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Advances in immersive virtual reality interventions for mental disorders: A new reality?

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Abstract

Immersive virtual reality (VR) has been identified as a potentially revolutionary tool for psychological interventions. This study reviews current advances in immersive VR-based therapies for mental disorders. VR has the potential to make psychiatric treatments better and more cost-effective and to make them available to a larger group of patients. However, this may require a new generation of VR therapeutic techniques that use the full potential of VR, such as embodiment, and self-led interventions. VR-based interventions are promising, but further well-designed studies are needed that use novel techniques and investigate efficacy, efficiency, and cost-effectiveness of VR interventions compared with current treatments. This will be crucial for implementation and dissemination of VR in regular clinical practice.

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Introduction

Immersive virtual reality (VR) has been identified as a potentially revolutionary tool for psychological treatment of mental disorders, which may gradually be adopted in regular clinical practice in the coming years [1]. With VR, individuals enter computer-generated simulations of real-life situations. Users can interact with the virtual surrounding, and the surrounding responds to the actions of the user in real time. VR simulations can trigger emotional, psychological, and physical reactions, such as anxiety, sweating, or joy, similar to reactions in real life [2]. This immersive characteristic of VR simulations — feeling real — makes it a powerful tool for therapy.

Early generation VR software and hardware enabled only simple simulations, mimicking real-world situations, and was mainly used for VR exposure therapy (VRET) for anxiety. However, developments have been progressing rapidly, and the potential goes far beyond using VR for exposure. With VR, activities that are impossible or infeasible in the real world can be carried out, enabling innovative strategies that could improve therapeutic interventions. Furthermore, the technology can be used for investigating mechanisms involved in the persistence of mental disorders, for example, heightened social stress reactivity in relation to psychosis liability or the role of distorted body image in eating disorders [3,4]. In this article, we aim to review recent advances and novel techniques using immersive VR-based therapies for mental disorders.

Recent VR-based intervention studies

A systematic review by Freeman et al [1] on immersive VR applications for mental health identified 154 intervention studies conducted on clinical and nonclinical populations. Clinical intervention studies have been conducted on anxiety disorders (n = 127), psychotic disorders (n = 6), substance-related disorders (n = 5), eating disorders (n = 10), and depression (n = 2) [1]. Since this review, several new studies have been reported, which will be the main focus of the current article.

Anxiety disorders

The most mature field concerns VR-based interventions that focus on anxiety disorders. Research from the first period mainly focused on VRET for specific phobias such as agoraphobia and fear of flying and heights. In the past decade, studies on VRET expanded their focus to more diverse anxiety-related disorders including social anxiety disorder, post-traumatic stress disorder, and

panic disorder with and without agoraphobia. In addition, more complex VR-based cognitive behavioral therapies (VR-CBTs) have emerged. Compared with waiting-list or placebo conditions, VRET has been shown to be very effective for anxiety [5–7]. However, a recent systematic review and meta-analysis showed that only small effects are found when comparing VR treatment with conventional treatments, indicating that treatment results are similar but not exceeding those of conventional therapies [5,7]. Although this is the most advanced field of VR interventions, to our knowledge, cost-effectiveness studies are absent.

Psychotic disorders

A systematic review by Rus-Calafell et al [8] identified eight intervention studies for psychosis. In this patient group, VR has been used as a tool for CBT, cognitive remediation, improving job interview skills and social skills [8]. Since 2018, one randomized controlled trial (RCT) (n = 116) reported VR-CBT to be effective in reducing paranoia and anxiety in daily life in patients compared with those in the waiting-list group [9], and this intervention was found to be cost-effective [10]. Furthermore, a social cognition training has been developed with different VR modules on emotion recognition, theory of mind using preprogrammed dialogs, and a social interaction module in which patients interact with avatars (controlled by the therapist by using a speech scrambler). The training was feasible and improved emotion recognition but no other facets of social cognition (n = 22) [11]. An RCT on this social cognition training is currently ongoing [12]. Furthermore, two study protocols on automated VR have been published, which are discussed in the following sections [13,14]. Another new study concerns the Danish Challenge project, a VR therapy based on 'AVATAR.' Originally, AVATAR is a digital 2D therapy (using a regular computer setup) for auditory verbal hallucinations, which was found to be effective in reducing the severity and distress of these hallucinations [15,16]. This personalized, targeted, and empowering therapy enables a 'face-to-face' dialog between the patient and an avatar matching the voice and appearance of his/her persecutory voice. In the Challenge project, patients create a 3D virtual avatar to go with the voice they hear. This voice is then controlled by the therapist through voice conversion technology. The addition of VR will increase presence, which is thought to be important for efficacy and might enhance generalization through practicing within VR environments in which the voices occur in daily life.

Substance use disorders

A 2020 systematic review showed that VR treatment has been investigated for a range of substance disorders, such as nicotine dependence, alcohol dependence, gambling disorder, and Internet gaming disorder [17]. Recent VR interventions used virtual environments for cue exposure for smoking and methamphetamine addiction [18–21], as well as approach and avoidance exercises for alcohol dependence [22,23]. Interventions using solely VRET to drug-related cues have shown heterogeneous results, and VR-CBT seems to be more promising [17,18].

Depression

No new trials have been completed since the two feasibility studies of Shah et al in 2015 [24], and Falconer et al in 2016 [25] which showed positive effects. One of these studies investigated three 1-h sessions of psychoeducation with VR-based relaxation, for which VR can be of added value as it requires less effort than traditional relaxation exercises and removes distractions [24]. Falconer et al. [25] investigated VR self-compassion exercises using the relatively novel technique of changing perspective, and this study will be further discussed in the following sections. Recently, the study protocol of an RCT was published, which aims to enhance the belief that personal attributes are adaptable instead of being fixed by use of a self-led single-session VR intervention (n = 159) [26]. The trial compares two Web-based interventions with a similar but more interactive, immersive, and fun intervention in VR.

Eating disorders

A systematic review on eating disorders showed that VR interventions mainly concern exposure to food and work on body image such as exposure to body shapes and embodiment of a healthy body [27]. The authors conclude that VR techniques may add to standard CBT as they decrease negative emotional responses to food stimuli and enable exposure to body shape. No new immersive VR intervention studies or protocols were published since 2018, except for one case study [28].

Forensic psychiatry

Recently, the first intervention study in forensic psychiatry has been published [29]. The VR aggression prevention training intervention included VR tasks on emotion recognition, de-escalation, and interactive role-playing. VR aggression prevention training did not decrease self-reported and staff-observed aggression in forensic inpatients more than in those in the waiting-list group. However, improvements in anger control skills, hostility, and impulsivity were reported.

New VR developments

The potential of immersive VR for mental health treatment is likely to be further realized by new applications and techniques that expand the therapeutic toolbox.

Automated VR treatment

One recent development involves stand-alone, self-guided, or automated VR treatments. This

development is driven by the notion that access to evidence-based psychological treatment can be challenging and waiting lists are a persistent problem [30]. Automated VR applications can make psychological therapy more readily available for many people and may also be used to increase treatment intensity, for example, by complementing face-to-face therapy with home VR exercises, or as a booster session after finishing treatment.

The first trials with stand-alone VR applications targeted specific phobias: fear of heights, fear of spiders, and speaking anxiety. Two RCTs on fear of heights reported large symptom reductions in patients after six 30-min sessions (n = 100, d = 2.0) [31] and six 5- to 40-min modules of stand-alone VR-CBT (n = 193, d = 1.1), compared with those in the waiting-list group [32]. Interestingly, in contrast to the first study that used a head-mounted display [31], Donker et al. [32] used low-cost cardboard goggles with people's own smartphones, showing that low-cost fully self-guided therapy with rudimentary VR goggles can be effective.

Furthermore, a single session of self-guided VRET for public speaking anxiety using a smartphone and Samsung Gear VR was equally effective as one session of a therapist-led treatment, with sustained effects after six months (n = 50) [33]. Similar positive results were found for a single-session gamified spider phobia therapy (n = 25, d = 1.3) [34]. In addition, an RCT (n = 100, d = 1.0) showed that automated VRET was similarly effective as in vivo therapy for spider phobia [35]. In conclusion, studies on automated interventions show very promising results for specific phobias.

A next step is currently undertaken with the development of two automated treatments for psychosis. The gameChange project aims to decrease avoidance and distress by a 6-session treatment using a virtual coach (n = 432) [14]. In the THRIVE study, patients with persistent persecutory delusions will be randomized across four 30-min sessions of automated VR cognitive treatment or VR relaxation [13]. These trials will provide the first findings on scalable automated VR therapy for patients with more complex disorders.

Embodiment

Another development is a technique that is called embodiment, body ownership, or body-swapping illusion, referring to the illusion that a virtual body is experienced as one's own body [36–38]. A person can feel embodied in a life-sized virtual body by watching the body from a first-person perspective. Often a mirror is used in the virtual surrounding so that someone can observe his/her entire virtual body. In addition, synchronous tactile stimulation and synchronous movements of the virtual body and the person's real body can reinforce the illusion of virtual body ownership even further [38].

Embodiment enables changes in self-perception and can result in changes in attitudes, cognition, and behavior through implicit learning [38]. For example, Banakou et al. [39] found that men embodied in the virtual body of old-aged Einstein showed improvements in cognitive task performance and a decrease in implicit bias against the elderly compared with participants embodied in the virtual body of a young man of their own age. This indicates that virtual body ownership could be used to improve executive functioning or to create different attitudes toward the elderly in society. Another study revealed that a group of domestic violence offenders who were embodied in a female victim during a VR abuse scenario improved on fear recognition [40]. Hence, embodiment may be used in the treatment of this specific form of aggression.

Concerning clinical treatment applications, embodiment has proven to be a promising technique for patients suffering from anorexia nervosa. Keizer et al [41] were the first to find that embodiment or body swapping was able to reduce overestimation of body size in patients. A recent case report describes the use of VR body swapping for a woman with anorexia nervosa as part of a successful multidisciplinary treatment [28]. VR body swapping with a healthy-sized body was used effectively to assess and drive changes in body size overestimation in the patient. However, the authors emphasize that repeated sessions seem needed to fully exploit VR body swapping as a therapeutic instrument.

Change of perspective

Change of perspective is another novel technique that is currently being tested. This technique enables patients to role-play with avatars and to replay the conversation afterward from the perspective of each interlocutor, or as an outsider. Patients can thus experience a virtual social scenario from multiple perspectives. This may increase understanding as people can observe and experience their behavior and interactions, which may be helpful when intervening on, for example, self-criticism, aggression, and empathy. In addition, this enables new opportunities for giving feedback. In the modular VR-SOAP (VR treatment for Improving Social Activities and Participation) treatment for people with psychosis, changing perspective is used to practice social skills (trial register: NL8741).

The techniques of embodiment and change of perspective can be combined. For example, research examined whether embodiment and perspective taking can enhance self-counseling and help participants to overcome a personal problem, by alternately switching (or body swapping) between a self-resembling avatar

(receiving therapy) and an avatar therapist resembling Sigmund Freud offering therapy. Thus, participants explained their problem to the virtual Freud and subsequently gave advice from the embodied perspective of Freud. Changes in mood and happiness were better when advice was given embodied by Freud instead of a self-resembling therapist avatar [42,43]. This finding suggests that embodied third-person perspective taking (in this case, Freud) can induce changes in thinking.

These techniques have also been used in experiments to enhance self-compassion [25,44,45]. Falconer et al [25] investigated three sessions of an 8-min immersive VR scenario in which patients with depression (n = 15) practiced giving compassion in one virtual body and then received it from themselves in another virtual body. This embodied experience led to improvements in self-compassion and depression directly after the intervention and at 4-week follow-up, indicating the clinical potential of this method.

Mechanisms of psychopathology

VR research is likely to increase the understanding of mechanisms of psychopathology and provide opportunities for improvement of psychological interventions. VR allows for controlled manipulations to an extent that was not possible before and can be used to test proposed learning mechanisms for anxiety such as deepened extinction, occasional reinforced extinction, and context variation [46]. Another example is the experimental exposure to neutral social situations in VR, as is illustrated by VR research on self-confidence and paranoia. Participants experienced more paranoid ideations in a neutral VR social environment after undergoing a manipulation to decrease self-confidence as compared with a high-confidence manipulation [47]. Furthermore, adding real-time physiological measures to VR such as heart rate variability and eye tracking holds the promise to provide insights into psychopathological processes, for example, by objectively measuring stress reactivity and dysfunctional visual attention strategies [48]. Such knowledge could be used for biofeedback and learning new gaze behavior in VR.

Challenges

Implementation in regular clinical practice has not progressed much, even for anxiety disorders [49–51]. To make the next step for implementation, it will be crucial to demonstrate the added value of VR in terms of cost-effectiveness, in terms of higher efficacy, or by treating patients who are unable to participate in conventional therapies. Newly developed intervention techniques will have to demonstrate whether these can induce stronger treatment effects than conventional therapies. Furthermore, high-quality (replication) treatment studies with active control groups are still limited for most disorders [1].

Dissemination of VR and eHealth innovations in general has proven to be tough. Several obstacles have been identified such as high costs, technical obstacles, availability, limited treatment indications, and lack of training facilities [6,52–54]. Dissemination of treatment protocols and education of health-care professionals is strongly needed. Although in the past, reservation against technology was identified as a barrier, a recent study revealed that attitudes have evolved and that psychologists generally have positive attitudes toward VR [51].

Another obstacle is software distribution. Working with (commercial) partners who can provide hands-on technical support to therapists could be crucial for widespread implementation. Another option is the use of open-source VR environments, which are starting to appear [55]. For example, Lindner et al [33] used the open-source app VirtualSpeech for speaking anxiety, and another study used the Samsung Gear VR with standard Samsung environments for VRET in patients with social anxiety [56].

Conclusions

VR has the potential to make psychiatric treatments better and more cost-effective and to make them available to a larger group of patients. However, this may require a new generation of VR therapeutic techniques that use the potential of VR that transcends the translation of conventional therapy into VR. VR enables content that is not possible in real life and automated treatments that require less therapist resources. Finally, to advance implementation, education of health-care professionals, smooth distribution, and reimbursement are strongly needed.

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