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Abstract

BACKGROUND: It has been proposed that the relationship between childhood trauma and hallucinations can be explained by dissociative processes. The present study examined whether the effect of childhood trauma on hallucination-proneness is mediated by dissociative tendencies. In addition, the influence of dissociative symptoms on a cognitive process believed to underlie hallucinatory experiences (i.e. reality discrimination; the capacity to discriminate between internal and external cognitive events) was also investigated.MethodPatients with schizophrenia spectrum disorders (n=45) and healthy controls (with no history of hallucinations; n=20) completed questionnaire measures of hallucination-proneness, dissociative tendencies and childhood trauma, as well as performing an auditory signal detection task. RESULTS: Compared to both healthy and non-hallucinating clinical controls, hallucinating patients reported both significantly higher dissociative tendencies and childhood sexual abuse. Dissociation positively mediated the effect of childhood trauma on hallucination-proneness. This mediational role was particularly robust for sexual abuse over other types of trauma. Signal detection abnormalities were evident in hallucinating patients and patients with a history of hallucinations, but were not associated with pathological dissociative symptoms. CONCLUSIONS: These results are consistent with dissociative accounts of the trauma-hallucinations link. Dissociation, however, does not affect reality discrimination. Future research should examine whether other cognitive processes associated with both dissociative states and hallucinations (e.g. deficits in cognitive inhibition) may explain the relationship between dissociation and hallucinatory experiences.

Keywords

mediates, relationship, between, dissociation, trauma, childhood, proneness, hallucination

Disciplines

Arts and Humanities | Life Sciences | Medicine and Health Sciences | Social and Behavioral Sciences

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ORIGINAL ARTICLE

Dissociation mediates the relationship between childhood trauma and hallucination-proneness

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Background. It has been proposed that the relationship between childhood trauma and hallucinations can be explained by dissociative processes. The present study examined whether the effect of childhood trauma on hallucination-proneness is mediated by dissociative tendencies. In addition, the influence of dissociative symptoms on a cognitive process believed to underlie hallucinatory experiences (i.e. reality discrimination; the capacity to discriminate between internal and external cognitive events) was also investigated.

Method. Patients with schizophrenia spectrum disorders ($n=45$) and healthy controls (with no history of hallucinations; $n=20$) completed questionnaire measures of hallucination-proneness, dissociative tendencies and childhood trauma, as well as performing an auditory signal detection task.

Results. Compared to both healthy and non-hallucinating clinical controls, hallucinating patients reported both significantly higher dissociative tendencies and childhood sexual abuse. Dissociation positively mediated the effect of childhood trauma on hallucination-proneness. This mediational role was particularly robust for sexual abuse over other types of trauma. Signal detection abnormalities were evident in hallucinating patients and patients with a history of hallucinations, but were not associated with pathological dissociative symptoms.

Conclusions. These results are consistent with dissociative accounts of the trauma-hallucinations link. Dissociation, however, does not affect reality discrimination. Future research should examine whether other cognitive processes associated with both dissociative states and hallucinations (e.g. deficits in cognitive inhibition) may explain the relationship between dissociation and hallucinatory experiences.

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Key words: Dissociation, hallucinations, psychosis, signal detection, trauma.

Introduction

Hallucinatory experiences, especially in the auditory modality, are regarded as pathognomonic symptoms of schizophrenia spectrum disorders, although similar complaints are also reported by patients with other diagnoses (Aleman & Larøi, 2008) and non-clinical individuals who do not meet diagnostic criteria for psychiatric disorders (e.g. Honig *et al*. 1998; Johns *et al*. 2002; Andrew *et al*. 2008; Lawrence *et al*. 2010). From a cognitive perspective, hallucinations are believed to arise from the misattribution of internally generated cognitive events (e.g. inner speech) to external sources (Bentall, 1990; Frith, 1992; Ditman & Kuperberg, 2005; Larøi & Woodward, 2007). Bentall (1990) proposed that hallucinatory experiences may be explained by reality discrimination, a metacognitive process used to discriminate agency between internal and external perceptions (for reviews, see Ditman & Kuperberg, 2005; Aleman & Larøi, 2008). According to this account, hallucination-prone individuals are impaired in their capacity to discriminate between internally and externally generated cognitive events and present a specific cognitive bias towards the misattribution of internal cognitive events to external sources.

Several studies have employed signal detection theory (SDT) to investigate the relationship between reality discrimination and hallucination-proneness. SDT assumes that the capacity to discern signals from noise relies on two parameters: perceptual sensitivity (i.e. the capacity to detect a signal from background noise); and response bias (i.e. the extent to which an individual is more or less likely to report the presence of a signal in background noise). Studies that employed auditory SDT tasks have generally supported the reality discrimination model of hallucinations by showing that both hallucinating patients and non-clinical hallucination-prone individuals are

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characterized by greater bias towards the detection of signals (and not by perceptual sensitivity impairment) when compared with controls (Bentall & Slade, 1985*a*; Rankin & O'Carroll, 1995; Barkus *et al*. 2007, 2011; Vercammen *et al*. 2008; Varese *et al*. 2011*a*).

Recent research has witnessed a growing interest in the contribution of trauma to hallucination-proneness. Large population-based investigations and several cross-sectional studies suggest traumatic events may increase the likelihood of experiencing psychotic symptoms (for reviews, see Read *et al*. 2004, 2005, 2008; van Os *et al*. 2010) and there might be specific associations between different types of adversities and specific psychotic complaints (Bentall & Fernyhough, 2008). In this context, the experience of early adversity, especially childhood sexual abuse (CSA), has been specifically linked to hallucinations in schizophrenia (Read *et al*. 2003) and bipolar disorder patients (Hammersley *et al*. 2003) as well as in community samples (Whitfield *et al*. 2005; Shelvin *et al*. 2007).

It has been proposed that the relationship between trauma and psychotic symptoms could be accounted for by dissociative processes (e.g. Moskowitz & Corstens, 2007; Moskowitz *et al*. 2009; Anketell *et al*. 2010). Dissociation has been defined as the 'lack of normal integration of thoughts, feelings and experiences into the stream of consciousness and memory' (Bernstein & Putnam, 1986, p. 727) and represents the core component of DSM-IV diagnosis of dissociative disorders. Although dissociative states can be experienced in the absence of antecedent trauma (Merckelbach & Muris, 2001; Mayer & Farmer, 2003), research findings suggest that dissociation is a pervasive sequela of traumatic events in non-psychotic samples (van Ijzendoorn & Schuengel, 1996) and that psychotic patients exposed to traumatic life experiences score higher on measures of dissociative tendencies compared with patients with no history of trauma (Goff *et al*. 1991; Holowka *et al*. 2003; Offen *et al*. 2003; Dorahy *et al*. 2009; Perona-Garcelán *et al*. 2010).

Although studies have linked dissociative tendencies to psychotic symptoms and psychosis-proneness in general (e.g. Startup, 1999; Pope & Kwapil, 2000; Moskowitz *et al*. 2005), increasing evidence suggests dissociation is specifically related to hallucinations rather than other psychotic symptoms (Altman *et al*. 1997; Escher *et al*. 2002*a*, *b*; Kilcommons & Morrison, 2005). Several cross-sectional studies have found robust associations between dissociative tendencies and hallucinatory experiences in psychotic patients (Kilcommons & Morrison, 2005; Perona-Garcelán *et al*. 2008, 2010), sexual abuse victims (Kilcommons *et al*. 2008), post-traumatic stress disorder patients (Anketell *et al*. 2010), non-psychotic adolescents (Altman *et al*. 1997; Yoshizumi *et al*. 2004) and adult non-clinical samples (Glicksohn & Barrett, 2003; Morrison & Petersen, 2003; Barkus *et al*. 2010; Varese *et al*. 2011*a*). In a longitudinal study of adolescents experiencing auditory hallucinations (Escher *et al*. 2002*a*, *b*), dissociation significantly predicted the persistence of hallucinations over a 3-year follow-up period. Finally, in a recent experience-sampling study (a structured diary method used to investigate different aspects of the participants' behavioural, emotional and cognitive experience as it occurs in real time; Delespaul, 1995), increased state dissociation was found to be a significant predictor of auditory hallucinations in the flow of daily life of psychotic patients (Varese *et al*. 2011*b*).

The accumulating evidence linking childhood trauma, dissociation and hallucinations has led to speculation that the effect of childhood trauma on hallucination-proneness may be mediated by increased dissociative tendencies (e.g. Moskowitz & Corstens, 2007; Anketell *et al*. 2010). This hypothesis, however, has not been empirically tested to date. Similarly, no published studies have yet investigated the interplay between dissociation and the cognitive mechanisms believed to underlie hallucinatory experiences. Allen *et al*. (1997) proposed that dissociation might represent a vulnerability to experience psychotic symptoms in virtue of its capacity of 'loosening the moorings in inner and outer reality' (p. 327), therefore making individuals vulnerable to psychotic states by impairing reality testing. From this perspective, it can be assumed that dissociative tendencies could directly interfere with discrimination between internally and externally generated events, resulting in reality discrimination difficulties.

The primary objective of this study was to test whether dissociation mediates the relationship between childhood trauma and hallucination-proneness in a sample of psychotic patients with diagnoses in the schizophrenia-spectrum. In addition, this study examined whether dissociation is related to reality discrimination difficulties by comparing patients with and without pathological dissociative symptoms using an auditory signal detection task. Corollary analyses (correlational and between-group differences analyses) were also carried out to replicate previous findings that linked hallucination-proneness to childhood trauma, dissociative symptoms and reality discrimination abnormalities (i.e. increased response bias in an auditory SDT task).

Method

Participants

Altogether, 45 patients with diagnoses in the schizophrenia spectrum (i.e. diagnoses of schizophrenia,

Table 1. *Means* (S.D.) *and observed frequencies for the clinical and demographic characteristics of the sample*

	Hallucinating	Remitted hallucinators	Non-hallucinating	Controls	F/χ^2
Age	45.6 (12.2)	39.4 (13.3)	48.3 (12.2)	39.5 (14.6)	$F(3, 62) = 1.93$ N.S.
Quick Test score	43.1 (4.1)	43.4 (5.0)	43.1 (5.1)	45.9 (3.3)	$F(3, 61) = 1.79$ N.S.
Years of education	13.6 (3.3)	13.7 (2.7)	11.9 (2.1)	16.1 (3.1)	$F(3, 62) = 6.87$***
Gender	Males = 6	Males = 7	Males = 11	Males = 11	$\chi^2(3) = 2.04$, N.S.
Diagnosis	Schizophrenia = 13 Schizoaffective = 2	Schizophrenia = 10 Scizoaffective = 4	Schizophrenia = 11 Scizoaffective = 5 Delusional disorder = 1	none	$\chi^2(4) = 3.29$, N.S.

N.S., Non-significant.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
The Quick Test was used to measure pre-morbid verbal intelligence.

schizoaffective disorder and delusional disorder, as confirmed by the referring clinicians or members of the patients' care teams) were recruited from in-patient and out-patient services in North Wales (UK). In addition, 20 healthy controls with no history of mental health difficulties or hallucinations were recruited through the Bangor University Community Research Panel via an invitation letter or email. Their eligibility was ascertained using a clinical interview comprising the Structured Clinical Interview for the Positive and Negative Syndromes Scales (SCI-PANSS; Opler *et al*. 1992) and additional items taken from the 'Demographic Data', 'Education and Work History' and 'Treatment and Hospitalization History' sections of the overview module of the Structural Clinical Interview for DSM-IV-TR Axis I Disorders (First *et al*. 2002). Non-clinical participants who disclosed past or current psychiatric complaints were deemed ineligible. The absence of lifetime history of hallucinations in the non-clinical group was ascertained using the hallucinations screening questions of the SCI-PANSS, which require participants to disclose whether they have ever experienced auditory hallucinations (e.g. 'Sometimes people tell me that they can hear noises or voices that others can't hear. What about you?') and hallucinatory experiences in other sensory modalities. None of the control participants recruited in this study reported past or current hallucinatory experiences.

For the purpose of the between-group analyses, patients were divided into three subgroups according to their responses to the hallucinations items of the SCI-PANSS. The hallucinating patients group ($n = 15$) comprised participants with a score $\geqslant 3$ on the hallucinatory behaviour item of Positive and Negative Syndrome Scales (PANSS) (i.e. symptom present). The remitted hallucinators group ($n = 14$) comprised non-hallucinating patients (PANSS hallucinations score = 1; i.e. symptom absent) who suffered from auditory hallucinations in the past. Finally, the non-hallucinating patients group ($n = 16$) included participants who reported no lifetime occurrence of hallucinatory experiences. Clinical and sociodemographic characteristics of the sample are reported in Table 1.

Between-group differences on the clinical and demographic variables were tested using analysis of variance (ANOVA) and Pearson's χ^2 test. There were no significant between-group differences for age, gender and pre-morbid IQ [as assessed by the Ammons Quick Test (QT); Ammons & Ammons, 1962]. Patients spent significantly less years in education compared with healthy controls, but there were no differences on education between the three clinical groups. In total, 40 patients were taking antipsychotic medication at the time of testing (13 hallucinating patients, 12 remitted hallucinators and 15 non-hallucinating patients).

Measures

PANSS (*Kay et al. 1987*)

The PANSS was used to assess the presence and severity of positive and negative psychotic symptoms in the week preceding the interview. Each symptom is scored on a scale ranging from 1 (symptom absent) to 7 (extreme symptom severity). The PANSS subscales have good reliability and validity (Kay *et al*. 1988).

The revised Launay–Slade Hallucination Scale (*LSHS-R; Bentall & Slade, 1985b*)

The LSHS-R is a widely used self-report measure of hallucination-proneness. The 12 items of the scale describe clinical and subclinical forms of auditory and visual hallucinations. Participants are asked to rate the degree to which the content of each item applies to themselves on a 5-point Likert scale (1 = 'certainly

does not apply' to 5 = 'certainly applies'). The LSHS-R had excellent internal consistency in this sample ($\alpha = 0.91$).

The Child Abuse and Trauma Scale (*CATS; Sanders & Becker-Launsen, 1995*)

The CATS is a 38-item self-report scale of the perceived stress and trauma experienced during childhood and adolescence. The questionnaire provides a total score reflecting the perceived severity of maltreatment during childhood, as well as four subscale scores assessing experiences of child sexual abuse (six items; e.g. 'Were there traumatic or upsetting sexual experiences when you were a child or teenager that you couldn't speak to adults about?'), punishment/physical abuse (six items; e.g. 'Did your parents ever hit or beat you when you did not expect it?'), neglect/negative home environment (14 items; e.g. 'As a child, did you have to take care of yourself before you were old enough?') and emotional abuse (seven items; e.g. 'Did your parents ridicule you?'; Kent & Waller, 1998). Participants are required to estimate how frequently they were exposed to the abusive experiences described in each item on a 5-point Likert scale (0 = never; 4 = always). In previous studies the CATS has shown good test–retest reliability (Sanders & Becker-Launsen, 1995) and convergent validity with other validated retrospective measures of childhood maltreatment (e.g. Kroll *et al*. 1996; Rankin, 1999; Baker & Festinger, 2011). In this study, the CATS presented good internal consistency both at the total scale ($\alpha = 0.95$) and at the subscales level (α coefficients ranging between 0.73 and 0.92).

The Dissociative Experiences Scale (*DES; Bernstein & Putnam, 1986*)

The DES is a self-report measure of dissociative symptoms and experiences. Participants are asked to estimate the frequency of 28 dissociative phenomena in their daily life using a 100 mm visual analogue scale. Using taxometric analysis, Waller *et al*. (1996) identified an eight-item subset of the DES [known as the Dissociative Experiences Scale – Taxon (DES-T)] used to estimate the probability that an individual belongs to the pathological dissociation taxon (Waller *et al*. 1996; Waller & Ross, 1997). The DES and the DES-T had good internal consistency in this sample ($\alpha = 0.93$ and $\alpha = 0.83$, respectively).

The Ammons QT (*Ammons & Ammons, 1962*)

The QT was included as a measure of pre-morbid verbal intelligence. Participants are required to associate a list of 50 words of increasing difficulty to four different line drawings. The test score is then calculated from the number of correct word–drawing associations before six consecutive incorrect responses. In previous studies, the QT has shown good convergent validity with other validated measures of verbal intelligence including the Wechsler Adult Intelligence Scale (e.g. Ammons & Ammons, 1962; Joesting & Joesting, 1972) and has been previously employed to assess verbal intelligence in psychotic samples (e.g. Kay *et al*. 1987).

The auditory signal detection task

An auditory SDT task previously employed to investigate the cognitive underpinnings of non-clinical hallucination-proneness (Barkus *et al*. 2007, 2011; Varese *et al*. 2011*a*) was used as a measure of reality discrimination. The task consisted of two 8-min blocks, comprising a total of 120 8-s epochs. Each epoch contained one 5-s burst of white noise and 3 s of silence. During 60% of the bursts of white noise, a 1-s androgynous voice was presented after 2 s. A third of the time the voice was clearly audible to participants; in the remaining epochs the voice was presented at auditory thresholds (auditory thresholds were estimated by prior testing using 10 pilot participants in the same age range as the experimental participants, i.e. age range 18–65 years) Stimuli were presented through standard stereo headphones. After each burst of white noise, participants indicated whether they perceived a voice by pressing mouse buttons labelled 'Yes' or 'No' using their preferred hand. Four measures were obtained: hits (positive responses when the voice was present); false alarms (positive responses when the voice was absent); misses (negative responses when the voice was present); correct rejections (negative responses when the voice was absent). From the relationship between hits and false alarms, measures of perceptual sensitivity (d') and response bias (β) were calculated using the computational methods described by Barkus *et al*. (2007). A d' value of zero indicates complete inability to discriminate between signals and background noise, whereas higher d' scores indicate better capacity to detect true signals. Conversely, any β score <1 suggests a bias towards the detection of signals when no signal is present, whereas scores equal to 1 indicate no response bias.

Procedure

Participants were tested individually in a quiet room in the Bangor University School of Psychology, or in other appropriate facilities in in-patient and out-patient units in North Wales (UK). After informed

Table 2. *Means* (s.d.) *for the PANSS, questionnaire measures and SDT task performance*

	Hallucinating	Remitted hallucinators	Non-hallucinating	Controls	ANOVA
Positive symptoms	18.36 (4.09)	11.07 (2.76)	12.06 (3.78)	7.30 (0.47)	$F(3, 61) = 37.58$***
Negative symptoms	12.85 (5.12)	9.71 (4.32)	10.03 (4.96)	7.25 (0.71)	$F(3, 61) = 7.36$***
Positive symptoms (without hallucinations)	14.21 (3.30)	9.86 (2.88)	11.06 (3.78)	6.30 (0.47)	$F(3, 61) = 22.79$***
LSHS-R	47.64 (6.40)	36.64 (10.34)	28.88 (8.67)	21.45 (6.95)	$F(3, 61) = 30.74$***
DES	42.59 (11.03)	26.06 (10.90)	23.93 (14.93)	14.86 (12.28)	$F(3, 60) = 13.70$***
CATS	63.93 (33.68)	43.92 (17.94)	46.19 (27.65)	23.35 (10.54)	$F(3, 60) = 8.68$***
Sexual abuse	7.07 (7.15)	1.69 (2.69)	2.93 (4.22)	0.40 (0.75)	$F(3, 60) = 7.48$***
Punishment	8.93 (3.39)	7.54 (3.20)	8.56 (4.50)	5.20 (2.37)	$F(3, 60) = 4.43$**
Negative home environment	25.33 (14.68)	19.38 (7.95)	18.00 (11.82)	9.05 (5.33)	$F(3, 60) = 7.46$***
Emotional abuse	13.67 (7.84)	9.46 (4.84)	9.50 (7.18)	5.45 (3.05)	$F(3, 60) = 5.57$**
β (response bias)	0.19 (0.38)	0.15 (0.38)	0.56 (0.35)	0.66 (0.38)	$F(3, 57) = 7.58$***
d′ (perceptual sensitivity)	1.07 (0.44)	1.10 (0.43)	1.40 (0.44)	1.87 (0.45)	$F(3, 57) = 12.56$***

PANSS, Positive and Negative Syndrome Scales; SDT, signal detection theory; ANOVA, analysis of variance; LSHS-R, revised Launay–Slade Hallucination Scale; DES, Dissociative Experiences Scale; CATS, Child Abuse and Trauma Scale.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

consent had been obtained, participants underwent the SCI-PANSS, completed the QT and were asked to fill in the LSHS-R and the DES. Participants were then asked to read a set of standardized instructions and completed the signal detection task. The task was described as a simple hearing test. At the completion of the task, participants were asked to fill in the CATS and were fully debriefed.

Results

Between-group differences on the PANSS and questionnaire measures and correlational analyses

Prior to mediation analysis, a series of one-way ANOVA was carried out to examine between-group differences on the PANSS and questionnaire measures. *Post-hoc* comparisons were conducted using Tukey's Honestly Significant Difference. Correlational analyses were also performed to examine the associations between DES, LSHS-R and CATS scores. All analyses involving the DES were carried out after excluding the DES hallucinations item to avoid any confound stemming from the overlapping content with hallucination-proneness.

Descriptive statistics for the PANSS and questionnaire measures are displayed in Table 2. The analyses of the PANSS revealed that all patient groups scored significantly higher than controls on positive symptoms (all p's < 0.01). Hallucinating patients presented significantly higher scores on the PANSS positive symptoms scale compared with the other patient groups (all p's < 0.001), whereas the remitted hallucinators *versus* non-hallucinating patients contrast was not significant ($p = 0.80$). To determine whether this result might be accounted for by differences on hallucinations scores, the analysis was also carried out after excluding the hallucinations item of the PANSS. The difference between the hallucinating and the other patient groups remained statistically significant (all p's < 0.05). In terms of negative symptoms, hallucinating patients scored significantly higher than participants with no history of mental health difficulties ($p < 0.001$). The comparison between the remitted hallucinators and healthy controls was not significant ($p = 0.99$), whereas the difference between non-hallucinating patients and healthy controls approached statistical significance ($p = 0.07$). All pairwise comparisons carried out between the clinical groups were not significant, although a trend towards significance was observed for the hallucinating patients *versus* remitted hallucinators contrast ($p = 0.08$).

The results of the hallucination-proneness scores showed that all patient groups scored significantly higher than healthy controls (all p's < 0.05). Among the clinical groups, hallucinating patients had significantly higher LSHS-R scores than the other groups considered (all p's < 0.01). In addition, remitted hallucinators scored higher than the non-hallucinating patients ($p = 0.05$). The analysis of dissociation scores revealed that hallucinating patients had significantly higher DES scores compared with both clinical and healthy controls (all p's < 0.01). No other between-group differences reached statistical significance,

Table 3. *Non-parametric correlations (Spearman's rho) between childhood trauma, dissociation and hallucination-proneness measures*

	LSHS-R	DES	CATS total	Sexual abuse	Physical abuse	Neglect
Aggregated sample						
DES	0.70***	–				
CATS total	0.58***	0.43***	–			
Sexual abuse	0.52***	0.35**	0.77***	–		
Physical abuse	0.35**	0.24	0.71***	0.44***	–	
Neglect	0.58***	0.41**	0.95***	0.70***	0.55***	–
Emotional abuse	0.49***	0.38**	0.87***	0.48***	0.64***	0.82***
Patient sample						
DES	0.62***	–				
CATS total	0.35*	0.32*	–			
Sexual abuse	0.37*	0.31*	0.72***	–		
Physical abuse	0.07	0.10	0.65***	0.32*	–	
Neglect	0.36*	0.23	0.93***	0.63***	0.45**	–
Emotional abuse	0.29	0.26	0.85***	0.35*	0.56***	0.79***

LSHS-R, Revised Launay-Slade Hallucination Scale; DES, Dissociative Experiences Scale; CATS, Child Abuse and Trauma Scale.

* $p<0.05$, ** $p<0.01$, *** $p<0.001$.

although a trend was observed for the remitted hallucinators *versus* healthy controls contrast ($p=0.06$).

The analysis of the childhood trauma measures revealed that both hallucinating and non-hallucinating patients scored significantly higher than healthy controls on the CATS ($p<0.001$ and $p<0.05$, respectively), whereas the comparison between remitted hallucinators and controls only approached statistical significance ($p=0.08$). The three patients groups did not differ significantly from each other in terms of CATS total scores (all p's >0.05). The analyses carried out at the subscale level showed that the hallucinating patients scored significantly higher than non-clinical controls on all CATS subscales (all p's <0.01). In addition, non-hallucinating patients reported significantly higher levels of neglect and physical abuse compared with participants with no history of mental health difficulties (all p's <0.05), whereas patients in the remitted hallucinators group scored higher than controls only on measures of neglect/negative home environment ($p<0.05$). The three patient groups did not differ from each other on physical abuse, neglect or emotional abuse (all p's >0.05). However, hallucinating patients reported significantly more CSA compared with both remitted hallucinators ($p<0.01$) and hallucinating patients ($p<0.05$).

To examine the associations between LSHS-R, DES and CATS scores, two separate correlational analyses were conducted on both the aggregated sample of participants (i.e. including both psychiatric and non-clinical participants) and exclusively on the psychiatric patients sample (see Table 3). Hallucination-proneness was significantly associated with dissociation and CATS total scores in both the aggregated and psychiatric sample analyses. In the aggregated sample, hallucination-proneness was significantly related to all subscales of the CATS, whereas only the associations with CSA and neglect were statistically significant in the psychiatric subsample analysis. In the aggregated sample, significant associations were also found between dissociation and CATS total scores, CSA, neglect and emotional abuse. However, only the relationship with CATS total scores and with CSA were significant when the analysis was restricted to psychiatric patients.

Mediation analyses

The hypothesized mediating role of dissociation in the relationship between childhood trauma and hallucination-proneness was tested using the general approach to mediation analysis developed by Imai *et al*. (2010*a*) This statistical approach provides a unified estimation procedure for mediation effects that can accommodate linear and non-linear relationships, parametric and non-parametric models and different types of mediators and outcome variables (i.e. both continuous and dichotomous) without the need of individually tailored statistical models. The analysis was carried out using the 'mediation' statistical package for R (Imai *et al*. 2010*b*). Point estimates for mediated, direct and total effects and their associated 95% confidence intervals were estimated using the non-parametric inference algorithm detailed by Imai *et al*. with 1000 bootstrap resamples. First, mediation analysis was employed to test whether the association

Table 4. *Point estimates (95% CI) for the total, direct and indirect (i.e. mediated via dissociative tendencies) effects of trauma on hallucination-proneness*

Independent variable	Indirect effect	Direct effect	Total effect
Analysis of the total sample			
CATS scores	0.12 (0.06 to 0.19)	0.12 (0.02 to 0.22)	0.24 (0.13 to 0.35)
Sexual abuse	0.65 (0.24 to 1.07)	0.58 (−0.02 to 1.12)	1.23 (0.68 to 1.76)
Physical abuse	0.56 (−0.06 to 1.21)	0.45 (−0.26 to 1.18)	1.00 (0.14 to 1.92)
Neglect	0.26 (0.11 to 0.42)	0.30 (0.09 to 0.48)	0.56 (0.32 to 0.78)
Emotional abuse	0.43 (0.17 to 0.72)	0.36 (−0.05 to 0.79)	0.79 (0.27 to 1.32)
Analysis of the patients sample			
CATS score	0.11 (0.06 to 0.17)	0.15 (0.07 to 0.24)	0.26 (0.17 to 0.35)
Sexual abuse	0.57 (0.24 to 0.97)	0.77 (0.27 to 1.20)	1.33 (0.92 to 1.77)
Physical abuse	0.19 (−0.47 to 0.86)	0.01 (−0.80 to 0.83)	0.21 (−0.83 to 1.31)
Neglect	0.13 (−0.03 to 0.28)	0.22 (−0.02 to 0.42)	0.35 (0.05 to 0.61)
Emotional abuse	0.24 (−0.02 to 0.54)	0.26 (−0.21 to 0.73)	0.49 (−0.10 to 1.08)

CATS, Child Abuse and Trauma Scale.

between CATS and LSHS-R scores is mediated by dissociative tendencies. In addition, separate analyses were carried out using the four CATS subscales as independent variables to examine whether the hypothesized mediating role of dissociation could be ascribed to specific experiences of childhood trauma. The analyses were conducted both on the aggregated sample and on the psychiatric patient sample alone.

The results of the aggregated sample analysis (see Table 4) indicated that the relationship between CATS scores and hallucination-proneness was positively mediated by DES scores. Similar findings were obtained when the analysis was restricted to the patient sample. When focusing on specific types of trauma, dissociation significantly mediated the effect of sexual abuse on hallucination-proneness in both the aggregated and psychiatric sample analyses. In the aggregated sample, dissociation also mediated the relationship between neglect/negative home environment and hallucination-proneness, as well as the effect of emotional abuse on hallucination-proneness. However, these effects were not significant when the analyses were performed exclusively within the patient sample.

Between-group differences on the signal detection task

Prior to examining the SDT data, four participants (two remitted hallucinators and two non-hallucinating patients) were dropped from the analysis as they reported hearing problems at the time of testing. Two one-way ANOVA were carried out on β and d′ scores in an attempt to replicate previous findings that linked auditory hallucinations to perturbed reality discrimination. The hallucinating and the remitted hallucinators groups presented significantly lower response bias scores compared with non-hallucinating patients and healthy controls (all p's <0.05). Conversely, there were no significant differences on β scores between hallucinating patients and remitted hallucinators ($p=0.99$), and between non-hallucinating patients and healthy controls with no history of mental illness ($p=0.87$). The analysis of the perceptual sensitivity data indicated that all patients had significantly lower d′ scores than controls (all p's <0.05), but no significant between-group differences were observed for *post-hoc* comparisons between the psychotic patient groups (all p's >0.05).

To investigate whether dissociation is directly related to reality discrimination difficulties, we examined the signal detection performance of patients with elevated levels of pathological dissociation compared with patients whose level of dissociation was non-pathological. The DES-T scores of participants in the patient groups were used to estimate their individual Bayesian probability of belonging to the pathological dissociation taxon. The analysis was carried out using the Excel adaptation of the SAS algorithm developed by Waller & Ross (1997) made available on the International Society for the Study of Trauma and Dissociation website (Perry, 2004). Following the cut-off proposed by Waller & Ross, participants with a Bayesian probability level >0.90 were assigned to the pathological dissociation group ($n=14$), whereas the remaining participants were assigned to the non-dissociative patient control group ($n=31$). Between-group differences on hallucination-proneness and signal detection performance were examined using a series of Mann–Whitney U tests. The analysis of the hallucination-proneness data indicated that patients with pathological dissociative symptoms scored

significantly higher than non-dissociative patients on the LSHS-R (mean = 45.86, S.D. = 8.25 and mean = 34.06, S.D. = 11.05 respectively; $U = 90.00$, $z = 3.12$, $p < 0.01$). However, the two groups did not differ significantly in terms of β (mean = 0.27, S.D. = 0.38 and mean = 0.32, S.D. = 0.42 respectively; $U = 167.50$, $p > 0.05$) and d′ scores (mean = 1.30, S.D. = 0.49 and mean = 1.09, S.D. = 0.57 respectively; $U = 155.00$, $p > 0.05$).

Discussion

Our results indicate that the relationship between childhood trauma and hallucination-proneness was positively mediated by dissociative tendencies. The mediational role of dissociation was particularly robust for experiences of sexual abuse relative to other types of trauma. Consistent with this, we found that hallucinating patients could be clearly distinguished from the other groups in terms of dissociation and the frequency of traumatic childhood sexual experiences. The results of the SDT task indicated that perturbed reality discrimination was primarily related to vulnerability to hallucinations and not dissociation. When patients belonging to the pathological dissociation group were compared with the non-dissociative patients, we found no significant differences in terms of signal detection performance. Conversely, patients in the hallucinating and remitted hallucinators groups had significantly lower β scores (i.e. greater response bias) compared with non-hallucinating patients and healthy controls.

Overall, these findings corroborate recent accounts suggesting that the trauma–hallucinations link might be explained by dissociative processes (Moskowitz & Corstens, 2007; Anketell *et al*. 2010) and are consistent with epidemiological and cross-sectional data suggesting an apparent specific association between CSA and hallucinations (Read & Argyle, 1999; Hammersley *et al*. 2003; Read *et al*. 2003; Shelvin *et al*. 2007). However, the mechanism through which dissociation might promote hallucinations remains to be clarified. Recent evidence suggests that weakened cognitive inhibition may represent a prevailing cognitive concomitant of dissociation (Dorahy & Green, 2008; Giesbrecht *et al*. 2008). In some individuals, this could be expressed by experiencing intrusive thoughts; while in others, it may promote the onset of auditory hallucinations. Other individual difference variations (possibly reality discrimination deficits) may account for the symptom that is expressed after the weakened cognitive inhibition. In keeping with this theory, recent empirical evidence has pointed to the importance of inhibitory processes in explaining auditory hallucinations as misattributed auditory mental representations that intrude into consciousness as a result of intentional inhibition deficits (Waters *et al*. 2003, 2006; Badcock *et al*. 2005). Further studies are required to determine whether these kinds of processes can explain the relationship observed between dissociation and hallucinations in this and previous studies.

With regard to SDT, our findings are consistent with previous patient studies (Bentall & Slade, 1985*a*; Vercammen *et al*. 2008). The finding that reality discrimination is related to hallucinations vulnerability rather than acute hallucinatory experiences is consistent with previous observations of impaired SDT performance in psychometric high-risk samples (Bentall & Slade, 1985*a*; Barkus *et al*. 2007, 2011; Varese *et al*. 2011*a*). This contrasts with the results from the DES, which showed that elevated dissociation was associated with current hallucinations (even though a trend suggesting higher dissociative tendencies in the remitted hallucinators compared with healthy controls was also observed). Hence, the findings might be interpreted in terms of a two-hit model, in which impaired reality discrimination (perhaps resulting from neurophysiological dysfunctions such as reduced connectivity between the frontal cortex and the auditory cortex; Ford *et al*. 2002; Ford & Mathalon, 2005) is an enduring vulnerability factor, perhaps predating the onset of psychosis, but increased dissociation (possibly representing a sequela of traumatic experiences) triggers the actual onset of hallucinatory experiences.

One finding was unexpected and is perhaps inconsistent with this account. The relatively infrequent childhood maltreatment reported by the remitted hallucinators and the lower level of dissociative tendencies observed in this group are apparently inconsistent with dissociative accounts of the origin of hallucinatory experiences. However, the present study focused exclusively on childhood trauma. Although early abuse and maltreatment is frequently regarded as the most prominent developmental antecedent of persistent dissociative tendencies, empirical evidence suggests that transient dissociative phenomena can be triggered by acute adult trauma and stressful life events (e.g. Cardena & Spiegel, 1993; Morgan *et al*. 2001). Given evidence suggesting that auditory hallucinations in the daily life of psychotic patients are predicted by increased levels of state dissociation (Varese *et al*. 2011*b*), future studies should consider the potential contribution of transient dissociation resulting from adult traumatic experiences on the vulnerability to hallucinations.

The findings of the present study add on to the existing literature documenting the pervasive prevalence of traumatic life experiences in psychotic

populations (for reviews, see Read *et al*. 2005, 2008). From a clinical perspective, these findings call for a more thorough examination for past exposure to traumatic events and the assessment of the impact of childhood trauma and its psychological sequelae on the maintenance of adult psychopathological complaints. Given evidence that trauma directly influences the content (Hardy *et al*. 2005; Thompson *et al*. 2010) and subjective appraisal of hallucinatory experiences (Andrew *et al*. 2008), the identification of trauma and abuse may be particularly beneficial in the assessment, formulation and treatment planning of patients suffering from auditory verbal hallucinations.

Several methodological limitations should be acknowledged. Childhood trauma was assessed using retrospective self-report measures. The use of these self-rated measures in psychotic samples has been criticized because of concerns about memory inaccuracies and bias stemming from current symptoms (Morgan & Fisher, 2007; Bendall *et al*. 2008). Although several studies indicate that patients' reports of child abuse have good concurrent validity, convergent validity with other assessment methods (i.e. case notes) and adequate test–retest reliability over long periods of time (Darves-Bornoz *et al*. 1995; Goodman *et al*. 1999; Fisher *et al*. 2011), future studies should ideally try to replicate our results using corroborated measures of abuse. The sample employed was modest in size, therefore limiting the generalizability and the statistical power of the present study. These findings should therefore be interpreted with caution and should be replicated in larger patient samples. As in other studies in this field, the present sample did not consist of a random selection of patients. Although we are not aware of any systematic bias in the participant selection to have occurred, the possibility that our findings may be affected by selection bias cannot be ruled out. Patients' primary diagnoses were confirmed by referring clinicians. We are not aware of any patient with co-morbid dissociative disorder to have taken part in the study; however, the possibility that our findings may be biased by co-morbid dissociative conditions cannot be excluded. Future studies will benefit from the use of purposely designed clinical instruments (such as the Structured Clinical Interview for DSM-IV Dissociative Disorders; Steinberg, 1994) to rule out the influence of co-morbid dissociative disorders. Finally, the correlational nature of our findings does not allow inferences about causality and we acknowledge that alternative models linking trauma, hallucinations and dissociative tendencies might be fitted to these data. For example, self-reported dissociation and trauma may be influenced by the participants' current mental state or may represent a consequence of psychotic experiences rather than their precursor (for a review, see Schäfer *et al*. 2008). Future studies might resolve these issues by the judicious use of longitudinal data.

Declaration of Interest

None.

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