Social environments and mental health

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CHAPTER 1

General introduction

Introduction

Technological developments provide new opportunities to extend, improve and innovate mental healthcare. One of such developments is immersive virtual reality (VR) [1]. With VR, individuals enter computer-generated simulations of real-like situations. For example, you can ride into the depths with a rollercoaster from your living room or stand on the Eiffel tower. Within seconds such VR simulations trigger psychological and physical reactions, such as anxiety, sweating or joy, similar to the reactions in real life [2]. This characteristic of VR simulations - feeling real - makes VR a powerful tool for assessment, therapies and experimental research in mental healthcare. In this thesis, new VR applications for psychotic and social anxiety disorders are investigated. First, some key features and characteristics of VR are presented.

Virtual Reality

VR systems have been around for more than 50 years. In 1956 the first 3D VR experience called *Sensorama* was invented by Morton Heilig [3]. The foundation for present VR systems was laid in the sixties by Ivan Sutherland who developed the head-mounted display (HMD) with a 3D view. Whereas these very first HMD VR systems were mounted in a building, extremely costly and only available for specialized laboratories, modern VR systems are now more readily available.

Modern VR systems exist of a computer generating an image, a display system presenting the visual information in 3D, and a tracker which continuously registers position and orientation of the user for real-time updating of the image (mostly ±60-90 times per second), see Fig 1. The generated images can be of three types: 360° videos, simulated VR, or a mixture of 360° videos and simulations. Generally, simulated VR is interactive. In contrast, 360° videos have limited interaction possibilities as videos are pre-recorded. Interaction entails that users can interact with the virtual surrounding and that the virtual world responds in real-time to the actions of the user. For example, a virtual character (avatar) directs her gaze at the user when he comes near, or the user can pick up and throw a virtual ball.

Presently, predominantly HMDs are used to display a VR environment in 3D. When an HMD is put on, people get quickly immersed within the virtual surroundings. Immersive means that the user has a sense of being present in the virtual surrounding. One can move throughout the virtual environment by changing the head and/or body orientation, by walking around, or by operating controllers or a joystick. Further, sounds are presented by (integrated) headphones or speakers and sometimes even scents are incorporated. More recently, hardware has been introduced for tactile sensory input. As an alternative to an HMD, a Cave Automatic Virtual Environment (CAVE) can be used. CAVEs are immersive VR environments where projectors are directed to the walls, floor, and roof of a room-sized cube. Inside the CAVE, users wear 3D glasses to see graphics in 3D generated by the CAVE. However, due to limited accessibility and high costs CAVEs are not widely used [4].

Fig 1. Example of a VR setup

1. HMD with integrated tracker;
2. controller for moving through the VR world;
3. screen, showing in 2D the VR world in which the client is located;
4. therapist interface for controlling the VR world;
5. microphone which can be used for avatar speech due to a speech transformer, and providing feedback*;
6. headphone and cover, enabling people to hear sound from the VR environment only*

**not used in this thesis*

In the past two decades, the development of VR software and hardware has been progressing extremely fast. VR systems are improving each year, with advances in graphics cards that enable handling increasingly sophisticated 3D environments [4]. Also, HMDs have improved markedly, with increased fields of view, higher-resolution images, comfortable lightweight designs, and appealing prices. These lower prices have made VR available for consumers and low budget VR systems are available for almost everyone by combining conventional smartphones with a cardboard box.

This development of VR was also reflected in a recent report by Goldman Sachs on the market value, which predicts that the VR industry will have a value of $80 billion a year by 2025 ($35 billion software and $45 billion hardware) [5]. Of this number $5.1 billion is accounted for by VR software in healthcare. Currently, VR technology is used in diverse ways in healthcare. Applications range from research, medical teaching and training (e.g., surgery training), to psychological health management (such as stress or pain management) and applications for assessment and therapies [6,7].

Psychosis and social anxiety

In this thesis, VR applications are researched for mental health, specifically for patients with a psychotic disorder or a social anxiety disorder.

Psychotic disorders

About 2-3% of the population meets the criteria for a psychotic disorder during their lifetime [8,9]. Patients with a psychotic disorder experience one or more of the following symptoms that are characteristic of psychotic disorders: delusions, hallucinations, negative symptoms, disorganized speech and grossly disorganized or catatonic behavior (see text box 1) [10]. Furthermore, affective symptoms (e.g., depression or mania), cognitive impairments and problems in social cognition can be present. Mostly, symptoms arise for the first time in adolescence or early adulthood. Psychotic episodes are caused by a combination of hereditary factors (i.e., genetic predisposition) and environmental factors (e.g., stress, drug use, viral infections, traumatic experiences, bullying, and exclusion) [11]. Psychotic disorders can have a strong impact on everyday life. Many patients experience troubles in social and

professional functioning (i.e., work or education). Their social networks are often small and fewer individuals with a psychotic disorder have a romantic relationship. Also, many patients avoid social activities which lead to more time being spent alone. Further, symptoms such as hallucinations and delusions are distressing in itself. Many patients have paranoid thoughts to some extent [12]. Often, such thoughts are strong and manifest as persecutory delusions, which are characterized by the belief that harm is occurring, or will occur, and that the persecutor has the intention to inflict harm [12]. The anxiety resulting from persecutory delusions also strongly contributes to the avoidance of social situations.

Box 1. Characteristic symptoms of psychotic disorders.

- Delusions – unfounded beliefs that are resistant to change, not shared by others, preoccupying and distressing that are held with strong conviction.
- Hallucinations – sensory perceptions in the absence of an external stimulus (e.g. hearing voices).
- Disorganized speech – e.g., frequent derailment or incoherence.
- Grossly disorganized behavior – difficulty in goal-directed behavior, disinhibition, agitation, or bizarre behavior.
- Catatonic behavior – decrease in someone's reactivity to their environment, such a stupor, mutism or motor rigidity.
- Negative symptoms – refer to an absence or lack of normal mental function, involving anhedonia (loss of experienced pleasure), apathy, avolition (decreased motivation to initiate and pursue self-directed activities) and diminished emotional expression.

Social anxiety disorder

People with a social anxiety disorder (SAD) experience extreme anxiety in social or performance situations in which they have to interact with other people and could be exposed to criticism [10]. The person fears acting in a humiliating and embarrassing way, and knows that this fear is unreasonable or excessive. Feared situations are often avoided or endured with extreme distress and anxiety. SAD mostly develops in adolescence or early adulthood [13]. The lifetime prevalence is estimated to be between 4% and 10%, with higher rates in women than men [14,15]. The generalized form of SAD is the most disabling and pervasive form [14]. People with generalized SAD experience intense anxiety in a broad range of social situations. Consequently, generalized SAD is characterized by avoidance of social situations and causes a great burden on everyday life, including impairments in everyday routines, educational and occupational functioning, social activities and relationships [14,16].

Psychological interventions

Cognitive behavioral therapy (CBT) is the most effective psychological intervention for both patients with a psychotic disorder and SAD [17–19]. CBT aims to change distressing, maladaptive behaviors and cognitions. Craske and Stein (2016) define CBT as a goal-oriented, skills-based treatment that reduces biases to interpret ambiguous stimuli as threatening, replaces avoidant and safety-seeking behaviors with approach and coping behaviors, and reduces excessive autonomic arousal through strategies such as relaxation training. CBT can include various components such as psychoeducation, behavior experiments, cognitive restructuring, challenging of negative expectancies, and exposure.

Both patients with SAD and psychotic disorders can experience a lot of distress due to perceived threat. This is reflected in safety behavior which are actions carried out with the intention to prevent or reduce perceived threat [20,21]. Examples are avoidance of public spaces, not opening the door for visitors, or keeping a close eye on people. Patients believe that the perceived threat was averted by their safety behaviors rather than concluding their threat beliefs were incorrect. Although safety behavior is relieving in the short-term, it is disabling in the long-term. E.g., not going to the grocery store as you are afraid others will hurt you causes relief at that moment, but in the long-term, this will make you dependent on others. Threat beliefs partly persist due to failures to obtain disconfirmatory evidence of these beliefs. To change such dysfunctional (safety) behavior and ideas by new experiences, CBT includes in vivo exposures and behavior experiments, imaginary, and homework exercises to learn new behavior. By doing exercises with relevant triggers, patients experience repeatedly that the feared consequence does not occur (expectation violation), which in turn can diminish symptoms [22]. VR may provide a helpful tool for CBT [23], as VR enables doing such exercises within the treatment room, and enables real-time observation of cognitions, emotions and (safety) behavior when somebody is within a feared (virtual) situation.

Mental health and VR applications

Initially, early generation VR software and hardware only made simple simulations possible. Therefore, research from this first period mainly focussed on specific phobias. The first known pilot studies on VR exposure therapy have been performed during the early 90s for treatment of fear of flying, fear of heights and agoraphobia [24,25]. After immersive VR started to become more available, research on the efficacy and acceptability of VR applications for psychiatric disorders has been continuously expanding. The use of VR as a tool for assessment, research and treatment has several advantages:

1. VR worlds provide *relevant environments* for practice and assessment. One can practice within (social) environments with which one has difficulty, e.g., a virtual mall or public transport.
2. The environment is completely *controllable*, enabling adaptation to personal needs. Herewith, amongst others, specific (pre-programmed) personal stimuli can be added to the VR environment, but it is also controllable in the way that the VR experience can be stopped at any time.
3. VR allows (immediate) *repetition* of exercises.
4. VR forms a s*afe* environment within a therapist's office, which lowers thresholds to practice new behavior [26].
5. VR can increase *motivation* as the new technology is attractive, especially to young people.
6. *Lower logistic efforts* are needed as no real places have to be accessed e.g., for exposure.
7. Enables *real-time* observation and measuring of mental and physiological states, and feedback can be provided immediately.

A recent systematic review by Freeman and colleagues (2017) on immersive VR applications for mental health identified in total 285 studies in clinical and non-clinical populations: 86 on assessment, 154 on interventions, and 45 on theory development [27]. Most studies were done on anxiety disorders (n = 192) and psychotic disorders (n = 44), followed by substance-related (n = 22) and eating disorders (n = 18). Though the number of studies was large, the authors argue that the quality of many treatment studies was rather low, i.e., small in sample sizes, rarely trials being pre-registered, and rarely conducted according to current research standards [27].

VR research in psychotic disorders has concerned several different fields: safety and acceptability, evaluation of neurocognition, performance and functional capacity, symptom assessment (mainly paranoia), and interventions. VR was found to be safe for people with a psychotic disorder and a promising method for assessing symptoms and neurocognitive deficits within ecologically valid environments [27,28]. Concerning treatment, a systematic review by Rus-Calafell and colleagues (2018) identified eight intervention studies. VR was used as a tool for the following interventions: CBT, cognitive remediation, improving job interview skills and social skills. The authors conclude that VR mediated interventions have the potential to facilitate learning new emotional and behavioral responses and that preliminary findings suggest that VR is promising for several interventions [28].

For SAD, 90% of the VR studies with patients concern treatment studies [27]. Interventions entailed VR exposure therapy or VR based CBT. Compared to waiting list or placebo conditions, VR based treatment was very effective. However, only small effects are found when comparing VR treatment to conventional treatments, indicating that treatment results are similar but not exceeding conventional therapies [6,29,30].

Challenges

Even though VR is a promising method for research and treatment of psychiatric disorders, and some impressive work has been done, much work remains [27,28]. In many respects, VR is still at the beginning. We still know little about how psychological problems exactly manifest within VR environments, and how mechanisms of disorders can be investigated with VR. Further, VR has not reached its full potential yet. For example, having a conversation with avatars has been possible only recently, as only pre-recorded interactions were possible for a long time which limited having complex social interactions. Further, the use of physiological measurements in VR applications - such as heart rate variability and skin conductance, which could provide objective measures of distress - is still limited.

Research has provided clear strengths and advantages of VR, however, there are also important limitations to the available evidence [27,31]. First, many VR studies have been conducted with small sample sizes. Second, though the ecological validity of VR has been shown, as VR induces similar psychological and physiological responses as the real world [32], evidence of generalization of assessment and treatment studies to daily life is still limited [28]. Third, often stimuli are used for which validation is still lacking; for example, avatars

are used for social interactions, though the quality in terms of visual looks, emotions, and interaction skills of these avatars is often unknown. Fourth, most intervention studies have been performed with specific VR applications for difficulties such as specific phobias. Also, possibilities to adapt the VR environment are often restricted, which prohibits a broad use of these applications. In contrast, more complex disorders – such as generalized SAD and psychotic disorders – will need different kinds of VR environments that can be personalized and are not confined to one environment to enhance generalization. Importantly, as a result of all aforementioned limitations, actual implementation and use of VR based therapeutic interventions is limited [29].

Aims

With the research described in this thesis, we aimed to expand knowledge on the field of VR and mental health by performing studies on the understanding, assessment and treatment of mental health disorders. First, a VR paradigm was used to increase understanding of social behavior in terms of interpersonal distance behavior in people with different psychosis liability. With a VR paradigm, interpersonal distance can be measured implicitly within a social environment, without the participant knowing that it is of interest and being measured. Next, we designed a VR emotion recognition task that can be used for diagnostic assessments as well as a training module [33,34]. This VR emotion recognition task also provides more insights into the (ecological) validity of virtual facial stimuli. The virtual characters used in this research are commercially available and are starting to get more widely used in scientific studies and interventions in the Netherlands [35]. However, no research on the validity of emotions displayed by the avatars has been performed yet.

To take the next step in the field of VR interventions, we developed a VR based CBT intervention (VR-CBT). We tested VR-CBT in both patients with a psychotic disorder (randomized controlled trial) and patients with generalized anxiety (uncontrolled pilot study). To gain more insight into the effects of VR-CBT in everyday life we combined classic outcome measures, such as interviews and questionnaires, with the experience sampling method (ESM). ESM is a structured diary method that assesses mental states, thoughts, activities and the appraisal hereof within the moment. This prevents recall biases and enables studying effects in the flow of everyday life. Finally, putative working mechanisms of VR-CBT were investigated using ESM. We examined whether treatment with VR-CBT influences momentary affective states as measured with ESM and whether VR-CBT changes the dynamic interplay between paranoia and affective states with network analysis.

Outline of the thesis

The main goal of this thesis is to increase our knowledge of the potential of VR for mental healthcare. This was done both by doing experimental assessment research (chapters 2-3) and by investigating the effects of a novel VR-CBT intervention (chapter 4-6).

In **Chapter 2** we discuss the association between social stress induced in a virtual environment and social behavior in terms of interpersonal distance. Further, the influence of psychosis liability and clinical characteristics on interpersonal distance was explored. **Chapter 3** explores a novel VR emotion recognition task in a healthy population sample. This was achieved by comparing the VR task to two conventional tasks, studying the relationship with sociodemographic factors, and by studying visual attention during the VR task. **Chapter 4** examines the effectiveness of VR-CBT for paranoia and social participation in patients with a psychotic disorder. In **Chapter 5** we extend the findings of chapter 4, by zooming in on the effects of VR-CBT with data collected by extensive diary assessment which measured mental states in the flow of daily life. Effects of paranoid, negative and positive mental states are studied, as well as the interplay between mental states. In **Chapter 6** the potential of VR-CBT is further examined by studying the feasibility and treatment potential of VR-CBT in patients with a generalized social anxiety disorder. **Chapter 7** discusses the most important findings of this thesis as well as their implications and limitations. Finally, directions for future research are discussed.

References

1. Castelvecchi D. Low-cost headsets boost virtual reality's lab appeal. Nature. 2016;533(7602):153-154. doi:10.1038/533153a

2. Martens MA, Antley A, Freeman D, Slater M, Harrison PJ, Tunbridge EM. It feels real: physiological responses to a stressful virtual reality environment and its impact on working memory. J Psychopharmacol. 2019;33(10):1264-1273. doi:10.1177/0269881119860156

3. Heilig M. Sensorama simulator. 1962.

4. Jerdan SW, Grindle M, van Woerden HC, Kamel Boulos MN. Head-Mounted Virtual Reality and Mental Health: Critical Review of Current Research. JMIR Serious Games. 2018;6(3):1-12. doi:10.2196/games.9226

5. Goldman Sachs Global Investman Research. Virtual & Augmented Reality. New York; 2016.

6. Valmaggia LR, Latif L, Kempton MJ, Rus-Calafell M. Virtual reality in the psychological treatment for mental health problems: An systematic review of recent evidence. Psychiatry Res. 2016;236:189-195. doi:10.1016/j.psychres.2016.01.015

7. Slater M, Sanchez-Vives M V. Enhancing Our Lives with Immersive Virtual Reality. Front Robot AI. 2016;3(74):1-47. doi:10.3389/frobt.2016.00074

8. GGZ Standaarden. Samenvattingskaart Zorgstandaard Psychose.; 2017.

9. Perälä J, Suvisaari J, Saarni SI, et al. Lifetime Prevalence of Psychotic and Bipolar I Disorders in a General Population. Arch Gen Psychiatry. 2007;64(1):19-28. doi:10.1001/archpsyc.64.1.19

10. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders (5th Ed.).; 2013. doi:10.1176/appi.books.9780890425596.744053

11. van Os J, Kapur S. Schizophrenia. Lancet. 2009;374(9690):635-645. doi:10.1016/S0140-6736(09)60995-8

12. Freeman D. Suspicious minds: The psychology of persecutory delusions. Clin Psychol Rev. 2007;27(4):425-457. doi:10.1016/j.cpr.2006.10.004

13. Kessler RC, Ruscio AM, Shear K, Wittchen H-U. Epidemiology of Anxiety Disorders. In: Stein M, Steckler T, eds. Behavioral Neurobiology of Anxiety and Its Treatment. Current Topics in Behavioral Neurosciences. 2nd ed. Berlin, Heidelberg: Springer; 2009:21-35. doi:10.1007/7854_2009_9

14. Stein MB, Stein DJ. Social anxiety disorder. Lancet. 2008;371(9618):1115-1125. doi:10.1016/S0140-6736(08)60488-2

15. Baxter AJ, Scott KM, Vos T, Whiteford HA. Global prevalence of anxiety disorders: a systematic review and meta-regression. Psychol Med. 2013;43(5):897-910. doi:10.1017/S003329171200147X

16. Katzelnick DJ, Kobak KA, Deleire T, et al. Impact of generalized social anxiety disorder in managed care. Am J Psychiatry. 2001;158(12):1999-2007. doi:10.1176/appi.ajp.158.12.1999

17. Turner D, van der Gaag M, Karyotaki E, Cuijpers P. Psychological Interventions for Psychosis: A Meta-Analysis of Comparative Outcome Studies David. Am J Psychiatry. 2014;(171):523-538. doi:10.1002/14651858.CD009533

18. Mayo-Wilson E, Dias S, Mavranezouli I, et al. Psychological and pharmacological interventions for social anxiety disorder in adults: a systematic review and network meta-analysis. The Lancet Psychiatry. 2014;1(5):368-376. doi:10.1016/S2215-0366(14)70329-3

19. Craske MG, Stein MB. Anxiety. Lancet. 2016;388(10063):3048-3059. doi:10.1016/S0140-6736(16)30381-6

20. Freeman D, Garety PA, Kuipers E, Fowler D, Bebbington PE, Dunn G. Acting on persecutory delusions: The importance of safety seeking. Behav Res Ther. 2007;45(1):89-99. doi:10.1016/j.brat.2006.01.014

21. Salkovskis PM. The Importance of Behaviour in the Maintenance of Anxiety and Panic: A Cognitive Account. Behav Psychother. 1991;19(1):6-19. doi:10.1017/S0141347300011472

22. Craske MG, Treanor M, Conway CC, Zbozinek T, Vervliet B. Maximizing exposure therapy: An inhibitory learning approach. Behav Res Ther. 2014;58:10-23. doi:10.1016/j.brat.2014.04.006

23. Gorini A, Riva G. Virtual reality in anxiety disorders: the past and the future. Expert Rev Neurother. 2008;8(2):215-233. doi:10.1586/14737175.8.2.215

24. North M, North S. Virtual environment and psychological disorders. Electron J Virtual Cult. 1994;2(4):37-42.

25. North M, SM N, JR C. Virtual Reality Therapy, an Innovative Paradigm. Vienna, Austria: IPI Press; 1996.

26. Garcia-Palacios A, Botella C, Hoffman H, Fabregat S. Comparing Acceptance and Refusal Rates of Virtual Reality Exposure vs. In Vivo Exposure by Patients with Specific Phobias. CyberPsychology Behav. 2007;10(5):722-724. doi:10.1089/cpb.2007.9962

27. Freeman D, Reeve S, Robinson A, et al. Virtual reality in the assessment, understanding, and treatment of mental health disorders. Psychol Med. 2017;47(14):2393-2400. doi:10.1017/S003329171700040X

28. Rus-Calafell M, Garety P, Sason E, Craig TJK, Valmaggia LR. Virtual reality in the assessment and treatment of psychosis: a systematic review of its utility, acceptability and effectiveness. Psychol Med. 2018;48(3):362-391. doi:10.1017/S0033291717001945

29. Eichenberg C, Wolters C. Virtual Realities in the Treatment of Mental Disorders: A Review of the Current State of Research. In: Virtual Reality in Psychological, Medical and Pedagogical Applications. InTech; 2012:35-64. doi:10.5772/50094

30. Carl E, Stein AT, Levihn-Coon A, et al. Virtual reality exposure therapy for anxiety and related disorders: A meta-analysis of randomized controlled trials. J Anxiety Disord. 2019;61:27-36. doi:10.1016/j.janxdis.2018.08.003

31. Botella C, Quero S, Baños RM, Perpiñá C. Virtual Reality and Psychotherapy. In: Riva G, Botella C, Legeron P, Optale G, eds. Cybertherapy. Vol 99. Amsterdam: IOS Press; 2004.

32. van Bennekom MJ, de Koning PP, Denys D. Virtual Reality Objectifies the Diagnosis of Psychiatric Disorders: A Literature Review. Front Psychiatry. 2017;8(163):1-7. doi:10.3389/fpsyt.2017.00163

33. Nijman SA, Veling W, Greaves-Lord K, et al. Dynamic Interactive Social Cognition Training in Virtual Reality (DiSCoVR) for social cognition and social functioning in people with a psychotic disorder: study protocol for a multicenter randomized controlled trial. BMC Psychiatry. 2019;19(272):1-11. doi:10.1186/s12888-019-2250-0

34. Klein Tuente S, Bogaerts S, van IJzendoorn S, Veling W. Effect of virtual reality aggression prevention training for forensic psychiatric patients (VRAPT) : study protocol of a multi-center RCT. BMC Psychiatry. 2018;18(251):1-9. doi:10.1186/s12888-018-1830-8

35. CleVR B.V. www.clevr.net.