BJPsych | The British Journal of Psychiatry (2008) 192, 258–263. doi: 10.1192/bjp.bp.107.044677

Virtual reality study of paranoid thinking in the general population

Daniel Freeman, Katherine Pugh, Angus Antley, Mel Slater, Paul Bebbington, Matthew Gittins, Graham Dunn, Elizabeth Kuipers, David Fowler and Philippa Garety

Background
Judging whether we can trust other people is central to social interaction, despite being error-prone. A fear of others can be instilled by the contemporary political and social climate. Unfounded mistrust is called paranoia, and in severe forms is a central symptom of schizophrenia.

Aims
To demonstrate that individuals without severe mental illness in the general population experience unfounded paranoid thoughts, and to determine factors predictive of paranoia using the first laboratory method of capturing the experience.

Method
Two hundred members of the general public were comprehensively assessed, and then entered a virtual reality train ride populated by neutral characters. Ordinal logistic regressions (controlling for age, gender, ethnicity, education, intellectual functioning, socio-economic status, train use, playing of computer games) were used to determine predictors of paranoia.

Results
The majority agreed that the characters were neutral, or even thought they were friendly. However, a substantial minority reported paranoid concerns. Paranoia was strongly predicted by anxiety, worry, perceptual anomalies and cognitive inflexibility.

Conclusions
This is the most unambiguous demonstration of paranoid ideation in the general public so far. Paranoia can be understood in terms of cognitive factors. The use of virtual reality should lead to rapid advances in the understanding of paranoia.

Declaration of interest
None. Funding detailed in Acknowledgements.

Paranoia denotes the unfounded fear that others intend to cause you harm (e.g. 'People are out to get me', 'Someone deliberately tried to irritate me', 'There is a conspiracy against me').[1] Interview and questionnaire research indicates that paranoid thinking occurs regularly in 15–20% of the general population.[2–4] Levels of trust in society are associated with social cohesion and mortality rates.[5]

There is a continuum of severity of paranoia in the general population.[6] At the extreme end are persecutory delusions seen in psychotic disorders such as schizophrenia. Consistent with this continuum view, non-clinical and clinical paranoid experiences are associated with the same risk factors[1,7] and the presence of non-clinical symptoms increases the likelihood of subsequent diagnosis of psychotic disorder.[8] Studying non-clinical paranoid experiences is therefore not only of interest in its own right, but informs the understanding of clinically severe persecutory delusions.

Questionnaire assessments of paranoia cannot rule out paranoid thoughts that are grounded in reality.[9] Even interview methods often cannot establish the truth of the claims underlying a suspicious thought. A laboratory method of eliciting truly paranoid thoughts overcomes the problem.

Clinical observation suggests that the most immediate trigger for a paranoid thought is the misinterpretation of an everyday experience such as a person's facial expression. However, this poses problems for the study of paranoid thinking, since it is impossible to give everybody the same everyday experience. This is particularly important, as people with paranoid thoughts often act differently with others (e.g. timidly) and thereby elicit different reactions. Our solution was to use the presence-inducing powers of computer-generated interactive (virtual reality) environments (this is the tendency to respond to virtual situations and events as if they were real).[10] Our chosen neutral social environment was an underground train ride (see online Fig. DS1).

The key advantage of this method is that paranoid responses must be unfounded as the computer characters are programmed to behave in ways deemed by consensus to be neutral. No matter what a person does, the characters will remain neutral in their apparent responses. In pilot studies we have shown that paranoid thinking about virtual reality characters can occur in students[11,12] and in people at high risk of developing psychosis.[13] In the current paper we report the first full-scale test in the general population.

Virtual reality can be used to identify the causes of paranoid thinking. In the current study we based our hypotheses about the factors that would predict the occurrence of paranoia on the Threat-Anticipation Model[1,14,15] (Fig.1). This explicitly acknowledges that there are multiple causes of paranoid thinking, but identifies the following as particularly important: affective processes, especially anxiety, worry, and interpersonal sensitivity; anomalous experiences such as hallucinations and perceptual anomalies; reasoning biases, particularly jumping to conclusions and belief inflexibility; and social factors such as adverse events and environments. In essence, it is hypothesised that at a time of stress the individual feels different and interprets these factors in a threatening way because of an anxious mood state and previous adverse experiences. Reasoning biases cause these fears to reach a delusional level of conviction.

In summary, we set out to demonstrate that individuals in the general population experience unfounded paranoid thoughts, and to determine factors predictive of paranoia. We hypothesised that a significant minority of the general public would have paranoid thoughts about the avatars, that these would be individuals prone to paranoid thoughts in day-to-day life and that factors from the cognitive model would predict paranoia in virtual reality.

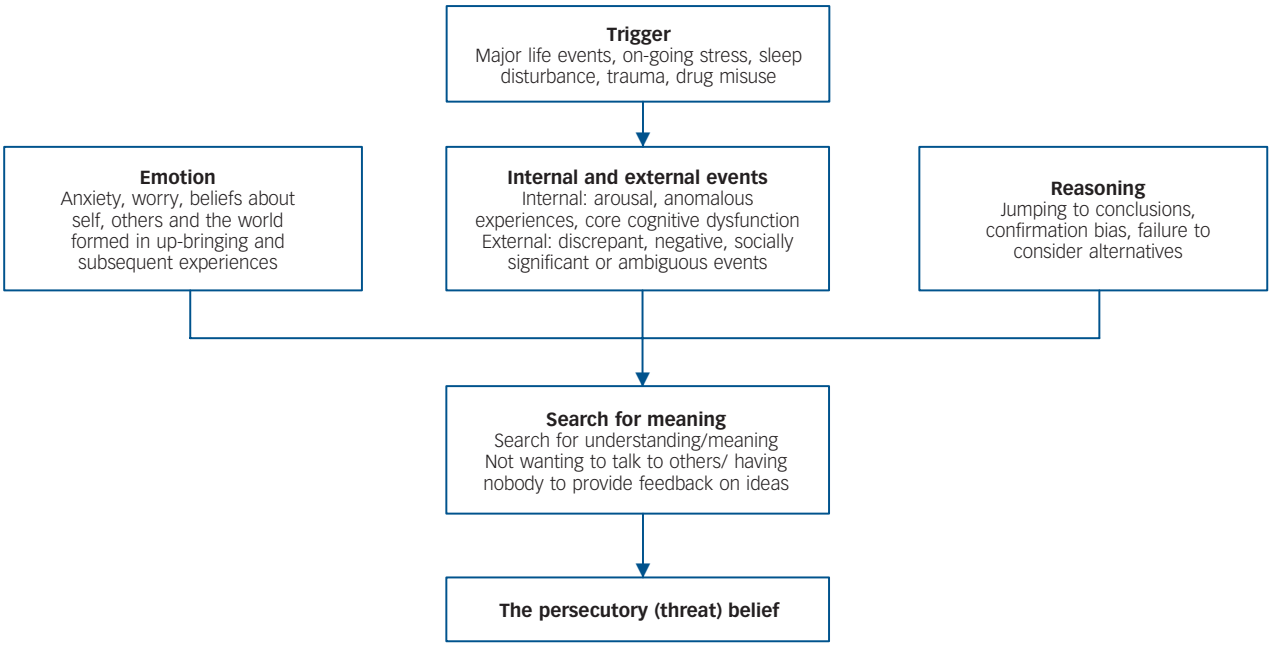

Fig. 1 Outline of factors involved in the development of persecutory delusions.

Methods

After completion of a comprehensive psychological assessment, participants spent 4 min in a London underground train virtual environment, followed by measurement of their subjective experience.

Participants

A representative sample of the local adult population was recruited. A leaflet advertising a study of 'people's reactions in virtual reality' at King's College London was sent to all households in local postcodes. Participants were not informed that the study was of paranoia until completion of testing. Individuals reporting a history of severe mental illness such as schizophrenia (n=7) were excluded from the study. Individuals with a history of epilepsy (n=2) were also excluded because of potential side-effects of virtual reality. A total of 100 male and 100 female participants were recruited. The study had received approval from the local research ethics committee. Testing took place from September 2006 to March 2007 (14 months after terrorist attacks on the London underground).

Virtual reality

The head-mounted display (see online Fig. DS2) used was a Virtual Research VR1280, which has a resolution of 1280 × 1024 in each eye, a 60° diagonal field of view and a refresh rate of 60 Hz. The tracking system used for the scenario was the Intersense IS900. The tracker uses a hybrid of inertial and ultrasonic sensors to determine the orientation and position of the user during the simulation. The sensors were laid out in a ceiling constellation grid above the user. The tracker data were accessed by a Virtual Reality Peripheral Network (VRPN) IS900 server.

The virtual reality environment comprised a 4 min journey between two stops on a London underground ('tube') train, populated by computer characters (see online Figs DS1 and DS3). The Distributed Immersive Virtual Environment (DIVE) software platform was used to create the overall scenario.[16] Both the train shell and the computer characters ('avatars') were created using 3D Studio Max run on Windows. The avatar motions were made using an optical motion capture system. Each avatar had its own background motion that repeated throughout the scenario. Each avatar had one motion that approximated their breath and another motion that randomised the direction of their gaze. In addition, several of the avatars responded to participants' gaze by looking in their direction (e.g. one avatar would occasionally smile at the user when looked at). The audio for the scene, comprising background tube noise and low-level snippets of conversation, was rendered in stereo, without spatialisation, using a Creative sound card.

Measures

Basic demographic data and information on use of the London underground were collected. Before entering the virtual environment, participants completed assessments of intellectual functioning and trait paranoia, followed by a battery of measures related to factors in the cognitive model of paranoia.

Cognitive ability

Wechsler Abbreviated Scale of Intelligence. This scale[17] is a standardised short and reliable measure of IQ. The Vocabulary and Matrix Reasoning sub-tests were used in the current study.

Paranoid thinking

Green *et al* Paranoid Thoughts Scale (GPTS) Part B. The GPTS[18] is a trait measure of paranoia. Each of the 16 items in the persecutory sub-scale (e.g. 'I was convinced there was a conspiracy against me') is rated on a 5-point scale. The presence of persecutory ideation is assessed over the past month and higher scores indicate greater levels of persecutory thinking. The questionnaire has been psychometrically evaluated in clinical

and non-clinical populations. The internal consistency of the scale and test–retest reliability are good.

Emotional processes

Depression Anxiety Stress Scales. This is a 42-item instrument[19] with three sub-scales measuring current symptoms of depression, anxiety and stress. Each of the sub-scales consists of 14 items with a 0–3 rating scale (0=did not apply to me at all, 3=applied to me very much). Higher scores indicate higher levels of emotional distress. The anxiety and depression sub-scales were used in the current study.

Penn State Worry Questionnaire. This[20] is the most established measure of trait worry style and has been used in non-clinical and clinical populations. Each of the 16 items are rated on a 5-point scale. Higher scores indicate a greater tendency to worry.

Worry Domains Questionnaire. This scale[21] assesses the occurrence of a range of common (non-paranoid) worries (i.e. in contrast to the Penn State Worry Questionnaire, the scale assesses content). It contains 25 items using a 5-point rating scale ('not at all' to 'extremely'). Higher scores indicate greater levels of worry.

Catastrophising Interview. The Catastrophising Interview[22] is an experimental assessment of worry. Individuals are asked what worries them about their main worry and this question is repeated for all their subsequent answers. The procedure is terminated when no further responses are given (i.e. the person can think of no more worries in the chain). Each answer is counted as a catastrophising step. Increasing numbers of catastrophising steps indicate a greater worry style.

Brief Core Schema Scales. This measure,[23] developed with non-clinical and psychosis groups, has 24 items each rated on a 5-point scale (0–4). Four sub-scale scores are derived: negative beliefs about self, positive beliefs about self, negative beliefs about others and positive beliefs about others. Higher scores reflect greater endorsement of items.

Interpersonal Sensitivity Measure. This is a 36-item scale[24] designed to assess interpersonal sensitivity, defined as undue and excessive awareness of, and sensitivity to, the behaviour and feelings of others. Self-statements are rated on a 4-point scale (1=very unlike self, 2=moderately unlike self, 3=moderately like self, 4=very like self). High scores indicate greater interpersonal sensitivity. The psychometric properties of the scale have been tested in non-clinical individuals, general practice attendees and psychiatric patients.

Reasoning

Cognitive Flexibility Scale. This is a 12-item self-report scale[25] assessing awareness that in any given situation there are options and alternatives, and the willingness and confidence to be flexible. Items are scores on a 6-point scale ('strongly agree' to 'strongly disagree'). Higher scores indicate greater levels of flexibility. Reliability and validity have been established in a non-clinical sample.

60:40 Beads Task. This probabilistic reasoning task[26] assesses data-gathering style. The key variable is the number of items requested before a decision is made.

Anomalous experience

Cardiff Anomalous Perceptions Scale. This 32-item questionnaire,[27] developed in both non-clinical and psychosis groups, assesses perceptual anomalies such as changes in levels of sensory intensity, distortion of the external world, sensory flooding and hallucinations. A higher score represents the reporting of a greater number of perceptual anomalies.

Maudsley Addiction Profile. This profile[28] was developed with a large sample from a substance misuse clinic. Respondents are asked directly about the use over the past month of illicit drugs, including cannabis, cocaine powder, crack cocaine, heroin, amphetamines and methadone.

Social

Life Stressor Checklist. The checklist[29] asks respondents about the occurrence of a range of severe life events (e.g. serious accident, physical attack, sexual abuse). If the respondent reports the occurrence of an event, subsequent questions ask when the event happened, whether the person thought at the time that serious harm or death could result, and whether feelings of intense helplessness, fear or horror occurred. We scored only events that reached the severity criterion related to post-traumatic stress disorder diagnosis. The total number of traumatic events, the total number of victimisation events, the number of childhood traumatic events, and the number of traumatic events in the past year were recorded.

Social Support Questionnaire. Each of the seven items of this instrument[30] has two parts. The first part assesses the number of people the respondent believes they can turn to in times of need (e.g. 'Whom can you really count on to be dependable when you need help?). The second part measures the degree of satisfaction with that support. Two scores are derived: number or perceived availability score and satisfaction score. Higher scores indicate greater perceptions of social support.

Social and Emotional Loneliness Scale for Adults. This 37-item self-report questionnaire,[31] developed in a non-clinical sample, has three sub-scales: romantic, family, and social loneliness. Each item is rated on a 7-point scale ('strongly disagree' to 'strongly agree'). Higher scores indicate greater levels of loneliness.

Measures of the virtual reality experience

After being in the virtual environment, participants completed a measure of persecutory thinking, visual analogue rating scales, and an assessment of their degree of immersion in the virtual environment.

State Social Paranoia Scale. This scale[32] has ten persecutory items (e.g. 'Someone stared at me in order to upset me'; 'Someone was trying to isolate me'; 'Someone was trying to make me distressed'), each rated on a 5-point scale. The items conform to a recent definition of persecutory ideation.[33] The scale has excellent internal reliability, adequate test–retest reliability, convergent validity with both independent interviewer ratings and self-report measures, and divergent validity with regard to measures of positive and neutral thinking. In the current study the internal reliability of the questionnaire was high (Cronbach's alpha=0.90). Higher scores on the scale indicate greater levels of persecutory thinking.

Visual analogue rating scales. Participants marked on separate 10 cm lines the degree to which the people on the train were

hostile, friendly and neutral. Higher ratings indicated greater endorsement of the characteristic.

Sense of Presence Scale. The scale[34] contains four questions, each rated on a 7-point scale, that assess immersion in the environment (e.g. 'Which was strongest, your sense of being on the virtual tube or being in the real world of the laboratory?). Higher scores indicate a greater sense of presence in the virtual world.

Effects of the simulator

Simulator Sickness Questionnaire. Virtual reality, particularly on early simulators, was known to cause side-effects similar to motion sickness. Possible causes may have been flicker, visual distortion and that earlier systems responded slowly to participants' movements. The 16-item Simulator Sickness Questionnaire,[35] derived from a large factor analysis, assesses three symptom clusters: oculomotor (e.g. blurred vision), disorientation (e.g. dizziness) and nausea (e.g. vomiting). Each item is assessed on a 4-point scale ('none' to 'very strong'). The total scores are weighted. Higher scores indicate a higher level of symptoms. Our participants completed the questionnaire immediately before and after the simulation, and after they had completed the other post-simulation instruments.

Analysis

Analyses were carried out using SPSS Version 12.02 and Stata Version 9 for Windows. The dependent variable was persecutory ideation assessed by the State Social Paranoia Scale,[32] grouped into six ordinal categories (corresponding to scores of 10, 11–15, 16–20, 21–25, 26–30, $\geqslant$30). There were two steps to the analysis. The first determined which, if any, of the variables had a direct effect on the score obtained: each variable was modelled separately using an ordinal logistic regression (proportional odds models as implemented by the Stata ologit command) controlling for age, gender, ethnicity, intellectual functioning, socio-economic status, level of education, gaming experience, and frequency of use of the London underground. The second step included all the independent variables. An ordinal logistic regression was carried out using the exploratory modelling technique backward elimination.[36] Variables were removed one by one, chosen by the variable with the largest *P*-value, until all variables had *P*-values less than 0.10. A number of other model types (Poisson, negative binomial, gamma, logistic), along with a standard linear regression followed by bootstrapping, were performed on the data, but it was clear, using the Akaike Information Criteria and the Bayesian Information Criteria,[37] that ordinal logistic regression produced the best fit for the data. The data-set contained very few missing values because the maximum number of participants who failed to complete each measure never exceeded three. The stepwise procedure was repeated manually in order to include as many participants as possible, and all but one participant were used in the final model. Principal component analysis was used as a sensitivity analysis to assess whether or not any co-linearity existed within the predictors. The results showed very little change when compared with the standard analysis. The proportionality assumption (that the increase in risk across the state paranoia categories is comparable) was checked for all the analyses by including the cut-points in the ordinal model as an interaction variable and then assessing the models log likelihood values. There was no evidence to reject the proportionality assumption for the study analyses. All hypothesis testing was two-tailed, and 95% confidence intervals are reported.

Results

Demographic data

The average age of the participants was 37.5 years (s.d.=13.3, range 18–77). The mean IQ score was 104.6 (s.d.=12.0, minimum=69, maximum=133). Further basic information on the participants is presented in the online Table DS1. It can be seen that there is a spread of participants across socio-economic categories, and the proportion in each category is broadly representative of the UK population.

Virtual reality side-effects

Weighted scores on the Simulator Sickness Questionnaire before entering the virtual environment, after leaving virtual reality and at the end of testing are presented in Table 1. Endorsement rates of items were low. Overall it can be seen that virtual reality did not have negative side-effects. There was an expected temporary increase in disorientation following taking off the headset, but levels of all symptoms were lower at the end of testing than before entering the virtual environment.

Occurrence of persecutory thoughts

What did the participants think about the computer characters? A selection of quotations from different participants are presented in Table 2. It can be seen that there are striking divergences in the views of the participants. As expected, the general view of the avatars was that they were neutral (mean VAS score=6.6, s.d.=2.6) or friendly (mean VAS score=5.0, s.d.=2.2). There was less frequent endorsement of the view that the avatars were hostile (mean VAS score=1.5, s.d.=1.8). Persecutory items on the State Social Paranoia Scale were commonly endorsed (mode=10, median=10, mean=12.6, s.d.=4.8, range 10–38), although the data were clearly skewed, with 105 participants reporting no paranoid thoughts. In the six ordinal categories (scores of 10, 11–15, 16–20, 21–25, 26–30, $\geqslant$30) there were 105, 64, 16, 9, 3 and 3 participants respectively. In an ordinal logistic regression there was a significant association between trait levels of paranoia and the occurrence of persecutory thinking in virtual reality (OR=1.04, *P*=0.001, 95% CI 1.02–1.07). Individuals who reported paranoid thoughts in day-to-day life were about twice as likely to experience persecutory thoughts in virtual reality compared with individuals who reported no paranoid thoughts in day-to-day life (OR=2.32, *P*=0.003, 95% CI 1.33–4.03). These findings validate the experimental procedure.

Prediction of persecutory thinking

The results of the ordinal logistic regressions are presented in Table 3. Experience of playing computer games is a strong predictor of paranoid thinking, perhaps indicating that game-playing individuals are more likely to automatically process the computer characters as real. Paranoid thinking is also strongly predicted by many factors in our cognitive model: higher levels of anxiety,

Table 1 Simulator Sickness Questionnaire (SSQ) scores

SSQ item	Before VR Mean (s.d.)	After VR Mean (s.d.)	At end of testing Mean (s.d.)
Total	18.0 (21.0)	19.1 (23.8)	12.6 (19.9)
Oculomotor	18.9 (21.4)	17.7 (20.4)	11.6 (17.0)
Disorientation	14.3 (22.8)	18.7 (30.5)	11.7 (24.8)
Nausea	12.3 (16.2)	13.8 (20.2)	9.5 (17.3)

VR, virtual reality environment.

Table 2 Participants' thoughts after leaving the virtual reality environment

Participants' responses
Positive
'It was nice much nicer than a real experience – people aren't so forthcoming with their feelings in a real situation. Thought they were pretty friendly'
'People were generally very friendly'
'One guy was checking me out – flattering'
'There were people smiling at you, which was nice'
Neutral
'Felt like a normal tube. People just trying to get where they want to go'
'Didn't think anyone thought anything about me. All getting on with own business. Nobody seemed to notice me'
'I thought they were like people on the tube – some smile, others ignore you'
'I thought everyone kept themselves to themselves'
Negative
'Thought a couple of the men were stuck up and nasty. Lady sitting down laughed at me when I walked past'
'There was an aggressive person – his intention was to intimidate me and make me feel uneasy'
'One guy looked pissed off and maybe one guy flicked the finger at me'
'There was a man who tried to stare me out. But I didn't give him any ammunition. Believe his intention was to start an argument'

depression, worry style, everyday worries, catastrophising worry, interpersonal sensitivity, negative ideas about self, negative ideas about others, cognitive inflexibility, perceptual anomalies, and loneliness associated with the family situation. When interpreting the odds ratios it should be remembered that the scales are continuous. Paranoia was not predicted by data-gathering style as assessed by the probabilistic reasoning task, number of social supports or degree of immersion in virtual reality.

When all the chosen independent variables were analysed together, paranoid thinking was predicted by higher levels of catastrophising worry, worry style, perceptual anomalies, and cognitive inflexibility (online Table DS2). It is also of interest that women and those who regularly used the London underground reported less paranoia.

Discussion

We have demonstrated that virtual reality is a safe and acceptable method of studying paranoia in the laboratory. Computer characters can elicit paranoid reactions. Consistent with the latest epidemiological research, over 40% of our general population sample had paranoid thoughts. Our study is the clearest demonstration yet that paranoid thinking is not confined to people with severe mental illness. This study was carried out about 1 year after the 2005 London underground bombings. The impact of terrorism on paranoid thinking in the general population is not known but should be researched. In this study, those who used the London underground less often were more paranoid. Our study also provides a theoretical advance in the understanding of persecutory ideation. The associations with anxiety, depression, worry, interpersonal sensitivity and negative ideas about self firmly place paranoia as an emotional concern. The associations of the continuous scales with paranoia are significant. For example, a 10-point increase in anxiety is associated with over twice the risk of paranoia and a 20-point increase is associated with over five times the risk of paranoia. However, non-affective factors are also implicated, notably the presence of subtle perceptual anomalies

Table 3 Ordinal logistic regressions for individual variables controlling for basic demographic data

Variable	OR	95% CI
Age	0.99	0.97, 1.01
Gender		
Female	0.69	0.41–1.18
Ethnicity		
White	–	–
Black and minority ethnic	1.81	0.91–3.56
Other	1.02	0.46–2.29
IQ	1.00	0.98–1.03
Education		
None/GCSE	–	–
AS/A-level	2.67*	1.12–6.40
Diploma	3.08*	1.27–7.44
Degree	1.42	0.67–3.04
Postgraduate	0.72	0.30–1.72
Plays computer games		
Yes	3.11***	1.78–5.43
London underground use		
Never	–	–
<Monthly	0.72	0.30–1.71
Monthly	0.49	0.21–1.15
Weekly	0.81	0.40–1.62
Daily	0.64	0.23–1.82
Socio-economic status		
Higher professional	–	–
Lower managerial and professional	2.88	0.84–9.88
Intermediate occupations	4.34*	1.02–18.40
Small employers and own account	2.48	0.53–11.62
Lower supervisory and technical	1.45	0.25–8.55
Semi-routine	2.61	0.58–11.76
Routine	3.06	0.67–13.87
Never worked and unemployed	3.06	0.84–11.14
Not classifiable (students)	1.92	0.50–7.45
Anxiety[a]	1.09**	1.02–1.15
Worry[a]		
Penn State Worry Questionnaire	1.04***	1.02–1.07
Worry Domains Questionnaire	1.04***	1.02–1.05
Catastrophising Interview	1.08***	1.04–1.13
Interpersonal sensitivity[a]	1.04***	1.02–1.07
Beliefs about[a]		
Self, negative	1.14*	1.03–1.26
Self, positive	0.95	0.89–1.01
Others, negative	1.12**	1.05–1.20
Others, positive	0.98	0.91–1.04
Depression[a]	1.05**	1.02–1.09
Cognitive flexibility[a]	0.94**	0.90–0.98
Jumping to conclusions[a]	1.01	0.94–1.08
Anomalous perceptions[a]	1.08**	1.02–1.14
Illicit drug use[a]		
Yes	1.61	0.82–3.17
Loneliness[a]		
Romantic	1.01	0.99–1.02
Family	1.03*	1.01–1.05
Social	1.01	1.00–1.03
Support satisfaction[a]	0.79	0.58–1.09
No. social supports[a]	0.90	0.77–1.05
No. lifetime traumas[a]	1.11	0.98–1.26
No. lifetime victimisations[a]	1.04	0.84–1.27
No. childhood abuse events[a]	1.05	0.70–1.58
No. recent traumas[a]	1.37	0.78–2.43
Sense of presence[a]	1.02	0.96–1.09

A, Advanced; AS, Advanced Subsidiary; GCSE, General Certificate of Secondary Education.
a. Individual variable controlling for age, gender, ethnicity, IQ, socio-economic status, education, playing computer games, London underground use.
*$P<0.05$, **$P<0.01$, ***$P<0.001$.

and inflexibility in thinking about dealing with situations. It is plausible that noticing anomalous experiences is accompanied by feelings of oddness that in the context of affective disturbance lead to threatening interpretations. It is of note that these factors have also been implicated in the development of clinical paranoia.[1]

There are two notes of caution. First, the identification of paranoid thinking inevitably depends on self-report. No other markers of the experience are available. The study therefore relied on people being able to report their thoughts. Second, the dependent variable had considerable skew, leading to ordinal scaling and a reduction in statistical power. Nevertheless the study indicates great promise for virtual reality in studying paranoia. Causal roles of psychological processes can be established by their manipulation before individuals enter virtual reality. It will be important to compare the reactions in virtual reality of a non-clinical group with patients with persecutory delusions. Another valuable research path will be to determine the environmental components that trigger paranoid thinking. It is also likely that exposure to virtual reality environments could be incorporated into the emerging cognitive–behavioural interventions for paranoia.[38]

Daniel Freeman, PhD, **Katherine Pugh**, BSc, Department of Psychology, Institute of Psychiatry, King's College London; **Angus Antley**, MS, Department of Computer Science, University College London; **Mel Slater**, DSc, Department of Computer Science, University College London, UK, and Universitat Politècnica de Catalunya, Barcelona, Spain; **Paul Bebbington**, PhD, Department of Mental Health Sciences, University College London, Royal Free and University College Medical School, London; **Matthew Gittins**, MSc, **Graham Dunn**, PhD, Health Methodology Research Group, School of Community Based Medicine, University of Manchester, Manchester; **Elizabeth Kuipers**, PhD, Department of Psychology, Institute of Psychiatry, King's College London; **David Fowler**, MSc, School of Medicine, Health Policy and Practice, University of East Anglia, Norwich; **Philippa Garety**, PhD, Department of Psychology, Institute of Psychiatry, King's College London, UK

Correspondence: Dr Daniel Freeman, Department of Psychology, PO Box 77, Institute of Psychiatry, King's College London, Denmark Hill, London, SE5 8AF, UK. Email: D.Freeman@iop.kcl.ac.uk

First received 5 Sep 2007, final revision 30 Nov 2007, accepted 10 Jan 2008

Acknowledgements

The work was supported by a Wellcome Trust Fellowship to D.F.

References

1 Freeman D. Suspicious minds: the psychology of persecutory delusions. *Clin Psychol Rev* 2007; **27**, 425–57.

2 Freeman D, Garety PA, Bebbington PE, Smith B, Rollinson R, Fowler D, Kuipers E, Ray K, Dunn G. Psychological investigation of the structure of paranoia in a non-clinical population. *Br J Psychiatry* 2005; **186**: 427–35.

3 Eaton WW, Romanoski A, Anthony JC, Nestadt G. Screening for psychosis in the general population with a self-report interview. *J Nerv Ment Dis* 1991; **179**: 689–93.

4 Olfson M, Lewis-Fernández R, Feder A, Gameroff MJ, Pilowsky D, Fuentes M. Psychotic symptoms in an urban general medicine practice. *Am J Psychiatry* 2002; **159**: 1412–9.

5 Kawachi I, Kennedy BP, Lochner K, Prothrow-Stith D. Social capital, income inequality, and mortality. *Am J Public Health* 1997; **87**: 1491–8.

6 van Os J, Verdoux H. Diagnosis and classification of schizophrenia: categories versus dimensions, distributions versus disease. In *The Epidemiology of Schizophrenia* (eds RM Murray, PB Jones, E Susser, J van Os, M Cannon): 364–410. Cambridge University Press, 2003.

7 Myin-Germeys I, Krabbendam L, van Os J. Continuity of psychotic symptoms in the community. *Curr Opin Psychiatry* 2003; **16**: 443–9.

8 Poulton R, Caspi A, Moffitt TE, Cannon M, Murray R, Harrington H. Children's self-reported psychotic symptoms and adult schizophreniform disorder. *Arch Gen Psychiatry* 2000; **57**: 1053–8.

9 Freeman D. The assessment of persecutory ideation. In *Persecutory Delusions: Assessment, Theory and Treatment* (eds D Freeman, R Bentall, P Garety). Oxford University Press, in press.

10 Sanchez-Vives MV, Slater M. From presence to consciousness through Virtual Reality. *Nat Rev Neurosci* 2005; **6**: 332–9.

11 Freeman D, Slater M, Bebbington PE, Garety PA, Kuipers E, Fowler D, Met A, Read C, Jordan J, Vinayagamoorthy V. Can virtual reality be used to investigate persecutory ideation? *J Nerv Ment Dis* 2003; **191**: 509–14.

12 Freeman D, Garety PA, Bebbington P, Slater M, Kuipers E, Fowler D, Green C, Jordan J, Ray K, Dunn G. The psychology of persecutory ideation II: a virtual reality experimental study. *J Nerv Ment Dis* 2005; **193**: 309–15.

13 Valmaggia LR, Freeman D, Green C, Garety P, Swapp D, Antley A, Prescott C, Fowler D, Kuipers E, Bebbington P, Slater M, Broome M, McGuire PK. Virtual reality and paranoid ideations in people with an 'at risk mental state' for psychosis. *Br J Psychiatry Suppl* 2007; **191** (suppl 51): s63–8.

14 Freeman D, Garety PA, Kuipers E, Fowler D, Bebbington PE. A cognitive model of persecutory delusions. *Br J Clin Psychol* 2002; **41**: 331–47.

15 Freeman D, Freeman J. *Paranoia: The 21st Century Fear*. Oxford University Press, in press.

16 Frecon E, Smith G, Steed A, Stenius M, Stahl O. An overview of the COVEN Platform. *Presence* 2001; **10**: 109–27.

17 Wechsler D. *Wechsler Abbreviated Scale of Intelligence (WASI)*. The Psychological Corporation, 1999.

18 Green C, Freeman D, Kuipers E, Bebbington P, Fowler D, Dunn G, Garety PA. Measuring ideas of persecution and reference: the Green et al Paranoid Thought Scales (GPTS). *Psychol Med* 2008; **38**: 101–11.

19 Lovibond PF, Lovibond SH. The structure of negative emotional states: comparison of the depression anxiety stress scales (DASS) with the Beck depression and anxiety inventories. *Behav Res Ther* 1995; **33**: 335–43.

20 Meyer TJ, Miller ML, Metzger RL, Borkovec TD. Development and validation of the Penn State Worry Questionnaire. *Behav Res Ther* 1990; **28**: 487–95.

21 Tallis F, Eysenck MW, Mathews A. A questionnaire for the measurement of nonpathological worry. *Pers Individ Dif* 1992; **13**: 161–8.

22 Vasey M, Borkovec TD. A catastrophising assessment of worrisome thoughts. *Cognit Ther Res* 1992; **16**: 505–20.

23 Fowler D, Freeman D, Smith B, Kuipers E, Bebbington P, Bashforth H, Coker S, Gracie A, Dunn G, Garety P. The Brief Core Schema Scales (BCSS): Psychometric properties and associations with paranoia and grandiosity in non-clinical and psychosis samples. *Psychol Med* 2006; **36**: 749–59.

24 Boyce P, Parker G. Development of a scale to measure interpersonal sensitivity. *Aust N Z J Psychiatry* 1989; **23**: 341–51.

25 Martin MM, Rubin RB. A new measure of cognitive flexibility. *Psychol Rep* 1995; **76**: 623–6.

26 Garety PA, Freeman D, Jolley S, Dunn G, Bebbington PE, Fowler D, Kuipers E, Dudley R. Reasoning, emotions and delusional conviction in psychosis. *J Abnorm Psychol* 2005; **114**: 373–84.

27 Bell V, Halligan PW, Ellis HD. The Cardiff Anomalous Perceptions Scale (CAPS). *Schizophr Bull* 2006; **32**: 366–77.

28 Marsden J, Gossop G, Stewart D, Best D, Farrell M, Lehmann P, Edwards C, Strang J. The Maudsley Addiction Profile (MAP). *Addiction* 1998; **93**: 1857–67.

29 Wolfe J, Kimerling R. Gender issues in the assessment of posttraumatic stress disorder. In *Assessing Psychological Trauma and PTSD* (eds J Wilson & T Keane). Guilford Press, 1997.

30 Sarason IG, Sarason BR, Shearin EN, Pierce GR. A brief measure of social support. *J Soc Pers Relat* 1987; **4**: 497–510.

31 DiTommaso E, Spinner B. The development and initial validation of the social and emotional loneliness scale for adults. *Pers Individ Dif* 1993; **14**: 127–34.

32 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**: 781–4.

33 Freeman D, Garety PA. Comments on the content of persecutory delusions: does the definition need clarification? *Br J Clin Psychol* 200; **39**: 407–14.

34 Slater M, Steed A, McCarthy J, Maringelli F. The influence of body movement on subjective presence in virtual environments. *Hum Factors* 1998; **40**: 469–77.

35 Kennedy RS, Lane NE, Berbaum KS, Lilienthal MG. Simulator Sickness Questionnaire: an enhanced method for quantifying simulator sickness. *Int J Aviat Psychol* 1993; **3**: 203–20.

36 Hocking RR. Analysis and selection of variables in linear-regression. *Biometrics* 1976; **32**: 1–49.

37 Belsley DA, Kuh E, Welsch RE. *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity*. Wiley, 1980

38 Freeman D, Freeman J, Garety P. *Overcoming Paranoid and Suspicious Thoughts*. Robinson Constable, 2006.