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VIRTUAL REALITY INTERVENTION FOR PSYCHOTIC DISORDERS USING 360-DEGREE VIDEO TECHNOLOGY – DEVELOPMENT AND INITIAL PILOT FOR FEASIBILITY

ABSTRACT

Virtual reality technologies have been utilized in the treatment of psychiatric disorders by offering means to practice challenging situations in a safe environment. In this narrative description, we illustrate the development of a virtual reality-based intervention rationale to treat paranoid ideations of individuals with psychotic disorders with immersive 360-degree video material. Using 360-videos with a head-mounted display was judged as an interesting and flexible low-tech solution compared to other solutions. 360-degree videos were filmed with a head-mounted camera, simulating everyday social situations which people with paranoid delusions often find threatening. These situations were chosen by a team consisting of clinicians and an expert by experience and included commuting, grocery shopping as well as walking in a crowded street or a dark alley. Five weekly sessions with a clinician were included in the treatment protocol, following a treatment manual and individualized case formulation. The patients were exposed to the simulations using a virtual reality headset. The goals of the pilot were to evaluate the feasibility of 360-degree videos as an immersive technology and the rationale for using this technology in an exposure-based psychotherapeutic treatment, as well as to create a detailed description of the development and materials for treatment for others to follow and use. The intervention was found feasible by the clinicians and was positively received by the first pilot patients. The only observed disadvantage was nausea and dizziness caused by specific video clips. 360-degree videos were deemed suitable as a material for exposure. As far as we know, 360-degree video technology has not been previously evaluated in the context of psychotic disorders. The utility of this technology and the content created in the treatment of paranoid ideation appears promising. Based on this pilot, creating a virtual reality intervention based on exposure for psychotic disorders is possible without excessive resources and without any specific technical know-how with 360-degree videos. Developing novel forms of treatment using low technology solutions, which are easy to pilot in a day-to-day clinical environment, may bridge the gap between controlled studies and standard practice. The process of development and implementation is carefully laid out so this paper can be used as a guide for the development of similar protocols.

KEYWORDS: SCHIZOPHRENIA, PSYCHOTIC DISORDERS, PSYCHOTHERAPY, EXPOSURE, VIRTUAL REALITY

BACKGROUND

Digital health technologies are an economically viable way to assess, monitor and treat psychiatric disorders and improve access to care [1,2,3]. One of the most promising and versatile forms of technology is virtual reality (VR), and its role in psychiatry is constantly increasing [4,5]. VR as a treatment paradigm is being studied and implemented in numerous psychiatric disorders, including anxiety disorders [6,7], specific phobias [8], post-traumatic stress disorder [9] and depression [10]. VR-based treatments have also been used to improve emotion recognition skills [11], social information processing [12] and aggression management [13]. Exposure to stressful situations in a VR environment aims to improve various skills, to decrease distress related to the corresponding real-life situations and to lower the threshold of going to these situations in vivo. Bridging VR environments and real life, and transferring what has been practiced in the clinical setting with the help of a trained clinician to one's own routines, is a central goal of any VR treatment [14].

VR-based interventions have also been utilized in the assessment and treatment of psychotic disorders, including cognitive symptoms (e.g., deficits in learning, attention and executive functions) [15], hallucinations [16,17] and delusional thinking [18,19]. Simulated environments can be used to reduce paranoid symptoms and negative affect in daily life, alleviate distress caused by paranoid ideation and persecutory delusions and to reduce paranoid conviction [20,21]. In some cases, VR-assisted therapy has been associated with somewhat better treatment results compared to conventional CBT when treating psychotic disorders [22,23,24], and automated versions of VR-based psychological therapy are being developed and studied for patients with persecutory delusions [25]. As individuals with psychotic disorders often experience difficulties in verbalizing internal experiences [26], conventional psychotherapy might not be the optimal and most motivating treatment approach for many, due to its focus on verbal communication and naming or describing emotions and internal states. VR solutions may shift treatment towards a more functional approach and help to increase level of motivation for the treatment of patients with such deficits [27].

VR simulations can be created with software development or by filming 360-degree video footage. Previously, it has been reported that 360-videos might be an affordable and easy way to implement an alternative to programmed VR environments when treating social anxiety, and that 360-videos also include the sense of presence that might trigger anxiety [28]. Furthermore, study protocols to use 360-videos to treat social anxiety have been developed and some initial results of their positive impact in treating social anxiety have been reported [29,30]. However, we are not aware of earlier use of 360-videos in treating psychotic disorders.

In this paper, we present a VR pilot project of the development of suitable 360-videos and utilizing them as material for exposure with individuals suffering from a psychotic disorder and paranoid ideation. Paranoid ideation is common in individuals with a psychotic disorder and often remains in the form of anxiety and various safety behaviours even with successful medication [31]. Possible therapeutic effects of VR simulations in treating paranoid ideation include changes in theory of mind and social cognition, as deficits in them may lead to misunderstandings and misinterpretations in social situations [32,33,34]. Furthermore, it has been proposed that VR-assisted therapy may become a preferred psychological treatment for delusions and social anxiety in this patient cohort [35]. The aim is to present novel tools and technical considerations, which minimize the amount of funds, to augment previous understanding required to successfully build a VR intervention. We focus on the feasibility of 360-videos as a technical solution and the rationale of utilizing them in the context of exposure-based therapy. Patient experiences are discussed briefly and on a general level and clinician experiences in more detail.

METHODS

The potential of different VR applications in the treatment of psychotic disorders were recognized by the Division of Psychoses and Forensic Psychiatry in Helsinki University Hospital (HUS). A multidisciplinary team was formed to further analyse the current literature and to organize a project with a goal to develop and implement a VR-based treatment for patients with psychotic symptoms and social phobia. The team consisted of professionals from the fields of psychiatry, clinical psychology, psychotherapy, clinical research, and included an expert by experience to broaden the viewpoints of the team from the patients' perspective. The project focused on examining the suitability of the developed treatment as well as VR in general as a new paradigm for treating patients with psychotic disorders in Finland. In addition, different hardware and software options for routine practice were mapped. The project was performed in collaboration with HUS and the Finnish

Institute for Health and Welfare (THL). In the early phases of the project, the team also received technical consultation from Aalto University (Department of Neuroscience and Biomedical Engineering). It was decided that the pilot project would be done as a part of standard clinical practice as an experimental treatment. Physicians in charge of the treatment of patients participating in the treatment were part of the research team and the ethical considerations of the study were guided by ethical recommendations of standard clinical practice, since no patient data was included in the study.

The first phase of the project was to specify the kind of VR application that would be developed and implemented in clinical practice. Based on literature, it was laid out that VR technology could be utilized in the treatment of all core symptoms of psychotic disorders: hallucinations, delusions and cognitive deficits. Advances in AVATAR therapy, an intervention utilizing a combination of digital image and speech modulation software to create an avatar through which the therapist communicates with the patient to make voices more manageable, sparked the initial interest in these applications [36]. It was later decided that the first pilot project would focus on alleviating distress caused by paranoid ideation using VR. This decision was made considering multiple viewpoints. First, AVATAR therapy is a treatment which was originally designed to be administered with standard computers. Although AVATAR therapy has been carried out in a VR environment with a head-mounted display since the original publication [37], the team decided to proceed with a solution that was specifically a VR solution. Second, licensing the AVATAR therapy software was deemed too expensive and impractical for pilot use. Third, based on our initial review of different software options, it was recognized that focusing on treating paranoid ideation as an area of application would include the most easily available options for technical implementation. Finally, distress caused by paranoid ideation and its connection to social avoidance are common problems in both inpatient and outpatient settings, and therefore, focusing on this symptom category was seen as potentially extremely beneficial. VR presented an easily modifiable method, which could be used to encompass a variety of everyday environments that typically are associated with varying degrees of stress with respect to the patient population.

After deciding that the treatment developed during the pilot project would focus on paranoid ideation, the team shifted its attention to find the most appropriate hardware and software for implementation. From available hardware options, the 'Meta Quest 2' (MQ2) solution was deemed the most suitable for its capability to view virtual reality content without an external computer. The MQ2 included both the head-mounted display and two controllers. The headset uses Oculus Insight technology for head and hand tracking, is equipped with a Fast-switch LCD display with a resolution of 1832 x 1920 pixels per eye and a refresh rate of 72Hz as well as 64GB of internal storage (256GB version is available as well).

Many ready-made software options and easy-to-use frameworks for the development of own software were considered, but the team ended up selecting 360-videos as the stimuli for the exposures. The team judged 360-videos as a flexible and interesting option that allows fast content creation that could be specifically tailored for an individual patient. A plan to film 360-videos and use them as material for exposure in the pilot project was laid out.

For filming the videos, an accessible and affordable hardware option was the GoPro MAX camera (GPM). The GPM is a 17 megapixel VR/Action camera with 1/2.3" (6.17 x 4.55 mm) sensor size which shoots footage in H.264 and H.265 formats. The team aspired to shoot footage in which the viewer would experience an environment from a first-person perspective with a 360-degree view. To do this, the camera was positioned in a way that there were no obstacles in front of the camera and the viewer would see as little as possible of the person filming the footage. The only position where this was possible was on top of the head of the person filming the footage. GPM is commonly used by alpine skiers and mountain bikers, and the standard package includes a helmet mount for the camera. However, filming the footage with a helmet-mounted camera in public places may result in an abnormal amount of people looking at the camera and therefore would not represent a real-life situation. Despite this potential problem, it was decided to film the footage with the GPM attached to a helmet.

For the stimuli, footage from common daily life situations, which commonly provoke delusional thinking and anxiety and which people with psychotic disorders tend to avoid, were filmed. The situations selected were visiting a grocery store, walking in a dark alley, travelling via public transport and walking through crowded spaces (e.g., shopping malls). Four videos were shot spanning these situations. Each video was 20-40 minutes in length and was divided into 3-4 shorter parts. The videos were stored in the internal storage of the headset. The option to host the videos on YouTube was considered since the MQ2 has a native YouTube application, but the large file sizes of the

360-degree videos made this solution impractical.

The treatment manual created during the project was modelled after the protocol used in the study by Pot-Kolder and colleagues in 2018 [20] with a smaller number of sessions. The treatment in the pilot consisted of five weekly sessions with a clinical psychologist with experience in psychological interventions. Every session was 60 minutes in length. The first session was dedicated to the client getting acquainted with the clinician and the treatment protocol as well as for working out an individualized case formulation, and the last session for reflecting on the experiences during the treatment. The three sessions in the middle were structured: 10 minutes on getting started and reflecting on the last session, 40 minutes of exposure exercises within the VR environment and 10 minutes of reflection. Patients and the clinicians communicated during the exposure to explore the experiences of the patient in each setting and to recognize and drop safety behaviours and to question harm expectancies. It was made clear from the beginning that the focus of the pilot treatment was to trial the feasibility of the treatment protocol, and this was discussed with all the participants. Furthermore, it was explicitly stated that the clinician and the patient were allowed to examine and try out the hardware and software in a cooperative and collaborative manner to make the procedure more flexible.

Standardized questionnaires were used both at the beginning and after treatment to evaluate the intervention and to scout out initial changes that might arise during the intervention. Further, feedback from the patient was gathered after every session. However, in this paper we focus on the clinicians' experiences, whereas the patients' experiences will be addressed at a general level and in detail in a separate study. Clinicians' viewpoints were gathered with predetermined questions ("How would you describe the overall clinical value of VR treatments when treating paranoid thoughts?", "How does utilizing VR affect the therapeutic alliance with the patient or to the effectiveness of psychosocial treatment with patients with a psychotic disorder?", "How would you generally describe patients who would benefit from VR treatments that you have now implemented?", "How could the treatment protocol now implemented be further developed?", "How easy or hard would you describe implementing a new VR-based treatment protocol into clinical practice?").

The patients were recruited from both inpatient and outpatient clinics in HUS as a part of routine clinical practice. Information about the pilot treatment was given to multidisciplinary teams in their workplace to scout out potential patients. The clinics were searching for patients who suffered from thoughts and emotions that hindered their ability to visit social environments and therefore deal with everyday situations. The only exclusion criterion for patient participation was an epilepsy diagnosis. Other strict inclusion and exclusion criteria were not laid out since the team wanted to test the intervention with patients with different history and status. Suitable patients were offered voluntary participation in the pilot as part of their treatment. Before starting the exercises, the patients were informed that some people may experience nausea and motion sickness while using the headset and that the exercise could be terminated at any point if the patient so chose.

RESULTS

We provide experiences of the first three patients receiving the treatment and present results from three different perspectives. First, the clinicians' experiences with the developed 360-videos and the treatment protocol are presented in detail. Second, the patient experiences will be presented at a general level. Finally, results regarding the suitability of the selected technology and the pilot process are presented.

Clinicians working with the patients (authors LS and HK) evaluated that the developed intervention and the materials used offered a more direct and accurate perspective on the thought processes of individuals and an easy-to-use way to administer an intervention based on exposure. The main clinical benefit of the intervention was that patients receiving the treatment were encouraged to face stressful real-life situations and to start in vivo exposure. Using the headset together with the patient created an environment of cooperation and common problem sharing which often led to a humorous and relaxed atmosphere. However, setting up the system prior to the exposure took time even when the patient and the clinician became experienced with the system, which must be considered when planning the schedule. Allocating more than 60 minutes per session seems therefore more optimal. The treatment rationale and manual were deemed by the clinicians as structured and comprehensive enough to offer a safe frame for therapeutic alliance and exposure exercises, and to enable any clinical professional experienced in psychological treatments for psychotic disorders to implement the intervention. Limiting the intervention length to five sessions was deemed suitable for the pilot phase. Because of its length, the treatment

protocol was easy to implement since both the clinician and the patient could easily commit to the treatment. The detailed responses of the clinicians regarding the feasibility of the piloted protocol and VR treatments can be viewed from *Table 1*.

From the clinicians' perspective, the patients were interested and excited about the treatment they received. After every session, patients gave excellent reviews regarding the working methods of the session. The most common negative side effect while conducting the treatment was nausea and dizziness caused by the video footage. This was

Table 1. Employment status of users who filled in FTN

Question	Clinicians' response
How would you describe the overall clinical value of VR treatments when treating paranoid thoughts?	The overall clinical value of VR treatment when treating paranoid thoughts seems to be prominent because it offers the possibility to perceive the ideation as it arises in concrete situations. VR treatment offers a functional approach to treating paranoid thoughts. The patients find it easier to recognize and share their experiences in VR exposure compared to generally used self-observations.
In your opinion, how does utilizing VR affect the therapeutic alliance with the patient or to the effectiveness of psychosocial treatment with patients with a psychotic disorder?	The manual of the treatment was structured enough to offer a safe frame and space for the therapeutic alliance. The VR system with all the technical operations provides the alliance with cooperation and common problem sharing that give space to relaxed and humorous atmosphere. This kind of parasympathetic activation is essential to start and benefit from the exposure.
How would you generally describe patients who would benefit from VR treatments that you have now implemented?	The patients with increased avoidance and a long-term isolation would be the main target group for the treatment. VR treatment can work for them as a first step to explore social situations and the world outside. After VR exposure the patients may have more interest and courage to proceed towards real-life situations. Also, patients with many social fears and distorted interpretations could benefit from exploring VR situations with clinician, to process perceptions, emotions and thoughts.
How could the treatment protocol now implemented be further developed?	The treatment itself is well structured and flexible enough to form individual targets for each patient. The length of one session is 60 minutes. It might be better to have longer sessions (e.g., 75 minutes) to make sure that the absolute duration of exposure is long enough. The 360-video materials could be further developed. The main problem with them is the nausea and dizziness caused by the movement and rotation of the camera. There are only four different videos that are all taken in wintertime and in the public spaces with only few individual contacts. A wider variation of situations could make exposures more individually planned and effective.
How easy or hard would you describe implementing a new VR-based treatment protocol into clinical practice?	Implementing a new VR-based treatment protocol requires trained clinicians and overall information of the treatment to help find suitable patients for the treatment. The written manual of the treatment is comprehensive enough to enable any clinical psychologist experienced in psychosis to implement the treatment. A decent induction and a possibility for supervision are needed. To make sure of a successful implementation there should also be an adequate amount of hardware and working spaces large enough for VR system.

related to specific videos created for the pilot, which included a lot of head rotations by the person filming the material. Any other adverse effects of the treatment weren't detected. Despite these challenges, going into the virtual world was generally perceived as a fun and an inspiring "new thing" by the patients.

The suitability of the 360-degree video technology was evaluated throughout the project. Creating the intervention using 360-degree videos as material for simulations allowed the project to be implemented without excessive time or monetary resources or prior technical know-how. The materials and technology were immersive enough to activate similar reactions and thought processes from the patients compared to corresponding real-life settings as evaluated by two individual clinicians. Developing the video materials further can be seen as an equally viable option as simulations created with software development. The pilot itself proved valuable for the patients it was tried on and the intervention is seen as the first concrete step on creating VR-based treatment protocols for standard practice.

DISCUSSION

This study presented a VR-based treatment protocol for paranoia and delusional thinking and initial findings from a clinical pilot project. Our results indicate that it is feasible to create a VR-based exposure intervention using 360-degree video technology and that utilizing this intervention can be highly beneficial for individuals with a psychotic disorder. Our findings can be used to create a road map for further development and research as well as a guide for similar pilot ventures.

Exposure exercises within a VR environment can be seen as a method for addressing safety behaviours, cognitive biases and emotions supporting the assumptions behind them as well as for improving patients' courage, confidence and skills to face stressful real-life situations. By confronting stressful situations in a safe and controlled environment, it may be possible to question false and harmful beliefs more easily. A VR-based intervention may also facilitate the understanding of the patients' internal experiences for the clinician, as both participants are immersed in the same environment. This method may move the therapeutic situation into "here and now", which might facilitate change in therapy and partially explain the results of the superiority of VR-based interventions compared to traditional therapeutic interventions when treating psychotic disorders.

Besides creating immersive exposure experiences, using VR can foster therapeutic working alliance by offering shared problems the patient and clinician can tackle together. Our initial results of the clinicians' experiences suggest that this kind of relaxed environment can work as a path for parasympathetic activation, which may be essential to start and benefit from exposure [38]. Of course, VR environments can also be used to relax and reflect after the exercise. In further research endeavours, the activation of the nervous system before, during and after the exposure could be measured with physiological measures and sensors. Our preliminary findings suggest that VR-based interventions are also seen as a novel and interesting treatment option from the patients' perspective, which might have a positive effect on overall treatment motivation.

Despite the numerous potential benefits and possibilities of VR-based interventions, some negative features of VR have also been reported. The most frequently reported negative effect of VR treatment is "cyber sickness", which refers to a feeling of motion sickness during VR simulations [39]. These perceived disadvantages need to be taken into consideration from an ethical perspective when designing treatment protocols that incorporate VR simulations. This was also apparent in our clinical pilot. This can be controlled by avoiding filming material in which the camera moves, which in our material was caused by the head movement of the person who filmed the footage. There is a possibility that an intervention based on VR exposure includes risks for psychological harm when conducted by an inexperienced clinician. Therefore, it is required that only clinicians trained in psychotherapeutic methods and at least basic principles in exposure carry out the treatment, and that the material used in exposure is selected in a trauma-sensitive manner with the individual case formulation in mind. Further, sensors that monitor the physiological response of the patient during exposure could be used to track the suitability of the selected materials with patients with difficulty articulating their experiences verbally.

Compared to computer-generated VR simulations, 360-degree videos are an interesting alternative for providing immersive experiences as a part of exposure exercises. Filming the videos is not overly complicated with a head-mounted camera. It was hypothesized beforehand that attaching the camera to a helmet would attract an unnecessary number of glances from the bystanders, but this was not the case. With all the videos, the material filmed showed situations which looked and felt normal. Benefits of using 360-videos are that they may represent lifelike situations in more detail

compared to programmed environments and therefore might lead to deeper levels of immersion, and that exposure training can be done in various environments, including the patient's home [29]. As 360-degree videos can be very large files, we recommend that such videos be filmed with a level of quality which allows multiple videos to be stored in the internal memory of a VR headset or which could be uploaded to a video streaming service (e.g., YouTube) relatively quickly. As with the video quality, a balance needs to be struck with the length of the videos. Longer videos could lower the time which is used in selecting the video, but shorter videos would allow a specific situation to be experienced more easily without the need to manually rewind the video.

A wide library of 360-videos would allow a tailored exposure therapy based on the individual needs of the patient. One solution to speeding up the process of using 360-videos as clinical tool with psychotic disorders would be a shared video library available for multiple researchers and clinical units. Such practice is already taking off in Finland. As the filming process of 360-degree videos isn't either difficult nor time-consuming, there is a possibility to create tailor-made materials for each patient. One need for tailored material has stemmed from a specific clinical problem in an inpatient unit in HUS where treatment time in a ward is lengthened because the patients' fears are in some way related to their own home. Creating 360-degree video materials from the individuals' home, with consent, could allow the patient to practice dealing with thoughts and emotions which the environment activates. Overall, VR-based interventions can make exposure as a therapeutic method more accessible to all in need, including those who cannot visit stressful environments in real life and those whose anxiety reaches levels which prevent in vivo exposure exercises.

CONCLUSIONS

To our knowledge, 360-degree video technology as a basis for exposure hasn't been used in the context of treating individuals with psychotic disorders. Based on our findings, this technology passes the initial tests of feasibility and calls for further investigation. The presented results show promise in widening the treatment options of psychotic disorders as the materials and treatment rationale received positive feedback from both patients and clinicians. However, findings are only indicative and can be used to form hypotheses for further research with carefully designed experimental studies and representative samples. In the Helsinki University Hospital, further studies will be conducted in the following years to fully realize the potential of VR treatments as an integrated part of other treatment. We hope that our work will be a source of inspiration for other research endeavours and lower the threshold for using VR treatments with this patient cohort.

LIST OF ABBREVIATIONS

VR (virtual reality), HUS (Helsinki University Hospital), THL (Finnish Institute for Health and Welfare), MQ2 (Meta Quest 2 VR headset), GPM (GoPro Max camera).

DECLARATIONS

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Patient records or data were not used in the study as the study is focused on the development and first clinician experiences of a new virtual reality intervention with a novel technical paradigm. Physicians in charge of the treatment of patients included in the study were part of the research team and the ethical considerations of the study was guided by ethical recommendations of standard clinical practice. Taking part in the treatment was voluntary for the patients and the decision to offer the intervention to a patient was decided with the physician in charge of the patient's treatment and the team of medical professionals who conducted the treatment. The need for informed consent and ethical approval was waived by guidance of the Research Ethics Committee of Helsinki University Hospital (HUS) as the study does not meet the criteria for medical research. The national legislation in Finland (Law on medical research 1999/488) states that such actions are not necessary if the criterion for medical research is not met. We confirm that the study was performed in accordance with relevant guidelines and regulations of the Declaration of Helsinki.

AVAILABILITY OF DATA AND MATERIALS

All data generated or analysed during this study are included in this published article and its supplementary information files.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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AUTHORS' CONTRIBUTIONS

KM oversaw the design and implementation of the project and writing of the manuscript. He also filmed the 360-video materials and instructed the clinicians. LS was one of the two clinicians performing the intervention, she also was a part of designing the treatment protocol and was a contributor in writing the manuscript. ML participated in the design of the project and was a major contributor in writing the manuscript. HK was one of the two clinicians performing the intervention, she also was a part of designing the treatment protocol and was a contributor in writing the manuscript. BK acted as the physician in charge of the treatment protocol, participated in the design of the project and was a major contributor in writing the manuscript. MM participated in the design of the project and was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

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