Recent Virtual Reality Advances In Psychotherapy: A Highly Selective Review

Hadri Sid Ahmed[1] and Bouramoul Abdelkrim[2]

[1] LICUS Laboratory, University of Skikda, Skikda, Algeria
hadri.sidahmed7@gmail.com
[2] MISC Laboratory, Constantine2 University. Constantine, Algeria.
abdelkrim.bouramoul@univ-constantine.com

Abstract. Virtual reality has proved its effectiveness in cognitive and behavioral therapies, particularly exposure therapies, for a wide range of mental disorders. Whether in symptoms detection or treatment, virtual reality has been used for the past 25 years and its techniques are constantly evolving. In this article we present and analyze a state of the art of the most recent work including Virtual Reality in psychotherapy for various mental disabilities, and thus cite the strengths of each study and deduce its weaknesses and shortcomings. The aim of this article is also to look beyond what is being done today, and to navigate towards new promising fields that can be included in psychotherapy Like Machine Learning and Affective Computing that could play a very important role in the future of Cognitive and Behavioral Therapy.

Keywords: Virtual Reality · Exposure Therapy · Artificial Intelligence · Affective Computing · Cognitive and Behavioral Therapy

1   Introduction

The virtual reality exposure in psychotherapy plays a very important role in the field of psychiatry. Many studies [11], [25], [23], [17], have been pursued on the subject and several experiments have been and are being conducted for various mental disabilities. Researchers are always looking for better results. In the first part of this literary review, we explain and introduce the concepts of Cognitive and Behavioral Therapy, Exposure Therapy, Virtual Reality and Virtual Reality in Psychotherapy. In the next section, we individually present and criticize a selection of studies that we judge interesting and promising. We will then discuss these experiences in general and present the limitations found. And finally, we will propose possible perspectives.

2   Disclaimer

What is different in this literature review compared to other surveys is that we focus on the most recent studies, so we limited our search for papers to the past 3 years (2018, 2019, 2020), but also limited the number of publishers to 3 (ACM, Springer and Elsevier). We opted for these publishers because of the quality of their papers. We inform that the purpose of this article is not to give an exhaustive list of what is being done in the field, but to give an idea of the most recent studies that we consider relevant. Our selection procedure has gone through a pre-selection which consists in collecting articles according to the title, keywords and abstract. Then follows an exclusion phase after a lateral reading of the articles in question. The exclusion criteria are that Virtual reality was a secondary aspect of the study or was not really present, the discarded articles were rather about telemedicine or therapy delivered through mobile applications.

3   Studies Characteristics

We note that the topics of scientific research and innovations in psychiatry addressed during the delineated time period (2018 - 2020) were dependent on trends in recent years. These trends were mainly limited to phobias (agoraphobia, acrophobia, social phobia etc.) and child psychiatry (Autism, Attention Deficit Hyperactivity Disorder etc.). Studies on depression, obsessive-compulsive disorders for example, are rare. Despite the fact that these illnesses are as widespread as phobias for example. We judge that this may be due to the fact that these mental deficiencies are not necessarily treatable by exposure therapy.

4   Basic Concepts

4.1   Cognitive and Behavioral Therapy

Cognitive and Behavioral Therapy started in the early 70s. T. Beck, One of its pioneers, stated it as follow: "In a broad sense, any technique whose major mode

of action is the modification of faulty patterns of thinking can be regarded as cognitive therapy" -[16]. Cognitive and Behavioral Therapies (CBT) represents the application of principles from scientific psychology to clinical practice. These therapies were initially based on learning theories like classical conditioning, operative conditioning and social learning theory -[5]. Cognitive and behavioral therapy is used in the treatment of a large set of mental disorders, like phobias, depression, anxiety disorders etc. In order to achieve that, CBT consists of three consecutive concepts [20].

- Managing anxiety-provoking thoughts: which is known as cognitive therapy. The first step is to track negative thoughts, which are then examined to see if they are justified, and if possible, they are replaced by more realistic and often more positive thoughts.
- Development of social skills: It has been shown that people with social phobias become anxious because they have poor social skills. The risk of rejection is greater if the person does not know how to initiate a conversation or reject an application. Social skills training is usually conducted in groups. Behavioral and social options are discussed, demonstrated and practiced through role-playing.
- Mastering avoidance: Behavioral therapy can only be successful if avoidance is overcome. A highly effective approach is the use of exposure exercises [3]. In this case, the patient is exposed to situations that cause anxiety. Usually, the patient begins with a comfortable situation. The exercise then continues with increasing difficulty in the situation. A social phobic will exercise, for example, going to a party, having a drink in a caf. Another key element in the treatment of anxiety and phobias based on behavioral therapy is the use of relaxation exercises [4]. This reduces physical tension, making other exercises less difficult.

4.2   Exposure Therapy

Exposure therapy is a sub-method of CBT that consists in bringing the patient to face anxiety-provoking situations in order to stimulate or activate the memory structures responsible for the exaggerated behaviors towards these situations [10], and thus be able to modify them. The anxiety-provoking situations must be in conformity with the real world but with a slight incompatibility in order to favor the creation of an alternative memory [28]. The process generally goes through 3 phases: The first phase triggers an intense physiological response from the patient. In the second phase, the intensity of the patient's reactions slowly diminishes. Finally, in the last phase the reactions become very weak, and therefore there is an incompatibility with the memory structure, the links between the stimulus and the reactions are weakened.

4.3   Virtual Reality

The concepts of Virtual Reality (VR) have been around since the mid-1960s and their definition has evolved over time, Fuchs and bishop define it as real-

time interactive graphics with 3D models, combined with a display technology that gives the user the immersion in the model world and direct manipulation [13]. While Cruz Neira describes it as follow Virtual reality refers to immersive, interactive, multi-sensory, viewer-centered, 3D computer generated environments and the combination of technologies required building environments [8]. Many definitions exist for Virtual Reality and they all have 3 aspects in common: Immersion which can be simulated by stimulating senses, the number of senses depends on the type of the VR application, perception to be present in an environment, and interaction with that environment [6].

4.4   Virtual Reality Exposure Therapy

In-vivo Exposure Therapy presents some limitations in terms of feasibility due to the difficulty to reproduce some fear-provoking situations in real life. We also note that patients can find the experiences too anxiety provoking. In these cases, researchers found alternatives like using photographs, Videos combined by dictated scenarios to push the patient to imagine the situation [12], [1]. However, studies like [15] and [30], showed that indirect Exposure therapy is effective but less than in-vivo therapy. And this is where Virtual Reality Exposure Therapy played an important role, both in the ability to reproduce real life situations by simulating the environment, and for security reasons by creating a bias for patients letting them know that nothing is real. Virtual Reality Exposure Therapy VRET is the combination of Virtual Reality Technologies with Exposure Therapy Concepts. It offers a realistic, secure and under control Virtual Environment (VE). VR has proven that its a powerful tool when it comes to Exposure Therapy, and it has been used for Cognitive and Behavioral Therapies for more than 25 years. [24]

5   Advances in Virtual Reality Exposure Therapy

In this section we present most recent studies/experiments using virtual reality for treating different mental disorders.

5.1   Virtual Reality Exposure Therapy for adults

5.1.1   Virtual Reality Exposure Therapy for Phobias In the study of Daniel Freeman et al [11], Virtual Reality Exposure Therapy was used in the goal of treating fear of heights (Acrophobia). The study was conducted on 100 Adult individuals, split into 2 groups, a group performing VRET, and a control group. The VRET consisted of a virtual environment with many scenes at different difficulties. The immersed patients are guided, advised and encouraged by a virtual coach, animated using voice and video captors on a real actor. The VRET consisted of 6 sessions of 30 minutes spread into 2 to 4 weeks depending on patients. Daniel et al reported good results and a real improvement compared to the control group. The authors estimated that the results are at least as good and

even better than the usual treatments (a face to face sessions with a therapist). On the other hand, the limitations of their experiments were relying only on the established fear of heights questionnaires which are not representative of a real height situation. Also, the authors do not know precisely which elements in their VRET reduced the fear of heights.

in the study conducted by Alexander Miloff et al [25], 100 patients diagnosed suffering from arachnophobia (fear of spiders) were divided into 2 equal groups, one following a standard in-vivo One Session Treatment (OST), and the other experiencing a Virtual Reality Exposure Therapy VRET. In the VRET the patients were projected in a laboratory room, where they need to approach a spider on a table in the other corner of the room, the spider was in a glass box, and they had to follow instructions to open the box and take the spider. The experience results show that there is a significant improvement in both methods, results were evaluated in terms of behavioral avoidance and self-reported fear using Behavioral Approach Test (BAT), Fear of Spider Questionnaire (FSQ), Spider Phobia Questionnaire (SPQ), Patient Health Questionnaire (PHQ), Generalized Anxiety Disorder Assessment (GAD) and Brunnsviken Brief Quality of Life Inventory (BBQ).

In the experience of Philip Lindner et al [23], Virtual Reality was used to treat patients suffering from Public Speaking Anxiety (PSA), 50 patients were divided into 2 groups. At the first phase, one group was following a single OST session followed by 4 weeks home administrated VRET. The other group was a control group. In the second phase the group 1 ended the therapy by following 12 months of in-vivo exposure therapy, while the group 2 was administrated the same VRET and ended with the same transition. In the first phase, authors report a significant improvement in anxiety reduction for group 1 compared to group 2. In the second phase group 2 showed significant improvement while group 1 maintained or improved its results in the 6 and 12 months follow up. This experience shows the feasibility and the efficacy of an exposure therapy with a low-cost equipment from patients home however the authors reported that most of results were self-rated also there was no VRET in the in-vivo transition phase which makes the study hybrid.

In the study of Ratchadawan Nimnual [26], 20 patients diagnosed suffering from nyctophobia (fear of the dark) were conducting a VRET during 4 weeks where they were exposed to anxious situations. The VRET is decomposed into 5 levels: a hallway, a classroom, a library, an elevator, and a bathroom, with an increasing difficulty from a level to another. Authors reported that the tool has been evaluated by psychotherapists, and has been proven that it can be used to treat nyctophobia, however all results published in the authors paper concerned the application evaluation and not the patients anxiety reports.

300 patients diagnosed with Agoraphobia participated in the study of Garca-Batista et al [14]. Agoraphobia is expressed by a high level of anxiety when a person finds themselves in a situation or place where it is difficult to escape or to get help if needed. Some examples of places or situations that can trigger an anxiety attack in an agoraphobic person are crowds, means of transportation,

being alone outside [2]. The pre and post evaluation were made by the Agoraphobic Cognition Questionnaire (ACQ) and the Body Sensation Questionnaire (BSD), after the pre evaluation, a semi structured interview was made to determine the most common situations that provoke anxiety for agoraphobic people in the Dominican Republic, those situations include mostly being in enclosed places, Open or public spaces, vehicles and common places. The scenes designs were based on the results obtained. 4 Scenarios have been developed, An apartment, a building with an elevator, a park and a public transportation scenario. The authors reported that their application can be used in the evaluation and the treatment of agoraphobia, the experience is considered as a pioneer study for the Dominican Republic. No clinical results have been shown in this paper, the authors reported that clinical testing using their application will take place in the near future.

90 participants were selected in the study of Clemmensen et al [7]. The aim of the study was to compare the efficacy of Virtual Reality Exposure Therapy with In vivo exposure therapy and VR relaxation therapy, in the treatment of Social Anxiety Disorder SAD. SAD or social phobia is the fear of the critical gaze and negative judgement of others, which leads the person to feel a disabling gene during social interactions (panic, higher heart rate), pushing the person to practice a policy of avoidance [29]. The virtual environment used in their experience was build through a 360 video. 3 scenarios were performed, riding a bus, going to a school cafeteria and a job interview. the Evaluation is going to be made by the Social Interaction Anxiety Scale questionnaire (SIAS). The experiment is still in process.

5.1.2   Virtual Reality Exposure Therapy for other Mental Disorders

In the experiments of Mujgan Inozu [17], 21 participants diagnosed with Contamination Obsessive Compulsive Disorders (C-OCD) which is known as the fear of contamination. OCD is a psychopathology composed by two factors, Obsessions: which are Recurrent and persistent thoughts, urges or impulses that are intrusive and unwanted, and that in most individuals cause marked anxiety or distress. Compulsions: Repetitive behaviors (e.g., hand washing, ordering, checking) or mental acts (e.g., praying, counting, repeating words silently) that the individual feels driven to perform in response to an obsession or according to rules that must be applied rigidly [2]. The patients were evaluated following PADUA Inventory Washington State University Revision Contamination 12, Obsessions and Washing Compulsions subscale (PI-WSUR-COWCS) Questionnaire, The State-Trait Anxiety Inventory (STAI), The Disgust Scale-Revised (DS-R), Immersive Tendencies Questionnaire (ITQ) and Yale-Brown Obsessive-Compulsive Scale (Y-BOCS). The individuals were divided into an experiment and a control group. The experience consisted of two phases: A training phase where participants were able to get used to a virtual environment, and an experimental phase where participants were facing 4 scenarios which were presented in a way that increases gradually their fear of contamination. The authors reported that the anxiety increased as the degree of dirtiness in the scenarios increased. They also

reported that in the post experiment, there were significant decreases in the post-test anxiety, disgust, and urge to wash scores in the experimental group. The limitations of this study were the population size, and gender distribution (mostly females). Also, the genericity of the scenarios as reported by the authors.

5.2   Virtual Reality Exposure Therapy for Child Psychiatry

In the study conducted by Horace et al [18], VRET has been used and the aim was to help Children with Autism Spectrum Disorder (ASD) to improve their responses in daily life social interactions, and act appropriately. The authors conducted their experiences on 94 children diagnosed with ASD, aged between 7 and 10 years. The experience consisted of 6 scenarios, 1 for emotion control and relaxation, 4 for daily life situations and social interactions, and finally 1 for consolidation and generalization. Many evaluations techniques and question-naires has been used on the pre and post experiments (refer to table 1). The authors reported a significant improvement especially on affective expressions and on social reciprocity. The authors stated that the virtual reality hardware equipment used in the experience was of high cost, the training space was a Cube (half-cave) of volume 2.75m3 built out of 4 wide projection screens. A hardware that cannot be used widely. An important portion of the results analyses is not built directly from children, but built on parents answers to some questionnaires, in the pre and post experiences.

In Katharina Krsl et al study [21], the aim was to help children with Attention Deficit Hyper Activity Disorder (ADHD) to improve their daily concentration, keep their focus sustainable and under control. For this purpose, they conducted a therapy by implementing a serious game The Virtual Schoolyard. The game was decomposed in 4 modules (levels) each one with a specific goal: Response Inhibition, Focused Attention, Vigilance and Working Memory. The authors reported that the Virtual Environment (VE) was highly immersive, and opting for a serious game therapy was due to the lack of motivation of children with ADHD, and therefore, gamifying the experience helped them increase their motivation. The authors conducted the experience on 6 patients only, and the results are still preliminary and concerns the evaluation of the application. An ongoing study is using these modules to be tested on a wider sample, consisting of children suffering from ADHD to deduce the short term and long-term impact of the application on their disorder.

In the study of Maooadah Sait et al [27], A web based virtual reality system has been built for children suffering from ASD, 9 participants diagnosed with ASD aged between 4 and 12 years old have followed the program, The goal of the system was to enable children to experience real school life situation in a safe and controlled environment, The scenes and scenarios contained classrooms, school yard with virtual characters. The results reported by the authors were more concerning the system evaluation than the children behavioral evaluation.

In the study of Alice J. Lin et al [22], 20 young adults (10 males and 10 females) aged between 18 and 21 years were designated to test the efficacy of a virtual reality game on improving their general mood. The aim of the study is

to see the effect of virtual reality games on people with depression and anxiety. Depression is a mental disorder characterized by episodes of low mood (sadness) accompanied by low self-esteem and a loss of pleasure or interest in activities usually felt as enjoyable by the individual. Depression leads to an overwhelming feeling of sadness that can last for days, months or even years [19]. Pre-evaluation and post-evaluation to collect information about the general mood of the participants has been performed, the authors reported an improvement of 3.6 in mens and 3.7 in womens mood score. They also reported a correlation between time spent on playing the game and the mood improvement. However, no information about the participants mental health have been specified, we cant know if those participants were suffering from chronic depression, also the sample size was not significant and the age window was too small.

Table 1. Studies Resume

Psychiatry Type	Disorders		population	population age	number of sessions	session duration	evaluation techniques
Adult Psychiatry	phobias	Acrophobia [11]	100	≥18	6	30 minutes	(HIQ), AQ
		Arachnophobia [25]	100	≥18	/	/	
		PSA [23]	50	Mean age = 30	/	/	PRPSA, PSAS
		Nyctophobia [26]	20	18 ≥ 45	/	/	/
		Agoraphobia [14]	300	18 ≥ 75	/	/	ACQ, BSQ
		SAD [7]	90	≥18	10 with 6 months follow up	/	/
	Others	C-OCD [17]	21	Mean age = 20.5	2 to 4	25 to 45 minutes	/
		Depression [22]	20	18 ≥ 21	/	10 to 45 minutes	SIAS
Child Psychiatry	ASD [18] [27]		94	7 ≥ 10	28	/	RPM, CAST, FT, ET, ABAS
			9	4 ≥ 12	2	/	/
	ADHD [21]		6	15 ≥ 18	/	/	/

(HIQ) : Heights Interpretation Questionnaire.   (PRPSA) : Personal Report of Public Speaking Anxiety.
(RPM) : Ravens Progressive Matrices.   (PSAS) : Public Speaking Anxiety Scale.
(CAST) : Childhood Autism Spectrum Test.   (ACQ) : Agoraphobic Cognition Questionnaire .
(FT) : Face Test.   (BSQ) : Body Sensations Questionnaire.
(ET) : Eye Test.   (SIAS) : Social Interaction Anxiety Scale.
(ABAS) : Adaptive Behavior Assessment System.

6   Discussion and Studies Limitations

We saw the use of Virtual Reality in psychiatry in different ways. Virtual Reality proved its importance and showed that it has a place now and in the future of psychiatry. Exposure Therapy by Virtual Reality brings many benefits in terms of:

- Safety: Patients are in a simulated environment where nothing is real and everything can be stopped at any time.

- Control: Simulation is usually broken down into different environments (levels) with different difficulties.

- Navigability: A scene can be experienced several times, or be accelerated.

- Reproducibility: some real-life situations cannot be reproduced in an in-vivo exposure for reasons such as the specificity, or rarity of the situation to be reproduced.

We also notice that there are still many unexplored areas in this field, which certainly has enormous potential. As was pointed out in section 3, the different mental illnesseses for which studies have been carried out and using VRET are few. But the real problem that we want to address in this section is the lack of automation in past and current experiences. Even if some of the studies discussed in this article claim automatic systems but have in reality, strong human interventions during their processes. As a result, these experiences depend crucially on the supervision of an expert in relation to the technology used (Virtual Reality) and the field of application (health/mental health), the automation that is pointed out in this article has to make the experiences autonomous, and in our opinion this can only be achieved by introducing Affective Computing and Machine Learning.

Table 2. Studies Characteristics

Study	Hardware Cost	Software development Complexity	EvaluationViability	Automatism Level
Freeman et al [11]	medium	high	Low	Medium
Alexander Miloff et al [25]	Low	low	Medium	Low
Philip Lindner et al [23]	Low	Unknown	Medium	Low
Ratchadawan Nimnual [26]	Low	Low	Low	Low
Garca-Batista et al [14]	Low	Medium	Low	Medium
Mujgan Inozu [17]	Low	Low	Low	Low
Clemmensen et al [7]	Low	Medium	Unknown	Low
Horace et al [18]	High	High	Low	Medium
Katharina Krsl et al [21]	Medium	Medium	Unknown	medium
Maooadah Sait et al [27]	Low	Medium	Unknown	Low
Alice J. Lin et al [22]	Low	Medium	Low	Low

7 Future Perspectives and Introduction to Affective Computing

Affective computing is a recent multidisciplinary academic field (emerged in the late 1990s) including Computer Science, Psychology, Sociology, Linguistics and

Mathematics. The main goal is to give the machine the ability to recognize, interpret and act on the user's emotions. In order to recognize emotions, systems are equipped with hardware and software to capture signals or patterns related to each emotion, these patterns may come from one or more modalities such as facial expressions, body posture or physiological signals [9]. Affective computing could be an asset in psychiatry. By adding an intelligent touch to the tools of virtual reality exposure we could cover the current gaps which are the lack of automation. Thanks to the techniques of Affective Computing one could collect the emotions and feelings of the person during the therapy sessions, the information collected represents a feedback on the current state of the person and could be reused as an input to be able to make decisions automatically. Decisions will be made in an intelligent way thanks to a decision-making system based on Machine Learning. Affective Computing could be applied in different ways, depending on the modalities by which data is collected (voice, facial expressions, body language, physiological signals etc.). A model therefore is trained on a set of data corresponding to the chosen modality. The decisions that are taken afterwards will have an impact on the virtual environment (increase in difficulty, stopping the simulation, moving on to the next level etc.). We strongly believe that Affective Computing combined with an intelligent decision-making system can push the Virtual Reality Exposure Therapy to the next level.

References

1. Arntz, A., Tiesema, M., Kindt, M.: Treatment of ptsd: A comparison of imaginal exposure with and without imagery rescripting. Journal of behavior therapy and experimental psychiatry **38**(4), 345–370 (2007)
2. Association, A.P.: Diagnostic and statistical manual of mental disorders (DSM-5®). American Psychiatric Pub (2013)
3. Barlow, D.H., Lehman, C.L.: Advances in the psychosocial treatment of anxiety disorders: Implications for national health care. Archives of General Psychiatry **53**(8), 727–735 (1996)
4. Butler, G.: Exposure as a treatment for social phobia: Some instructive difficulties. Behaviour Research and Therapy **23**(6), 651–657 (1985)
5. Canceil, O., Cottraux, J., Falissard, B., Flament, M., Miermont, J., Swendsen, J., Teherani, M., Thurin, J.M.: Psychothérapie: trois approches évaluées. Theoretical methods and Practical Applications. Udgivet af Hoffmann fra Freie Universitat i Berlin. Oversat fra tysk. new York (2004)
6. Cipresso, P., Giglioli, I.A.C., Raya, M.A., Riva, G.: The past, present, and future of virtual and augmented reality research: a network and cluster analysis of the literature. Frontiers in psychology **9**, 2086 (2018)
7. Clemmensen, L., Bouchard, S., Rasmussen, J., Holmberg, T.T., Nielsen, J.H., Jepsen, J.R.M., Lichtenstein, M.B.: Study protocol: Exposure in virtual reality for social anxiety disorder-a randomized controlled superiority trial comparing cognitive behavioral therapy with virtual reality based exposure to cognitive behavioral therapy with in vivo exposure. Bmc Psychiatry **20**(1), 32 (2020)
8. Cruz-Neira, C.: Virtual reality overview. In: SIGGRAPH. vol. 93, pp. 1–1 (1993)

9. Daily, S.B., James, M.T., Cherry, D., Porter], J.J., Darnell, S.S., Isaac, J., Roy, T.: Chapter 9 - affective computing: Historical foundations, current applications, and future trends. In: Jeon, M. (ed.) Emotions and Affect in Human Factors and Human-Computer Interaction, pp. 213 – 231. Academic Press, San Diego (2017). https://doi.org/https://doi.org/10.1016/B978-0-12-801851-4.00009-4, http://www.sciencedirect.com/science/article/pii/B9780128018514000094

10. Foa, E.B., Kozak, M.J.: Emotional processing of fear: exposure to corrective information. Psychological bulletin **99**(1), 20 (1986)

11. Freeman, D., Haselton, P., Freeman, J., Spanlang, B., Kishore, S., Albery, E., Denne, M., Brown, P., Slater, M., Nickless, A.: Automated psychological therapy using immersive virtual reality for treatment of fear of heights: a single-blind, parallel-group, randomised controlled trial. The Lancet Psychiatry **5**(8), 625–632 (2018)

12. Frueh, B.C., Turner, S.M., Beidel, D.C.: Exposure therapy for combat-related ptsd: A critical review. Clinical Psychology Review **15**(8), 799–817 (1995)

13. Fuchs, H., Bishop, G.: Research directions in virtual environments (1992)

14. García-Batista, Z.E., Guerra-Peña, K., Alsina-Jurnet, I., Cano-Vindel, A., Martínez, S.X.H., Jiménez-Payano, D., Moretti, L.S., Medrano, L.A.: Design of virtual environments for the treatment of agoraphobia: Inclusion of culturally relevant elements for the population of the dominican republic. Computers in Human Behavior **102**, 97–102 (2020)

15. Götestam, K.G.: One session group treatment of spider phobia by direct or modelled exposure. Cognitive Behaviour Therapy **31**(1), 18–24 (2002)

16. Hoffman, N.: Foundations of cognitive therapy. Theoretical methods and Practical Applications. Udgivet af Hoffmann fra Freie Universitat i Berlin. Oversat fra tysk. new York (1984)

17. Inozu, M., Celikcan, U., Akin, B., Cicek, N.M.: The use of virtual reality (vr) exposure for reducing contamination fear and disgust: Can vr be an effective alternative exposure technique to in vivo? Journal of Obsessive-Compulsive and Related Disorders **25**, 100518 (2020)

18. Ip, H.H., Wong, S.W., Chan, D.F., Byrne, J., Li, C., Yuan, V.S., Lau, K.S., Wong, J.Y.: Enhance emotional and social adaptation skills for children with autism spectrum disorder: A virtual reality enabled approach. Computers & Education **117**, 1–15 (2018)

19. Kanter, J.W., Busch, A.M., Weeks, C.E., Landes, S.J.: The nature of clinical depression: Symptoms, syndromes, and behavior analysis. The Behavior Analyst **31**(1), 1–21 (2008)

20. Klinger, E.: Apports de la réalité virtuelle à la prise en charge de troubles cognitifs et comportementaux. Ph.D. thesis (2006)

21. Krösl, K., Felnhofer, A., Kafka, J.X., Schuster, L., Rinnerthaler, A., Wimmer, M., Kothgassner, O.D.: The virtual schoolyard: attention training in virtual reality for children with attentional disorders. In: ACM SIGGRAPH 2018 Posters, pp. 1–2 (2018)

22. Lin, A.J., Cheng, F., Chen, C.B.: Use of virtual reality games in people with depression and anxiety. In: Proceedings of the 5th International Conference on Multimedia and Image Processing. pp. 169–174 (2020)

23. Lindner, P., Miloff, A., Fagernäs, S., Andersen, J., Sigeman, M., Andersson, G., Furmark, T., Carlbring, P.: 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 **61**, 45–54 (2019)

24. Maples-Keller, J.L., Bunnell, B.E., Kim, S.J., Rothbaum, B.O.: The use of virtual reality technology in the treatment of anxiety and other psychiatric disorders. Harvard review of psychiatry **25**(3), 103 (2017)
25. Miloff, A., Lindner, P., Dafgård, P., Deak, S., Garke, M., Hamilton, W., Heinsoo, J., Kristoffersson, G., Rafi, J., Sindemark, K., et al.: Automated virtual reality exposure therapy for spider phobia vs. in-vivo one-session treatment: A randomized non-inferiority trial. Behaviour research and therapy **118**, 130–140 (2019)
26. Nimnual, R., Yossatorn, Y.: Therapeutic virtual reality for nyctophobic disorder. In: Proceedings of the 2019 3rd International Conference on Virtual and Augmented Reality Simulations. pp. 11–15 (2019)
27. Sait, M., Alattas, A., Omar, A., Almalki, S., Sharf, S., Alsaggaf, E.: Employing virtual reality techniques in environment adaptation for autistic children. Procedia Computer Science **163**, 338–344 (2019)
28. Scozzari, S., Gamberini, L.: Virtual reality as a tool for cognitive behavioral therapy: a review. In: Advanced computational intelligence paradigms in healthcare 6. Virtual reality in psychotherapy, rehabilitation, and assessment, pp. 63–108. Springer (2011)
29. Stein, M.B., Stein, D.J.: Social anxiety disorder. The lancet **371**(9618), 1115–1125 (2008)
30. Tuschen-Caffier, B., Vögele, C., Bracht, S., Hilbert, A.: Psychological responses to body shape exposure in patients with bulimia nervosa. Behaviour research and therapy **41**(5), 573–586 (2003)