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Brave New Worlds—Review and Update on Virtual Reality Assessment and Treatment in Psychosis

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In recent years, virtual reality (VR) research on psychotic disorders has been initiated. Several studies showed that VR can elicit paranoid thoughts about virtual characters (avatars), both in patients with psychotic disorders and healthy individuals. Real life symptoms and VR experiences were correlated, lending further support to its validity. Neurocognitive deficits and difficulties in social behavior were found in schizophrenia patients, not only in abstract tasks but also using naturalistic virtual environments that are more relevant to daily life, such as a city or encounters with avatars. VR treatments are conceivable for most dimensions of psychotic disorders. There is a small but expanding literature on interventions for delusions, hallucinations, neurocognition, social cognition, and social skills; preliminary results are promising. VR applications for assessment and treatment of psychotic disorders are in their infancy, but appear to have a great potential for increasing our understanding of psychosis and expanding the therapeutic toolbox.

Key words: psychosis/schizophrenia/virtual reality

Introduction

Social media companies expect that virtual reality (VR) soon will become a part of our daily life routines.[1] Indeed, VR applications have already set foot in mental health care and research. Over the past decade, VR has been developed, particularly for the treatment of anxiety disorders. A meta-analysis showed that VR exposure therapy is as effective as conventionally delivered cognitive behavioral therapy (CBT) for fear of flying, acrophobia, arachnophobia, panic disorder, and social phobia.[2] In the field of psychosis, VR research is less advanced. Freeman introduced VR as a new paradigm in schizophrenia research,[3] proposing potential uses for VR, such as diagnostic assessment and treatment. In recent years, several promising VR initiatives have been developed. In this article, the literature of VR and psychosis up to May 2014 is reviewed.

Characteristics of Virtual Reality

The defining characteristic of VR is the experience of a sense of presence in an interactive three-dimensional world.[3] A computer generates an image, which is presented to the user through a screen or a head mounted display (figure 1). The virtual world changes according to the participant's movements and actions, because a tracker feeds back the user's position and orientation to the computer in order to update the image. The result is an experience that elicits psychological and physiological responses remarkably similar to those in the real world. This ecological validity offers a unique possibility to explore interactions between individual and complex everyday environments in an experimental, controlled way. It also allows practising social behavior, and has the potential of providing corrective experiences, eg in showing patients that their paranoid interpretation of a neutral virtual situation is unfounded.[4]

Paranoia and Validity of VR

As a first step, studies explored whether VR experiences can elicit symptoms relevant to psychosis. Freeman used a virtual library environment to explore paranoid ideations in a sample of students without a history of mental illness.[5] A substantial minority reported paranoid thoughts

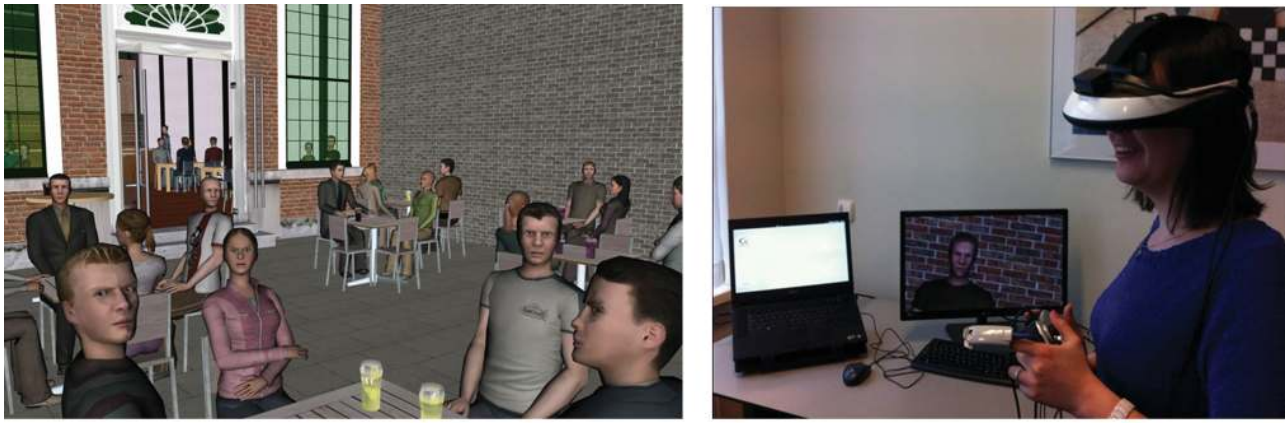

Fig. 1. Virtual social environment and VR set-up.

about virtual characters (avatars) that were programmed to exhibit neutral behavior, a finding that has been replicated in several studies since.[6,7] Paranoid thoughts about avatars were correlated with levels of anxiety, interpersonal sensitivity, perceptual abnormalities and paranoia in real life.[7,8] Subsequently, individuals with (sub)clinical symptoms were included in small studies. VR was shown to be safe in patients at ultra-high risk for psychosis[9] and psychotic disorders.[7,10,11] Patients with persecutory delusions as well as healthy controls provided several types of 'evidence' supporting their paranoid beliefs, but patients more often used their own mood/affect and pre-existing beliefs about threat in daily interactions as evidence.[12] There was no exacerbation of psychotic symptoms after exposure to VR experiments and no increase in anxiety. The main side effect of VR is cyber sickness, ie, feelings of nausea and dizziness. In the clinical pilot studies, symptoms of cyber sickness were not or only slightly higher after VR exposure compared to before.[7,10] Real life symptoms (paranoia, social anxiety) and correlates of psychosis (cognitive biases) were associated with paranoid thoughts about avatars, with correlation coefficients up to 0.7.[7,9,10] It was concluded that VR can be used safely in patients with psychotic disorders and that it is a valid approach to study symptoms and mechanisms of psychosis.

Cognition and Social Behavior

VR is also used as a tool for assessing clinical characteristics other than paranoia. In a virtual maze task, patients with schizophrenia performed worse than healthy controls on speed, attention, and working and spatial memory.[13–15] An fMRI study showed that various brain regions were activated during a virtual maze task in schizophrenia patients and controls, but that task-related neural circuits identified in patients did not correspond well with regional neuroanatomy.[16] Cognitive problems in goal-directed navigation were also found in naturalistic virtual environments such as finding targets in a city.[17] Compared to healthy controls, schizophrenia patients were less flexible in changing strategies for finding the best bus route,[18] were slower and less successful in a shopping task[19] and had poorer medication management skills in a virtual apartment.[20]

VR enables to investigate interactions between individual and social environment in great detail. Schizophrenia patients showed a reduced amount of eye gaze in common social situations, in particular during negative social interactions with avatars.[21] Patients had more difficulties to interpret verbal and nonverbal social cues, as well as avatars' facial emotions.[22] Also, patients kept more distance to avatars than controls, and had larger angles in head orientation towards avatars,[23] perhaps reflecting discomfort in social situations, or cognitive deficits.

Treatment

Several pilot studies suggest that VR treatments for psychotic disorders will become available in the near future. Paranoid delusions may ameliorate by VR training. In an uncontrolled pilot study (N = 33), patients were instructed to recollect whether they had seen particular avatars during a virtual street walk and which facial emotion these had exhibited. Afterwards, they received error feedback on their ratings. Paranoia declined significantly from pre to post at a medium effect size, in particular in those patients who had lower confidence in their own ratings, indicating that corrective feedback provided by VR tasks indeed improves symptom severity.[4]

Based on the idea that it is difficult for patients to gain control over verbal auditory hallucinations because these are invisible entities, avatar therapy was developed, in which patients create an avatar of the entity they believe is talking to them.[24] A proof-of-concept study (N = 26) showed that frequency and intensity of the auditory hallucinations, the disruption they cause to life, and the beliefs patients develop about their hallucinations

improved when patients had short dialogs with an avatar of their voices.

Other studies focused on training of social skills. A VR conversation scenario training, involving greeting, initiating, and managing a conversation, as well as interpreting facial emotions of avatars and choosing correct responses, was compared with traditional role-playing in a randomized controlled trial (RCT) (N = 91).[25] Social skills improved in both groups, but patients in the VR group liked the training better and improved significantly more on conversational skills and assertiveness. A pilot study of another VR social skills training (N = 12) showed significant improvement in negative symptoms, psychopathology, social anxiety and discomfort, avoidance, and social functioning.[26] Cognitive training programs may also be developed for improving neurocognition. A virtual shop was used for training schizophrenia patients being a salesperson, aiming at training of executive functions, problem solving, categorization, memory, and attention. In an RCT (N = 95), performance on the Wisconsin Card Sorting Test as well as work performance were better after VR training compared to treatment as usual.[27]

Next Steps

At this point, we know that use of VR is feasible and safe in patients with psychotic disorders, that real life symptoms and VR experiences are correlated to a degree that supports validity, and that preliminary studies of novel treatments are promising. Although most studies to date were small, the results suggest that VR may develop into an important tool for assessment and treatment of psychotic disorders.

Psychotic syndromes can be understood as disorders of adaptation to social context,[28] but measurement of the social environment of individuals, and their psychological and physiological response to it, remains a major challenge. Experience sampling methods (ESM) have been developed, using within-day self-assessments at random moments in the normal daily living environment of individuals.[29] This approach has opened the realm of daily life, but ESM in its present form does not provide objective detailed information about the social environment. Daily social environments are highly complex, are never exactly the same, and are strongly influenced by the individual's behavior. VR environments can be used to experimentally map interactions between patient and carefully designed, controlled virtual social environments in relation to symptom domains, physiological responses and behavior, allowing to make a more personalized, and contextual diagnostic assessment. In addition, all kinds of sensors and measures can be added to VR, in order to monitor individuals' physiological and behavioral responses to VR exposures, such as heart rate and galvanic skin response for autonomic stress response, kinetic information for eye gaze, and body movements, but also EEG or fMRI for brain activation patterns.

VR treatments are conceivable for most dimensions of psychotic disorders. Already, interventions for delusions, hallucinations, neurocognition, social cognition, and social skills are investigated. It is clear, however, that the possibilities of VR are only beginning to be explored. With current technology, more options for interaction can be added to VR environments. For instance, virtual scenarios can be developed in which storylines change based on the patient's actions, and level of difficulty is automatically adapted to error rates or arousal. In the longer term, self-management of patients with (home-based) VR applications can be envisioned, which is desirable in a world where 69% of all patients with a diagnosis of schizophrenia does not receive treatment[30] and health care costs are spiralling.

VR applications for assessment and treatment of psychotic disorders are in their infancy, but appear to have a great potential for increasing our understanding of psychosis and expanding the therapeutic toolbox.

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