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Review article

Virtual reality-based interventions for patients with paranoia: A systematic review

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ABSTRACT

Background and objective: Paranoia is an important psychiatric symptom with a remarkable effect on daily life. Virtual reality (VR)-based treatments are influential and safe for patients with paranoia. This study aimed to evaluate the effectiveness, and define the clinical and technical characteristics of available VR strategies for the treatment of patients with paranoia.

Materials and methods: Studies published up to 25/11/2021 reporting VR-based interventions for the treatment of patients with paranoia were reviewed in five databases, including PubMed, Embase, Web of Science, PsycINFO, and Scopus.

Results: Out of 302 initial search results, eight were included in the present study based on the inclusion criteria. Six studies were randomized clinical trials with the interventions in the experimental group being based on VR, compared to routine interventions as controls. Two were before-after studies. The most commonly used hardware and software were head-mounted display and Unity3D, respectively. Interventions had a range of 1–16 sessions with follow-up durations of 0–6 months. All investigations showed positive results in the main target, including improved social participation, reduced level of anxiety, as well as diminished suspicious ideas and paranoid symptoms.

Conclusions: Our findings demonstrated that VR-based interventions are effective treatments. Although the use of VR technology is limited for a variety of reasons, such as cost, it improves symptoms in patients with paranoia.

1. Introduction

Psychotic disorders are considered severe mental health problems leading to abnormal thoughts and conception (Heckers et al., 2016). The term refers to a spectrum of disorders that is one of the major causes of long-term disability worldwide (Howes and Murray, 2014). A notable feature of psychosis is paranoid delusion (Heckers et al., 2016; Bird et al., 2019), sometimes known as a persecutory delusion (Freeman, 2016), which is the most common type. Paranoia is the groundless threatening idea that other people intend to cause harm (Freeman, 2016; Meisel et al., 2018) and can also be a strong belief called paranoid delusion. This may be due to the misinterpretation of interpersonal behaviors (Freeman et al., 2005) leading to a sense of vulnerability (Riches et al., 2019). Frequent and persistent suspicions adversely affect the quality of life and performance (Bird et al., 2019) causing the patient to interact less with others, prefer more isolation, quit activities (Freeman, 2007), and probably develop suicidal ideation (Collett et al., 2016).

Although medications are still the mainstay of the treatment of psychotic disorders, delusions and the level of functioning are not always cured by antipsychotics (Collett et al., 2016). With the effect size reported to be 0.26–0.49 for different antipsychotics (Davis et al., 2003), they have made a great contribution to the treatment, but not for all patients. Antipsychotic medications are most effective in reducing

Abbreviations: VR, virtual reality; VR-CBT, virtual reality based-cognitive behavioral therapy; VE, virtual environment; RCT, randomize controlled trial; HMD, head-mounted display; ESM, experience sampling method; GPTS, green's paranoid thoughts scale; PANSS, positive and negative syndrome scale; PSYRATS, the psychotic symptoms rating scale; BCSS, brief core schema scales.

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positive symptoms, such as auditory hallucinations (Meisel et al., 2018). On the other hand, they are less influential for social isolation (Pandita and Won, 2020), as well as cognitive, social, and occupational functions (Valmaggia et al., 2007; Pandita and Won, 2020). The treatment is usually long and the patient might experience side effects, such as weight gain, movement disorders, or heart complications (Lincoln and Peters, 2019; Rus-Calafell et al., 2018; Moritz et al., 2014; Gega et al., 2013) that increase the burden. Consequently, alternative or effective complementary therapies are yet needed to make a significant improvement (Freeman et al., 2019).

Appropriate intervention is expected to reduce annoying symptoms, increase community participation, enhance the quality of life, as well as improve cognitive and social functioning (Freeman et al., 2016; Pot-Kolder et al., 2020). Promising results have been achieved by targeted cognitive behavioral therapy (CBT) for psychosis. With the effect size of 0.65, the main strength might be the lasting impact of this intervention (Gould et al., 2004). These techniques provoke and facilitate learning safety in fearing situations (Lincoln and Peters, 2019; Freeman et al., 2017; Valmaggia et al., 2015). Treatment of paranoid symptoms when a patient is in a state of fear (Miller and Bugnariu, 2016; Freeman et al., 2003) allows them to learn the proper response and eliminate the symptoms of paranoia progressively (Freeman et al., 2019). However, for many patients with persecutory delusions, it is very tough to get into a real stressful situation because of intense anxiety. The chance of practicing in an ordinary situation is also reduced when patients are admitted to a hospital (Freeman et al., 2019, 2017). Furthermore, the social environment and reactions of others cannot be controlled by the therapist (Monaghesh and Hajizadeh, 2020) and a real-world type of treatment, if achievable, is time-consuming (Carl et al., 2019). One feasible solution is simulating social situations using virtual reality (VR).

The VR is a technology that digitally furnishes a 3D ambiance (Slater and Sanchez-Vives, 2016) and VR environments range from complete immersion in which individuals can physically interact with objects and virtual people to non-immersion levels (Miller and Bugnariu, 2016). The virtual social world is a controlled environment experienced with the guidance of a therapist. By creating immersion environments, VR provides control over the social environment as one of the main etiological factors of mental conditions (Freeman et al., 2017; Valmaggia et al., 2015). Therefore, as VR produces responses resembling real-world events (Sanchez-Vives and Slater, 2005; Slater et al., 2013), it has the potentials to be used for evaluating (Wen et al., 2018) and understanding the causes (Freeman et al., 2003) and treating diverse health conditions (Veling et al., 2016). The VR has been introduced as a safe and effective treatment in a broad range of psychiatric disorders, including autistic spectrum disorders (Jarrold et al., 2013), phobia (Botella et al., 2017), post-traumatic stress disorder (Deng et al., 2019), anxiety disorders (Opriş et al., 2012), and paranoia (Veling et al., 2016). A meta-analysis showed a large effect size for VR therapy on anxiety disorders, which was comparable to in vivo conditions (Carl et al., 2019).

Despite the complexity of psychosis, promising results have been achieved for distinct aspects of this clinical condition. The VR provides valuable facts giving a better understanding of paranoia conditions (Freeman et al., 2017; Freeman et al., 2008) while providing an endurable situation for patients (Valmaggia et al., 2007). The VR helps patients with paranoia to learn how to deal with the symptoms when occurring in a social situation and how to continue an activity (Freeman et al., 2016; Battegazzorre, 2019). Although patients know this is a simulation, their learning is transferred to the real world (Freeman et al., 2003). The experiences of social skills training (Rus-Calafell et al., 2018) show that VR-based therapies are time-saving (Freeman et al., 2003) and improve the patient-doctor relationship (Pandita and Won, 2020). They have the potential to be faster, more effective, and more attractive to patients than face-to-face procedures (Josman et al., 2008; Mitchell et al., 2007) and are safe to use for patients with annoying hallucinations (Freeman et al., 2003).

In recent years, several reports have systematically reviewed the results of researches examining the effects of VR-based treatments on various mental conditions. The only available review concerning paranoia in the time frame of this study investigated the utility and acceptability of VR for patients with psychotic disorders. The latter investigation reported the benefits of VR for assessing psychosis, as well as the delivery of relevant therapies (Rus-Calafell et al., 2018). This review included only eight trials about VR-based treatments that targeted social skill training and cognitive remediation. Looking for different answers, our study aimed to review and evaluate available VR-assisted therapies for paranoia and their efficacy. The main objectives were (i) to investigate the evidence of the efficacy of VR-based interventions for paranoia, and (ii) to identify the key features of these interventions in association with their efficacy.

2. Materials and methods

This systematic review was performed using the Population, Intervention, Comparison, Outcomes, and Study (PICOS) framework to recognize proper sources and to search for related evidence to form a focused question and facilitate literature search. Within this framework, the population includes patients with paranoia or paranoid delusions. The intervention entailed VR therapy with the comparison groups encompassing routine therapy, non-VR-based treatment, pre-treatment VR-based, and untreated conditions. In addition, the outcome included the effect of interventions on the symptoms of the disease.

2.1. Literature search

In order to collect data, five important medical, health, and psychological databases, namely PubMed, Embase, Web of Science, PsycINFO, and Scopus were searched on 19/07/2020. The search was performed without a time limit. Journals and sites related to psychology, psychiatry, and technology were searched manually to ensure that all sources were identified. Moreover, the references of all included studies were manually searched to check any additional investigations that were not identified during the electronic database search. To update the results, a second search was performed on 25/11/2021. Generally, the following keywords and search strategies were used for all databases:

(VR OR "Virtual Reality" OR "Virtual Realities" OR "Virtual Environment" OR Simulation) AND (Paranoi* OR persecutory) AND (treat* OR therapy*).

Next, the results obtained from various sources were reviewed to remove duplicates and were entered into Endnote resource management software.

2.2. Inclusion and exclusion criteria

The inclusion and exclusion criteria were determined based on the defined PICOS. The inclusion criteria were 1) being published in English, 2) being conducted on patients with paranoia, psychotic disorder with paranoid delusion (measured using clinical diagnostic criteria or a subjective self-rating scale), 3) being conducted for therapeutic purpose, 4) the intervention being based on the VR that digitally provided three-dimensional space. Review articles, letters, abstracts, conferences, editorials, notes, and sources with no available full text were excluded.

2.3. Study selection

After removing duplicate references, screening was performed in two stages. In the first stage, the titles and abstracts of the identified articles were reviewed to select relevant studies based on the inclusion criteria. Afterwards, in the second phase, two researchers separately reviewed the full text of articles, which were identified according to the relevant criteria. The decisive agreement was made through discussing the disagreement between scholars in the selection of articles.

2.4. Quality assessment

To assess the quality of the included studies, a CASP Randomised Controlled Trial Standard Checklist was provided. The CASP tools were provided to teach people how to critically evaluate different types of evidence (NCCf, 2011). The included studies were divided into three categories of poor, moderate, and good based on their quality score. All the papers regardless of their methodological quality underwent data extraction and synthesis due to the technical and developmental nature of the original papers. Therefore, we did not exclude investigations that technically had good quality but did not meet the requirements of the checklists.

2.5. Data extraction

Selected studies were reviewed thoroughly and data were extracted by a researcher using the designed data extraction sheet and were then verified by a second researcher. The chosen data were Publication data (i.e., author, year, and country), the aim of the study, study design, sample size, the data of participants (i.e., diagnosis, age, and gender), used technology, scenario/avatar, methodology data, evaluation (i.e., time, test, and scores), and results.

3. Results

3.1. Study selection

The flowchart for the inclusion of studies, the process of selecting articles, the details on the number of studies obtained by each database, the number of initial and screened studies, excluded studies, and eventually included studies is shown in Fig. 1. Overall, 302 studies were identified and after removing duplicates, as well as screening their title and abstract, articles were selected for full-text review. Next, conference abstracts, reviews, unrelated topics, and studies that did not report results were excluded. One more paper that was not available as full text and no reply was received from the authors was also excluded (Tarnanas et al., 2009). Finally, eight studies remained for review.

3.2. Characteristics of studies

The full characteristics of the included studies are shown in Table 1. From the included studies, four were conducted in the Netherlands, three in the UK, and the other one in Germany. Six studies were randomized controlled trials (RCTs) and two were pretest-posttest studies. The general aim was to evaluate the effectiveness of using virtual environments in improving the symptoms of patients with persecutory delusions and paranoia. The total samples in the included studies were 598 patients with a mean age of about 37 years in six investigations except for two studies, in which the age range were reported to be 20–36 and 18–65 years. The follow-up duration had a range of 0–6 months.

3.3. Quality of the included studies

Our systematic review consisted of seven studies that were evaluated using CASP tools. The quality of the evaluated studies was generally high. Five (63%) studies were of good quality and three (37%) studies

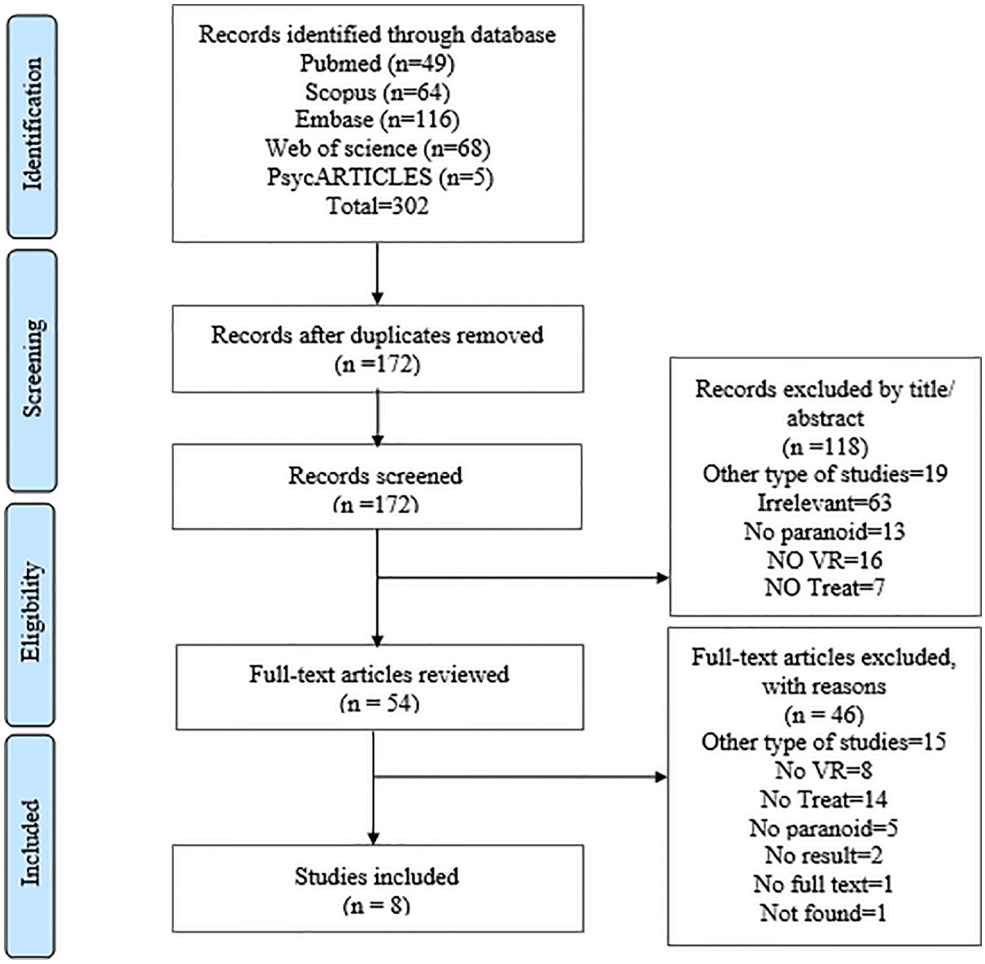

Fig. 1. PRISMA flow diagram illustrating study selection.

Table 1
Summary characteristic of included studies in systematic review.

Author, year, Country	Aim of study	Study design	Sample size		Participants Diagnosis	Age (mean)		Gender (male/female)	
			experiment	control		experiment	control	experiment	control
Berkhof et al., 2021 Netherlands (Berkhof et al., 2021)	To investigate differences between VR-CBT and CBTp in their effect on the level of paranoid delusion in daily life, level of social activities, proportion of time spent in social company, levels of distress, anxiety and depression.	RCT	53	53	psychotic disorder and at least moderate level of paranoid ideations	18–65	18–65	–	–
Geraets et al., 2020 Netherlands (Geraets et al., 2020)	Examined whether treatment with VR-CBT for paranoia influences momentary affective states, and whether VR-CBT changes the adverse interplay between affective states and paranoia.	RCT	43	48	Psychotic disorder, paranoid ideations	38.1	49.9	29/14	34/14
Pot-Kolder et al., 2020 Netherlands (Pot-Kolder et al., 2020)	Determine the short-term cost-effectiveness of VR-CBT.	RCT	58	58	Patients with a psychotic disorder suffering from paranoid ideation	36.5	39.5	40/18	42/16
Brown et al., 2020 UK (Brown et al., 2020)	To test the idea that Virtual reality of compassion imagery one way of reducing negative beliefs and paranoia.	RCT	50	50	Paranoid ideations	27.8	31.1	30/20	31/19
Pot-Kolder et al., 2018 Netherlands (Pot-Kolder et al., 2018)	Investigated the effects of VR-CBT paranoid thoughts and social participation.	RCT	58	58	Psychotic disorder with paranoid ideation in the past month	36.5	39.5	40/18	42/16
Freeman et al., 2016 UK (Freeman et al., 2016)	To test the hypothesis that VRCT would lead to greater delusion reduction than alone VR-exposure.	RCT	15	15	Persecutory delusions	42.1	40.6	10/5	6/9
Moritz et al., 2014 Germany (Moritz et al., 2014)	Evaluated a brief intervention aimed to induce doubt and to decrease delusions.	Pre-post test	33		Schizophrenia	$M = 40.5$		21/12	
Gega et al., 2013 UK (Gega et al., 2013)	Explore the feasibility of the VE system as a therapy tool for patients who were recovering from psychosis and who had residual paranoia and comorbid social anxiety	Pre-post test	6		Paranoia and social anxiety	20 to 36		6 /0	

were of medium quality. Therefore, none of the studies were excluded.

3.4. Interventions

The VR technology creates a virtual environment using tools that create a situation, image, and sound meant to enhance the sense of presence. A summary of the technology used in the reviewed studies is described in Table 2. The most common hardware was head-mounted display (HMD), which was utilized in five studies. Inone research, a speaker was used to produce the sound. A recording camera and a room with specific dimensions to create a virtual environment were applied in one investigation. Unity3D was the most frequently used software. Designed scenarios included a variety of social environments with a number of human avatars. Interventions continued for 16 sessions in five studies, for 12 sessions in one, and 1 in another study lasting for 1–2 h. One of the investigations did not explain the number and duration of sessions. These sessions were mostly offered in hospitals and mental health care centers.

In the RCTs, the experiment groups received VR-based treatments and the control group received routine care. The pretest-posttest studies had no control group and patients were evaluated before and after the intervention by VR. After the first pre-intervention evaluation, patients were evaluated several times during treatment sessions. In five studies, the examination was performed in three stages. In one research, the assessment was carried out at baseline and during the intervention. In another study, pre- and post-intervention evaluations were performed. One investigation did not describe the exact timing of assessments. Relevant tools were utilized to evaluate several items, including distress, perceived social threat, thoughts, feelings, social contexts, momentary paranoia, persecution, patients' thoughts, self-compassion, compassion for others, and the level of anxiety.

4. Outcomes

In almost all studies, the results showed that VR-based interventions reduced paranoid thoughts, delusions, and safety behaviors (Moritz et al., 2014; Gega et al., 2013; Pot-Kolder et al., 2018; Geraets et al., 2020; Brown et al., 2020). According to one study, VR-CBT treatment was more effective than conventional therapy in improving the symptoms of feeling suspicious, disliked, hurt, and anxious (Geraets et al., 2020). Two studies demonstrated a decline in the anxiety of patients (Gega et al., 2013; Pot-Kolder et al., 2018). Two investigations revealed that patients found themselves safe from what they used to be scared of (Freeman et al., 2016; Pot-Kolder et al., 2018). One study evaluated the cost-effectiveness of VR-based interventions and found that these interventions, in addition to increasing the social participation of patients, were cost-effective (Pot-Kolder et al., 2020). One study did not provide exact results because it is ongoing (Berkhof et al., 2021). All the details are described in Table 2.

5. Discussion

This manuscript reviewed available VR technologies and investigated the effect of VR-assisted CBT in the treatment of patients with paranoia or paranoid delusions. According to the reviewed studies, the use of VR has various purposes in the treatment of patients with

Table 2
Intervention characteristic of included studies in systematic review.

Author, year	Technology used		Scenario / Avatar	Methodology			Evaluation			Results
	Hardware	Software		Sessions	Duration	Place	Evaluation time	Tools	Evaluated items	
Berkhof et al., 2021	Oculus Rift head-mounted display and navigate through the virtual environments using a controller	–	Café, shopping street, supermarket, bus ride, office, living room/ The level of difficulty of the particular social environment can be modified by adjusting the number, gender and ethnic appearance of virtual characters (avatars) present in the situation.	16	1:15 h	–	Before treatment, after treatment and three months after treatment	EMA[1], GPTS[2], PSYRATS[3], SIAS[4], IDS-SR[5], SBQ[6]	Paranoid thoughts, Social participation, Paranoid delusions and hallucinations, Social anxiety, Depressive symptoms, Safety behavior,	Comparison of VRcbt and CBTp will provide information about the relative (cost-) effectiveness of VRcbt for this population.
Geraets et al., 2020	HMD[7], Logitech F310 Game pad, Sony HMZ, high-definition resolution of 1280 × 720 per eye, 51•6 diagonal field of view, and a 3DOF tracker for head rotation.	Vizard software	Street, bus, café, supermarket	16	1 h	seven treatment centers in the Netherlands	6–10 days at baseline, post treatment and 6 month follow-u	ESM[8], EMA	Paranoia (suspicious, dislike, hurt), negative affect (anxious, insecure, disappointed, lonely, guilty, unsafe, annoyed), positive affect (cheerful, enthusiastic, relaxed, I like myself)	Decreased paranoid ideation and negative mental states in the experimental group compared to control group. No change in interplay between affective states and paranoia
Pot-Kolder et al., 2020	HMD, Logitech F310 Game pad, Sony HMZ, high-definition resolution of 1280 × 720 per eye, 51•6 diagonal field of view, and a 3DOF tracker for head rotation.	Vizard software	Street, bus, café, and supermarket	16	0:30– 1 h	seven treatment centers in the Netherlands	At baseline and at 3 and 6 months post baseline.	GPTS	Time spent with others, momentary anxiety, momentary paranoia	Offering VR-CBT to patients with paranoid delusions is an economically viable approach toward improving patients' health in a cost-effective manner, improves social participation
Brown et al., 2020	HMD, HTC Vive PRO with a resolution of 1440 × 1600 pixels per eye and a field of view of 110°. It was powered by a computer with an Intel i7 CPU, a Nvidia GeForce GTX1080 graphics card.	Windows 10 operating system.	Tube train and lift / the train had 12–13 avatar and the lift had three or four avatars	1	1h	–	At baseline and During the intervention.	GPTS, visual analogue scale	Paranoia severity, Self-compassion, compassion for others	Targeting negative beliefs about the self and others using compassionate imagery causes reductions in paranoia.
Pot-Kolder et al., 2018	HMD, Logitech F310 Game pad, Sony HMZ, high-definition resolution of 1280 × 720 per eye, 51•6 diagonal field of view, and a 3DOF tracker for head rotation.	Vizard software	Street, bus, café, supermarket/ Therapists could change vary the number of human avatars (0–40), the characteristics of the avatars (including sex and ethnicity), and the avatars' responses to the patient (neutral or hostile, eye contact) to match the paranoid fears of the patient,	16	1 h	Seven Dutch mental health centers.	At baseline, after treatment (3 months from baseline), and at a 6 month follow-up visit.	Momentary paranoia and perceived social threat subscales. Secondary outcomes: the safety behavior questionnaire, persecutory delusions, GPTS, social interaction anxiety scale, Beck depression inventory. Functional outcomes: social and occupational	Momentary thoughts, feelings, social contexts, symptoms, negative affect, positive affect, momentary paranoia, and perceived social threat.	VR-CBT reduces paranoid ideation, momentary anxiety, and safety behaviors in real-life social situations.

(*continued on next page*)

Table 2 (*continued*)

Author, year	Technology used		Scenario / Avatar	Methodology			Evaluation			Results
	Hardware	Software		Sessions	Duration	Place	Evaluation time	Tools	Evaluated items	
			therapists could also make the avatars say pre-recorded sentences.					functioning assessment scale Manchester short assessment of quality of life, after the fourth and eighth sessions, presence in virtual reality: the Igroup presence questionnaire, and cyber sickness symptoms with the simulator sickness questionnaire.		
Freeman et al., 2016.	HMD	Unity3D, XVR	Underground train and lift/ The underground scenarios from no avatar to 22. The lift scenarios from two avatars to 6.	16	1:40 _ 2:10	Patient's home or hospital	Before and During the testing day	Before(PANSS[9], PSYRATS[10], the Safety Behaviors Questionnaire, Persecutory Beliefs, the Beck Anxiety Inventory, the Beck Depression Inventory), during test (visual analogue rating scales)	Conviction, distress	Patients learned that they were safe than they had feared, then VRCT could prove highly effective in treating delusions.
Moritz et al., 2014	For the noise condition: applied PC speakers.	Unity 3D, artificial characters: 3D modeling software DAZ-studio. Body animations: (BVH[11]) data from the motion capturing procedure.	Virtual street/ 6 different avatars were created, each showed a neutral, angry or happy face, and the participant only met one avatar at a time	–	–	In- and outpatient facilities of two psychiatric hospitals in Hamburg	Before and after the experiment	Paranoia Checklist, POD[12]	The degree to which subjects remembered the identity, location and effect of each of the pedestrians.	Reduce paranoid symptom severity in patients with schizophrenia via virtual reality.
Gega et al., 2013	15×15 m portable booth a video-processing unit with a camera linked to a computer and video recorder, a screen monitor, and an adjustable sitting stool	camera	One hundred especially video clips that last 2–10 min and depict a variety of social situations/ The characters in these situations could be hostile, rude, neutral or friendly. Some characters ask innocuous questions or personal questions.	12	1 h	–	At baseline (week 0), at 12 and 24 week	Persecution (GPTS, beliefs about self and others (BCSS[13]), social anxiety (Social interaction anxiety scale)	Persecution, patients thought, anxiety	Reduced paranoia, social anxiety and change people's negative beliefs about themselves and others using the virtual environment.

[1] Ecological Momentary Assessment.
[2] Green's Paranoid Thoughts Scale.
[3] Psychotic Symptom Rating Scales.
[4] Social Interaction Anxiety Scale.
[5] Inventory of Depressive Symptomatology Self-Report.
[6] Safety Behaviours Questionnaire – persecutory delusions.
[7] Head-Mounted Display.
[8] Experience Sampling Method.
[9] the Positive and Negative Syndrome Scale – positive subscale.
[10] the Psychotic Symptoms Rating Scale – Delusions.
[11] Bio vision hierarchical.
[12] Paranoia, obsessive-compulsive and depression questionnaire.
[13] Brief Core Schema Scales.

paranoia, such as eliminating paranoid thoughts, reducing social anxiety, enhancing community participation, and changing their negative beliefs about themselves and others. Ultimately, patients believe that they are safe from what they are afraid of, and understand that the thoughts of suspicion about people are wrong. Indeed, the studies we reviewed investigated the effect of VR-based interventions on improving the symptoms of the disorder (Moritz et al., 2014; Gega et al., 2013; Freeman et al., 2016; Pot-Kolder et al., 2020, 2018; Geraets et al., 2020; Brown et al., 2020; Berkhof et al., 2021). One study evaluated paranoia, as well as positive and negative symptoms effects showing a decrease in paranoia and negative effects, while no significant effect was observed on the positive mental state (Geraets et al., 2020).

The majority of the reviewed studies used non-immersion environments making it possible to create the desired setting and avatars that interact with patients. However, immersion environments might be one step beyond (Fernández-Sotos et al., 2020). Only one research reported the judgment of patients and some participants complained of the VR environments to be un-real. While being aware of the virtual nature of the environment might reduce patients' anxiety, sufficient immersion is needed to create a strong sense of presence and emotional engagement, which is necessary for a successful treatment (Gega et al., 2013). The VR technology provides diverse features to elevate people's sense of immersion, especially in programs that focus on treating social anxiety disorders. To this end, avatars were designed to be more realistic and sociable in order to better communicate with patients (Oing and Prescott, 2018). The same happened for patients with paranoia in all the reviewed papers. The VR provides a safe environment for the patient and allows therapists and researchers to accurately identify the paranoid symptoms that may arise as a result of exposure (Moritz et al., 2014; Freeman et al., 2016).

Different hardware and software are used to create a virtual environment in the reviewed studies. The HMD and 3DOF tracker were applied to move in the laboratory environments (Moritz et al., 2014; Gega et al., 2013; Freeman et al., 2016; Pot-Kolder et al., 2020, 2018; Geraets et al., 2020; Brown et al., 2020; Berkhof et al., 2021). In a study that used a camera to create an environment, a 15 × 15 m^2 portable room with a variety of equipment was utilized that included a seating area and screen (Gega et al., 2013). The camera was used to create a virtual environment that allowed the recording of several video clips from distinct social situations. Various software is also used to design VR, of which Unity3D is more common. In studies that used Unity3D, XVR, and Vizard software to design VR, few scenarios were created (Moritz et al., 2014; Freeman et al., 2016; Pot-Kolder et al., 2020, 2018; Geraets et al., 2020; Brown et al., 2020). It is not possible to compare these methods as all of them achieved desirable results or measured different outcome measures. The expense of the equipment and lack of VR specialists, especially for the mentally ill cases, limited the practice (Botella et al., 2017). This is reflected in the partially low number of studies we could include. The Cost-effectiveness of VR-based interventions was measured and approved in one study (Pot-Kolder et al., 2020). Researchers have used VR -CBT for in- and out-patients as VR is easy to use in each office that is suitable for CBT.

6. Limitations

A common limitation for all systematic reviews is the bias in the selection of articles. Therefore, the search strategy was planned to include all studies in this field. Moreover, only papers published in English were included. We did not manage to reach the full text of one study as described before. The limitations mentioned by the reviewed studies are related to the momentary evaluations of the interventions and the limited number of scenarios. Despite evidence for cost-effectiveness, the high cost of the technology is one of the obstacles to widespread use and a long-term review is needed for a conclusion (Freeman et al., 2016; Pot-Kolder et al., 2020). Moreover, the results of the two studies are limited due to the absence of a control group (Gega et al., 2013; Pot-Kolder et al., 2018) making it impossible to compare the effectiveness of VR-based interventions with other interventions. The fact that some patients probably with deeper psychopathology might be afraid to participate also limits the generalizability of the results (Moritz et al., 2014). The number of studies is low though they show the promising effects of VR-based interventions on improving paranoia. The increase in studies with time will allow having a comparison between techniques.

Future investigations can address the mentioned limitations by larger sample size, comparing the results to a control group, and considering a longer follow-up duration. It might be useful to include the effect of gender and disorder duration. Manifestation of psychiatric symptoms is influenced by several psychological factors. The experience of the reviewed studies indicates that measuring different psychological factors might give a better understanding of etiology, as well as a deeper insight into the impact of VR-based interventions. A good example might be the comprehensive approach for understanding the cognitive and behavioral components of patients' reactions to the environmental stimuli, including coping styles, mental states, personal characteristics, cognitive ability, and the details of the VR environment. The application of VR-based interventions within a different social context and using suitable scenarios might provide more interesting findings as well.

Conclusions

This review identifies the features required for VR-based interventions. In addition, we presented the evaluations made by studies to determine the effectiveness of interventions. This review shows that VR-based interventions are effective in the treatment of patients with paranoia. Although the use of VR technology is limited for a variety of reasons, including cost, this type of intervention is more attractive than conventional interventions. The VR-based interventions improve symptoms in patients with paranoia, increase the social participation of patients, as well as reducing stress and suspiciousness. Moreover, it provides better control of treatment sessions for therapists. With the advent of cost-effective, user-friendly, and supported VR systems, more research can be performed on VR based on preliminary studies to develop new applications for VR in psychotherapy.

Ethics approval and consent to participate

The study is approved by ethical committee of Tabriz University of Medical Sciences (IR.TBZMED.REC.1399.584).

Consent for publication

Not applicable.

Availability of data and material

All data generated or analyzed during this study are included in this article.

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CRediT authorship contribution statement

Elham Monaghesh: Data curation, Writing – original draft. **Taha Samad-Soltani:** Conceptualization, Methodology, Supervision. **Sara Farhang:** Validation, Investigation, Writing – review & editing.

Declaration of Competing Interest

None.

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