obese patients and reduction of perfectionisms, body dissatisfaction and negative attitudes towards the body in anorectic patients. A few controlled studies demonstrated the effectiveness of VR in the treatment of eating disorders [88-90].

In contrast, research on the effectiveness of VR in the treatment of *sexual dysfunction* is still in an experimental stage. In one study, VR was integrated into psychodynamic psychotherapy for the treatment of erectile dysfunction and premature ejaculation in N= 160 men [12]. VR seemed to help to work through events and associations that were creating the sexual problems. Positive outcomes remained stable after one year follow-up [91].

Furthermore, VR has been used to assess attention impairments in order to diagnose *Attention Deficit Disorder* (ADD). A VR classroom scenario was created, in which children had to perform attention task while being distracted by classroom noises, activities occurring outside the window, or persons passing by [92]. In a clinical trial conducted by the same research group, it was demonstrated that the system could reliably distinguish between children with ADD and healthy controls.

Another virtual environment was developed to treat people with *schizophrenia* [93]. VR scenarios can be individually tailored to simulate patients' hallucinations, such as voices or walls appearing to close in, to teach patients to ignore hallucinations in real life. But even though VR treatment might be an effective adjunct in the treatment of schizophrenics, indications for VR exposure have to be carefully pondered.

The treatment of *addiction* by means of VR seems to be a promising area as well. Similar to exposure therapy in specific phobias, repeatedly showing cues of alcohol or tobacco should lead to extinction of craving. Virtual environments presenting virtual cigarettes [94] or bottles and glasses of alcohol [95] were able to significantly decrease craving.

4. Implications for research and therapy

Hereafter, the findings presented here will be discussed with regard to their implications for research and therapy.

4.1. Research

The studies examining the efficacy of VR treatment in psychotherapy that were conducted up to that point are various with respect to their designs, treatment methods, and results. A multitude of case reports and pilot studies with questionable generalizability were published to demonstrate that VR can be an effective tool in the treatment of mental disorders. To provide a clearer overview of the studies proving the effectiveness of VR in anxiety disorders, the study designs and results of all controlled trials were listed in table 2. All controlled trials that examined the VR or AR treatment of at least one group of participants suffering from an anxiety disorder and that used a standardized outcome measure of anxiety were included. As the table shows, most RTCs have been effected in the field of aviophobia. Particularly with reference to specific phobias, considerable systematic research has been conducted in the past years. However, while the effectiveness of VR and

Study	**Clinical Sample**	***N***	**Design**	**No. sessions**	**Results**
Fear of heights					
Coelho et al. (2008)	Acrophobia	15	Between-subjects	3	VR and in vivo exposure were equally effective, despite shorter treatment times of VR
Emmelkamp et al. (2001)	Acrophobia	10	Within-subjects	2	Exposure in vivo did not lead to any significant improvements after VR exposure
Emmelkamp et al. (2002)	Acrophobia	33	RCT	3	VR and in vivo exposure were equally effective; results stable after 6 months
Krijn et al. (2004)	Acrophobia	37	RCT	3	VR administered by HMD and CAVE were equally effective; results stable after 6 months
Krijn et al. (2007)	Acrophobia	26	RCT	4	Self-statements did not additionally enhance effectiveness of VR treatment
Fear of flying					
Krijn et al. (2007)	Aviophobia	59	RCT	4	VR treatment and CBT were equally effective and superior to bibliotherapy
Malty et al. (2002)	Aviophobia	45	RCT	5	VR treatment was superior to attention placebo group on self-report measures, but not avoidance test; results not stable after 6 months
Mühlberger et al. (2001)	Aviophobia	30	RCT	1	VR treatment and relaxation training were equally effective
Mühlberger et al. (2003)	Aviophobia	45	RCT	1	VR treatment in combination with CBT was more effective than CBT alone
Mühlberger et al. (2006)	Aviophobia	30	RCT	1	Presence of a therapist did not influence effectiveness of VR treatment
Rothbaum et al. (2000)	Aviophobia	49	RCT	8	VR and in vivo exposure were equally effective in comparison to a waitlist control group; results stable after 6 and 12 months
Rothbaum et al. (2006)	Aviophobia	75	RCT	8	VR and in vivo exposure were equally effective in comparison to a waitlist control group; results stable after 6 to 12 months
Tortella-Feliu et al. (2011)	Aviophobia	60	RCT	6 max.	VR exposure, computer-aided exposure with a therapist's assistance, and self-administered computer-assisted exposure were equally effective; results stable after 12 months
Wiederhold & Wiederhold (2003)	Aviophobia	30	RCT	8	VR exposure in combination with biofeedback was more effective than VR exposure alone
Fear of spiders/ cockroaches					
Bochard et al. (2006)	Arachnophobia	11	Within-subjects	5	Modified 3D computer games were effective in the treatment of arachnophobia
Garcia-Palacios et al. (2002)	Arachnophobia		Between-subjects	4 on average	83% of the VR exposure group showed clinically significant improvement, in comparison to 0% of the waitlist control group

Study	**Clinical Sample**	***N***	**Design**	**No. sessions**	**Results**
Hoffman et al. (2003)	Arachnophobia	36	RCT	3	VR treatment including tactile stimulation was more effective than VR without tactile stimulation; both treatment groups were superior to waitlist control group
Juan et al. (2005)	Arachnophobia, cockroach phobia	9	Open trial	1	AR treatment significantly reduced participants' fear and avoidance
Michaliszyn (2010)	Arachnophobia	43	RCT	8	VR and in vivo exposure groups showed clinically significant improvement in comparison to waitlist control group
Social Phobia					
Anderson et al. (2003)	Social Phobia	10	Within-subjects	8	The combination of VR and anxiety management resulted in reduction of public speaking anxiety on self-report; stable at 3 months follow-up
Harris et al. (2002)	Fear of public speaking	14	Between-subjects	4	VR treatment reduced self-reported anxiety and physiological reactions significantly in comparison to waitlist control group
Klinger et al. (2005)	Social Phobia	36	RCT	12	VR treatment and CBT showed equally significant improvements in anxiety and avoidance behavior
Price et al. (2011)	Social Phobia	41	RCT	8	Involvement score predicted therapy outcome
Robillard et al. (2010)	Social Phobia	45	RCT	16	VR treatment and combination of CBT and VR were both effective in comparison to waitlist control group
Roy et al. (2000)	Social Phobia	10	Between-subjects	12	VR treatment and CBT equally showed significant improvements in anxiety and avoidance behavior
Wallach et al. (2009)	Fear of public speaking	88	RCT	12	CBT as well as VR and CBT combined resulted in significant improvements of self-rated anxiety and 4 out of 5 anxiety measures in contrast to waitlist control group; results stable at 12 months follow-up
OCD					
Kim et al. (2008)	OCD	63	Matched between-subjects	1	Participants with OCD experienced significantly higher anxiety, but also showed a higher decreased ratio of anxiety than healthy controls
Panic disorder					
Botella et al. (2007)	Panic disorder	37	RCT	9	CBT including VR exposure and CBT including exposure in vivo resulted in equal symptom reductions in comparison to waitlist control group; results stable at 12 months follow-up

Study	**Clinical Sample**	*N*	**Design**	**No. sessions**	**Results**
Choi et al. (2005)	Panic disorder	40	RCT	12	CBT including VR exposure and a panic disorder program were equally effective; results did not stable at 6 months follow-up
Penate et al. (2008)	Panic disorder	27	Matched between subjects	11	CBT including VR exposure and CBT including exposure in vivo were equally effective in addition to antidepressive medication
Pérez-Ara et al. (2010)	Panic disorder		Between-subjects	8 max.	Interoceptive exposure using VR and traditional interoceptive therapy equally reduced symptoms; results stable at 3 months follow-up
Pitti et al. (2008)	Panic disorder	28	Matched between-subjects	11	CBT including VR exposure and CBT including exposure in vivo were equally effective in addition to antidepressive medication
Vincelli et al. (2003)	Panic disorder	12	RCT	9	VR treatment and CBT equally reduced the number of panic attacks, the level of depression and state and trait anxiety
PTSD					
Beck et al. (2007)	subsyndromal PTSD	6	Within-subjects	10	Motor vehicle accident survivors showed significant reductions of re-experiencing, avoidance, and emotional numbing after VR treatment
Difede et al. (2006)	PTSD	17	Between-subjects	14	Survivors of 9/11 undergoing VR exposure showed significantly greater improvement on CAPS scores than waitlist control group
Difede et al. (2007)	PTSD	21	Quasi-experimental	14 max.	Survivors of 9/11 undergoing VR exposure showed significantly greater improvement on CAPS scores than waitlist control group
Gamito et al. (2010)	PTSD	10	Between-subjects	12	Portuguese war veterans in the VR condition showed significant reduction of depressive and anxiety symptoms in comparison to waitlist control group
Ready et al. (2006)	PTSD	14	Open trial	20 max.	Vietnam veterans showed significant symptom reductions at 3 and 6 months follow-up; 2 participants experienced an increase in symptoms during VR exposure
Ready et al. (2010)	PTSD	11	RCT	10	No significant differences between VR and present-centered therapy at posttreatment and 6 months follow-up in Vietnam veterans

Study	Clinical Sample	*N*	Design	No. sessions	Results
Rizzo et al. (2009)	PTSD	20	Open trial	10	Participants of "Virtual Iraq" showed clinically and statistically significant symptom reductions
Reger et al. (2011)	PTSD	24	Open trial	3-12	Significant symptom reduction in Iraq or Afghanistan active duty soldiers
Rothbaum et al. (2001)	PTSD	10	Open trial	8-16	Vietnam veterans showed significant symptom reductions on the CAPS at 6 months follow-up; self-reported intrusion symptoms were significantly lower at 3 but not at 6 months follow-up

Table 2. Overview of VR treatment outcome studies

AR exposure in treating specific phobias seems to be proven, the application of VR in more complex disorders like panic disorder, obsessive-compulsive disorder, and PTSD needs to be further evaluated. Treatment protocols in this field of research are still in an experimental phase and lack controlled studies to prove their effectiveness. In addition, the majority of studies examining the effects of VR-based treatment combines different treatment approaches and therefore makes it difficult to analyze VR outcomes separately. Future research should also work out which groups of patients benefit most from VR and how environments can be adapted to patients' needs. Additionally, comparable outcome measures such as behavioral avoidance tests should be included in future studies. Finally, sample sizes are often too small to generalize study findings and longer-term catemneses are frequently missing.

Alongside the realization of further outcome studies, future research should focus on underlying cognitive and physiological processes of VR exposure. Moreover, the role of the therapist-patient-relationship should be further investigated. Although some studies indicate that the assistance of a therapist might be reduced (e.g. [35]), the consequences of a changing role of the therapist still need to be explored. For instance, the exposure of war veterans to frightening war scenarios might impair trust towards the therapist and therefore influence treatment outcome.

4.2. Therapy

A significant number of studies has furnished evidence for the effectiveness of using VR in psychotherapy. However, if therapists decide to include VR into treatment sessions, they should act in accordance with certain guidelines in order to abet positive outcomes and minimize negative treatment effects. To date, just a few treatment manuals have been published. For example, Rothbaum et al. [95] presented an abbreviated treatment manual for exposure therapy of acrophobia. VR was used to replace conventional exposure as a component of behavioral therapy. According to the manual, treatment sessions should include symptom assessment, breathing retraining, cognitive restructuring, hyperventilation exposure and VR exposure. The authors recommend arranging VR settings as follows:

1. Sitting on plane, engines off
2. Sitting on plane, engines on
3. Taxiing
4. Takeoff
5. Smooth flight
6. Landing
7. Thunderstorm and turbulent flight

Another treatment manual was developed by Spira et al. [96]. The authors describe in detail twelve steps to treat combat-related PTDS with the aid of meditation, biofeedback, and VR.Furthermore, Bouchard et al. [98] outlined a treatment manual for VR exposure therapy of specific phobias, can be used with different VR software. In approximately eight sessions, patients are supposed to overcome their fears and stop avoidance behaviors by participating in cognitive restructuring and graduated VR exposure. In addition, guidelines to enhance the sense of presence and minimize potential negative side effects of immersion are provided. However, even though first publications are promising, more evidence-based treatment manuals focusing on specific syndromes are required in order to advance VR usage in psychotherapy.

5. Conclusion

The current state of research presented in this article furnishes considerable evidence for the effectiveness of virtual and augmented environments in the treatment of several mental disorders. However, VR treatment is not yet part of ordinary mental health care. Possible explanations for that could be:

1. *Costs:* Acquisition of VR equipment is (still) expensive, and training is needed to apply VR tools.
2. *Reservations against technology:* A myriad of therapists have reservations regarding modern technologies and therefore do not consider using them. German studies demonstrated a relatively high readiness to make use of therapy that integrates text messages or e-mails, but not VR [99, 100].
3. *Limited indications:* VR exposure might be contraindicated in patients with PTSD or co-morbid mental disorders. Despite the potential benefits of using modern technologies in psychotherapy, indications with regard to the patient and specific disorder always need to be balanced. In some cases, VR treatment might not be as efficient as conventional therapy.

On the other hand, in the case of obvious indication of VR treatment, therapists should be open with respect to embedding VR technologies into therapy. Those who apply VR in therapy should be aware that VR tools always have to be part of a broader therapy plan and only complement, but cannot replace the skills of well-trained clinicians. Advantages of VR treatment include:

1. *Cost reduction:* With further technological advancements as well as increased amounts of research on the effectiveness and applicability of VR and AR, technical and financial costs of those tools will probably be reduced [1].

2. *Lower logistic efforts:* Using VR usually reduces logistic and therefore financial costs in the long term, because no real places have to be accessed in order to expose patients to fear inducing situations.
3. *Controllability of settings:* Virtual scenes can be easily controlled and adjusted to each patient`s needs.
4. *Therapy motivation:* Use of VR might increase therapy motivation, especially in younger patients. For these reasons, integration of virtual environments into day-to-day clinical practice will hopefully be extended in the future. According to a representative survey of the German population [101], 15.7% (*n*= 375) of the respondents would "maybe" make use of VR treatment in case of suffering from a phobia, and 7.4% (*n*= 177) estimated the use of VR as "rather" or "very probable". The results indicated that persons under the age of 35 who were already familiar with modern technologies were most likely to consider VR therapy. It can therefore be concluded that a certain group of the population would take advantage of an expanded offer of VR in psychotherapy.

Author details

Christiane Eichenberg and Carolin Wolters
University of Cologne, Germany

6. References

[1] Segal R, Bhatia M, Drapeau M (2011) Therapists' Perception of Benefits and Costs of Using Virtual Reality Treatments. *Cyberpsychology, Behavior, and Social Networking 14*(1-2): 29–34.
[2] Hobbs CN, Kreiner DN, Honeycutt MW, Hinds RM, Brockman CJ (2010) The Illusion of Control in a Virtual Reality Setting. *North American Journal of Psychology, 12*(3): 551-564.
[3] Botella CM, Juan MC, Banos RM, Alcaniz M, Guillén V, Rey B (2005) Mixing realities? An application of augmented reality for the treatment of cockroach phobia. *Cyberpsychology & Behavior, 8*(2): 162-171.
[4] Eichenberg C (2011) Application of „Virtual Realities" in Psychotherapy: Possibilities, Limitations and Effectiveness. In J.-J. Kim (ed.), *Virtual reality (pp 481-496).* Rijeka: InTech.
[5] Glantz K, Rizzo A, Graap K (2003) Virtual Reality for Psychotherapy: Current Reality and Future Possibilites. *Psychotherapy: Theory, Research, Practice, Training, 40*(1/2): 55-67.
[6] Garcia-Palacios A, Hoffman HG, See SK, Tsay A, Botella C (2001) Redefining therapeutic success with virtual reality exposure therapy. *CyberPsychology & Behavior 4*: 341–8.
[7] García-Palacios A, Botella C, Hoffman H, Fabregat S. (2007) Comparing Acceptance and Refusal Rates of Virtual Reality Exposure vs. In Vivo Exposure by Patients with Specific Phobias. *CyberPsychology & Behavior 10* (5): S. 722–724.
[8] Parsons TD, Rizzo A (2008) Affective Outcomes of Virtual Reality Exposure Therapy for Anxiety and Specific Phobias: A meta-analysis. *Journal of Behavior Therapy and Experimental Psychiatry, 39:* 250-261

[9] Powers MB, Emmelkamp PMG (2008) Virtual reality exposure therapy for anxiety disorders: A metaanalysis. *Journal of anxiety disorders 22* (3): 561-569

[10] Kessler RC, Chiu WT, Demler O, Merikangas KR, Walters EE (2005) Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the national comorbidity survey replication. *Archives of General Psychiatry, 62:* 617-627

[11] Eichenberg, C. (2007). Der Einsatz von „Virtuelle Realitäten“ in der Psychotherapie: Ein Überblick zum Stand der Forschung. *Psychotherapeut, 52, 5*, 362-367.

[12] Optale G, Marin S, Pastore M, Nasta A, Pianon C. (2003) Male Sexual Dysfunctions and Multimedia Immersion Therapy (Follow-Up). *CyberPsychology & Behavior 6*(3): 289-294.

[13] American Psychiatric Association. (2000) *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.

[14] World Health Organization. (2008). *ICD-10: International statistical classification of diseases and related health problems (10th Rev. ed.)*. New York, NY: Author.

[15] Curtis, GC, Magee, WJ, Eaton, WW, Wittchen, H-U & Kessler, RC (1998) Specific fears and phobias. Epidemiology and classification. *The British Journal of Psychiatry 173:* 212-217.

[16] Rothbaum BO, Hodges LF, Kooper R, Opdyke D, Williford J, North M (1995) Virtual reality graded exposure in the treatment of acrophobie: a case report. *Behavior Therapie 26*: 547-554.

[17] Rothbaum BO (1995) Effectiveness of computer-generated (virtual reality) graded exposure in the treatment of acrophobia. *The American Journal of Psychiatry, 152* (4): 626-628.

[18] Emmelkamp P, Bruynzel M, Drost L, van der Mast C (2001) Virtual realitiy treatment in acrophobia: a comparison with exposure in vivo. *Cyberpsychologie and Behavior 3*: 335-341.

[19] Emmelkamp P, Krijn M, Hulsbosch L, de Vries S, Schuemie MJ, van der Mast C (2002) Virtual reality treatment versus exposure in vivo: a comparative evaluation in acrophobia. *Behavior Research and Therapie 4:* 509-516.

[20] Krijn M, Emmelkamp PM, Biemond R, de Wilde de Ligny C, Schuemie MJ, van der Mast CA (2004) Treatment of acrophobia in virtual reality: the role of immersion and presence. *Behav Res Ther 42*(2): 229-39.

[21] Krijn M, Emmelkamp PMG, Olafsson RP, Schuemie MJ, van der Mast CA (2007) Do self-statements enhance the effectiveness of virtual reality exposure therapy? A comparative evaluation in acrophobia. *CyberPsychol Behav 10*: 362–370.

[22] Coelho CM, Santos JA, Silva C, Wallis G, Tichon J, & Hine, TJ (2008) The role of self-motion in Acrophobia Treatment. *CyberPsychology & Behavior, 11*(6): 723-725.

[23] Coelho, CM, Silva, CF, Santos JA, Tichon J, & Wallis G (2008) Contrasting the Effectiveness and Efficiency of Virtual and Real Environments in the Treatment of Acrophobia. *PsychNology, 6*(2): 203-216.

[24] Choi YH, Jang DP, Ku JH, Shin MB, Kim SI (2001) Short-term treatment of acrophobia with virtual reality therapy (VRT): A case report. *Cyberpsychology & Behavior, 4*(3): 349-354.

[25] Wiederhold BK, Gevirtz RN, Spira JL (2001) Virtual Reality Exposure Therapy vs. Imagery Desensitization Therapy in the Treatment of Flying Phobia. In G. Riva, C.

Galimberti (Eds), *Towards CyberPsychology: Mind, Cognitions and Society in the Internet Age* (Kap. 14). Amsterdam: IOS Press.

[26] Rothbaum, BO, Hodges L., Smith S, Lee JH (2000) A controlled study of virtual reality exposure therapy for fear of flying. *J Consult Clin Psychol, 68:* 1020–1026.

[27] Rothbaum BO, Zimand E, Hodges L, Lang D, Wilson J (2006) Virtual reality exposure therapy and standard (in vivo) exposure therapy in the treatment of fear of flying. *Behav Ther 37*: 80–90.

[28] Wiederhold B, Gevirtz R, Spira J (2001) Virtual reality exposure therapy vs. imagery desensitization therapy in the treatment of flying phobia, in G. Riva, C. Galimberti (eds). *Towards CyberPsychology: Mind, Cognition, and Society in the Internet Age*. Amsterdam: IOS Press. pp 254-272.

[29] Wiederhold BK, Wiederhold MD (2003) Three year follow-up for virtual reality exposure for fear of flying. *Cyberpsychol Behav 6*: 441-445.

[30] Mühlberger A, Herman MJ, Wiedemann G, Ellgring H, Pauli P (2001) Repeated exposure off light phobics to flights in virtual reality. *Behav Res Ther 39*: 1033-1050.

[31] Mühlberger A, Widemann G, Pauli P (2003) Efficacy of a one-session virtual reality exposure treatment for fear of flying. *Psychother Res 13*: 323-336.

[32] Mühlberger A, Weik A., Pauli P, Wiedemann G (2006) One-session virtual reality exposure treatment for fear of flying: 1-Year follow-up and graduation flight accompaniment effects. *Psychotherapy Research 16*(1): 26-40.

[33] Maltby N, Kirsch I, Mayers M, Allen GJ (2002) Virtual reality exposure therapy fort he treatment of fear of flying: a controlled investigation. *J Consult Clin Psychol 70*: 1112-1118.

[34] Krijn M, Emmelkamp PMG, Olafsson RP, et al. (2007) Fear of flying treatment methods: virtual reality exposure vs. cognitive behavioral therapy. *Aviat Space Environ Med 78*: 121–128.

[35] Tortella-Feliu M, Botella C, Labres J, et al. (2011) Virtual Reality Versus Computer-Aided Exposure Treatments for Fear of Flying. *Behavior Modification 35*(1): 3-30.

[36] Garcia-Palacios A, Hoffman H, Carlin A, Furness TA III, Botella C (2002) Virtual reality in the treatment of spider phobia: A controlled study. *Behaviour Research and Therapy, 40*, 983-993.

[37] Rinck M, Kwakkenbos L, Dotsch R, Wigboldus DHJ, Becker ES (2010) Attentional and behavioural responses of spider fearfuls to virtual spiders. *Cognition & Emotion 24*(7): 1199–1206.

[38] Carlin AS, Hoffmann HG, Weghorst S (1998) Virtual reality and tactile augmentation in the treatment of spider phobia: a case study. *Behaviour Research and Therapie 35*: 153-158.

[39] Hoffmann HG, García-Palacios A, Carlin A, Furness III TA (2003). Interfaces that heal: Coupling real and virtual objects to treat spider phobia. *International Journal of human-computer interaction, 16*(2): 283-300.

[40] Michaliszyn D, Marchand A, Bouchard S, Martel M-O, Poirier-Bisson, J (2010) A randomized controlled clinical trial of in virtuo and in vivo exposure for spider phobia. *Cyberpsychology, Behavior and Social Networking 13(6):* 689-695.

[41] Bouchard S, Côté S, St-Jaques J, Robillard G, Renaud P (2006) Effectiveness of virtual reality exposure in the treatment of arachnophobia using 3D games. *Technology and Health Care 14*: 19-17.

[42] Juan MC, Alcaniz M, Monserrat C, Botella C, Banos RM, Guerrero B (2005) Using augmented reality to treat phobias. *IEEE Computer Graphics and Application 05*: 31-37.
[43] Bretón-López J, Quero S, Botella C, García-Palacios A, Banos RM, Alcaniz M (2010) An augmented reality system validation for the treatment of cockroach phobia. *Cyberpsychology, Behavior and Social Networking 13*: 705-710.
[44] Juan MC, Joele D (2011) A comparative study of the sense of presence and anxiety in an invisible marker versus a marker augmented reality system for the treatment of phobia towards small animals. *International Journal of Human-Computer Studies 69*(6): 440–453.
[45] Kessler, RC, McGonagle KA, Zhao S, et al. (1994) Lifetime and 12-month prevalence of DSM-III-R psychiatric disorders in the United States. Results from the National Comorbidity Survey. *Archives of General Psychiatry 51*: 8–19.
[46] Roy S, Klinger E, Légeron P, Lauer F, Chemin I, Nugues P (2003) Definition of a VR-Based Protocol to Treat Social Phobia. *CyberPsychology & Behavior 6*: 411-420.
[47] Klinger E, Bouchard S, Légeron P, Roy S, Lauer F, Chemin I, Nugues P (2005) Virtual Reality Therapy Versus Cognitive Behavior Therapy for Social Phobia: A Preliminary Controlled Study. *Cyberpsychology and Behavior 1*: 76-88.
[48] Robillard G, Bouchard S, Dumoulin S, Guitard T, Klinger E (2010) Using virtual humans to alleviate social anxiety: Preliminary report from a comparative outcome study. Annual *Review of CyberTherapy and Telemedicine 8*: 46-48.
[49] Harris SR, Kemmerling RL, North MM (2002) Brief Virtual Reality for Public Speaking Anxiety. *CyberPsychology & Behavior 5*(6): 543-550
[50] Anderson, Page L.; Zimand, Elana; Hodges, Larry F.; Rothbaum, Barbara O. (2005): Cognitive behavioral therapy for public-speaking anxiety using virtual reality for exposure. In: *Depress. Anxiety* 22 (3), S. 156–158.
[51] Wallach HS, Safir MP, Bar-Zvi M (2009) Virtual Reality Cognitive Behavior Therapy for Public Speaking Anxiety: A Randomized Clinical Trial. *Behavior Modification 33*(3): 314–338.
[52] Ter Heijden N, Brinkman W-P (2011) Design and evaluation of a virtual reality exposure therapy system with free speech interaction. *Journal of CyberTherapy and Rehabilitation 41*(1): 41-56.
[53] Price M, Mehta N, Tone EB, Anderson PL (2011) Does engagement with exposure yield better outcomes? Components of presence as a predictor of treatment response for virtual reality exposure therapy for social phobia. *Journal of Anxiety Disorders 25*(6): 763–770.
[54] Cornwell BR, Heller R, Biggs A, Pine DS, Grillon C (2011) Becoming the Center of Attention on Social Anxiety Disorder: Startle Reactivity to a Virtual Audience during Speech Anticipation. *J Clin Psychiatry 72*: 942-948.
[55] Grant BF, Hasin DS, Stinson FS, et al. (2006) The epidemiology of DSM-IV panic disorder and agoraphobia in the United States: results from the National Epidemiologic Survey on Alcohol and Related Conditions. *J Clin Psychiatry 67: 363–74.*
[56] Vincelli F, Choi YH, Molinari E, et al. (2001) A VR-based multicomponent treatment for panic disorders with agoraphobia. *Studies in Health Technology and Informatics 81*: 544–550.

[57] Choi YH, Vincelli F, Riva G, Wiederhold BK, Lee JH, Park KH (2005) Effects of group experiental cognitive therapy for the treatment of panic disorder with agoraphobia. *CyberPsychol Behav 8*: 387-393.

[58] Botella C, García-Palacios A, Villa H, et al (2007) Virtual reality exposure in the treatment of panic disorder and agoraphobia: a controlled study. *Clin Psychol Psychother 14*: 164-175.

[59] Penate W, Pitti CT, Bethencourt JM, de la Fuente J, Gracia R (2008) The effects of a treatment based on the use of virtual reality exposure and cognitive-behavioral therapy applied to patients with agoraphobia. *Int J Clin Health Psychol 8*: 5-22.

[60] Pitti CT, Penate W, de la Fuente J, et al. (2008) Agoraphobia: combined treatment and virtual reality. Preliminary results. *Actas Esp Psiquiatra 36*: 94-101.

[61] Pérez-Ara MA, Quero S, Botella C, Banos R, Andreu-Mateu S, García-Palacios A, Bréton-Lopez J (2010) Virtual reality interoceptive exposure for the treatment of panic disorder and agoraphobia. *Annual Review of CyberTherapy and Telemedicine 8*: 61-64.

[62] Meyerbröker K, Morina N, Kerkhof G, Emmelkamp PMG (2011) Virtual Realitiy Exposure Treatment of Agoraphobia: a Comparison of Computer Automatic Virtual Environment and Head-Mounted Display. *Annual Review of Cybertherapy and Telemedicine 9:* 51-56.

[63] Kim K; Kim C-H, Cha KR, Park J, Han K, Kim YK, et al. (2008) Anxiety Provocation and Measurement Using Virtual Reality in Patients with Obsessive-Compulsive Disorder. *CyberPsychology & Behavior* 11 (6), S. 637–641.

[64] Kim, K, Kim SI, Cha KR, Park J, Rosenthal MZ, Kim J-J, et al. (2010) Development of a computer-based behavioral assessment of checking behavior in obsessive-compulsive disorder. *Comprehensive Psychiatry 51*(1): 86–93.

[65] Kim, K, Roh D, Kim, SI, Kim C-H (2012) Provoked arrangement symptoms in obsessive–compulsive disorder using a virtual environment: A preliminary report. *Computers in Biology and Medicine 42*(4): 422–427.

[66] Redemann L (2003). Die psychodynamisch imaginative Traumatherapie (PITT). *ZPPM 1*(2): 1-8.

[67] Rothbaum BO, Hodges L, Alarcon R, et al. (1999) Virtual reality exposure therapy for PTSD Vietnam Veterans: a case study. *J. Trauma. Stress 12:* 263–271.

[68] Rothbaum BO, Hodges L, Ready D, et al. (2001) Virtual reality exposure therapy for Vietnam veterans with posttraumatic stress disorder. *J Clin Psychiatry 62*: 617-622

[69] Ready, David J.; Pollack, Stacey; Rothbaum, Barbara Olasov; Alarcon, Renato D. (2006): Virtual Reality Exposure for Veterans with Posttraumatic Stress Disorder. In: *Journal of Aggression, Maltreatment & Trauma* 12 (1-2), S. 199–220.

[70] Ready DJ, Gerardi RJ, Backschneider AG, Mascaro N, Rothbaum BO (2010). Comparing Virtual Reality Exposure Therapy to Present-Centered Therapy with U.S. Vietnam Veterans with PTSD. Cyberpsychology, Behavior and Social Networking 13(1): 49-54.

[71] Gerardi M, Rothbaum BO, Ressler K, Heekin M, Rizzo A (2008) Virtual reality exposure therapy using a virtual Iraq: Case report. *J. Traum. Stress 21*(2): 209–213.

[72] Tworus R, Szymanska S, Illnicki S (2010). A Soldier Suffering from PTSD Treated by Controlled Stress Exposition Using Virtual Reality and Behavioral Training. *Cyberpsychology, Behavior, and Social Networking 13*(1): 103-107.

[73] Rizzo AA, Reger G, Difede J, et al. (2009) Development and clinical results from the virtual Iraq exposure therapy application for PTSD. *IEEE Explore: Virtual Rehabilitation* 2009.

[74] McLay RN, Wood DP, Webb-Murphy JA, Spira JL, Wiederhold MD, Pyne JM, Wiederhold BK (2011) A Randomized, Controlled Trial of Virtual Reality-Graded Exposure Therapy for Post-Traumatic Stress Disorder in Active Duty Service Members with Combat-Related Post-Traumatic Stress Disorder. *Cyberpsychology, Behavior, and Social Networking 14*(4): 223–229.

[75] Reger GM, Holloway KM, Candy C, Rothbaum BO, Difede JA, Rizzo AA, Gahm GA (2011) Effectiveness of virtual reality exposure therapy for active duty soldiers in a military mental health clinic. *J. Traum. Stress 24*(1): 93–96.

[76] Rothbaum BO, Rizzo A, Difede J (2010) Virtual reality exposure therapy for combat-related posttraumatic stress disorder. In: *Annals of the New York Academy of Sciences 1208*(1): 126–132.

[77] Gamito P, Oliveira J, Morais D, et al. (2007) War PTSD: a VR pretrial case study. Annual *Review of Cybertherapy & Telemedicine 5*: 191–198.

[78] Gamito P, Oliveira J, Rosa P, Morais D, Duarte N, Oliveira S, Saraiva T (2010) PTSD Elderly War Veterans: A Clinical Controlled Pilot Study. *Cyberpsychology, Behavior, and Social Networking 13*(1): 43-48.

[79] Difede J, Cukor J, Patt I, Giosan C, Hoffman H. (2006) The Application of Virtual Reality to the Treatment of PTSD Following the WTC Attack. *Ann. N.Y. Acad. Sci.1071:* 500-501.

[80] Difede J, Cukor K, Jayasinghe N, Patt I, Jedel S, Spielman L, Giosan C, Hoffman HG (2007) Virtual Reality Exposure Therapy for the Treatment of Posttraumatic Stress Disorder Following September 11, 2001. *J Clin Psychiatry 68*(11): 1639-1647.

[81] Freedman SA, Hoffman HG, García-Palacios A, Weiss PL, Avitzour S, Josman N (2010) Prolonged Exposure and Virtual Reality Enhanced Imaginal Exposure for PTSD following a Terrorist Bulldozer Attack: A Case Study. *Cyberpsychology, Behavior, and Social Networking 13*(1): 95-101.

[82] Saraiva T, Gamito P, Oliveira J, Morais D, Pombal M, Gamito L, Anastácio M (2007) The use of VR exposure in the treatment of motor vehicle PTSD: A case-report. *Annual Review of CyberTherapy and Telemedicine 5:* 199-205.

[83] Beck JG, Palyo SA, Winer EH, Schwagler BE, Ang EJ (2007) Virtual Reality Exposure Therapy for PTSD Symptoms After a Road Accident: An Uncontrolled Case Series. *Behavior Therapy 38* (1): 39–48.

[84] Fidopiastis C, Hughes CE, Smith E (2009) Mixed reality for PTSD/TBI assessment. *Annual Review of CyberTherapy and Telemedicine 7*: 216-220.

[85] Riva G, Raspelli S, Algeri D, Pallavicini F, Gorini A, Wiederhold BK, Gaggioli A (2010) Interreality in Practice: Bridging Virtual and Real Worlds in the Treatment of Posttraumatic Stress Disorders. *Cyberpsychology, Behavior, and Social Networking 13*(1): 55-65.

[86] Fischer G (2000) *Mehrdimensionale Psychodynamische Traumatherapie MPTT. Manual zur Behandlung psychotraumatischer Störungen.* Heidelberg: Asanger.

[87] Riva, G. (1998) Virtual reality in psychological assessment: The Body Image Virtual Reality Scale. *Cyber Psychology and Behavior*, *1*: 37–44.

[88] Ferrer-García M, Gutiérrez-Maldonado J (2012) The use of virtual reality in the study, assessment, and treatment of body image in eating disorders and nonclinical samples. A review of the literature. *Body Image 9*(1): 1-11.

[89] Perpiná C, Botella C, Banos RM, Marco H, Alcaniz M, Quero S (1999) Body image and virtual reality in eating disorders: Is exposure to virtual reality more effective than the classical body image treatment? *CyberPsychology & Behavior, 2*: 149–159.

[90] Riva G, Bacchetta M, Baruffi M, Molinari E (2001) Virtual Reality–Based Multidimensional Therapy for the Treatment of Body Image Disturbances in Obesity: A Controlled Study. *Cyberpsychology & Behavior 4*: 511-526.

[91] Riva G, Bachetta M, Baruffi M, Molinari E (2002) Virtual-reality-based multidimensional therapy for the treatment of body image disturbances in binge eating disorders: A preliminary controlled study. *IEEE Transactions on Information Technology in Biomedicine: A Publication of the IEEE Engineering in Medicine and Biology Society, 6*: 224–234.

[92] Rizzo A, Buckwalter J, Bowerly Tvan der Zaag C, Humphrey L, Neumann U, Chua C, Kyriakakis C, van Rooyen A, & Sisemore D. (2000) The virtual classroom: A virtual reality environment for the assessment and rehabilitation of attention deficits. *CyberPsychology and Behavior 3*: 483–501.

[93] Nowak R. (2002, June 26) VR hallucinations used to treat schizophrenia. *New Scientist*. Retrieved from http://www.newscientist.com/news/news.jsp?id_ns99992459.

[94] Girard B, Turcotte V, Bouchard S, Girard B (2009) Crushing Virtual Cigarettes Reduces Tobacco Addiction and Treatment Discontinuation. *CyberPsychology & Behavior, 12*(5): 477-483.

[95] Lee J-H, Kwon H, Choi J, Yang B-H (2007) *Cue-exposure therapy to decrease alcohol craving in virtual environment*. *CyberPsychology & Behavior 10*(5): 617-623.

[96] Rothbaum BO, Hodges L, Smith S (1999) Virtual Reality Exposure Therapy Abbreviated Treatment Manual: Fear of Flying Application. *Cognitive and Behavioral Practice 6*: 234-244.

[97] Spira JL, Wiederhold BK, Pyne J, Wiederhold MD (2006). *Virtual Reality Treatment Manual. In Virtuo Physiologically-Faciliated Graded Exposure Therapy in the Treatment of Recently Developed Combat-related PTSD*. San Diego: The Virtual Reality Medical Center.

[98] Bouchard S, Robillard G, Larouche S, Loranger C (2012). *Description of a Treatment Manual for In Virtuo Exposure with Specific Phobia.* In: C. Eichenberg (ed.) (2012). Virtual Realities. Rijeka: InTech.

[99] Eichenberg, C. & Kienzle, K. (2011). Psychotherapeuten und Internet: Einstellung zu und Nutzung von therapeutischen Online-Angeboten im Behandlungsalltag. *Psychotherapeut.*

[100] Eichenberg, C. & Molitor, K. (2011). Stationäre Psychotherapie und Medien: Ergebnisse einer Befragungsstudie an Therapeuten und Patienten. *Psychotherapeut, 2,* 162-70. DOI: 10.1007/s00278-011-0833-4.

[101] Eichenberg C, Brähler E: Das Internet als Ratgeber bei psychischen Problemen: Eine bevölkerungsrepräsentative Befragung in Deutschland. *Psychotherapeut.* DOI 10.1007/s00278-012-0893-0.