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Cognitive triggers of auditory hallucinations: An experimental investigation

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It has proved difficult to establish the internal process by which mental events are transformed into auditory hallucinations. The earlier stages of the generation of hallucinations may prove more accessible to research. Cognitions have been reported by patients as a trigger of auditory hallucinations, but the role of these preceding thoughts has not been causally determined. Therefore, the role of cognition in triggering auditory hallucinations was tested in an experimental study. Thirty individuals who experienced auditory hallucinations in social situations entered a neutral social situation presented using virtual reality. Participants randomised to the experimental condition were instructed to think their hallucination-preceding thoughts, and those randomised to the control condition were instructed to think neutral thoughts. Twenty-seven participants (93%) were able to spontaneously identify a cognition which preceded a hallucination. There was no difference between the experimental and control groups in the occurrence or severity of auditory hallucinations in virtual reality. Virtual reality did not lead to physical side effects or an increase in anxiety. The relationship between antecedent cognitions and auditory hallucinations is likely to be more complex than the one tested. It is argued that the effect of cognition on auditory hallucinations may be mediated by affect but this needs to be investigated through further experimental research.

1. Introduction

A clear consensus has developed that auditory hallucinations are internal mental events, such as cognitions, which are perceived by the individual to be of a non-self origin (e.g. Aleman & Laroi, 2008; David, 2004; Slade & Bentall, 1988). This definition of hallucinatory experience has guided most research on the topic, which has addressed the question 'How do internal mental events come to be perceived as external to the self?' Mechanisms studied include self-monitoring, attributional biases, and mental imagery (e.g. Aleman, Böcker, Kahn, & De Haan, 2002; Bentall, 1990; Frith, 1987). In this challenging research area, most theories have had mixed empirical support; for example a self-monitoring bias has been linked with hallucinations in some studies (e.g. Johns & McGuire, 1999; Johns et al., 2001) but not in others (e.g. Johns, Gregg, Allen, Vythelingum, & McGuire, 2006; Versmissen et al., 2007). In addition, the experimental methods used to investigate the hallucinatory mechanism have not developed significantly beyond the source monitoring paradigms developed in the early 1990s, which assess the processing of analogue stimuli rather than internal mental events. The mechanisms resulting in auditory hallucinations remain somewhat of a black box. In contrast, developers of cognitive-behavioural interventions for psychosis have focussed upon the factors, chiefly negative appraisals, that lead to distressing hallucinatory experience (e.g. Chadwick & Birchwood, 1994). This has been a productive avenue of research with replicated findings and direct clinical relevance (e.g. Trower et al., 2004), but it has (deliberately) not concerned the causes of hallucinations.

Aspects of the hallucinatory process other than the externalisation mechanisms have received insufficient attention. One such area is the early stages of hallucination occurrence: internal processes which may trigger a hallucination. External contextual triggers have been the subject of some investigation. For example, Tarrier (1987) found that individuals with schizophrenia most often reported the occurrence of auditory hallucinations when they were unoccupied or alone, in social situations, or exposed to traffic noise. The importance of social situations in the occurrence of auditory hallucinations has been further supported by studies using experience sampling methodology (Beck & Rector, 2003; Delespaul, deVries, & van Os, 2002; Verdoux, Husky, Tournier, Sorbara, & Swendsen, 2003).

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The precipitating role of internal factors, principally cognitions (thoughts, images, and mental representations), in the triggering of auditory hallucinations has been somewhat neglected. Such a triggering role for cognitions is especially likely since, according to the consensus in hallucination theories, cognitions can be viewed as the raw material from which auditory hallucinations are created. There is support from patient interview studies for the existence of cognitive antecedents to auditory hallucinations. Petch (2006) found that 73 out of 75 individuals who heard voices reported cognitive antecedents to auditory hallucinations (e.g. 'I might not make it in my chosen career', 'I should have been punished'). In a larger study, Nayani and David (1996) found that while many people reported emotions precipitating auditory hallucinations (e.g. 52% of the sample reported sadness precipitating hallucinations), cognitive cues were 'less often reported as precipitants'. It is reasonable, however, to assume that emotional triggers will often be preceded by cognitions. In summary, both the social context and the internal mental context (cognitions) may be relevant to the precipitation of the hallucinatory process.

The current study investigates whether cognitive antecedents play a causal role in the occurrence of auditory hallucinations in a social context. To control for external contextual triggers, all voice hearers received an identical social event presented using virtual reality methodology (see Freeman, 2008). Cognition was then manipulated by instructing half the participants to focus on cognitions which they had identified as antecedents to auditory hallucinations, and the other participants to focus on neutral cognitions. It was predicted that there would be a difference in the frequency, loudness, and clarity and distress of auditory hallucinations between individuals who focussed on antecedent cognitions and individuals who focussed on neutral cognitions. It was also predicted that there would be a link between the content of antecedent cognitions and that of auditory hallucinations. As virtual reality is a novel methodology in this population, a secondary aim of the research was to monitor the safety and acceptability of the method with individuals who hear voices.

2. Method

2.1. Participants

The inclusion criteria for participants were: auditory hallucinations occurring at least once a day; the auditory hallucinations occurred in social contexts; and in the age range of 18–65 years old. Exclusion criteria were: evidence of an organic cause of hallucinations; inability to identify cognitive antecedents; inability to understand instructions or comprehend English; continuous auditory hallucinations; or a history of epilepsy. Participants were recruited via the South London and Maudsley NHS Foundation Trust or Internet websites for voice hearers such as voice-hearers.com and voicesforum.org.uk. Thirty individuals participated.

2.2. Virtual reality

The virtual reality equipment and environment was that used by Freeman, Pugh et al. (2008). The virtual environment displayed was a 4-min underground train journey, which included computer-generated commuters. The overall scenario was created using a Distributed Immersive Virtual Environment software platform (DIVE; Carlsson & Hagsand, 1993), and the train interior and the computer characters were created by 3D Studio Max. The equipment used was a head-mounted virtual reality system. The computer-generated characters were of both sexes and of several ethnicities. These characters repeated background movements throughout the journey, including breathing and occasionally looking around, and each character had its own movements. The environment was designed to be neutral and non-threatening. The background sounds in the environment were rendered in stereo, without spatialisation, using a Creative sound card and delivered via headphones. The sounds were those commonly heard on a tube train, e.g. rumbling of the train, low-level snatches of conversation, and train announcements such as 'mind the closing doors'. It is important to note that these sounds were distinguished by the researcher from auditory hallucinations in the assessment of voices.

2.3. Measures

2.3.1. Auditory hallucinations

Auditory hallucination severity was assessed using the Psychotic Symptom Rating Scale: Auditory Hallucinations (PSYRATS: AH; Haddock, McCarron, Tarrier, & Faragher, 1999) which is a semi-structured interview designed to provide a dimensional measure of hallucinatory experience over the past week. Higher scores indicate greater severity of auditory hallucinations. It has excellent inter-rater reliability, good test–retest reliability, and good validity (Drake, Haddock, Tarrier, Bentall, & Lewis, 2007; Haddock et al., 1999).

The Topography of Voices Rating Scale (TVRS; Hustig & Häfner, 1990) was used to assess an individual's experience of their voices before and after virtual reality. The original four subscales version was used, which assesses intensity, volume and clarity of auditory hallucinations as well as the distress associated with them. For ease of interpretation, the scores were reversed such that a score of 5 was equal to *higher* rather than lower intensity, distress, volume or clarity. A total score was calculated by adding up the individual subscores. When individuals heard no voices, they scored zero on this questionnaire.

2.3.2. Anxiety and depression

Two affective scales were administered: The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) and the Liebowitz Social Anxiety scale (LSAS; Liebowitz, 1987). The HADS is a 14-item self-report scale which measures anxiety and depressive symptoms. Higher scores are indicative of higher symptomatology. The HADS is a reliable and valid measure of anxiety and depression (Herrmann, 1996). The LSAS is a 24 item self-report version of the original Liebowitz Social Anxiety Scale which is designed to measure fear and avoidance across a number of different social situations. Higher scores indicate higher social anxiety. It has been shown to be reliable (Baker, Heinrichs, Kim, & Hofmann, 2002) and correlates significantly with other measures of social phobia. It has also been shown to be a reliable measure of social anxiety in individuals diagnosed with schizophrenia (Pallanti, Quercioli, & Hollander, 2004). For the purposes of this study, avoidance relating to social situations was not measured, as *fear* of social situations was the target for investigation. Anxiety was also measured using two other measures: heart rate (using a handheld baton-style device) and a subjective units of distress scale of 0 (not at all anxious) to 10 (extremely anxious).

2.3.3. Virtual reality side effects

Participants completed the Simulator Sickness Questionnaire (SSQ; Kennedy, Lane, Berbaum, & Lilienthal, 1993) to measure any adverse physical effects of entering the virtual reality environment. There are three symptom scores: nausea, oculomotor, and disorientation. The SSQ is considered to be the 'gold standard' instrument for the assessment of simulator sickness (Johnson, 2005). Higher scores indicate greater side effects. Adverse effects, distress and intrusions following the experience in the Virtual Reality tube situation were measured a week later using the Intrusions Monitoring Interview (Valmaggia et al., 2007).

2.3.4. Identification of cognitive antecedents and neutral cognitions

Cognitive antecedents to auditory hallucinations were identified following the method of Petch (2006), which was derived from the Cognitive Assessment Schedule (CAS; Chadwick and Birchwood, 1994). Participants were asked to describe a specific example of hearing a voice, and questions were asked to determine whether the person had experienced any cognitive antecedents to this voice. Participants were asked whether this was a common cognition which preceded voice hearing. If participants were unable to spontaneously describe any cognitive antecedents to a voice (3 participants), they were provided with a list of cognitions derived from the Automatic Thoughts Questionnaire (ATQ; Hollon & Kendall, 1980) and the Anxious Self-Statements Questionnaire (ASSQ; Kendall & Hollon, 1989) and asked whether any of those thoughts ran through their mind just before they heard a voice. Neutral cognitions were selected by surveying a sample of nineteen psychologists and asking them to think of cognitions which were 'non-emotive, and neutral'. Based on these responses, a list of 14 neutral cognitions (e.g. photocopying) was drawn up. Participants were instructed to read the list and select the cognition which was the most neutral for them. The concept of a neutral cognition was carefully explained, and it was ensured that participants understood the meaning.

2.3.5. Links between cognition and voice content

Links between the content of antecedent cognitions and auditory hallucinations were investigated based on participants' descriptions of the antecedent cognitions and voices determined above. Links were rated both by the interviewer (first author) and by a second rater (also a psychologist). A direct content link refers to a clear link between an antecedent cognition and an auditory hallucination in terms of topic content. Two types of direct content links were identified: (i) the content of the cognition was directly mirrored in the content of the voice (e.g. thought: 'what can I do, I'm powerless'; voice: 'you have no power') and (ii) the content of the voice followed on from the content of the cognition (e.g. thought: 'worrying about flat: boy upstairs making noise'; voice: 'you have to move, we don't want you in this area'). There was 97% agreement between raters, as there was a discrepancy in one cognition-voice link.

2.4. Design

This was a between-subjects experimental study of a population of individuals who experienced auditory hallucinations. Participants were randomly allocated to one of two conditions: the experimental group (focussing on antecedent cognitions) or the control group (focussing on neutral cognitions).

2.5. Procedure

Participants were first administered the PSYRATS: AH (Haddock et al., 1999). Then the cognitive antecedents and neutral cognitions were determined. The following questionnaires were then completed: HADS (Zigmond & Snaith, 1983), LSAS (Liebowitz, 1987), TVRS (Hustig & Häfner, 1990) and SSQ (Kennedy et al., 1993). Before entering VR, anxiety and heart rate were measured. Participants experienced a 4-min Virtual Reality tube journey, during which half the participants were instructed to focus on the antecedent cognition (experimental group) and half were instructed to focus on the neutral cognition (control group). The instructions for each of the conditions are presented below:

Experimental group
'While you are exploring the carriage, I'd like you to try to focus on the thought which you described a few minutes ago as being a thought you often have before you hear a voice. Can you remember what the thought was? [ensure participant identifies the thought correctly]. OK, so I'd like you to try and focus on ________, try to think about that thought while you're on the tube train' [ensure the participant understands the instructions and can summarise what they have to do].

Control group
'While you are exploring the carriage, I'd like you to try to focus on the thought which you described a few minutes ago as being the most neutral thought from that list. Can you remember what the thought was? [ensure participant identifies the thought correctly]. OK, so I'd like you to try and focus on ________, try to think about that thought while you're on the tube train' [ensure the participant understands the instructions and can summarise what they have to do].

After being in VR, a participant's heart rate and anxiety were measured again, following which the SSQ (Kennedy et al., 1993) was completed. Participants were asked to describe any auditory hallucinations they had experienced while in virtual reality, and then completed the TVRS (Hustig & Häfner, 1990) relating to the time in virtual reality. They also completed a short written measure of the extent to which they were able to follow the instructions.

2.6. Analysis

Analyses were conducted using SPSS for windows Release 15.0 (2007). Where data were non-normal, they were transformed using log transformation (log 10) with a constant of +1 (Field, 2005). All parametric tests were checked with the equivalent non-parametric test to ensure they were not producing a different result. For the purposes of clarity, descriptive statistics are presented using raw data. Chi square tests were used to examine differences in voice occurrence between the two groups. Multiple *t*-tests were conducted for analyses of differences in voice severity. The study was powered only to detect a large effect (odds ratio of 6) of focussing on antecedent cognitions.

3. Results

3.1. Demographic and clinical data

Twenty participants (66%) were male and 10 participants were female (34%). The mean age of the participants' was 42.4 (SD = 9.7). Twenty eight participants (93%) reported having a psychiatric diagnosis, principally schizophrenia ($n = 19$; 63%). Other reported diagnoses included schizoaffective disorder ($n = 4$), bipolar disorder ($n = 1$), anxiety ($n = 1$), PTSD ($n = 1$), and depression ($n = 1$). The mean number of years since diagnosis was 14.6 (SD = 8.5). Twenty six (87%) participants reported that they were prescribed antipsychotic medication. The median score on the Psychotic Symptoms Rating Scale for auditory hallucinations was 27, which is similar to other samples of individuals with a diagnosis of schizophrenia (e.g. Haddock et al., 1999). The 11 items on the PSYRATS: AH can be clustered into three factors: physical characteristics (Mean score = 9.57, SD = 2.99), emotional characteristics (Mean score = 8.53, SD = 3.03), and cognitive interpretation (Mean score = 6.97, SD = 2.41). The PSYRATS indicated that on average, participants heard voices at least once an hour, and found most of them distressing. As measured by the Hospital Anxiety and Depression Scale, many of the participants scored in the clinical range for depression ($n = 13$; 43%) and anxiety ($n = 22$; 74%).

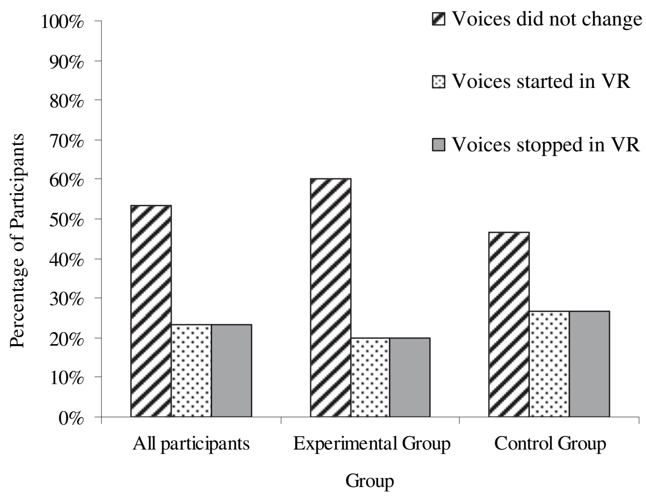

Fig. 1. The Effect of virtual reality on auditory hallucinations.

Twenty nine (96%) participants scored higher than the mean of a sample of control participants on the Liebowitz Social Anxiety Scale (Fresco et al., 2001), and 15 (50%) scored higher than the mean of a sample of individuals diagnosed with social phobia (Fresco et al., 2001).

3.2. *Effect of the manipulation*

Ten participants heard voices in VR in the experimental group and eight participants heard voices in VR in the control group. There was no significant association between focus of cognition (group) and occurrence of auditory hallucinations, $\chi^2_{(1)} = 0.56$, $p = 0.46$, odds ratio = 0.57, 95% CI = 0.13–2.50, $d = 0.28$. A logistic regression analysis was carried out to control for the baseline occurrence of auditory hallucinations but there remained no effect of group, $\chi^2_{(2)} = .56$, $p = 0.76$.

Table 1 shows that there were no differences between the two groups in any aspect of voice severity as measured by the TVRS. To control for any baseline differences in voice severity, change scores were calculated for both groups by taking the baseline voice TVRS scores away from the TVRS scores in virtual reality; there remained no significant differences between the two groups (see Fig. 1).

3.3. *Cognition and hallucinations content links*

Associations between the content of antecedent cognitions and that of auditory hallucinations in the past week were examined based on data from the semi-structured interview. A relationship between the content of antecedent cognitions and auditory hallucinations was apparent in nine (30%) participants. Of these, only three (10%) voices directly mirrored cognitions (for example, thought: 'a friend hasn't rung me', voice: 'your best friend hates you and that's why he didn't ring you'), while 6 (20%) of the voices were deemed to have content which followed on from the content of cognition (for example, thought: 'someone might be out to get me', voice: 'prostitute, we will kill you').

3.4. *Safety and acceptability of virtual reality*

Table 2 shows that participants experienced the same, or lower, levels of physical symptoms after being in virtual reality. Four minutes in virtual reality did not cause motion sickness. There was no difference in the participants' anxiety levels and heart rates before and after virtual reality. Results of the Intrusions Monitoring Interview indicated that 93% of participants did not experience unwanted thoughts about the virtual reality in the following week.

4. Discussion

This is the first study to experimentally investigate the role of thoughts in triggering auditory hallucinations. The majority of individuals in this study were able to identify cognitive antecedents to auditory hallucinations. However, the experimental manipulation provided no evidence that antecedent cognitions were the triggers for auditory hallucinations. The occurrence of voices in VR was the same whether individuals focussed on their identified triggering thoughts or unrelated neutral thoughts. There were no differences in loudness, clarity, frequency or distress of voices between the two groups. No support was provided for the idea that focussing on specific cognitions (i.e. those which have been identified as antecedents to voices) triggers auditory hallucinations.

Several explanations could account for these findings. Antecedent cognitions may be epiphenomenal and not play any role in the occurrence of auditory hallucinations. These results could be taken as evidence for Frith's (1987) and Frith, Rees, and Friston's (1998) self-monitoring theory which does not place emphasis on external or internal contextual variables in the triggering of auditory hallucinations. However, given that there is other evidence for both internal (e.g. Nayani & David, 1996) and external (e.g. Tarrier, 1987) contextual influences on auditory hallucinations, two alternative explanations for the current results are favoured here. It is proposed that the lack of association between cognition and auditory hallucinations may have been due to (i) a failure to activate affect or (ii) a heterogeneity of mechanism (e.g. some voices may be triggered by cognition and affect, whereas some may be a result of a more stable cognitive deficit or bias).

Negative affect has been consistently implicated in the triggering of auditory hallucinations (Freeman & Garety, 2003; Johns & McGuire, 1999; Johns et al., 2001; Morrison & Haddock, 1997;

Table 1
Mean TVRS Scores in virtual reality for each group.

	Mean (SD)					95% Confidence Interval of the Difference	
	Experimental group ($n = 15$)	Control group ($n = 15$)	t (28)	p	Effect Size (d)	Upper	Lower
Loudness	1.93 (1.62)	2.00 (2.07)	−0.10	0.92	0.04	−1.46	1.33
Clarity	2.33 (1.98)	1.93 (2.12)	0.54	0.60	0.20	−1.12	1.92
Distress	2.27 (1.94)	1.87 (1.88)	0.57	0.57	0.21	−1.03	1.83
Distraction	1.53 (1.30)	1.13 (1.51)	0.78	0.44	0.28	−0.65	1.45
Total	8.07 (6.53)	6.96 (6.94)	0.46	0.65	0.17	−3.91	6.17

Loudness (1 = very quiet; 5 = very loud). Clarity (1 = very mumbled; 5 = very clear). Distress (1 = very comforting; 5 = very distressing). Distraction (1 = very easy to ignore; 5 = compelling me to obey them).

Table 2
The effect of virtual reality on motion sickness, heart rate and anxiety.

Scale/subscale	Mean score (SD)		*t* (df)	*p*	95% Confidence interval of the difference	
	Pre virtual reality	Post virtual reality			Upper	Lower
Nausea	46.27 (35.72)	34.34 (28.52)	2.04 (29)	0.05	−0.01	23.86
Oculomotor	46.40 (51.74)	26.92 (24.02)	1.69 (29)	0.10	−2.69	28.67
Disorientation	41.82 (30.46)	33.41 (38.79)	2.88 (28)	<0.01**	3.73	22.15
Total weighted score simulator Sickness	502.98 (400.18)	353.64 (320.24)	2.28 (28)	0.03*	12.61	238.21
Heart rate	86.32 (18.33)	83.82 (13.23)	1.53 (27)	0.14	−1.01	6.88
Anxiety	3.71 (2.32)	3.32 (2.56)	1.19 (24)	0.25	−0.37	1.37

*$p < 0.05$; **$p < 0.01$.

Nayani & David, 1996) and cognitive precipitation of hallucinations is likely to be linked to affective change (Brugger, Regard, Landis, & Oelz, 1999; Yui, Goto, Ikemoto, & Ishiguro, 1997). This was the first study using virtual reality methodology with individuals with auditory hallucinations, and hence particular care was taken to minimise stress during the research. Although 80% of antecedent cognitions in the current study were negatively valenced, there was no indication that those who focussed on antecedent cognitions had higher anxiety ratings or heart rate than those who focused on neutral cognitions. The focus on antecedent cognitions in the current study may have failed to activate affect. This may be a result of the rather contrived nature of the experimental procedure. If auditory hallucinations are triggered by a cognitive affective pathway, then this may explain the results of the study.

However, affective content does not appear to play a role in the occurrence of *all* auditory hallucinations. Many individuals who do not have a psychiatric diagnosis hear neutral voices which do not appear to be linked to strong affect (Honig et al., 1998). In this study, a few participants described their voices as coming 'out of the blue' and as unrelated to any internal or external contextual factors. Many researchers propose different routes to psychotic symptoms (e.g. Aleman & Laroi, 2008; Garety, Kuipers, Fowler, Freeman, & Bebbington, 2001; Jones, 2008; Myin-Germeys & van Os, 2007). It may be that different groups of voice hearers have different pathways to voice occurrence. Perhaps some individuals may experience voices following a cognitive trigger which generates affective change, but it may be that some individuals have a more persistent cognitive deficit, such as that proposed by Frith et al. (1998). If it is the case that there is a heterogeneity of mechanism in the occurrence of auditory hallucinations, this study will have been underpowered to find a triggering effect of cognition.

There may also be methodological explanations for the failure to find an effect of the experimental manipulation. For instance, the study was only powered to detect large differences between the groups – although it should be noted that there appear not even to be trends in the data. In addition, virtual reality was a new experience for all the participants, and was designed to be a neutral, ecologically valid environment (Sanches-Vivez & Slater, 2005). However, this paradigm has not been used before in the study of auditory hallucinations, and its effect on voices has not been studied. Given the evidence that auditory hallucinations decrease when an individual is concentrating on something (e.g. Margo, Hemsley, & Slade, 1981; Tarrier, 1987), a novel and interesting environment might conceivably inhibit auditory hallucinations.

Alternatively, it could perhaps be argued that the virtual reality experience was mildly anxiety-provoking for many of the participants and this could have overridden the effect of the cognitive instruction (Freeman, Gittins et al., 2008). Subjective observation of participants indicated some found the environment interesting, and hence were distracted and perhaps heard fewer voices as a result; others found it anxiety-provoking irrespective of condition and perhaps heard more voices as a consequence. Despite these concerns, it is of note that the same number of participants heard voices in virtual reality and outside virtual reality; and it appears that the methodology neither increased nor inhibited voices for most individuals, rather that it was an ecologically valid neutral environment and it was safe and acceptable to participants. In future studies it would be of interest to examine a less neutral (and more anxiety-provoking) environment, for example, by adding further avatars.

A further methodological limitation of the research is the artificial nature of the cognitive manipulation. Naturally occurring antecedent cognitions are likely to be fleeting and to occur spontaneously; most people do not 'try' to think about a certain thought for a few minutes. It would be of interest to also use a more naturalistic method such as time experience sampling (e.g. Myin-Germeys & van Os, 2007) to investigate the role of cognition in the precipitation of auditory hallucinations. In addition, there is a possibility that thinking about a thought may have interfered with voice generation via subvocalisation. Further, some participants experienced cognitive difficulties (presumably due to a long history of mental illness) and consequently found it difficult to follow the instructions to focus on certain cognitions while in virtual reality. Finally, in this study, as with all research on auditory hallucinations, determining whether an individual is experiencing an auditory hallucination inevitably relies on self-report.

In summary, despite almost all participants in this study subjectively reporting that their voices were preceded by thoughts, an experimental manipulation of cognition revealed no triggering effect of antecedent cognitions. The link between antecedent cognitions and auditory hallucinations is unlikely to be simple. It is argued that cognition may particularly trigger auditory hallucinations in clinical groups when affect is also elicited. In future studies, it is suggested that (i) the effect of cognition on affect is monitored, and that (ii) affect is manipulated directly.

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