

## Virtual reality – a valuable tool to advance treatment of mental disorders

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### Summary

Human-computer interactions are a new path of treatment in mental healthcare. Virtual Reality technology is an interesting example of a digital tool that can be used in the treatment of mental disorders. It may be useful for improving personal competencies or overcoming deficits. This paper presents a range of successful VR applications in psychiatry and psychology. VR was found to be effective in the treatment of anxiety disorders, PTSD, schizophrenia, eating disorders, and substance use disorders.

Repetitiveness of virtual experience in a particular environment offered by VR technology makes it a promising option in the treatment of mental disorders. Another asset of VR is a good control of intensity of therapeutic interventions that can be regulated by a therapist. Moreover, at the VR session can be individualized for each patient and it may be adapted to his/her personal preferences and needs. VR offers sense of “being here and now” during the session. It is also an engaging method of training for patients who do not want to use the conventional training techniques.

Recently, VR use has become more available and acknowledged. However, there are still certain limitations for its broader use in the sector of mental health. The most significant one being the high cost of VR software designing, as well as VR hardware devices, which are still too expensive for mass adoption.

**virtual reality, psychotherapy, psychiatry, cyberpsychology**

### INTRODUCTION

New digital technologies are now entering all aspects of our lives. One hundred and sixty years after the nascence of Freud, we are witnessing the moment when computational science is merging with the field of psychiatry and psychotherapy. Long after the beginning of 20<sup>th</sup> century and the psychoanalytic revolution in the understanding of human behavior, and after the cognitive-behavioral approaches conquer-

ing main stream psychology in the 60's, now, in the wake of 21<sup>st</sup> century, we can observe a new trend that is already ahead of all conventional forms of treatment in mental health. It is cyberpsychology, psychology based on human-computer interaction.

Thanks to the use of certain digital devices, it is possible to introduce a human being into a selected three-dimensional environment and make him/her interact with a computer-generated world by multi-sensory channels. This technology is called Virtual Reality (VR) and it was first described in 1986 by Jaron Lamier. Although technology avenues have advanced a lot since then, the idea itself has not change. VR still involves three core dimensions, ie. 1/ The first is

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an immersion usually achieved by head mounted display.; 2/ The second one is an interaction, which is possible thanks to electronic gloves or trackers.; and 3/ The third one is a subjective “sense of presence” which refers to the awareness of physical participation in the digital created world [1].

The two most common modes of VR application are exposure-based therapy and behavioral skills training (2). VR enables doctors and psychologists to observe the patient’s behavior and interactions with virtual objects or stimuli. Depending on the training goal, it also allows them to control and modify environment. Patient’s particular experience is evoked in order to improve his/her competencies or overcome limitations. Researchers have tried to use VR in the treatment of various mental disorders. It was reported as a valuable tool for treatment of anxiety disorders, substance dependence, obesity, eating disorders, and schizophrenia (3). The aim of our review is to present most significant approaches to VR treatment and to reflect future possibilities for VR use in therapy of the mental health disorders.

### **Application of VR in the treatment of anxiety disorders**

According to the Turner and Casey’s meta-analysis of clinical trials, a majority of previous VR applications in mental health were associated with specific phobias e.g., social phobia, arachnophobia, acrophobia, aerophobia etc. [2,4]. A person suffering from a specific phobia experiences augmented amount of anxiety, related to a particular item or situational context, which results in avoidance of situations or objects that trigger it.

The traditional and widely accepted methodology of managing this problem is cognitive – behavioral therapy integrated with systematic desensitization (CBT-SD) based on the exposure in vivo or imaginal exposure.

The digital modification of this therapy is Virtual Reality Exposure Therapy (VRET). It differs from the conventional one in the manner of exposure. VRET users are directly immersed in the virtual reality world with a digital presence of a particular feared stimulus. In both techniques

a controlled exposure to specific stimuli normalizes affective regulation. The use of VRET is fast-developing and spreading fast to the clinical practice, with each month bringing several new and excellent studies and meta-analyses on the subject. A majority of studies that investigating VRET [4–6] demonstrate its effectiveness. However, comparisons of VRET and CBT-SD did not show any significant differences between the effects of the two forms of therapy [5]. An experimental study of Triscari [7] suggests the same efficacy of those two approaches. The study compared group of patients with aerophobia receiving either CBT treatment combined with SD (both in vivo exposure and imaginal exposure) or CBT fortified with VRET [7]. Linder [8] demonstrates high efficacy of both self-led (conducted at home) and therapist-led VRET in patients suffering from public speaking anxiety (PSA). Nevertheless, in his research the comparison of VRET with traditional face-to-face CBT therapy that was drawn from meta-analysis showed no significant difference in therapeutic progression. Emmelkamp’s findings demonstrate that VRET, a method that makes people experience a “sense of presence” during treatment, is an equivalent to CBT with in vivo exposure. Thus, it provides better therapeutic outcomes than CBT with imaginal exposure. A meta-analysis of 14 clinical trials of the VRET application in patients suffering from specific phobias confirmed important behavioral improvement right after VR training and also during a post-treatment assessment [9]. However, there were again no significant differences between VRET and CBT in vivo exposure. In turn, Freeman’s results [10] suggested that VRET could in fact be the more beneficial intervention. He applied VRET to patients with fear of heights (acrophobia) who were assisted and guided by virtual coach created with actor’s voice and motion capture technology. The effects of this form of treatment exceeded those of the therapist-assisted interventions and were comparable to the effects of best psychological interventions reported in a meta-analysis of researches on phobia treatments. In a meta-analysis of studies on VR therapy of anxiety disorders prepared by Fernandez-Alvarez [11] were examined post-treatment deterioration rates. Findings show very low deterioration frequency, which leads to a conclusion that there are no

harmful effects of using VR interventions in the treatment of anxiety disorder.

VRET has proved to be a promising form of treatment also in the case of patients suffering from post-traumatic stress disorder (PTSD) [6,12,13]. Findings show high effectiveness of VR approach to PTSD treatment after various traumatic events. However, it does not seem to provide better improvement than application of traditional treatment options, such as imaginal prolonged exposure, eye movement desensitization, pharmacological interventions or others. [6,12,13]. Nevertheless, the use of VRET in PTSD is widely explored and each year brings new findings. Norr *et al.* [14] showed that VRET can be more effective than conventional therapies if applied to younger populations, also independently people not taking antidepressants, group with higher hyperarousal symptoms and greater suicide risk. All this implies that the choice of type of the treatment should be personalized to each patient.

### **Application of VR in the treatment of schizophrenia**

Another mental disorder where VR therapy application has been widely explored is schizophrenia. VR technology has enriched cognitive-behavioral interventions for schizophrenia. There are many important utilizations of VR as far as assessment and treatment of schizophrenia are concerned [15], eg. One of them is assessment of positive symptoms severity in patients' daily lives. Psychotic experiences such as hallucinations or paranoid ideation can be directly reported by patients during a VR session [15]. Persecutory ideation in VR environment differs among clinical and non-clinical groups and this is why VR can facilitate assessment of patients with schizophrenia and schizophreniform disorders. Freeman *et al.* found that the delusional clinical group was 12 times more likely to report persecutory ideation during a VR session [15].

Virtual reality scenarios can be also used to observe interdependence of schizophrenic symptoms and some personal risk factors. Jongeneel *et al.* [16] aimed to manipulate the virtual environment that influenced the liability to psychosis and found a self-esteem to be a modulator of psychotic responses. They demonstrated that

negative self-esteem can lead to a deterioration in a schizophrenic symptoms after exposure to social stressors.

Another important VR implementation in the treatment of schizophrenia involves different programs of cognitive rehabilitation. People suffering from schizophrenia usually manifest different dysfunctions within attention, processing speed, learning and memory, problem solving, executive functions, and social cognitions. There is evidence that VR techniques are effective in amelioration of related neurological symptoms [17,18]. VR was also reported to be effective method of Social Skills Training (SST). SST improves patients' quality of life and it is beneficial in their day-to-day functioning. By reinforcing social and cognitive skills, both the schizophrenia symptoms and related deficits can notably decrease. When using VR-based treatment, it is possible to create virtual environment similar to patients' daily lives what makes it possible for them to practice their social performance in many dimensions. During a VR session, a patient can meet and interact with animated agents (avatars), thus work on his/her direct communication skills. Patient's activation and freedom of reactions in virtual environment creates an opportunity to gain the corrective experience. VR application appears to be successful in improving social cognition and social skills of schizophrenia patients [19]. In 2014, Rus-Calafell *et al.* used a VR treatment program based on Soskitrain scenarios treatment that included working on seven areas of social activity: emotion recognition, interpretation of expressions and intentions, expressing emotions, assertive communication, interactional and conversational skills [20]. The treatment reduced patients' social anxiety and discomfort. In addition, the training outcomes included improvement in learning emotion perception, assertive behaviors, and longer time spent in a conversation. It was found that an integrated VR program for social skills training (SOSKITRAIN) reduced negative schizophrenia symptoms [19]. What deserves special attention is the fact that VR SST in schizophrenia treatment seems to be an interesting method for patients who usually have no interest in conventional SST. Most of schizophrenia patients demonstrate little or no motivation for traditional forms of training, which greatly hinders their

progression and improvement. Hence, VR technology is especially useful in that respect as it seems to attract patients and increase their willingness to participate in SST [21].

Furthermore, the implementation of VR was found to be beneficial also in vocational rehabilitation of patients suffering from schizophrenia. In 2013, Tsang and Man [17] reported some remarkable results. They used a shopping mall scenario to practice patients' problem-solving skills and their communication with other people by playing a shop assistant role. The tasks varied from simple and easy to more elaborate ones, and patients were given a direct feedback during their performance. The results of the study revealed significantly better work performance and self-efficacy after VR training than after application of compared but more conventional non-VR trainings. The advantage of virtual reality vocational training system (VRVTS) has an asset of the potential infinite number of performance repetitions [17]. Patients can get a complex task involving multiple cognitive functions. The VR experience is similar to a real-life one, but is less demanding and stressful. What is more, patients can receive an immediate feedback and can change the level of task difficulty depending on their personal learning speed. Similar systems of vocational rehabilitation could be created for countless scenarios and job contexts. VR could thus become a valuable tool to considerably increase employability of patients suffering from schizophrenia. As an employment is an essential element of human psychological balance, due to positively affecting self-image identity and providing a sense of hope, it is also an important for improving patients' mental health and combatting the illness [17].

VR has proved in therapy of schizophrenia not only in terms of aiming cognitive or vocational rehabilitation. There are novel therapies that have recently emerged thanks to the VR technology. Percie du Sert *et al.* [22] constructed a virtual scenario enabling schizophrenic patients to interact with their auditory hallucinations. Namely, a patient can converse with a representation of his persecutory voice. It is called Avatar Therapy (AT) and it seems beneficial in terms of therapeutic targets in a relational therapy approach. Patients learn how to better reg-

ulate their negative emotions related to the voices they hear. In theory, this is also a way to practise assertiveness and strengthen personal sense of self. The results demonstrating the effectiveness of AT were replicated also in subsequent study conducted by the same research team [23]. Schizophrenia symptoms, particularly auditory verbal hallucinations and depressive mood were reduced after treatment. Nevertheless, Percie's therapy is not the only novel approach to psychosis treatment. There is an entire range of Virtual Reality Assisted Therapies dedicated to schizophrenic patients. Recently there have been attempts to implement VR-CBT interventions involving the use of avatars which match to the patients' paranoid ideations. [24]. Patients are offered a possibility to challenge their delusional suspicious thoughts by interacting with their avatars in a direct way. AT proved effective in reducing patients' feeling of anxiety and momentary paranoia, and its effects exceeded those reported in the control group treated with traditional CBT interventions.

#### **Application of VR in the treatment of eating disorders**

VR protocols were also addressed to patients with obesity and eating disorders: anorexia, bulimia nervosa, and compulsive eating disorder (ED). All these disorders share some common features: unhealthy weight-control behaviors and body image disturbance [25]. In particular, therapy can focus on regulation of eating habits or working with personal body image to convert it into positive and satisfactory one. Conventional, widely-accepted forms of treatment of eating disorders includes cognitive-behavioral interventions teaching patients how to change their patterns of thinking and behaviors. However, as all these disorders have slightly different clinical presentations, there is a need to develop efficient and comprehensive methods for their treatment. Applying VR to the therapy of ED proved to be meaningful for both, assessment and treatment [26,27].

In 1999, Perpiñá and his research team were pioneers with their findings that VR environment could be more efficient in therapy of body image (BI) disturbance, than a Standard Body

Image Treatment (SBIT), which – at that time – consisted of cognitive-behavioral techniques and relaxation [28]. Body image refers to the mental perception of one's own body. In virtual reality one can create subjectively perceived and desired body image by manipulating a virtual three-dimensional human figure, making different body parts bigger or smaller on demand [26]. The patient can notice and discuss any discrepancy between reality and his/her imagination. It is a useful tool to help the patients understand that perception of their own body is basically a relative concept.

Another reason to apply VR to correct a distorted body image is to try to make it more realistic and positive. This approach is represented by Riva [29], who based his findings on the "allocentric lock theory". The theory explains obesity and eating disorders as a consequence of an "allocentric negative body image", which is a distorted perception of one's body. It is a consequence of the feedback about one's body received from others and internalization of those opinions. What is more, the distorted self-perceptions are too firm to allow any information to update, even after evident body changes, for example significant weight loss. VR-based body-image protocol developed by Riva allows introducing changes into the personal perception of one's body. This treatment protocol involves reliving past experience in Virtual Reality with the support of a psychotherapist, and at the same time expression of feelings. This way, a user is able to recognize cognitive errors in their perception of various situations and to interpret them in a different way. They can also experience a given situation from a third person perspective and thus change the negative view concerning their bodies or any other body-related misperception they might have. Riva's comprehensive VR-based CBT treatment resulted in a significant patient improvement [29].

The treatment based on changing eating habits aims to normalize patients' disturbed eating patterns. During a VR session it is possible to uncover a trigger for abnormal eating behavior [26]. In simulated real-life situation one can observe a cue-elicited emotional response. Taking this into consideration, many researchers try to create the procedures for treating individuals suffering from eating disorders. In their work

with a patient suffering from bulimia nervosa, Ronceroa and Perpiñá introduced VR as a part of complex cognitive-behavioral treatment [30]. VR sessions were to help the patient regain control over her behaviors, plan her meals and create new, healthy eating habits, eg. eating in the same place or focusing on eating. In the second stage, the patient was exposed to image of unhealthy food and encouraged to replace unhealthy behaviors and distorted thoughts with more adequate ones. In this research, the VR proved to be an important part of treatment strategy, as it reduced bulimia's symptoms and dysfunctional behaviors, including binges, vomits, food avoidance, and fear of eating. After the treatment, the patient was more able to control impulses and scored better results on psychopathology scales. Meanwhile, the search for the right methodology of implementing VR to the treatment of ED and obesity still continues in various laboratories around the world.

#### Application of VR in the treatment of substance use disorders

Researchers are also trying to find the right way to introduce Virtual Reality techniques into therapy of substance use disorders (SUD), including drug, alcohol and nicotine dependence. The most broadly examined use of VR in SUD is connected with a treatment of nicotine dependence [4]. VR approach to the smoking cessation is based on Cue Exposure Therapy (CET). It is well known that smokers develop a connection between smoking a cigarette and diverse "cues" which include specific places, objects or people [31]. It was demonstrated that those cues can elicit an urge to smoke, called a craving, which is considered the main source of addiction itself. Thus, the presence of a particular cue can trigger a compulsive smoking behavior or can relapse in return for ex-smokers. A nicotine-dependent person usually associates smoking with social situations or daily activities that cannot be avoided. In Virtual Reality CET, a patient is repeatedly exposed to the trigger that provokes craving in order to extinguish the cue-reactivity [32]. VR environment is designed in the way that confronts the patient with his/her particular cues. It is customized to include his/her smoking-related triggers e.g. specific items,

people or situations. During a VR CET session, the patient is immersed in virtual surroundings and tries to apply previously acquired coping skills to endure exposure to cues. Virtual Reality CET proves effective in reducing craving and, in consequence, leads to higher quitting rates and lower number of cigarettes smoked daily after a treatment [31]. Some findings also suggest that VR environment can elicit better cue-induced craving than the less advanced methods, including the traditional cue exposure [33].

It seems that there is common belief among researchers that the future possibilities of VR technology can notably enhance the efficacy of substance abuse treatments, including those related to alcohol and drug dependence.

#### Application of VR in the treatment of other mental disorders

Beside the already mentioned most common and explored implementations of VR in mental health care, there are also enthusiastic attempts to apply it in the treatment of other mental dis-

orders. Some researchers try to tailor VR to the therapy of sleep or sexual dysfunctions, like premature ejaculation or impotence for instance. However, due to the relative scarcity of data, it is impossible to evaluate the effects of VR use in therapy of these disorders. Furthermore, VR was reported to be a valid method of cognitive rehabilitation, applied to help patients with some neurological problems, including dysfunctions after brain lesions, strokes or spinal cord injuries. VR has also some medical applications in physical rehabilitation.

What is more, recent studies present endeavors to use VR in all sorts of non-clinical settings, such as skill or self-development training, for example, for acquaintance of relaxation, spatial skills training, improving peripheral vision etc. It was also reported that VR approach is significantly more effective than some widely accepted standard programs for management and prevention of psychological stress [34]. These are just a few examples of potential directions and domains where adaptation of VR technology could be beneficial.

**Table 1.** Comparison of VR treatment and conventional one in mental disorders (placed at the end of document).

Mental disorder	Conventional treatment	VR application in treatment	Comparison of VR method with a conventional treatment
Specific phobia	Cognitive behavioral therapy integrated with systematic desensitization (CBT-SD)	Virtual Reality Exposure Therapy (VRET).	VRET=CBT-SD in vivo VRET>CBT-SD imaginal exposure
Schizophrenia	Assessment of presence of positive symptoms Cognitive rehabilitation Cognitive vocational training	Assessment of presence of positive symptoms in VR Cognitive rehabilitation in VR environment Virtual reality vocational training system (VRVTS)	Various data Various data VRVTS > Cognitive vocational training
Eating disorders (ED)	Cognitive changing eating habits Standard Body Image Treatment (SBIT)	Changing eating habits in VR VR Body Image Treatment (VRSBIT) VR Body Image Treatment based on "allocentric negative body image"	No significant data VRSBIT> SBIT No data
Substance use disorders (SUD)	Cue Exposure Therapy (CET)	Virtual Reality Cue Exposure Therapy (VRCET)	VRCET > CET

## DISCUSSION

The patient's full immersion that is offered by the use of virtual reality brings many advantages to therapy, and while the same effect is much more difficult to achieve with previous, traditional treatment options. Discovering a new, computer-generated world can be exciting and engaging. A variety of feasible interventions makes it possible to tailor the environment to one's particular preferences. Apparently, even patients with severe mental illnesses agree to work with VR technologies and more importantly, they consider it a very attractive treatment option and express a huge interest in experimenting with this type of help [1]. The use of a new VR technology can significantly enhance the motivation for rehabilitation in people with mental disabilities [21]. Besides, the VR enables interaction with "real-life" avatars and places. A patient becomes an active participant of a newly-constructed, virtual world. Users usually experience a "sense of presence", which refers to a psychological concept of "being here and now" and elicits subjective impression of really being inside the simulated environment. It is sometimes defined as "the feeling of being in a world that exists outside the self" [35]. VR users also have a feeling of "social presence" which means that they consider the interaction with people or animals that seem to move and exist real. The "sense of presence" can be especially important for patients with severe mental illnesses like schizophrenia [21]. They do not need to rely on their imagination, but rather they can be confronted with a new three-dimensional environment, shaped to resemble their previous experiences and are offered an opportunity to cope with difficulties they tend to encounter in their everyday lives.

What is even more important, the interaction and dynamics of stimulation in VR may be well controlled. It enables both patient-therapist and therapist-patient direct feedback. It is possible to put an experience on hold and thus prevent to go through non-therapeutic situations with errors in learning. It can be paused also to introduce other therapeutic techniques or to start a discussion, which makes treatment more comprehensive and supervised [36].

Virtual reality is not just an innovation to be used in medical services, but also a prom-

ising option for all the patient-centered forms of therapy instead of pathology-centered practice [3]. During VR experience, patients are fully involved into their therapeutic process, which seems to be crucial for the success results of each treatment. Virtual reality protocols applied to help a concrete user are based on his/her specific personal needs. The exploration of patient's preferences, thoughts and emotions makes him/her feel important and allows the active participation in the recovery process.

VR devices are becoming more and more available. In the last few years, several huge commercial companies have released into the general market some VR systems that are affordable for an individual user. An advantage of VR over traditional cognitive behavioral therapy (CBT) is that it does not always require a therapist's presence, so it can be cheaper in the long-term use. The big interest and demand for VR on the market accelerates the process of its adaptation for at-home use. It is therefore anticipated that self-guided trainings and self-assessment VR programs will soon appear on the market.

Unfortunately, it is still within the realm of dreams and expectations that future when VR interventions will be commonly available in the public mental health care sector. For the time being, the high cost of software designing hinders the popularization of this technology. The development of one particular virtual scenario costs hundreds thousands of euro, and therefore VR is currently more accessible in research centers and institutions than in the public or even private healthcare facilities. Moreover, software is still largely under construction process and is not yet good enough to be repetitive, changeable, and applicable enough to be used in the treatment of many different dysfunctions. The VR treatment frequently consists in reconstruction of one's individual experience. A VR environment designed especially for a particular individual can be considered useless when applied to a patient with slightly different experiences. Therefore, it is not a multi-contextual tool until now and it still cannot serve in widespread clinical use.

In recent years, we have witnessed a huge technological leap forward in VR techniques and utilization and we can assume that VR technologies will shortly become more flexible and will be used in daily psychological and psychiatric

practice. We can expect VR to be applied in the treatment of a wide range of dysfunctions, life strains, and crises and as well as used to enhance personal competencies and skills. The hardware that is continually more available for a general market reinforces the development of VR applications and software for specific groups of clients. The potential alternative paths to use VR interventions in mental health care seem to be limited only by the limits of human imagination. Many previous digital technologies have significantly enhanced the quality of healthcare service and now similar expectations emerge in regard to VR-assisted treatment in psychotherapy and psychiatry. VR technologies hold a promise of achieving level of treatment that is more controllable and fully client-centered. It is strongly believed that following this direction therapy of many patients will advance. The first decade of new millennium was the time of VR birth and in the recent years we have observed rapid advances, including improved graphics quality, motion tracking precision, speed, processing power and others [2]. The future may bring a full integration of modern digital possibilities into the domain of mental health care.

## REFERENCES

1. Da Costa RMEM, De Carvalho LAV. The acceptance of virtual reality devices for cognitive rehabilitation: A report of positive results with schizophrenia. *Comput Methods Programs Biomed.*, 2004; 73(3):173-82.
2. Turner WA, Casey LM. Outcomes associated with virtual reality in psychological interventions: where are we now? *Clinical Psychology Review.*; 2014; 34(8): 634-644.
3. Cipresso P [Ed], Serino S [Ed]. *Virtual reality: Technologies, medical applications and challenges.* Nova Science Publishers, Inc.
4. Freeman D, Reeve S, Robinson A, Ehlers A, Clark D, Spanlang B, et al. Virtual reality in the assessment, understanding, and treatment of mental health disorders. *Psychological Medicine*, 2017;47(14):2393-2400.
5. Maples-Keller JL, Bunnell BE, Kim S-J, Rothbaum BO. The Use of Virtual Reality Technology in the Treatment of Anxiety and Other Psychiatric Disorders. *Harv Rev Psychiatry*, 2017;25(3):103-113.
6. Maples-keller JL, Yasinski C, Manjin N, Rothbaum BO. Virtual Reality-Enhanced Extinction of Phobias and Post-Traumatic Stress, *Neurotherapeutics*, 14(3):554-563.
7. Triscari MT, Faraci P, Catalisano D, D'Angelo V, Urso V. Effectiveness of cognitive behavioral therapy integrated with systematic desensitization, cognitive behavioral therapy combined with eye movement desensitization and reprocessing therapy, and cognitive behavioral therapy combined with virtual reality expo. *Neuropsychiatr Dis Treat.*, 2015;11:2591-2598
8. Lindner P, Milo A, Fagnäs S, Andersen J, Sigeman M, Andersson G, et al. Therapist-led and self-led one-session virtual reality exposure therapy for public speaking anxiety with consumer hardware and software : A randomized controlled trial.; *Journal of Anxiety Disorders* 2018;61:45-54.
9. Morina N, Ijntema H, Meyerbröker K, Emmelkamp PMG. Can virtual reality exposure therapy gains be generalized to real-life? A meta-analysis of studies applying behavioral assessments. *Behav Res Ther.*; 2015;74:18-24.
10. Freeman D, Haselton P, Freeman J, Spanlang B, Kishore S, Albery E, et al. Automated psychological therapy using immersive virtual reality for treatment of fear of heights : a single-blind, parallel-group, randomised controlled trial.; *Lancet Psychiatry*, 2018;5(8):625-632.
11. Fernández-Álvarez J, Rozental A, Carlbring P, Colombo D, Riva G, Anderson PL, et al. Deterioration rates in Virtual Reality Therapy: An individual patient data level meta-analysis. *Journal of Anxiety Disorders*, 2019;61:3-17.
12. Botella C, Serrano B, Baños RM, Garcia-Palacios A. Virtual reality exposure-based therapy for the treatment of post-traumatic stress disorder: A review of its efficacy, the adequacy of the treatment protocol, and its acceptability. *Neuropsychiatric Disease and Treatment*, 2015;11:2533-2545.
13. Reger GM, Smolenski D, Norr A, Katz A, Buck B, Rothbaum BO. Does virtual reality increase emotional engagement during exposure for PTSD? Subjective distress during prolonged and virtual reality exposure therapy. *Journal of Anxiety Disorders*, 2018;61:75-81.
14. Norr AM, Rizzo AA, Smolenski DJ, Rothbaum BO, Reger MA, Katz AC, et al. Virtual reality exposure versus prolonged exposure for PTSD : Which treatment for whom? *Depress Anxiety*, 2018;35(6):523-529.
15. Freeman D, Pugh K, Vorontsova N, Antley A, Slater M. Testing the Continuum of Delusional Beliefs: An Experimental Study Using Virtual Reality. *J Abnorm Psychol.*, 2010;119(1):83-92.
16. Jongeneel A, Pot-kolder R, Counotte J, Gaag M Van Der, Velling W. Self-esteem moderates affective and psychotic responses to social stress in psychosis : A virtual reality study. *Schizophr Res.*, 2018;202:80-85.
17. Tsang MMY, Man DWK. A virtual reality-based vocational training system (VRVTS) for people with schizophrenia in vocational rehabilitation. *Schizophr Res.*, 2013;144(1-3):51-62.
18. Sohn BK, Hwang JY, Park SM, Choi J-S, Lee J-Y, Lee JY, et al. Developing a Virtual Reality-Based Vocational Rehabilitation Training Program for Patients with Schizophrenia. *Cyberpsychology, Behav Soc Netw.*, 2016;19(11):686-691.

19. Rus-Calafell M, Gutiérrez-Maldonado J, Ribas-Sabaté J. A virtual reality-integrated program for improving social skills in patients with schizophrenia: A pilot study. *J Behav Ther Exp Psychiatry*, 2014;45(1):81-89.
20. Kopelowicz A, Liberman RP, Zarate R. Recent advances in social skills training for schizophrenia. In: *Schizophrenia Bulletin*. 2006;32(Suppl 1):12-23.
21. Park K-M, Ku J, Choi S-H, Jang H-J, Park J-Y, Kim SI, et al. A virtual reality application in role-plays of social skills training for schizophrenia: a randomized, controlled trial. *Psychiatry Res.*, 2011;189(2):166-72.
22. Percie O, Phraxayavong K, Dellazizzo L, Potvin S, Connor KO, Dumais A. Exploration of the dialogue components in Avatar Therapy for schizophrenia patients with refractory auditory hallucinations : A content analysis., *Clin Psychol Psychother.*, 2018;25(6):878-885.
23. Percie O, Potvin S, Lipp O, Dellazizzo L, Laurelli M, Breton R, et al. Virtual reality therapy for refractory auditory verbal hallucinations in schizophrenia : A pilot clinical trial. *Schizophr Res.* pii: 2018;S0920-9964(18)30108-7
24. Kompus K. Virtual-reality-assisted therapy in patients with psychosis. *The Lancet Psychiatry*. 2018;5(3):189-191
25. PERPIÑÁ C, BOTELLA C, BAÑOS R, MARCO H, ALCAÑIZ M, QUERO S. Body Image and Virtual Reality in Eating Disorders: Is Exposure to Virtual Reality More Effective than the Classical Body Image Treatment? *CyberPsychology Behav.*, 1999;2(2):149-155.
26. Wiederhold BK, Riva G, Gutiérrez-Maldonado J. Virtual Reality in the Assessment and Treatment of Weight-Related Disorders. *Cyberpsychology, Behav Soc Netw.*,2016;19(2):67-73.
27. de Carvalho M, Dias T, Duchesne M, Nardi A, Appolinario J. (2017) Virtual Reality as a Promising Strategy in the Assessment and Treatment of Bulimia Nervosa and Binge Eating Disorder: A Systematic Review. *Behav Sci (Basel)*, 7(3)
28. Cash TF, Grant JR. Cognitive-behavioral treatment of body-image disturbances. In V. B. Van Hasselt & M. Hersen (Eds.), *Sourcebook of psychological treatment manuals for adult disorders*. New York, NY, US: Plenum Press. 1996; pp. 567-614.
29. Riva G. The key to unlocking the virtual body: Virtual reality in the treatment of obesity and eating disorders. In: *Journal of Diabetes Science and Technology*, 2011;5(2):283-292.
30. Roncero M, Perpiñá C. Normalizing the eating pattern with virtual reality for bulimia nervosa: A case report. *Rev Mex Trastor Aliment.*, 2015;6:152-159.
31. Culbertson CS, Shulenberger S, De La Garza R, Newton TF, Brody AL. Virtual reality cue exposure therapy for the treatment of tobacco dependence. *J Cybertherapy Rehabil.*, 2012;5(1):57-64.
32. Ferrer-García M, García-Rodríguez O, Pericot-Valverde I, Yoon JH, Secades-Villa R, Gutiérrez-Maldonado J. Predictors of smoking craving during virtual reality exposure. *Presence Teleoperators Virtual Environ.*, 2013;21:423-434.
33. Kuntze MF, Stoermer R, Mager R, Roessler, Mueller-Spahn F, Bullinger H. Immersive virtual environments in cue exposure. *Cyberpsychol Behav.*, 2001;4(4):497-501.
34. Gaggioli A, Pallavicini F, Morganti L, Serino S, Scaratti C, Briguglio M, et al. Experiential virtual scenarios with real-time monitoring (interreality) for the management of psychological stress: A block randomized controlled trial. *J Med Internet Res.*, 2014;16(7):e167.
35. Riva G, Waterworth J. Presence and the self: a cognitive neuroscience approach. *Presence Connect [Internet].*; 2003;3:1-14. Available from: <http://www.informatik.umu.se/~jwworth/Riva-Waterworth.htm>
36. Riva G, Mantovani F, Gaggioli A. Presence and rehabilitation: Toward second-generation virtual reality applications in neuropsychology. *Journal of NeuroEngineering and Rehabilitation.*, 2004;1(1):9.