

Virtual reality and paranoid ideations in people with an ‘at-risk mental state’ for psychosis

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Background Virtual reality provides a means of studying paranoid thinking in controlled laboratory conditions. However, this method has not been used with a clinical group.

Aims To establish the feasibility and safety of using virtual reality methodology in people with an at-risk mental state and to investigate the applicability of a cognitive model of paranoia to this group.

Method Twenty-one participants with an at-risk mental state were assessed before and after entering a virtual reality environment depicting the inside of an underground train.

Results Virtual reality did not raise levels of distress at the time of testing or cause adverse experiences over the subsequent week. Individuals attributed mental states to virtual reality characters including hostile intent. Persecutory ideation in virtual reality was predicted by higher levels of trait paranoia, anxiety, stress, immersion in virtual reality, perseveration and interpersonal sensitivity.

Conclusions Virtual reality is an acceptable experimental technique for use with individuals with at-risk mental states. Paranoia in virtual reality was understandable in terms of the cognitive model of persecutory delusions.

Declaration of interest None.

Recent research has shown that it is feasible to use virtual reality (VR) to study persecutory ideation under controlled experimental conditions (Freeman *et al*, 2003, 2005). In these studies psychological variables identified from a cognitive model of persecutory delusions (Garety *et al*, 2001; Freeman *et al*, 2002) have been used to predict the occurrence of persecutory thoughts about computer characters in a neutral virtual reality social environment. The advantage of this controlled experimental approach is that stimuli can be controlled and any persecutory ideation that occurs is known to be unfounded and hostility cannot be provoked by the participant. In the future, such virtual environments may be used not only to learn about the causes of paranoia but as an element of treatment, as has occurred for anxiety disorders (Krijn *et al*, 2004). The present study was designed to test whether this innovative experimental technique is safe to use with individuals at risk of psychosis, and could be used to investigate cognitive models of psychosis in this group. We expected that virtual reality would be safe and acceptable in this group, and predicted that neutral behaviour by computer-generated characters in a typical social setting would be able to induce persecutory thoughts in participants with an at-risk mental state. We then tested the hypothesis that the development of persecutory thoughts in these conditions would be associated with factors implicated in cognitive models of persecutory delusions (Garety *et al*, 2001; Freeman *et al*, 2002). As far as is known this is the first test of the virtual reality procedure with a clinical group.

METHOD

The design closely followed that developed in previous studies with non-clinical participants (Freeman *et al*, 2003, 2005). Participants completed a number of assessments

before entering a virtual environment. Immediately after leaving this environment, post-virtual reality assessments were administered. In addition, there was a further follow-up assessment after 1 week to determine whether there had been any adverse reactions to the procedure.

There were 21 participants recruited via Outreach and Support in South London (OASIS), a specialised service for people at high risk of psychosis (Broome *et al*, 2005b). All participants were aged between 16 and 35 years, had never experienced a psychotic episode, and were being managed clinically by OASIS in the community. Briefly, participants met one or more of the following criteria, assessed with a detailed clinical assessment using the Comprehensive Assessment of the At-Risk Mental State (CAARMS; Phillips *et al*, 2000): (a) attenuated positive psychotic symptoms; (b) brief limited intermittent psychosis (BLIP); or (c) a recent decline in functioning, together with either schizotypal personality disorder or a first-degree relative with a psychotic disorder.

Virtual reality environment

The virtual environment was a tube train ride developed by a team at University College London. The environment was modelled on the interior of a London Underground train carriage, and was displayed in colour (see data supplement in the online version of this paper).

All seats in the train carriage were taken by 20 computer-generated characters, known as ‘avatars’ – these were male and female, and several different ethnicities were represented. At the first stop, one avatar disembarked and another boarded. Importantly, the avatars were programmed to exhibit only neutral behaviour; they could glance up and around the carriage and they changed facial expressions occasionally (for example, smiling), but they did not display any overtly hostile or overly friendly behaviour. The background noises and sounds associated with being in a London Underground train were played (e.g. when the carriage doors closed participants would hear ‘Mind the closing doors’, while at other times there was the background rumble of a moving train). The environment was designed so that a majority of the general population would find it a neutral experience.

The virtual environment was displayed in an immersive projection system

commonly referred to as a 'CAVE' (Fakespace Systems, Iowa) (Cruz-Neira *et al.*, 1993), with four projection walls (3 walls and the floor). The specific system was a ReaCTor (Trimension, West Sussex). Participants had their head position and orientation tracked with an inertial/ultrasonic system (IS900 VET tracking system; Intersense, Massachusetts). They also carried a tracked (Intersense) joystick in their right hand. They wore lightweight CrystalEye LCD shutterglasses (Stereo-Graphics, California), which delivered a stereo view of the virtual world, which surrounded them on four sides. Participants could move through the virtual environment with a combination of walking and whole body turning, and also by pressing a button on the joystick, which moved them forwards in the virtual space in the direction in which they were pointing.

Assessment instruments

Pre-virtual reality measures

The Green *et al.* Paranoid Thoughts Scales (G-PTS; further details available from C.G.) is a newly developed instrument to measure current ideas of reference and current ideas of persecution based upon a precise definition of persecutory ideation (Freeman & Garety, 2004). The two sub-scales are both 16-item self-report measures scored from 1 to 5 (1=not at all, 5=totally). The scales have displayed good reliability and validity in a large non-clinical sample and in a clinical sample of 50 individuals with persecutory delusions.

The Paranoia Scale (PS; Fenigstein & Venable, 1992) is a 20-item self-report scale to assess paranoia in the general population, and includes items assessing both ideas of persecution and reference. Each item is rated on a five-point scale (1–5). Total scores can range from 20 to 100, with higher scores indicating greater paranoid ideation. The PS has demonstrated good reliability and validity in a large non-clinical sample. This measure was included as an additional reliability check for the newer G-PTS, and to enable comparison of the levels of paranoia in the group with other studies.

The Interpersonal Sensitivity Scale (IPSM; Boyce & Parker, 1989) is a 36-item scale designed to assess interpersonal sensitivity. Self-statements are rated on a four-point scale (1=very unlike self, 4=very like self). The scale generates a total score ranging from 36 to 144 as well as five

sub-scales: 'interpersonal awareness' (7 items, range 1–28); 'need for approval' (8 items, range 8–32); 'separation anxiety' (8 items, range 8–32); 'timidity' (8 items, range 8–32) and 'fragile inner self' (5 items, range 5–20). Higher scores indicate greater interpersonal sensitivity. The IPSM has good psychometric properties.

The Depression Anxiety Stress Scales (DASS) is a 42-item instrument with three sub-scales measuring current negative emotional states of stress, anxiety and depression. Each of the sub-scales consists of 14 items with a 0–3 scale (0=did not apply at all to me, 3=applied to me very much). Participants are asked to rate the extent to which they have experienced each state over the past week. The psychometric qualities of this scale have recently been established in a large UK non-clinical population (Crawford & Henry, 2003).

The Launay–Slade Hallucinations Scale (LSHS; Launay & Slade, 1981) is a 12-item self-report scale to measure hallucinatory predisposition by assessing clinical and sub-clinical hallucinatory phenomena. Participants answer 'yes' or 'no' to each item. Higher scores indicate a greater predisposition to hallucinatory experiences.

The 'Beads Task' (Garety *et al.*, 1991) assesses data gathering style. Individuals are presented with a pair of containers holding beads of two different colours in a given ratio (in this study 60:40). The ratio of colours is reversed in each jar. With the containers hidden from view, a bead is drawn from one container, shown to the participant and then replaced. The task is to work out which container has been chosen. Individuals with delusions typically require significantly fewer items than controls before making a decision, indicating the presence of a data gathering or 'jumping-to-conclusions' bias (van Dael *et al.*, 2006).

The Wisconsin Card Sorting Task (WCST; Heaton *et al.*, 1993) is the most widely used test for executive functioning in schizophrenia research (van Beilen, 2004). Scores are calculated for the number and percentage of errors, correct responses, perseverative and non-perseverative responses, and perseverative and non-perseverative errors. In the current study perseverative errors (higher scores reflecting greater mental inflexibility) was the variable of interest.

The National Adult Reading Test (NART; Nelson, 1982) aims to give an

accurate measure of (pre-morbid) IQ by assessing the ability to read non-phonetic words.

Post-virtual reality measures

Pre- and Post Virtual Reality Visual Analogue Scales

In order to assess whether the procedure caused distress in participants, state anxiety was assessed before and after entering the virtual environment by asking individuals to mark a standard 10 cm visual analogue scale from 0 (not at all anxious) to 10 (extremely anxious). Similarly, participants were asked to rate on a 10 cm visual analogue scale how unpleasant (score 0) or pleasant (score 10) their experience in the tube had been.

The Virtual Reality Questionnaire (Freeman *et al.*, 2005)

This is a 20-item self-report questionnaire used to assess thoughts about the virtual reality avatars. Each item is scored on a 1–5 scale (1=do not agree, 5=totally agree). The scale has 3 sub-scales: virtual reality–persecution (e.g. 'Someone had it in for me', 'Someone stared at me in order to upset me', 'Someone was trying to isolate me', 'Someone was trying to make me distressed'); virtual reality–neutral (e.g. 'No-one had any particular feelings about me') and virtual reality–positive (e.g. 'I felt very safe in their company'). The higher the score on a sub-scale the more items were endorsed.

The Post Virtual Reality Semi-Structured Interview (Freeman *et al.*, 2003)

This is a 10-min semi-structured interview conducted to assess the spontaneous impressions participants made of the environment and the virtual characters. The interviews were tape recorded and then rated (masked to responses on the questionnaires) for persecutory content on a 6-point scale (0=none to 5=marked). This score from interview was used as a validity check for the self-report virtual reality–persecution scale.

Presence is the extent to which participants in a virtual reality respond to virtual objects and events as if they are real. One of the methods of assessing presence is by the use of a self-rating questionnaire. In this study we used a Presence Questionnaire (Slater *et al.*, 1998) that consists of 6 items, each rated on a scale of 1 to 7 with higher

scores indicating greater sense of presence. In the present study, a high sense of presence was defined as a score 6 or 7. No normative reliability or validity data are currently available on this measure, however it has been used in many experimental studies with consistent results (e.g. Slater & Steed, 2000).

Follow-up assessment

To investigate whether the virtual reality experience had triggered any persisting adverse reactions, all participants were contacted by telephone 1 week after the experiment. Participants were asked whether they had thought about the experiment, whether they had had any intrusions regarding the virtual reality environment, and whether their mood and behaviour had been affected in any way by the experiment.

Procedure

The study had received approval from the local NHS research ethics committee. Oral and written information about the study was given to the patients and written informed consent obtained. Participants were asked to complete the measures described above before entering the virtual environment. There was then a training task to help participants familiarise themselves with virtual reality. Once a participant was comfortable with the equipment, the experimental environment was presented. Within the virtual reality training module, a 'door' was opened revealing a passage to the underground train. Participants were instructed to enter the carriage and to stay on board for two stops. They were asked to form an impression of their environment and the people in the carriage – in particular, what they felt towards the people on the tube and what they thought the people on the tube felt towards them. The 'journey' lasted for 4 min, and took them on the London Underground Central Line from 'St Paul's', stopping at 'Chancery Lane', through to 'Holborn' where the participant was to disembark. While on the train, the participant was free to move up and down the carriage. Station stops were announced via a recording played through the audio system. After the virtual tube ride, participants were asked to complete a post-virtual reality visual analogue anxiety measure, the Virtual Reality

Questionnaire, the Presence Questionnaire, and a brief semi-structured interview with the researcher. Participants received a small payment to reimburse their time.

Statistical analysis

All analyses were conducted using SPSS for Windows (Version 13). All significance test results are quoted as two-tailed probabilities. Associations between the pre-virtual reality measures and persecutory ideation in virtual reality were examined by Pearson's correlations. With 21 participants, the study had 80% power to detect a correlation coefficient of 0.54 at a significance level of 0.05 using a two-tailed test (i.e. the study had power only to detect large effect sizes). The study was designed to test the applicability of the procedures to a group with at-risk mental state and predict the occurrence of paranoia within this patient group, meaning that a control group was unnecessary.

RESULTS

The demographic and clinical characteristics of the participants are displayed in Tables 1 and 2. Most of the participants were young men in full-time employment or students. A substantial proportion (43%) were from minority ethnic groups.

All participants were experiencing attenuated positive symptoms, although a quarter of the participants ($n=5$) also had a history of a BLIP (a very brief period of frank psychosis) and a minority ($n=2$) had a family history of mental health problems. The Global Assessment of Functioning Scale mean score was 56.7 (s.d.=13.5). The sample had an average IQ, as indexed by the NART. Scores on the G-PTS were highly correlated with scores on the PS ($R=0.91$, $P<0.001$).

Experience of the virtual reality environment

On average 29% of the participants endorsed a score 6 or 7 on the Presence Questionnaire (i.e. had the greatest sense of immersion in the experience). The degree of immersion in the virtual reality environment can be illustrated by considering one of the items of the Presence Questionnaire, 'the sense of actually being in the tube train

versus being in the laboratory'. Participants were asked to rate how much they agreed with this statement on a visual analogue scale ranging from 1 (laboratory) to 7 (tube train); 12 participants (57%) felt they were in a tube train during the experiment (i.e. scored 5, 6 or 7), two people (10%) scored 4 on this item, while 7 participants (33%) had a sense of being in a laboratory (i.e. scored 3, 2 or 1).

The virtual reality experience was rated as pleasant (45%) or neutral (25%) by the majority of participants, while a minority rated it as unpleasant (30%). Anxiety did not increase from before virtual reality (mean anxiety score=3.2, s.d.=2.4) to after it (mean anxiety score=3.7, s.d.=3.3), $Z=-1.065$, $P=0.287$. At the one-week follow-up, 16 participants (76%) reported having thought about the virtual reality experience (e.g. 'I spoke to my friend about it' or 'I thought about it a couple of times, because it was real and unreal at the same time. I quite liked it'), but none of the participants reported having had unsolicited or

Table 1 Demographic and clinical features

Characteristic	Participants, $n=21$
Gender, n	
Male	13
Female	8
Mean age, years (s.d.)	25.0 (4.7)
Ethnicity, n	
Asian	1
Black African	1
Black British	2
Black Caribbean	5
White British	12
Occupation, n	
Employed	5
Student	9
Unemployed	7
At risk criterion, n	
Attenuated symptoms	14
Attenuated symptoms and BLIP	5
Attenuated symptoms and family history	2
GAF score, mean (s.d.)	56.7 (13.5)
NART pre-morbid IQ score, mean (s.d.)	98.4 (8.8)

BLIP, brief limited intermittent psychosis; GAF, Global Assessment of Functioning; NART, National Adult Reading Test.

Table 2 Mean scores and standard deviation of the baseline assessment measures

	Mean score	s.d.
Green Paranoid Thoughts Scale total	72.1	33.7
Paranoia Scale	50.7	19.7
Launay–Slade Hallucinations Scale	5.3	3.7
Depression Anxiety Stress Scales		
Anxiety	15.0	12.4
Depression	21.5	12.5
Stress	19.8	13.7
Interpersonal Sensitivity Scale (IPSM)		
Total	92.0	19.7
Interpersonal awareness	18.6	5.8
Need for approval	21.7	6.9
Separation anxiety	19.4	6.5
Timidity	21.0	4.8
Fragile inner-self	11.3	4.1
Pre-virtual reality anxiety	3.2	2.4

intrusive thoughts or images. No participant reported negative emotions associated with the experience at follow-up and no one had modified their behaviour or avoided going anywhere because of the experiment.

Persecutory ideation in the virtual reality environment

The majority of participants (57%) endorsed at least one paranoid item in relation to the avatars on the virtual reality–persecution sub-scale. The most endorsed item was ‘Someone was trying to make me distressed’; 10% ‘agreed a little’ with this statement, 10% ‘agreed moderately’ and 24% ‘agreed very much’ with it. The least endorsed item was ‘Someone had it in for me’; 15% of the participants ‘agreed a little’ and 5% ‘agreed moderately’ with this statement. Almost all participants (95%) endorsed at least one neutral item about the virtual reality environment, and 86% agreed with at least one positive statement. Overall, although most of the participants reported some paranoid

experiences, the environment was mainly experienced as neutral or positive.

The masked ratings of persecutory ideation from the recorded post-virtual reality semi-structured interview significantly correlated with virtual reality–persecution scores ($R=0.60$, $P=0.005$). The interview of one participant could not be recorded and scored due to a technical problem with the tape recorder. When interviewed, 13 participants (65%) reported neutral or positive impressions about the virtual reality experience (e.g. ‘They did not have any expression, I did not think anything about them’, ‘One girl kept smiling at me, she may have fancied me’). The remaining 7 participants (35%) reported slight to moderate paranoid interpretations (e.g. ‘I thought one girl was staring at me. She made me angry. I wanted to hit her, so I moved away’, ‘I felt that some people were against me because of their body-language and the whispering and the laughing. I thought that some of them wanted to harm me and that they had an attitude. I felt very angry towards them, and if somebody would have said anything to me I would have wanted to harm them.’).

Correlations of the measures with the sub-scales of the Virtual Reality Questionnaire are shown in Table 3. The key sub-scale for this study is virtual reality–persecution. It had 10 significant correlations and 8 non-significant correlations with the other measures. Persecutory ideation in virtual reality was predicted by higher levels of trait paranoia, anxiety, stress, ideas of a fragile inner self, immersion in virtual reality, and perseveration.

On the beads task four participants (19%) ‘jumped to conclusions’ (i.e. decided after three beads or fewer) and all but one produced the correct answer. However, the number of draws needed to come to a decision on the beads task was not associated with the occurrence of paranoid thinking in virtual reality ($R=-0.02$, $P=0.950$).

DISCUSSION

Our first concern when using this novel experimental technology with a clinical group at high risk of psychosis was to ensure its safety. The study has demonstrated the safety of the procedures: there were no adverse reactions, levels of anxiety were not raised, and the experiment did not create

Table 3 Correlations of measures with the Virtual Reality Questionnaire

	Virtual Reality–Persecution	
	R	P
Green Paranoid Thoughts Scale total	0.61**	0.004
Paranoia Scale	0.48*	0.027
Launay–Slade Hallucinations Scale	0.36	0.116
Depression Anxiety Stress Scales		
Anxiety	0.57**	0.008
Depression	0.42	0.068
Stress	0.50*	0.023
Interpersonal Sensitivity Scale (IPSM)		
Total	0.16	0.504
Interpersonal awareness	0.23	0.345
Need for approval	-0.13	0.588
Separation anxiety	0.27	0.266
Timidity	0.12	0.612
Fragile inner-self	0.46*	0.049
Pre-virtual reality anxiety	0.55*	0.011
Post-virtual reality anxiety	0.74**	0.000
Sense of presence	0.49**	0.026
National Adult Reading Test, score	0.21	0.383
WCST perseverative responses	0.59**	0.007
WCST perseverative errors	0.56**	0.010

WCST, Wisconsin Card Sorting Task.

* $P < 0.05$, ** $P < 0.01$.

intrusive thoughts. Indicating the clinical and research promise of this approach, many of the individuals with at-risk mental state did experience unfounded paranoid thoughts about the virtual reality characters. These individuals were more likely to experience paranoid thoughts in day-to-day life, validating the methodology. A method of capturing paranoid thoughts in the laboratory for this clinical group has therefore been shown. There is also therefore the longer-term potential for the procedures to be adapted for aiding psychological interventions such as cognitive behaviour therapy.

Understanding the causes of paranoid thoughts

Our second hypothesis was that persecutory ideas induced by the virtual reality procedure would be associated with a number of baseline factors thought to play a key role in the development of psychosis. Cognitive models of delusions postulate that paranoid thoughts are appraisals of experiences (e.g. Bentall *et al*, 1994; Garety *et al*, 2001; Freeman *et al*, 2002, 2006; Broome *et al*, 2005a). The appraisals are hypothesised to be influenced by emotional processes and reasoning biases. Uniquely, virtual reality enables researchers to investigate the determinants of such appraisals (such as emotion or reasoning) by controlling the event, so that everyone is exposed to a similar experience. As predicted by the cognitive model of persecutory delusions, anxiety, stress and interpersonal sensitivities were associated with higher levels of paranoid ideation in the virtual reality tube environment. There were also trends for depression to be associated with the presence of paranoid thoughts in virtual reality. Intriguingly, the results exactly match those of the previous virtual reality studies with non-clinical populations (Freeman *et al*, 2003, 2005), which found the same associations between paranoid ideations and other variables. This is supportive of a continuum view of psychotic experiences. The current study also examined executive functioning in relation to paranoid thinking. A perseverative thinking style was positively correlated with persecutory ideation. This suggests that a rigid thinking style might be associated with persecutory appraisals. Perseverative errors on the Wisconsin Card Sorting Test are often interpreted as reflecting cognitive inflexibility, and they are a consistent finding in patients with

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schizophrenia compared with non-clinical controls (van Beilen, 2004). Intriguingly, our results in participants with an at-risk mental state exactly match those of the previous virtual reality studies in non-clinical populations (Freeman *et al*, 2003, 2005), which found the same associations between paranoid ideations and these variables. This suggests that similar mechanisms may underlie anomalous experiences in clinical and non-clinical samples and is supportive of a continuum view of psychotic experiences.

Limitations

A key limitation of the current work is the small sample size. This means that the generalisability of the results to other at-risk mental state groups may be limited. Further, there was limited ability to detect associations with the pre-virtual reality assessments. Examining interactions between predictors was also precluded by the sample size. The scope of the study would have been widened by the inclusion of a matched non-clinical group. The question could then have been addressed of whether individuals at risk of psychosis have greater levels of paranoia in virtual reality compared with non-clinical individuals. It could also be argued that the use of virtual reality technology might be off-putting for potential participants in research, and that only a highly selected group take part. Our anecdotal evidence from this study is that at-risk mental state individuals who did not wish to take part did so for reasons unrelated to the technology (e.g. being in full-time employment, not being interested in any kind of research, being away on holiday).

Clinical implications

Virtual reality is a safe and feasible technique that can be used to investigate the factors associated with paranoid ideations not only in the general population but also in a clinical sample. By creating a controlled situation, environmental factors associated with paranoia could be investigated. Furthermore, virtual reality could be integrated into cognitive-behavioural interventions for psychosis (e.g. Valmaggia *et al*, 2005). Integrated into cognitive-behavioural therapy, virtual reality could help patients with delusions test out their beliefs and try alternative coping strategies (Greenwood *et al*, 2006).

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