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Studying and Treating Schizophrenia Using Virtual Reality: A New Paradigm

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Understanding schizophrenia requires consideration of patients' interactions in the social world. Misinterpretation of other peoples' behavior is a key feature of persecutory ideation. The occurrence and intensity of hallucinations is affected by the social context. Negative symptoms such as anhedonia, asociality, and blunted affect reflect difficulties in social interactions. Withdrawal and avoidance of other people is frequent in schizophrenia, leading to isolation and rumination. The use of virtual reality (VR)—interactive immersive computer environments—allows one of the key variables in understanding psychosis, social environments, to be controlled, providing exciting applications to research and treatment. Seven applications of virtual social environments to schizophrenia are set out: symptom assessment, identification of symptom markers, establishment of predictive factors, tests of putative causal factors, investigation of the differential prediction of symptoms, determination of toxic elements in the environment, and development of treatment. The initial VR studies of persecutory ideation, which illustrate the ascription of personalities and mental states to virtual people, are highlighted. VR, suitably applied, holds great promise in furthering the understanding and treatment of psychosis.

Key words: virtual reality/schizophrenia/delusions/hallucinations

Introduction

Ivan Sutherland,[1] the highly influential American computer scientist, published a short article in the mid-1960s entitled "The Ultimate Display." He defined the ultimate display as "a room within which the computer can control the existence of matter …. With appropriate programming such a display could literally be the Wonderland into which Alice walked." A few years later, Sutherland reported on the first stages of realizing this ambition: the Sword of Damocles.[2] The name of this display originated from the cumbersome machinery suspended from the laboratory ceiling. The user was fitted into a large headset that contained 2 small cathode ray tubes, one for each eye, which displayed a computer-generated 3-dimensional image of a simple wire-framed room. The headset was attached to a large mechanical arm, which was fixed to the ceiling and that tracked the person's movement, allowing the image to be altered as the individual moved in the virtual room. Although the potential of such devices became more realizable in the 1980s, when the term "virtual reality" (VR) became popularized, all the main elements were in place in the Sword of Damocles.[3,4] A computer generated an image; a display system presented the sensory information; and a tracker fed back the user's position and orientation in order to update the image. The elements combined to substitute sense data from the natural world with sense data about an imaginary world that changed in response to the user's actions. The result is a "sense of presence" in an interactive 3-dimensional virtual world.[5]

VR is much less unusual now. The equipment is less intrusive and far more comfortable for the user, and environments of great complexity can be rendered (see figures 1 and 2). It is used widely in many areas, for instance, the defence and aviation industries, medical training and practice, and the arts and entertainment. Perhaps the most striking application of VR to psychiatric problems has been for the treatment of height phobia. For example, Emmelkamp et al[6] randomized 33 patients with acrophobia to 3 sessions of exposure to heights in vivo or in VR. Both forms of exposure were equally efficacious. Even though the patients knew the VR heights were not real, anxious responses were still triggered. The patients' responses to real or VR environments were equivalent. These researchers have also shown that virtual heights can be presented equally effectively with a Head-Mounted Display or a Cave Automatic Virtual Environment[7] system in which images are projected into a room and the user wears stereoscopic shutter glasses.[8] VR has also been applied to the treatment of other anxiety conditions such as posttraumatic stress disorder (PTSD) and flying phobia.[9–11]

The use of VR for public speaking anxiety holds wider interest. Pertaub et al[12] asked nonclinical individuals to

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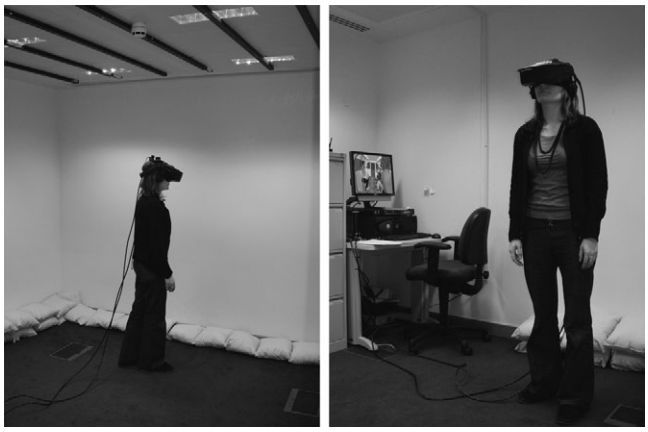

Fig. 1. Pictures From the Author's Virtual Reality Laboratory.

give a presentation in front of a positive, neutral, or negative virtual audience. The audience contained 8 characters (''avatars''). Participants were clearly affected by their audience. They generally responded favorably to the positive audience (eg, ''It was clear that the audience was really positive and interested in what I was saying and it made you feel like telling them what you know'') and were put off by the negative audience (eg, ''I was upset, really thrown. I totally lost my train of thought.''). Higher levels of anxiety toward the virtual audience were associated with public speaking fears, which is expected if virtual audiences elicit similar responses to real audiences. Anticipation of giving a speech in front of a virtual audience has been shown to elicit startle reactivity as assessed by eyeblink, heart rate, and skin conductance.[13] Exposure to virtual audiences has been successfully used in treatment for people with social phobia centered on public speaking.[14,15] Just as an individual immersed in VR will show a startle response to a virtual object exploding,[16] or their heart rate will increase above a virtual precipice,[17] so an avatar will elicit reactions similar to those of a person in real life.

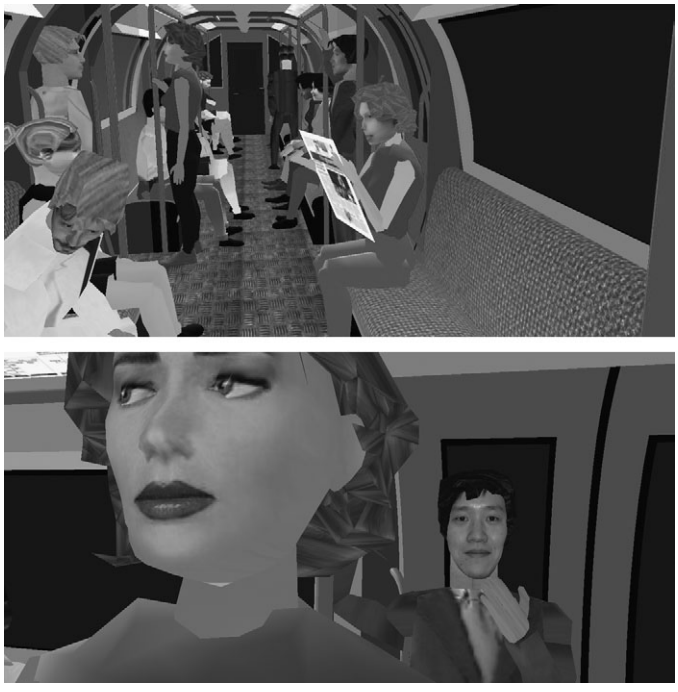

Fig. 2. Pictures of the Tube Train Virtual Environment.

It is the ability of VR to present social environments that trigger responses equivalent to the real world that offers the potential of the technology in the understanding and treatment of psychosis. There is a basic point that bears repetition: the interactions of patients in the social world are key to understanding and treating psychosis. Paranoid fears concern threats from others and misinterpretations of their behaviors[18]; hallucinations are frequently triggered by anxious anticipation of social situations[19] and the intensity of episodes relates to the social context[20]; the nature of the relationship that individuals have with their voices affects their level of distress and mirrors social relationships in the real world[21]; and many negative symptoms (eg, affective flattening, asociality) are defined by behavior in social situations.[22] Symptom expression—the content of delusions and hallucinations—is intimately connected with the social world. At a broader level, the impact of the social environment can be seen in the higher rates of psychosis in immigrant groups[23] and in urban areas.[24] Moreover, individuals with psychosis may be sensitive to stresses such as life events,[25] daily social hassles,[26] urban environments,[27] and high levels of expressed emotion.[28] Difficulties with social situations lead to isolation and avoidance. The targets of treatments—reducing symptoms, improving coping, and increasing activities—all relate to interactions in the social world. If the social environment can be controlled, then multiple applications to research and treatment are apparent.

The 7 Uses of VR for Psychosis

Symptom Assessment

Symptom assessment is usually carried out with the interviewer and patient sitting in a (bare) clinic room talking, with retrospective recall of the past week or month. In contrast, VR can provide a standardized assessment of actual symptom occurrence. To date, this has only been used for the experimental investigation of persecutory ideation. VR assessment of persecutory ideation confers particular benefits. Questionnaire assessments of paranoia cannot rule out paranoid thoughts that are grounded in reality.[29] Even interview methods often cannot establish the truth of the claims underlying a suspicious thought. However, if a neutral social situation is presented using VR, any paranoid thoughts that occur are known to be unfounded. Moreover, the person cannot act in a way to elicit hostile reactions from the avatars. In the author's initial work with students, a library

scene was used,[30,31] but subsequently a 5-minute ride on a London underground train between 2 stations has been developed.[32] Consistent with continuum views of paranoia, it has been shown that approximately one-third of the general population have persecutory thoughts about the computer characters. Validating the methodology, those higher in trait paranoia experience higher levels of persecutory ideation in VR. In a study of 200 nonclinical members of the general population, comments ranged from positive (eg, "One guy was checking me out—flattering.") to neutral (eg, "Didn't think anyone thought anything about me. All getting on with own business. Nobody seemed to notice me.") to paranoid (eg, "Thought a couple of the men were stuck up and nasty. Lady sitting down laughed at me when I walked past.").[32]

The study can be considered as the most unambiguous demonstration of paranoid thinking in the general public. Significant ascription to the avatars of personalities and mental states is made. Individuals at high risk of psychosis[33] and individuals with persecutory delusions (M. Fornells-Ambrojo, PhD, C. Barker, PhD, D. Swapp, PhD, M. Slater, DSc, A. Antley, MSc, D. Freeman, PhD, unpublished data) have similarly been found to have persecutory thoughts about the neutral avatars. In recent work in the laboratory, individuals who experience auditory hallucinations in social situations have been reporting voices in the virtual train. Environments pertinent to other symptoms of schizophrenia could be developed. VR has already started to be used to assess social perception in people with schizophrenia.[34] Nonsocial environments have been successfully used to administer neuropsychological tasks[35] and to test medication management skills[36] in individuals with schizophrenia.

Establishing Symptom Correlates

VR will provide an ideal setting to study behavioral and physiological correlates of symptoms. It is relatively simple to record a participant's movement in VR. Eye tracking can also be combined with VR. Measures of arousal such as heart rate, blood pressure, and skin conductance can be taken; an example of the assessment of fear responses in VR is provided by Mühlberger et al.[37] It is plausible that adaptations of the virtual scenarios, using joysticks for navigation, can be used in functional magnetic resonance imaging studies.[38] (Intriguingly, individuals who are only *thinking* about walking have navigated along a virtual street via feedback from electroencephalogram recordings.[39]) Physiological and behavioral recordings of interest can then be examined in relation to symptom occurrence.

Identification of Predictive Variables

The work on persecutory ideation is striking. The same controlled neutral environment is interpreted very differently. There follows a key question: what are the individual factors that predict a threatening interpretation? To address this question, the participants in the large general population study, prior to entering VR, were assessed on a battery of measures derived from a cognitive model of persecutory delusions.[18,40] Persecutory ideation in VR was strongly predicted by higher levels of anxiety, worry, perceptual anomalies, and cognitive inflexibility. This is a clear demonstration of the research potential of VR in identifying predictive factors. The factors examined were cognitive and social, but physiological and genetic variables could also be used. Similarly, the dependent variable could be the occurrence of other psychotic symptoms. It should be noted that identification of predictor variables using this methodology is of most use in groups where the occurrence of the symptom is to some extent unknown (eg, general population samples); looking at the predictors, eg, in a group with persecutory delusions is of limited interest because paranoid thinking is already known to occur.

Identification of Differential Predictors

In the study of nonpsychotic disorders, there is increasing interest in the differential prediction of symptoms, eg, the causes of PTSD or depression after a trauma.[41] Examination of differential predictors of individual psychotic symptoms has not yet occurred, presumably because of the diagnostic focus of so much research. In the author's work, there has been interest in identifying not only the causes of psychotic and emotional disorders that are shared but also the factors that are distinct for each condition.[42] In the large general population study,[32] social anxiety in VR was also assessed. Clustered bivariate logistic regressions were carried out, testing interactions between potential predictors and the type of reaction in VR, paranoid, or anxious (D. Freeman, PhD, M. Gittins, MSc, K. Pugh, BSc, A. Antley, MSc, M. Slater, DSc, G. Dunn, PhD, unpublished data). Anxiety, worry, and depression were associated with both social anxiety and paranoid reactions (ie, were shared factors). The presence of perceptual anomalies, however, increased the risk of paranoid reactions but decreased the risk of social anxiety (ie, it was a differential predictor). The result is consistent with an earlier pilot study.[31] Assessing multiple symptoms in VR provides a powerful method of examining differential predictors.

Identifying Environmental Predictors

The research strategies described depend on the social environment being constrained. Alternatively, the virtual world can be altered to determine the environmental elements that increase the likelihood of delusional ideas, hallucinations, or social difficulties. For example, paranoid ideation may partly depend on the size of a room, whether the person feels "trapped" in the situation, the

distribution and distance of other people, the amount of eye contact, the facial expressions of other people, and the level of background noise. These kinds of dimensions can be systematically altered and the impact on symptoms examined. Such a research approach could be used to understand the particular difficulties of urban environments.[27]

Establishing Causal Factors

VR provides an excellent method to establish causal roles. The factor of interest is manipulated and the effects on symptom occurrence in the virtual environment examined. For example, a causal role for anxiety in paranoia could be determined by examining differences in symptom occurrence in VR after randomization to an anxiety-inducing, anxiety-reducing, or control condition. Within- or between-subject designs could be used. Causal roles of medication and illicit substances could be similarly examined. If there is a demonstrated manipulation procedure for the variable of interest, then the short-term effect on symptom occurrence can be examined using VR. There are a number of ongoing studies of this type taking place in the author's VR laboratory.

Developing Treatment

The use of VR dovetails with the emerging cognitive-behavioral interventions for psychosis.[43–46] Three applications are readily apparent. An educational component could teach individuals about the factors that make symptoms better or worse. For example, one could demonstrate how emotional state affects hallucinations by having the individual enter VR after a mood manipulation (up or down). Similar practical exercises could help individuals learn about the effects of cognitive processes such as focus of attention or style of reasoning.

The second use would follow that developed for anxiety disorders: exposure to persecutory fears. The alternative way to frame this is as behavioral experiments testing out the threat beliefs. Hierarchical tests of fears could be presented using virtual environments. VR experiments are likely to feel safer and easier to the patient than tests of fears in real life and could precede them.

The third use of VR for psychosis would be learning to cope with symptoms as they occur. A variety of coping strategies could be tried out for learning how to remain engaged in a social situation even when symptoms occur. Clinical studies of these techniques in psychosis are yet to be carried out. VR has, however, been used in rehabilitation interventions for a range of problems,[47,48] including schizophrenia.[49,50]

Practical Issues of Using VR

When Sutherland[1] wrote about the ultimate display, the capabilities of computer displays were limited: "Some have only the fundamental ability to plot dots. Displays being sold now generally have built in line-drawing capability. An ability to draw simple curves would be useful." VR today is moving toward photorealism. The characters in the tube scenario in figure 2 are animated using recordings of real people, utilizing the technique of optical motion capture. The characters are even given the motion of breathing. According to a formulation of Moore's Law, the power of computers per unit cost doubles every 2 years. This rate of advance is seen for VR, which has become affordable, and the scenarios presented more realistic. Nonetheless, appropriate scenarios need to be developed for individuals with psychosis, and specialist technical support is essential. A range of scenarios will be necessary. There is wide variability in the content of symptoms of people with psychosis, and therefore, the triggering environments will differ. Virtual environments developed for social phobia, claustrophobia, and agoraphobia are likely to be applicable to psychosis. It would be helpful to validate scenarios developed for psychosis against the real-life equivalents. A further issue is that VR does not obviate the need to ask participants about their experience. The presence of positive symptoms such as delusional thoughts and hallucinations requires verbal report to establish. The State Social Paranoia Scale[51] has been validated as an assessment of persecutory ideation in VR, but other symptom measures will need to be developed.

Side effects of VR in individuals with psychosis will need to be monitored. The main concern is simulator sickness, which includes dizziness, nausea, headache, and eyestrain.[52] Also, it is inadvisable to test individuals who have seizures when watching television or playing video games. In the author's studies with members of the general population[32] and individuals with persecutory delusions (M. Fornells-Ambrojo, PhD, C. Barker, PhD, D. Swapp, PhD, M. Slater, DSc, A. Antley, MSc, D. Freeman, PhD, unpublished data), the Simulator Sickness Questionnaire[53] has been administered before and after VR exposure. No evidence of VR inducing sickness has been found, but the time in VR was brief. In the clinical studies, a 1-week follow-up conducted over the telephone found that patients were unaffected by their VR experience (M. Fornells-Ambrojo, PhD, C. Barker, PhD, D. Swapp, PhD, M. Slater, DSc, A. Antley, MSc D. Freeman, PhD unpublished data).[33] Side effects will relate to the specific equipment used, the scenario, and the length of immersion and should be routinely monitored.[52] In relation to psychosis, the incorporation of VR into delusional systems needs consideration. In the author's work, paranoid comments about the equipment have been rare, perhaps because participants have provided informed consent to participate. The most common comments from patients are about their enjoyment of the experience and appreciation of the opportunity to try a new technology. This bodes very well for the future applications of VR to psychosis set out in this article.

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References

1. Sutherland I. The Ultimate Display. *Proceedings of the International Federation of Information Processing Congress*. 1965;2:506–508.
2. Sutherland I. A Head-Mounted Three Dimensional Display. *Proceedings of the Joint Computer Conference*. 1968;33: 757–764.
3. Rheingold H. *Virtual Reality.* New York, NY: Simon & Schuster; 1991.
4. Woolley B. *Virtual Worlds.* London, UK: Penguin; 1993.
5. Sanchez-Vives MV, Slater M. From presence to consciousness through virtual reality. *Nat Rev Neurosci*. 2005;6:332–339.
6. Emmelkamp PMG, Krijn M, Hulsbosch AM, de Vries S, Schuemie MJ, van der Mast CAPG. Virtual reality treatment versus exposure in vivo: a comparative evaluation in acrophobia. *Behav Res Ther*. 2002;40:509–516.
7. Cruz-Neira C, Sandin DJ, DeFanti TA. Surround-screen projection-based virtual reality: the design and implementation of the CAVE. *ACM Computer Graphics (SIGGRAPH) Proceedings*. 1993;Vol 27:135–142.
8. Krijn M, Emmelkamp PMG, Biemind R, de Wilde de Ligny C, Schuemie J, van der Mast, CAPG. Treatment of acrophobia in virtual reality: the role of immersion and presence. *Behav Res Ther*. 2004;42:229–239.
9. Gregg L, Tarrier N. Virtual reality in mental health. *Soc Psychiatry Psychiatr Epidemiol*. 2007;42:343–354.
10. Krijn M, Emmelkamp PMG, Olafsson RP, Biemond R. Virtual reality exposure therapy of anxiety disorders: a review. *Clin Psychol Rev*. 2004;24:259–281.
11. Pull CB. Current status of virtual reality exposure therapy in anxiety disorders. *Curr Opin Psychiatry*. 2005;18:7–14.
12. Pertaub DP, Slater M, Barker C. An experiment on public speaking anxiety in three different types of virtual audience. *Presence Teleoperator Virtual Environments*. 2002;11:68–78.
13. Cornwall BR, Johnson L, Beradi L, Grillon C. Anticipation of public speaking in virtual reality reveals a relationship between trait social anxiety and startle reactivity. *Biol Psychiatry*. 2006;59:664–666.
14. Anderson PL, Zimand E, Hodges LF, Rothbaum BO. Cognitive-behavioural therapy for public-speaking anxiety using virtual reality for exposure. *Depress Anxiety*. 2005;22:156–158.
15. Harris SR, Kemmerling RL, North MM. Brief virtual reality therapy for public speaking anxiety. *Cyberpsychol Behav*. 2002;5:543–550.
16. Nichols S, Haldane C, Wilson JR. Measurement of presence and its consequence in virtual environments. *Int J Hum Comput Stud*. 2000;52:471–491.
17. Meehan M, Insko B, Whitton M, Brooks FP. Physiological measures of presence in stressful virtual environments. *ACM Trans Graph*. 2002;21:645–652.
18. Freeman D, Freeman J. *Paranoia: The 21st Century Fear* Oxford, UK: Oxford University Press. 2008.
19. Beck AT, Rector NA. A cognitive model of hallucinations. *Cognit Ther Res*. 2003;27:19–52.
20. Delespaul P, deVries M, van Os J. Determinants of occurrence and recovery from hallucinations in daily life. *Soc Psychiatry Psychiatr Epidemiol*. 2002;37:97–104.
21. Birchwood M, Meaden A, Trower P, Gilbert P, Plaistow J. The power and omnipotence of voices. *Psychol Med*. 2000; 30:337–344.
22. Andreasen NC. Negative symptoms in schizophrenia. *Arch Gen Psychiatry*. 1982;39:784–788.
23. Kirkbride JB, Fearon P, Morgan C, et al. Heterogeneity in incidence rates of schizophrenia and other psychotic syndromes: findings from the 3-center AESOP study. *Arch Gen Psychiatry*. 2006;63:250–258.
24. Spauwen J, Krabbendam L, Lieb R, Wittchen H-U, van Os J. Evidence that the outcome of developmental expression of psychosis is worse for adolescents growing up in an urban environment. *Psychol Med*. 2006;36:407–415.
25. Bebbington PE, Wilkins S, Jones P, et al. Life events and psychosis: results from the Camberwell Collaborative Psychosis Study. *Br J Psychiatry*. 1993;162:72–79.
26. Myin-Germeys I, van Os J, Schwartz JE, Stone AA, Delespaul P. Emotional reactivity to daily life stress in psychosis. *Arch Gen Psychiatry*. 2001;58:1137–1144.
27. Ellett L, Freeman D, Garety PA. The psychological effect of an urban environment on individuals with persecutory delusions: the Camberwell walk study. *Schizophr Res*. 2008;77–84.
28. Butzlaff AM, Hooley JM. Expressed emotion and psychiatric relapse. *Arch Gen Psychiatry*. 1998;55:547–552.
29. Freeman D. The assessment of persecutory ideation. In: Freeman D, Bentall R, Garety P, eds. *Persecutory Delusions: Assessment, Theory and Treatment. Oxford, UK: Oxford University Press*; 2008.
30. Freeman D, Slater M, Bebbington PE, et al. Can virtual reality be used to investigate persecutory ideation? *J Nerv Ment Dis*. 2003;191:509–514.
31. Freeman D, Garety PA, Bebbington P, et al. The psychology of persecutory ideation II: a virtual reality experimental study. *J Nerv Ment Dis*. 2005;193:309–315.
32. Freeman D, Pugh K, Antley A, et al. A virtual reality study of paranoid thinking in the general population. *Br J Psychiatry*. In press.
33. Valmaggia L, Freeman D, Green C, et al. Virtual reality and paranoid ideations in people with an 'at risk mental state' for psychosis. *Br J Psychiatry*. 2007;191(suppl 51):s63–s68.
34. Kim K, Kim J-J, Kim J, et al. Characteristics of social perception assessed in schizophrenia using virtual reality. *Cyberpsychol Behav*. 2007;10:215–219.
35. Sorkin A, Weinshall D, Modai I, Peled A. Improving the accuracy of the diagnosis of schizophrenia by means of virtual reality. *Am J Psychiatry*. 2006;163:512–520.
36. Kurtz MM, Baker E, Pearlson GD, Astur RS. A virtual reality apartment as a measure of medication management skills in patients with schizophrenia. *Schizophr Bull*. 2007;33: 1162–1170.
37. Mühlberger A, Bülthoff HH, Wiedemann G, Pauli P. Virtual reality for the psychophysiological assessment of phobic fear. *Psychol Assess*. 2007;19:340–346.
38. Mraz R, Hong J, Quintin G, et al. A platform for combining virtual reality experiments with functional magnetic resonance imaging. *Cyberpsychol Behav*. 2003;6:359–368.
39. Pfurtscheller G, Leeb R, Keinrath C, et al. Walking from thought. *Brain Res*. 2006;1071:145–152.

40. Freeman D. Suspicious minds: the psychology of persecutory delusions. *Clin Psychol Rev*. 2007;27:425–457.
41. Ehring T, Ehlers A, Glucksman E. Contribution of cognitive factors to the prediction of post-traumatic stress disorder, phobia and depression after motor vehicle accidents. *Behav Res Ther*. 2006;44:1699–1716.
42. Freeman D, Garety PA. Connecting neurosis and psychosis: the direct influence of emotion on delusions and hallucinations. *Behav Res Ther*. 2003;41:923–947.
43. Freeman D, Freeman J, Garety P. *Overcoming Paranoid and Suspicious Thoughts.* London, UK: Constable & Robinson; 2006.
44. Beck AT, Rector NA. Cognitive approaches to schizophrenia. *Annu Rev Clin Psychol*. 2005;1:577–606.
45. Birchwood M, Fowler D, Jackson C, eds. *Early Intervention in Psychosis.* Chichester, UK: Wiley; 2000.
46. Kingdon DG, Turkington D. *Cognitive Therapy for Schizophrenia.* New York, NY: Guilford; 2004.
47. Schultheis MT, Rizzo AA. The application of virtual reality technology in rehabilitation. *Rehabil Psychol*. 2001;46:296–311.
48. Lee JH, Ku J, Cho W, et al. A virtual reality system for the assessment and rehabilitation of the activities of daily living. *Cyberpsychol Behav*. 2003;6:383–388.
49. Da Costa RMEM, de Carvalho LAV. The acceptance of virtual reality devices for cognitive rehabilitation: a report of positive results with schizophrenia. *Comput Methods Programs Biomed*. 2004;73:173–182.
50. Ku J, Han K, Lee HR, et al. VR-based conversation training program for patients with schizophrenia: a preliminary clinical trial. *Cyberpsychol Behav*. 2007;10:567–574.
51. Freeman D, Pugh K, Green C, Valmaggia L, Dunn G, Garety P. A measure of state persecutory ideation for experimental studies. *J Nerv Ment Dis*. 2007;195:781–784.
52. Nichols S, Patel H. Health and safety implications of virtual reality: a review of empirical evidence. *Appl Ergon*. 2002;33:251–271.
53. Kennedy RS, Lane NE, Berbaum KS, Lilienthal MG. Simulator Sickness Questionnaire: an enhanced method for quantifying simulator sickness. *Int J Aviat Psychol*. 1993;3:203–220.