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Research report

Cognitive correlates of the spontaneous out-of-body experience (OBE) in the psychologically normal population: Evidence for an increased role of temporal-lobe instability, body-distortion processing, and impairments in own-body transformations

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ABSTRACT

Recent findings from studies of epileptic patients and schizotypes have suggested that disruptions in multi-sensory integration processes may underlie a predisposition to report out-of-body experiences (OBEs: Blanke et al., 2004; Mohr et al., 2006). It has been argued that these disruptions lead to a breakdown in own-body processing and embodiment. Here we present two studies which provide the first investigation of predisposition to OBEs in the normal population as measured primarily by the recently devised Cardiff anomalous perception scale (CAPS; Bell et al., 2006). The Launay–Slade Hallucination scale (LSHS) was also employed to provide a measure of general hallucination proneness. In Study 1, 63 University students participated in the study, 17 of whom (26%) claimed to have experienced at least one OBE in their lifetime. OBEers reported significantly more perceptually anomalies (elevated CAPS scores) but these were primarily associated with specific measures of temporal-lobe instability and body-distortion processing. Study 2 demonstrated that OBEers and those scoring high on measures of temporal-lobe instability/body-distortion processing were significantly impaired, relative to controls, at a task requiring mental own-body transformations (OBTs) (Blanke et al., 2005). These results extend the findings from epileptic patient studies to the psychologically normal population and are consistent with there being a disruption in temporal-lobe and body-based processing underlying OBE-type experiences.

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1. Introduction

Recent research from the cognitive neurosciences suggests that hallucinations are not necessarily indicative of, or restricted to, an underlying psychopathology (see Bentall, 1990, 2003; Brugger, 2002; Slade and Bentall, 1988). The emerging picture is one where proneness to both sensory anomalies and hallucination is seen more as a continuum along which we can all be placed (Bentall, 1990; Claridge, 1997; Lopez Rodrigo et al., 1997; Meehl, 1962; Mohr and Blanke, 2005; Slade and Bentall, 1988; Strauss, 1969; Verdoux and Van Os, 2002; van Os et al., 2000). In addition, studying hallucinations in the normal population can greatly aid theoretical models of brain function by comparing instances when such 'positive' experiences occur, to the more traditional deficits approach of Cognitive Neuropsychology (see ffytche, 2000; ffytche and Howard, 1999; Frith, 2004, for discussion). When viewed in concert, both the traditional neuropsychological 'deficit' approach, and this more recent 'positive' approach can lead to valuable insights in brain function and make important contributions to theories of consciousness, embodiment and the 'self'.

One important form of hallucination that has received considerable attention in recent years is the out-of-body experience (OBE: see; Blanke and Metzinger, 2008; Brugger, 2002, for reviews). Blackmore (1982) defined the OBE as "*…an experience in which a person seems to perceive the world from a location outside his physical body*" (Blackmore, 1982, p. 1). Thus, in an OBE the observer experiences a form of dissociation between the perceiving 'self' and its typical physical moorings. Although some recent authors have tried to foster definitions which include the perception of a 'self' or some form of autoscopic body-image during the OBE (see Blanke et al., 2005; Ehrsson, 2007; for examples), seeing a representation of the physical self in an OBE is not a necessary condition for the experience. Indeed, some have suggested that actual reports of seeing some form of body representation during an OBE are quite rare (Gabbard and Twemlow, 1984; Irwin, 1985; Murray and Fox, 2005) and others have suggested treating separately experiences where people do see a double and when they do not separately (see Cheyne and Girard, 2009; Terhune, 2009).

A typical feature of the OBE is that it is experienced as being extremely real at the time of the experience – with all the experiential qualities of three-dimensional veridical perception (Blackmore, 1982, 1987; Blanke and Mohr, 2005; Blanke et al., 2004; Brugger, 2002; Eastman, 1962; Mohr et al., 2006). Understanding the neural and cognitive correlates of the OBE (and kindred hallucinations of the 'self') is important as current estimates suggest they also occur in around 10%–15% of the psychologically normal population (∼25% in undergraduate populations) where there is no evidence of any underlying psychopathology (Alvarado, 2000; Blackmore, 1982, 1986; Irwin, 1985). OBEs can occur in a variety of contexts including being part of the near-death experience (NDE), as a result of taking hallucinogenic drugs, and can occur in response to life-threatening stressful situations (though they are more common during relaxed yet wakeful states: Alvarado, 2000; Appleby, 1989; Blackmore, 1982; Braithwaite, 2008a, 1998; Eastman, 1962; Green, 1968; Noyes and Kletti, 1976, 1977; Siegel, 1977, 1980). They can occur as part of migraine aura (Comfort, 1982; Lhermite, 1951; Lippman, 1952, 1953; Sacks, 1995; Todd and Dewhurst, 1955) though, are more commonly associated with paroxysmal discharges that form complex partial seizures of the temporal-lobe and limbic system (Devinsky and Lai, 2008; Fauget, 1979; Gloor, 1986; Gloor et al., 1982; Bear, 1979; Halgren et al., 1978; Penfield, 1955; Penfield and Perot, 1963; Sacks, 1995; Siegel, 1980, 1977; Tadokoro et al., 2006).

Recent studies have suggested that the OBE could be linked to a disruption in multi-sensory integration processes which typically sub-serve the processing of embodiment and a coherent unified perception of the 'self' (Blanke et al., 2002, 2004, 2005; Blanke and Metzinger, 2008). For example, direct cortical stimulation of the epileptic brain can artificially induce distortions in vestibular processing, 'sensed presence' experiences and OBEs – providing the stimulatory amplitude is sufficient (Arzy et al., 2006; Blanke et al., 2002, 2004). These experiences can mimic those reported by the patient as part of their spontaneous pre-seizure aura – but can also be induced in epileptics that have never reported these specific hallucinations before (Blanke et al., 2002; see Tong, 2003). In addition, patient studies have identified the temporal–parietal junction (TPJ), the angular gyrus, and the intraparietal sulcus as neurological regions involved in generating or mediating such experiences (Blanke et al., 2002, 2004; Blanke and Thut, 2007; De Ridder et al., 2007).

In addition, behavioural studies have argued that that the brain processes involved in the mental transformation of one's own body may be the same as those implicated in the computation of the exocentric perspective in the OBE (Blanke et al., 2005; Blanke and Mohr, 2005; Brugger, 2002; Easton et al., 2009; Mohr et al., 2006). Findings from electrophysiological (ERP) and Transcranial Magnetic Stimulation investigations of performance at body transformation tasks, have implicated the selective involvement of the TPJ in the mental transformation of one's own body (see Blanke et al., 2005). Similar impairments at own-body transformation (OBT) tasks have also been shown for participants who scored positively on a measure of schizotypy-related perceptual aberration (but only for males: Mohr et al., 2006).

The emerging view argues that the altered perspective reported in a typical OBE may result from a simultaneous breakdown in parietal networks sub-serving multi-sensory egocentric processing (Blanke et al., 2005; Blanke and Mohr, 2005) and medial temporal-lobe structures involved in exocentric perspective-taking (Lambrey et al., 2008; Ruby and Decety, 2001, 2004; Saxe et al., 2006). Irrespective of the neurological underpinnings, a breakdown in integration between visual and proprioceptive/vestibular feedback may be the trigger for the feeling of spatial separation from the physical self and relocation of the perceiving 'self' into extra-personal space. Such decoupling effects between the senses are not unprecedented and have been induced in the laboratory resulting in body-distortions for either specific limbs or body parts (i.e., the rubber-hand illusion: Botvinick and Cohen, 1998; Ehrsson et al., 2007) or for the whole body (Ehrsson, 2007).

By this account then, OBEs may result, at least in part, from a failure to successfully integrate multi-sensory information due to conflicting information between the senses, which in turn leads to a form of perverse integration of the 'self' and its relationship to its immediate environment (Blanke and Arzy, 2005; Blanke et al., 2002, 2004, 2005; Blanke and Metzinger, 2008; Bunning and Blanke, 2005; Mohr and Blanke, 2005). Although the OBE can occur as a result of an underlying pathology and psychosis, other observations have shown that anomalous experiences can and do occur in the psychologically normal population. For example, Persinger and colleagues have argued that propensity to report paranormal/mystical experiences can be related to increased signs of temporal-lobe disturbance in the normal, non-epileptic brain (Neppe, 1983; Makarec and Persinger, 1987, 1990; Persinger, 2001; Persinger and Makarec, 1986, 1993; Persinger and Koren, 2001). In addition, these researchers have also provided evidence that OBEs and other anomalous experiences can be induced artificially by the application of weak (<10,000 nanoTesla) complex magnetic fields to the temporal-lobes (see Persinger, 2001; for a review). Although this method is controversial (see Braithwaite, 2008b; for a critique) the implication is that individuals who show elevated signs of temporal-lobe instability are more vulnerable and susceptible to being stimulated in this manner (presumably due to a lack of inhibitory regulation in localized neuronal assemblies: see Persinger, 2001; for a review).

While the studies demonstrating the artificial induction of such experiences in epileptic patients provide an important comparative model for the non-epileptic brain, it is not a clear or direct demonstration that similar forms of temporal instability exists within the non-epileptic population. Indeed, in the study of Blanke et al. (2002) the epileptic patient being described did not experience an OBE as part of their general aura or at lower amplitudes of pre-surgical electrical stimulation (see also Tong, 2003). Such experiences only occurred during higher levels of electrical stimulation – which arguably may not have a natural endogenous homologue in the non-epileptic brain.

Furthermore, the studies which have argued for elevated signs of temporal-lobe instability in non-epileptics, have done so more in relation to general paranormal experiences and spiritual belief (which includes experiences of déjà vu, generic aura experiences, hyper-religiosity, etc) and have not typically been directed to specific instances of perceptual OBE. Therefore, while such studies are consistent with the notion that aura-like experiences are associated with signs of paroxysmal discharges and temporal-lobe dysfunction in the normal population; these previous investigations do not investigate this association in relation to OBE reports from the psychologically normal and non-pathological population. It should also be noted that in the study of Blanke et al. (2005), which provided a detailed investigation of performance at OBTs in both a patient and normal controls, none of the control participants were actual OBEers. As a consequence, few, if any studies to date have demonstrated that, naturally occurring spontaneous OBEs reported by the psychologically normal population are related to associated signs and indicators of paroxysmal disturbances in temporal-lobe processing and/or disruptions in body-based representations.

Of the studies which have examined the OBE in the normal population, these have typically been carried out in conjunction with clinically and psychiatric inspired notions of schizotypy or the 'healthy schizotype' (Claridge, 1997; Claridge et al., 1996). For example, McCreery and Claridge (2002) demonstrated that OBEers scored significantly higher than non-OBEer controls but only on the measures associated with aberrant perceptions and beliefs (see also McCreery and Claridge, 1995). All other schizotypal measures did not reveal reliable differences between OBEers and the non-OBEer control groups. Similarly, Murray and Fox (2005) employed a host of questionnaire measures to investigate factors associated with propensity to report OBEs in relation to different aspects of body experience. They found that OBEers produced significantly elevated scores on measures of somatoform dissociation, self-consciousness, and body dissatisfaction – suggesting important differences between the body experiences of OBEers relative to non-OBEers. However, none of these previous studies employed measures designed specifically to measure perceptual anomalies alone or indicate the presence of temporal-lobe dysfunction – a factor more recently implicated as being important.

Mohr et al. (2006) did investigate the incidence of body-based perceptual aberrations, however, these researchers employed measures of perceptual aberration from a schizotypy questionnaire (Chapman et al., 1978), and did not directly delineate between self-claimed OBEers and non-OBEers. As such, there was no direct comparison between OBE and non-OBE groups. While it is perfectly reasonable to assume that OBEers may score higher on measures of body-based perceptual aberration (as suggested by McCreery and Claridge, 2002) it is conceivable that one may score high on such a scale and not necessarily have had an OBE. Not all dimensions of dissociation directly implicate a propensity to have an OBE and may pertain more to other forms of body-distortion experience such as autoscopy and/or sensed presence experiences (Arzy et al., 2006; Blanke et al., 2004; Brugger, 2002; Brugger et al., 1997). While all these phenomenological experiences may be related at some level (as variants from disruptions in the body-image and multi-sensory integration) it remains an open question as to how distinct they are as well. In addition, many previous studies have employed measures of hallucination, delusion and perceptual distortion that derive both their content and language from clinical psychiatry which may not ideally map onto the rate and range of sensory anomalies in the normal population (Bell et al., 2006). These issues can be compounded further by the fact that many of these clinical measures can make it difficult to separate perceptual and cognitive distortions, or underlying sensory anomalies from resultant delusional beliefs. Therefore, although it is a central theme running through current neuroscientific accounts of the OBE, a clear demonstration that self-claimed OBEers (specifically) may well display increased signs of temporal-lobe instability/dysfunction and suffer from distortions in the processing of body-based information remains to be demonstrated. The current study sought to address this omission.

2. Overview of the present study

The present study investigated the cognitive correlates of hallucination proneness with regard to a specific form of anomalous experience reported by a sizable minority of the psychologically healthy general population – namely the OBE. In addition, the present study was directed at investigating spontaneous OBEs that occur in the absence of known situational and artificial agonists (i.e., recreational drugs, anaesthesia, etc).[1] Study 1 sought to provide a questionnaire-based investigation of two important components identified as being involved in the triggering and phenomenological content of, the OBE in the normal population. These were (i) signs of temporal-lobe instability and disturbances in temporal-lobe processing (using a psychometrically verified measure); and (ii) disruptions and distortions in body-based processing. Therefore, we used the presence of anomalous perceptions that are known to occur in direct conjunction with paroxysmal discharge in the temporal-lobe/limbic system as an indicator of the presence of neural instability in non-epileptics. Study 2 provided additional behavioural evidence from the OBT task devised and employed in previous studies investigating the OBE (Blanke et al., 2005; Mohr et al., 2006).

We employed the CAPS (Bell et al., 2006) as a measure of individual propensity to experience anomalous perceptions. To our knowledge, we provide the first empirical investigation of an OBE sample group using the CAPS measure. Coupled to this we also administered a revised Launay–Slade Hallucination Scale (LSHS: Launay and Slade, 1981) as a general measure of hallucination proneness in our sample.

The CAPS measure is highly appropriate for the present study. Firstly, it is a measure of predisposition to anomalous perceptual experience and not one of delusional belief per se – a distinction that can be confounded in some measures of hallucination proneness (Bell et al., 2006). The items on the measure are directed more towards the nature of anomalous perceptual experience, rather than include dimensions directed towards general schizotypy or psychosis and the language employed is somewhat liberated from that of previous clinical and psychiatric measures. In addition, when constructing the measure Bell et al. (2006) removed items that did not occur in clear waking consciousness (i.e., dreaming) from the CAPS measure – thus eliminating nebulous experiences from dreams and related states which can be problematic to assess and interpret (see Bell et al., 2006, for a discussion and justification).

Secondly, the CAPS measures predisposition to anomalous experience across a variety of sensory modalities including measures for temporal-lobe instability and body-distortion processing – factors that have been identified as being important for both hallucination proneness in general, and specifically to the OBE (Bell et al., 2006; Blanke et al., 2002, 2004, 2005; Blanke and Metzinger, 2008; Ehrsson, 2007; Makarec and Persinger, 1987, 1990; Persinger and Makarec, 1986, 1993; Mohr et al., 2006). The temporal-lobe instability subscale of the CAPS contains items that are common in pre-seizure aura-type experiences reported by temporal-lobe epileptic patients (either spontaneously or via direct electrical stimulation; Gloor, 1986; Gloor et al., 1982; Halgren et al., 1978; Penfield, 1955; Penfield and Perot, 1963), and in attenuated form by the normal population (Makarec and Persinger, 1987, 1990; Persinger and Makarec, 1986, 1993; Persinger, 2001). As such, these items and experiences are known to be associated with varying forms of paroxysmal discharge activity underlying temporal-lobe dysfunction and can form part of the pre-surgical evaluation of epileptic patients. Indeed, based on the prior work reviewed in the Section 1, it was predicted here that OBEers would produce particularly elevated scores specifically on measures of temporal-lobe instability and body-distortion while they may well remain indistinguishable on other dimensions not directly implicated in the cognitive processes underlying the OBE.

The use of the CAPS was coupled to the use of a revised LSHS (Launay and Slade, 1981; see also Morrison et al., 2000). The LSHS is a measure of general hallucination proneness rather than just one of propensity to experience sensory anomalies. Employing this scale also makes the present findings (using psychologically normal individuals) comparable to a large previous literature which has employed the LSHS to explore hallucination proneness in both the patient and general population (see Bentall, 1990, 2003) as well as to previous studies of the OBE (McCreery and Claridge, 1995, 2002). Previous research has shown that responses to the CAPS and the LSHS were correlated – suggesting a possible relationship between the existence of anomalous perceptions and predisposition to hallucinations (Bell et al., 2006). As such, a general pattern of agreement between the CAPS and LSHS would be expected with the present sample here.

Study 2 coupled the significant subscales identified from the CAPS measure from Study 1, to performance at a mental OBT task. Tasks of this nature are thought to measure similar perspective-taking mechanisms to that implicated in the out-of-body perspective reported by OBEers (Blanke et al., 2005; Mohr et al., 2006; Easton et al., 2009). In the OBT task observers are presented with a schematic manikin type figure which is either facing the observer or facing away from the observer. Participants are instructed to try to adopt the perspective of the manikin and hence – engage perspective-taking processes and decide on what hand (left/right) is the figure wearing a distinctive glove and bracelet. The typical finding is that individuals have more difficulty with taking the perspective of the manikin when it differs from their own (Blanke et al., 2005; Mohr et al., 2006). We were interested in whether this cost was magnified or reduced for OBEers relative to non-OBEers – which would be consistent with the notion that these individuals may have distinct biases in body transformation processing.

Finally, for the present study it is important to be clear on what counted as an OBE and thus, qualified as inclusion criteria to the OBEer group. The present study employed Blackmore's (1982) definition for OBEs but with some additional a priori constraints. An a priori pre-screen was devised

[1] We fully acknowledge that OBEs have been associated with other situational factors such as drugs, anaesthesia, sleep-paralysis, etc, but these broaden the scope beyond that of the current study where factors associated with the occurrence of spontaneous OBEs are more pertinent and are arguably far more frequent.

to exclude any OBEs that occurred as the result of recreational drug use, alcohol, anaesthesia, or as a direct result of prescription medication. Only one OBEer from Study 2 failed to satisfy this criterion and was removed from the analysis. In addition, although we noted whether the OBEers experienced a representation of the self during the OBE or not – we did not use that information as exclusion criteria. Both visual experiences (i.e., seeing the environment from another vantage point) and bodily experiences of displacement (feeling as if one is no longer in one's body and is now experiencing the environment from outside of oneself) were counted as an OBE in the present study.

3. Methods

All questionnaire measures were administered in person in the laboratory under the supervision of an experimenter.

3.1. *Participants*

Sixty-three participants took part in the study between September 2005 and May 2008. Forty-eight participants (76%) were females and 56 (88%) self-reported that they were right handed. None reported any personal medical history of seizure, epilepsy or were diagnosed with having migraine. All participants were undergraduate or postgraduate students (MSc/PhD) from the School of Psychology at the University of Birmingham, UK. Participants ranged in age from 19 to 35 years, with a mean average age of 21 years (OBE group mean age 21.4, non-OBE group mean age = 20.8). All received course credit or a small financial payment for taking part in the study.

3.2. *Questionnaire measures*

3.2.1. *The revised LSHS*

A revised LSHS was employed (Launay and Slade, 1981). The LSHS consisted of a 12-item questionnaire (see Table 1). The present version incorporated the revised method of scoring the responses which allowed for items to be rated using a 5-point scale to measure agreement with statements pertaining to hallucinatory episodes (0 = certainly does not apply to me; 1 = possibly does not apply to me, 2 = unsure, 3 = possibly applies to me, 4 = certainly applies to me: see Morrison et al., 2000). These scores were summed for each participant and an overall score of hallucination proneness was ascertained.

Table 1 – The revised Launay–Slade Hallucination-scale (LSHS) used in the present study. Participants provided an agreement score on a scale of 0–4 (0 = certainly does not apply to me) (4 = certainly applies to me in response to each item).

Q. no.	Statement
1	No matter how hard I try to concentrate, unrelated thoughts always creep into my mind
2	In my daydreams I can hear the sound of a tune almost as clearly as if I were actually listening to it
3	Sometimes my thoughts seem as real as actual events in my life
4	Sometimes a passing thought will seem so real that it frightens me
5	The sounds I hear in my daydreams are usually clear and distinct
6	The people in my daydreams seem so true to life that sometimes I think they are
7	I often hear a voice speaking my thoughts aloud
8	In the past I have had the experience of hearing a person's voice and then found that no one was there
9	On occasions I have seen a person's face in front of me when no one was in fact there
10	I have heard the voice of the devil
11	In the past I have heard the voice of God speaking to me
12	I have been troubled by hearing voices in my head

3.2.2. CAPS

The CAPS is a 32-item measure of perceptual anomalies which also includes dimensions of levels of distress, distraction and frequency of anomalous experience (Bell et al., 2006). More importantly, the CAPS contains nine subscales which seek to measure; (1) temporal-lobe instability; (2) body-distortion processing; (3) experiences of unexplained source; (4) non-shared sensory experience; (5) distorted sensory experience; (6) changes in sensory intensity; (7) verbal hallucinations; (8) sensory flooding; and (9) hearing thoughts out loud/thought echo. The questions contributing to each individual subscale range from two to six. The CAPS has a high level of reliability and correlates strongly with other measures of hallucination proneness like the revised LSHS (see Bell et al., 2006, 2008).

An illustrative question from the temporal-lobe instability subscale of the CAPS is "*Do you ever sense the presence of another being, despite being unable to see any evidence?*" An example question from the body-distortion subscale is "*Do you ever have the sensation that your body, or part of it, is changing or has changed shape?*" Participants respond initially to each question with a yes/no response (scored 1/0, respectively). Thus the maximum overall CAPS score for any participant was 32. For questions where a 'yes' response was given, there were three additional subscales that needed to be answered which asked how distracting, how distressing and how frequent such experiences were (each one of these additional subscales was scored on a Likert scale of 1–5).

3.2.3. *OBE versus non-OBE grouping*

In conjunction with the pre-screen (described above) participants were assigned to the OBE group on the basis of their answer to the question "*Have you ever had an experience where you have perceived/experienced the world from a vantage point outside of the physical body?*" This was an additional question we added to the end of the CAPS questionnaire. In addition to this question participants were given further qualifying information that (i) such an experience can feel totally real at the time of the experience with all the phenomenological qualities of veridical perception and (ii) that such experiences can be fleeting and transient or more sustained. If a response of "yes" was provided then additional contextual and situational information about the experience(s) was also ascertained such as their physical/emotional state at the time of the experience

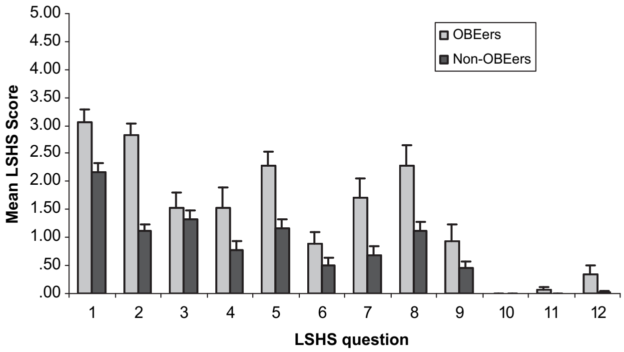

Fig. 1 – Mean LSHS scores for each question from both OBE and non-OBE groups (error bars = 1 SE).

(i.e., relaxed, borderline sleep, dreaming, awake)[2] how often they had experienced an OBE (only once/more than once/ regularly), whether the experience was visual in nature, and whether they saw their physical self during the experience. Associated phenomenology was also documented (i.e., feelings of dizziness, floating sensations, disorientation, dissociation, duality of consciousness, other sensory experiences, etc).

3.3. *Results*

Of the 63 participants who took part in this study, 17 of these (26%) claimed to have experienced at least one OBE at some point in their life. Of the OBEer group, four (24%) claimed to have experienced multiple (more than one) vivid OBE and continued to do so. The vast majority of OBEs were reported as occurring during a relaxed/borderline sleeping state – though two are of note as they occurred during (i) a ski jump accident, and (ii) a charity parachute jump. Of the OBE group, only six (35%) reported seeing their own body or some form of body representation of the physical self during the OBE, with all the others reporting only the shift in perspective (either visually, as a bodily sensation, or both).

The mean average LSHS score for the whole sample was 11.6 (SD = 7.3). The OBE group had an elevated LSHS score (mean = 17.5, SD = 7.0) relative to the non-OBE control group (mean = 9.4, SD = 6.1) – this difference was significant [$t(61) = 4.469$, $p < .001$]. According to the scores gleaned from the LSHS, OBEers were significantly more hallucinatory-prone than non-OBEers. Of the four individuals (24%) that reported having had more than one previous OBE, their average LSHS score was elevated relative to the rest of the OBE group at, 22.3.

Only six (13%) of the non-OBE group scored higher than the mean for the whole OBE group. Fig. 1 shows the mean responses for both groups across all questions from the LSHS. As can be seen, OBEers showed a general trend to produce elevated responses across the questions from the LSHS.

The overall total CAPS score for the combined sample was 9.90 (SD = 5.05). Scores were severely non-normally distributed – as would be expected for a questionnaire which measures a host of psychological dimensions and where most psychologically healthy people score very low. As a consequence of this, these CAPS data were analysed using non-parametric Mann–Whitney tests. Again, the OBEers scored significantly higher (mean = 13.53, SD = 6.52) relative to the non-OBEer scores (mean = 8.57, SD = 3.63) in terms of their overall total scores – this difference was significant (Mann–Whitney $U = 217$, $z = 2.71$, $p < .006$). The difference was less in magnitude than that seen for the LSHS – which might suggest that OBEers were not significantly elevated in terms of their scores for all nine of the subscales (explored and discussed below). In addition, only three (6.5%) people from the non-OBE group scored higher than the mean value for the OBE group. The highest CAPS score from the OBE group was 23 (out of a possible highest score of 32) with scores ranging from 4 to 23 (range = 19). The highest CAPS score reported from the non-OBE group was 18 with scores ranging from 1 to 18 (range = 17).

The difference between the groups was also explored in terms of the dimensions of (i) distress, (ii) distraction and (iii) frequency of the anomalous perceptions via a series of separate between-subjects Mann–Whitney *U*-tests (in line with the procedure of Bell et al., 2006). This revealed that the OBE group scored significantly higher on all three dimensions with distress, ($U = 153.5$, $z = 3.68$, $p < .001$); distraction, ($U = 153$, $z = 3.69$, $p < .001$); and frequency, ($U = 134$, $z = 3.99$, $p < .001$); respectively (see Fig. 2). The largest mean difference between the groups was in terms of the frequency of occurrence of perceptual anomalies – with such anomalies being significantly more frequent within the OBE group.

Although OBEers tended to score higher on all dimensions of the CAPS, importantly, OBEers only displayed statistically significant elevated scores for some of the nine subscales. Scores from the OBEer and non-OBEer groups were directly compared across these nine subscales where the *p*-values were corrected for multiple comparisons via the False Discovery Rate procedure (Benjamini and Hochberg, 1995). For pairwise contrasts, this entails ordering the contrasts by

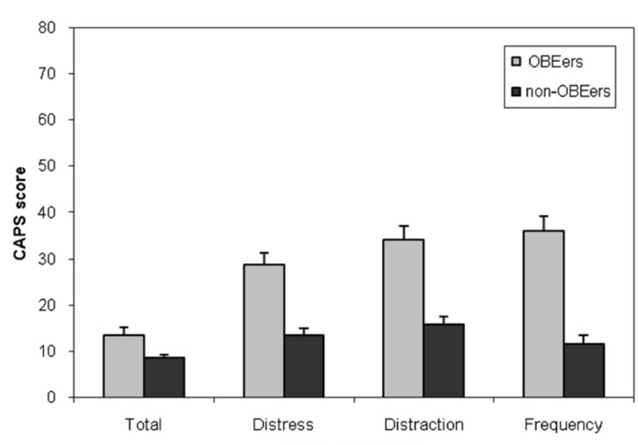

Fig. 2 – CAPS scores for the OBE and non-OBE groups (error bars = 1SE). Note the total scores are based on yes/no responses and the distress, distraction, and frequency scores are based on responses to a 5-point Likert scale.

[2] As noted earlier, an a priori decision not to include experiences reported as part of dreams was made (to be consistent with the criteria of how the CAPS was constructed). This also negated sleep-paralysis experiences for the present sample.

Table 2 – Mean CAPS scores for both the non-OBE and OBE groups across the nine subscales. Note these scores are ranked in terms of the degree of difference between the groups with the subscale revealing the largest difference at the top. An asterisk (*) indicates that the difference is significant after correction for the False Discovery Rate (Benjamini and Hochberg, 1995).

Subscale	Non-OBEer	OBEer	Difference (*d*)	Mann–Whitney
Temporal-lobe instability	1.33	2.88	1.56	$p<.001$*
Body-distortion	.85	2.00	1.15	$p<.001$*
Thought echo/out loud	.24	.76	.52	$p<.002$*
Sensory flooding	.11	.29	.18	$p=.052$
Non-shared sensory experience	1.07	1.65	.58	$p=.074$
Unexplained source	1.70	2.59	.89	$p=.091$
Verbal hallucinations	.33	.59	.26	$p=.227$
Sensory intensity	2.20	2.71	.51	$p=.273$
Distorted sensory experience	1.24	1.47	.23	$p=.500$

descending p-value. The first contrast is tested against $\alpha=.05$, subsequent values are compared against $\alpha=(i/k)\times.05$, where k is the total number of contrasts tested (here, $k=9$) and i is the rank-order of the contrast. For the largest p-value, $i=9$ and for the smallest p-value $i=1$. As soon as $p<\alpha$, this contrast and all subsequent ones are considered significant (Benjamini and Hochberg, 1995). As can be seen in Table 2, the OBEers were statistically distinguishable only in terms of (i) temporal-lobe instability, (ii) body-distortion, and a smaller effect for (iii) thought echo. All other subscales failed to reliably distinguish between the two groups (see Section 3.4 for further clarification).

The average CAPS score for those OBEers reporting having had more than 1 previous OBE was 19 (SD = 4.3) relative to a score of 12.4 (SD = 6.9) for OBEers who only reported 1 experience and 8.6 (SD = 3.6) for the non-OBEers. This is in line with the pattern of results from the LSHS where, in both cases, the mean average for observers reporting more than 1 OBE was marginally elevated relative to the mean of the rest of the OBE group (and both are elevated relative to non-OBEers). Finally, Table 3 provides additional contextual information as well as individual scores of the temporal-lobe and body-distortion subscales of the CAPS for the OBEer group from Study 1.

3.4. *Discussion*

Twenty-six percent of the present sample reported at least one OBE during their lifetime. This is consistent with previous studies which have examined the occurrence of OBEs in university student populations (see Alvarado, 2000; for a review). None of our OBEers reported any medical history of seizure, of being diagnosed with epilepsy, or migraine (with or without aura). Despite this, the present findings clearly show that OBEers reported significantly more perceptual anomalies (as measured by the CAPS) relative to the non-OBEers. In addition to this, the revised LSHS also revealed that OBEers had a tendency to be more hallucinatory-prone compared to non-OBEers. The increased scores for both the CAPS and the revised LSHS suggest a relationship between the propensity to have anomalous sensory experiences and a bias towards hallucination proneness in general – at least for the OBEers sampled here. This is in line with the findings from previous studies examining anomalous perceptions in psychosis, schizophrenia and schizotypy (Bell et al., 2006, 2008; Bentall, 2004; McCreery and Claridge, 2002; Mohr et al., 2006; Easton et al., 2009). Importantly, although there was a small trend for OBEers to score higher on all CAPS subscales, only two of

Table 3 – The experiential context and state of the OBEer, whether they saw an image of themselves during their OBE(s), the number of OBEs they have experienced, and CAPS score for measures of neural instability and body-distortion.

OBEer	Context/state	Vision of self	No. of OBEs	Neural instability	Body/dist
1	Borderline sleep	No	One	1	1
2	Parachute jump	Yes	One	4	2
3	Relaxed/resting	No	One	1	0
4	Relaxed/resting	Yes	More than one	4	3
5	Relaxed/resting	No	One	1	1
6	Relaxed/resting	Yes	One	2	1
7	Relaxed/resting	No	One	4	2
8	Ski jump accident	Yes	One	2	1
9	Borderline sleep	No	One	4	4
10	Borderline sleep	No	One	4	3
11	Relaxed/resting	No	One	4	2
12	Relaxed/resting	No	More than one	3	2
13	Borderline sleep	Yes	One	4	3
14	Relaxed/resting	Yes	One	4	4
15	Relaxed/resting	No	More than one	2	2
16	Borderline sleep	No	One	2	1
17	Relaxed/resting	No	More than one	3	2

Note: the highest possible score per participant for both the temporal-lobe instability subscale and the body-distortion subscale is 4.

these subscales were reliable and noteworthy (discussed more fully below). None of the other subscales produced reliable or meaningful differences between the OBEers and non-OBEers. Such a finding suggests that certain factors may be more directly related to, and be more important for, the OBE relative to other factors. In addition, these findings suggest that the CAPS was well suited not only for examining anomalous sensations in the normal population, but also, crucial factors specifically pertaining to the OBE. These results extend those of previous studies which have typically employed basic measures of schizotypy as a general indicator of propensity to report perceptual aberration (McCreery and Claridge, 1995, 2002; Mohr et al., 2006; Easton et al., 2009).

Based on the prior research reviewed in the Section 1, it was predicted that OBEers should show elevated scores specifically on dimensions of (i) temporal-lobe disturbances/instability, and (ii) body-based distortion experiences. Both these predictions were confirmed. These particular findings are consistent with recent accounts positing that the OBE may occur due to a disturbance of multi-sensory integration in the TPJ, and may underlie an impairment in the brain's ability to constantly integrate multi-sensory information about the self, and one's own body in peripersonal space (Blanke et al., 2002, 2004; Blanke and Metzinger, 2008; Blanke and Thut, 2007; De Ridder et al., 2007; Mohr and Blanke, 2005; Mohr et al., 2006). The present findings are also consistent with accounts which have shown elevated signs of temporal-lobe disturbance in relation to general paranormal/mystical experience – though here we relate it specifically to the OBE in the psychologically normal population (cf. Neppe, 1983; Makarec and Persinger, 1987; Persinger and Makarec, 1993; Persinger and Koren, 2001; see Persinger, 2001).

Further to the pattern seen across the subscales, OBEers also showed significantly elevated measures of distress, distraction, and frequency for the reported experiences relevant to non-OBEers (see also Bell et al., 2008; for similar results within a schizophrenic sample). The OBEers not only reported more perceptual anomalies, but also that they tended to have them more frequently. The finding that OBEers report increased levels of distress may appear to be at odds with the commonly reported view that OBEs themselves are typically reported as being pleasant (Alvarado, 2000; Blackmore, 1982; Irwin, 1985). However, it may not be the case that OBEers are being distressed specifically by the occurrence of their OBE per se. Indeed, the individual items on both the CAPS and the revised LSHS suggest that OBEers may also be predisposed to a number of other associated experiential phenomena as well (perhaps as a consequence of diffuse temporal-lobe dysfunction). That is to say, the measures of distress, distraction and frequency, while elevated for the OBE group in general, might not directly relate to the OBE itself.

In addition to elevated scores on measures of temporal-lobe and body-distortion, the data provided in Table 2 seem to also suggest a significant effect for thought-echo experiences and a borderline (though non-significant) effect of sensory flooding. However, we suggest that these two effects are most likely best explained as artefacts, based on the fact that these dimensions are practically at floor level in both groups. This means that even the slightest change in one group might manifest itself as an apparently significant difference – when in fact there are no meaningful differences here. This can be seen in Table 2 as the lowest scores for any dimension measured in the non-OBEer group were for thought echo (.24) and sensory flooding (.11). In real terms, only four participants from the non-OBEer replied 'yes' to an item on the sensory-flooding subscale, which compares to five people in the OBEer group (a difference of just one person). For thought-echo experiences, the same number of people (11) in both groups replied 'yes' to an item on this subscale. However, the OBEer groups provided an overall score of 13 compared to 11 from the non-OBEers. Moreover, both the sensory-flooding and thought-echo subscales of the CAPS are the only ones to have only two questions representing that subscale, thus potentially reducing reliability for these specific subscales. All other subscales have between three and six items contributing to their relative dimension. As a consequence, we are not convinced that these latter two effects reflect any real psychological differences between the groups and a closer look at the overall levels provided by both groups, and the difference necessary to produce a significant effect, supports this interpretation – at least with the current data set.

The findings from the CAPS also challenge the notion that significantly elevated scores on measures of hallucination proneness merely reflect an uninformative response bias in certain groups. This in turn can lead to some circularity in the underlying reasoning of what such measures show and how such findings can be used to guide theory. By this argument, the fact that hallucinatory-prone groups score higher on measures of hallucination proneness (hence the circularity) is not that informative.

However, such concerns are more pertinent perhaps to measures like the LSHS rather than the multi-dimensional CAPS – which is a further reason for why the CAPS is an attractive tool for studies of this nature. While it was certainly the case that responses on the LSHS were significantly elevated for the OBE group (and on the vast majority of items on that measure) relative to the non-OBE group – only two dimensions (from a total of nine) on the CAPS were reliable. As such, while generic response biases may well be present in hallucinatory groups (and indeed this is a central tenet of some accounts of hallucination: see Bentall, 1990, 2003) – the responses for the CAPS dimensions appeared more selective and not general. Such selective findings cannot merely be explained by a sole generic response bias in the OBE sample. We return to these issues in the Section 7.

5. Study 2: temporal-lobe/body-distortion factors and behavioural performance at mental OBT tasks

The findings from Study 1 are in line with accounts positing both an increased temporal-lobe dysfunction and body-based distortion experiences in OBEer groups. In a follow-up investigation, Study 2 here expanded on these findings by employing a behavioural task which measures participant's ability to carry out mental OBTs (cf. Blanke et al., 2005; Mohr et al., 2006). In contrast to previous studies we now investigate performance on this OBT task as a direct function of (i) whether or not participants had experienced a previous OBE or not, and in relation to (ii) high or low scores on a both the temporal-lobe instability and body-distortion processing subscales of the CAPS measure.

5.1. *Method*

The general method followed that of Study 1 with the following exceptions. Firstly, the CAPS subscale measures for (i) temporal-lobe instability and (ii) body-distortion were employed as these were the only reliable subscales identified in Study 1. Secondly, all participants took part in the OBT manikin task outlined in previous studies (Blanke et al., 2005).

5.1.1. *Participants*

Forty new participants took part in the study (none of these had taken part in Study 1). However, one participant was removed from the study for not satisfying the full inclusion criteria for the OBE group (discussed below). Of the remaining 39 participants, 11 (28%) reported having had an OBE previously. Thirty-two participants (82%) were females and 34 (87%) self-reported that they were right handed. None reported any personal medical history of seizure, epilepsy or were diagnosed with having migraine. All participants were undergraduate or postgraduate students (MSc/PhD) from the School of Psychology at the University of Birmingham, UK. Participants ranged in age from 19 to 28 years, with a mean average age of 21 years (OBE group mean age 19; non-OBE group mean age = 22). All received course credit or a small financial payment for taking part in the study.

5.1.2. *Questionnaire measures*

Each participant completed both the temporal-lobe and body-distortion subscales of the CAPS. (Bell et al., 2006). The order of presentation of these subscales was randomised across participants. The responses from both these subscales were pooled (summed) to provide a combined temporal-lobe/body-distortion score (TL-BDs). This was used to carry out a median-split analysis to generate a new grouping factor (high/low TL–BDs) to complement the OBE versus non-OBE grouping.

5.1.3. *Behavioural task*

5.1.3.1. Stimuli and procedure. All participants took part in a version of the OBT task. The stimuli were taken from a previous study (Blanke et al., 2005; see Fig. 3). In this task, observers are presented with a schematic manikin figure. The manikin could be presented either facing forward towards the participant (with a different perspective to the participant) or facing away from the participant (sharing the same egocentric perspective as the participant). Front-facing and Away-facing figures were drawn in a black font presented on a white background. Both Front and Away-facing figures had the same general outline and differed only in terms of the clothing (which contained added cues to signify whether to figure was facing forward or away) and the presence of a face (Facing) or the back of a head (Away). The figure wore a distinctive gray glove and black bracelet which could occur on either the right or left hand (See Fig. 3).

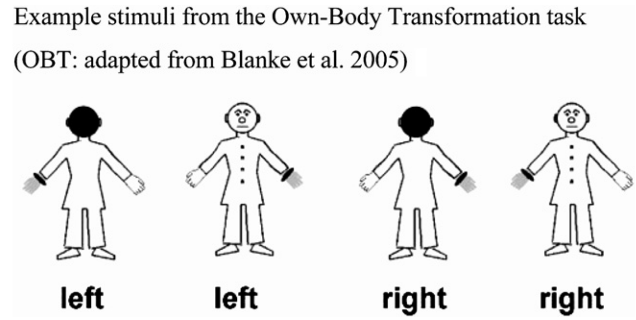

Fig. 3 – An illustration of the OBT stimuli employed in Study 2 (adapted from Blanke et al., 2005). The correct responses are given below each figure.

The experiment was programmed in E-prime© software v1.2 (Psychology Software Tools) and run on a Pentium PC fitted with a 17-inch Samsung SyncMaster monitor. The stimuli were presented centrally and viewed at an unfixed but general distance of 60 cm. Each trial began with the presentation of a black central fixation cross on a white background. The fixation cross was presented for 1000 msec and then followed by the presentation of the schematic manikin which remained on the screen until response or 5000 msec had elapsed. There was an inter-stimulus interval of 1000 msec between trials. There were four exemplars of the manikin (see Fig. 3).

One block of trials was the 'baseline' condition where, following the protocol of Blanke et al. (2005), participants were instructed to respond to what visual-field (LVF – up-arrow/RVF – down-arrow) the distinctive glove was in as they viewed the computer screen (from their own perspective). This condition did not involve an imagined change in own-body position or visuospatial perspective.[3] This was also to ensure that participants had no general problems in making left/right judgements. In the crucial 'experimental' block the instructions changed and now participants were told they had to imagine themselves to be in the figure's body position and to adopt the appropriate perspective of the figure. The task now required participants to respond to whether the glove/bracelet were on the left hand (up-arrow keyboard response) or right hand (down-arrow keyboard response) of the manikin. Both blocks consisted of 96 trials (24 trials per manikin for each block). The order of the blocks was randomised across participants and trial type (Facing/Away) within each block was also fully randomised. The experiment began with a separate block of 36 practice trials which were not analysed. Participants were instructed to respond as fast and as accurately as they could. The experiment lasted about 35 min (including the administration of the questionnaire). The questionnaire was always completed after the OBT task.

[3] Blanke et al. (2005) also note that running this condition as a comparison also helps to identify and dissociate the central mechanisms of the OBT from those associated with the mere perception of the human body (as well as assessing the participants ability to make effective left/right decisions).

5.2. Results

5.2.1. Questionnaire responses

Forty participants took part in the study. One of the OBEers was removed as the experience occurred under anaesthetic during a dental operation and thus did not satisfy our pre-screen restrictions of ‘spontaneous’ OBE. The analysis was based on the remaining 11 OBEers (28%) and 28 non-OBEers. Of the OBE group, 4 (36%) claimed to have experienced more than one vivid OBE and five (45%) reported seeing a representation of their physical self during the OBE. The average TL–BD score for the combined sample was 2.74 (SD = 2.05). For the OBEers the average of the TL–BD scores was 4.36 (SD = 1.91) relative to a score of 2.11 (SD = 1.75) for the non-OBEers. This difference was significant (Mann–Whitney $U = 60.00$, $z = 2.97$, $p < .004$). The highest TL–BD score from both groups was the same – at a score of 6 (from a possible maximum of 8). However, only one non-OBEer provided this score in comparison to four separate OBEers providing the same result. These findings replicate those from Study 1 in that OBEers display significantly elevated signs of both temporal-lobe disturbances and body-distortion experiences relative to non-OBEers (see Table 4).

5.3. Results

5.3.1. Behavioural OBT task

Reaction times (RTs) faster than 200 msec, more than 2.5 standard deviations above the mean, time-outs (trials not responded to within 5000 msec), and incorrect responses were all removed from the analysis. The analysis was carried out on the remaining mean correct RTs.

Any participant generating more than 15% errors in any one cell was considered too error prone and removed from the sample.

Participants took longer to perform the OBT task (974 msec; SD = 276 msec) than the visual-field lateralization baseline task (535 msec; SD = 96 msec). This difference was significant, $F(1, 38) = 94.286$, $p < .001$ with the lateralization task being significantly faster than the OBT task. For the main OBT task the overall RT performance (collapsed across perspectives) for the OBEers was 996 msec (SD = 301 msec) relative to 965 msec (SD = 272 msec) for the non-OBEers. For both groups, trials which contained a ‘Facing’ perspective were slower relative to those containing an ‘Away’ perspective. This difference was much larger for OBEers (236 msec; SD = 166 msec) relative to non-OBEers (73 msec: SD = 119 msec; see Fig. 4). A 2 × 2 (Group: OBEer/non-OBEer) × Perspective (Facing/Away) mixed ANOVA revealed a significant main effect of Perspective $F(1, 37) = 42.341$, $p < .001$. Facing figures were significantly slower than ‘Away’ figures. There was a significant interaction between Perspective and Group, $F(1, 37) = 11.758$, $p < .003$. OBEers were significantly slower, relative to the non-OBEers, at responding to Facing relative to Away trials. The main effect of Group was not significant, $F(1, 37) = .098$, $p = .756$. In addition, the interaction is due primarily to the OBEers displaying an increased RT cost for processing ‘Facing’ figures, relative to non-OBEer controls, and to a lesser extent a slight benefit for processing ‘Away’ figures (see Fig. 4).

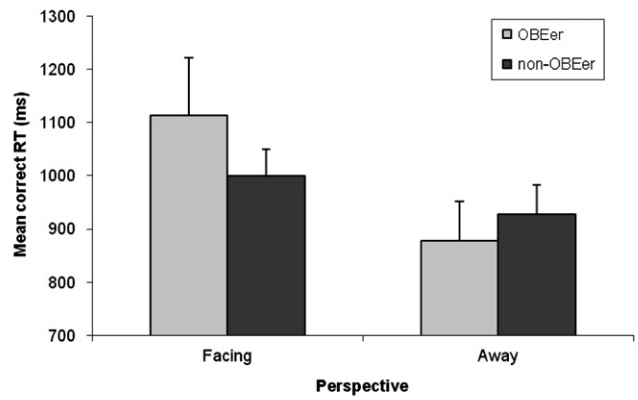

Fig. 4 – Mean correct RTs (in msec) plotted for both ‘Facing’ and ‘Away’ perspective trials across both OBEer and non-OBEer groups (error bars = 1 SE).

We repeated the above analysis but now generated two groups based on a median-spilt procedure to create both a low scoring TL–BD and high scoring TL–BD group as the between-subjects factor. This procedure led to four OBEers to be classed in the low TL–BD group and four non-OBEers to be classed in the high TL–BD group. For the OBT task the overall RT performance (collapsed across perspectives) for the high TL–BD group was 1044 msec (SD = 344 msec) relative to 946 msec (SD = 247 msec) for the low TL–BD group. For both groups, trials which contained a ‘Facing’ perspective were slower relative to those containing an ‘Away’ perspective and this difference was much larger for the high TL–BDs group

Table 4 – The experiential context and state of the OBEer, whether they saw an image of themselves during their OBE(s), the number of OBEs they have experienced, and combined TL–BD scores from Study 2.

OBEer	Context/state	Vision of self	No. of OBEs	Comb TL–BD score
1	Borderline sleep	Yes	More than one	3
2	Borderline sleep	Yes	One	5
3	Borderline sleep	No	One	1
4	Relaxed/resting	No	More than one	6
5	Relaxed/resting	Yes	One	6
6	Borderline sleep	No	More than one	5
7	Relaxed/resting	Yes	One	5
8	Borderline sleep	No	One	4
9	Borderline sleep	Yes	One	1
10	Borderline sleep	No	More than one	6
11	Relaxed/resting	No	One	6

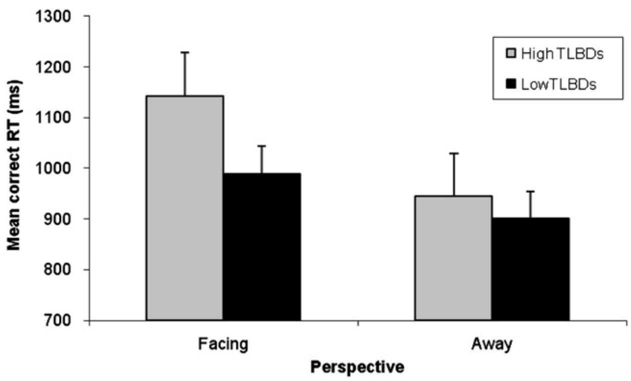

Fig. 5 – Mean correct RTs (in msec) plotted for both 'Facing' and 'Away' perspective trials across both high TL–BDs and low TL–BDs groups (error bars = 1 SE).

(197 msec; SD = 169 msec) relative to low TL–BDs group (88 msec: SD = 135 msec; see Fig. 5).

A 2 × 2 (Group: high TL–BDs/low TL–BDs) × Perspective (Facing/Away) mixed ANOVA revealed a significant main effect of Perspective $F(1, 37) = 30.612$, $p < .001$; and a significant interaction between Perspective and Group, $F(1, 37) = 4.399$, $p < .05$. The main effect of Group was not significant, $F(1, 37) = .981$, $p = .328$. Again, RTs for 'Facing' trials were still significantly slowed relative to 'Away' trials. In addition, this difference was greater for the high TL–BD group with this group showing significantly slowed RTs relative to the low TL–BD group specifically for 'Facing' figures (though the mean difference is smaller in this comparison: see Fig. 5).

5.3.2. *Accuracy OBT task*

For the lateralization baseline task the overall proportion correct was 98% (SD = 1.07%). The overall proportion correct responses for the OBT task were 93% (SD = 3.05%). Responses for the lateralization task were significantly more accurate relative to the OBT task, $F(1, 38) = 91.44$, $p < .001$. This follows the pattern described earlier for RTs and suggests that performance for the lateralization task is both faster and more accurate relative to the OBT task.

Accuracy at the OBT task for OBEers was 93.0% (SD = 3.31%) and for non-OBEers it was, 92.5% (SD = 2.98%). For the OBEer versus non-OBEer grouping, only the main effect of Perspective approached significance, $F(1, 37) = 3.240$, $p = .08$, with a trend for fewer correct responses for Facing trials relative to Away trials. This is in line with the pattern seen for RTs. All other differences (main effects and interactions) between the groups were not reliable [all Fs < 2 all ps > .210]. As such, there was no evidence of a speed-accuracy trade off (see Table 5).

Table 5 – Percent correct for the OBT task as a function of group (SD in parentheses).

Group	Facing	Away
Non-OBEer	92.3 (4.5)	93.3 (3.6)
OBEer	92.1 (4.3)	94.3 (3.5)
Low TL–BDs	92.3 (4.5)	94.0 (3.5)
High TL–BDs	92.0 (4.4)	93.0 (3.5)

This pattern was also observed when participants were split up on the basis of their TL–BD scores.

6. Discussion

The results from Study 2 are as follows. Firstly, OBEers scored significantly higher on CAPS measures of combined temporal-lobe disturbance and body-distortion processing. This is consistent with the findings from Study 1 and suggests that such results are a robust indicator of important differences between these groups. Secondly, OBEers were significantly slower than the non-OBEer controls at carrying out mental OBTs for stimuli that did not share the same perspective as themselves (i.e., Facing stimuli). A similar pattern emerged for RT performance when the sample was divided up in terms of their high/low scores on the combined TL–BD subscales. These findings mesh well with those from previous studies which have investigated case studies of epileptic patients or employed clinically inspired measures of schizotypy in the normal population (cf. Blanke et al., 2002, 2004, 2005; Easton et al., 2009; Mohr et al., 2006). In addition, the current behavioural findings extend those of Study 1 and provide further support that questionnaire measures like the CAPS are capable of indexing, at least in part, underlying differences in certain forms of cognitive processing associated with OBEs. The present findings are consistent with the notion that the OBE itself is a form of hallucinatory aura occurring in a selective sub-group of the population who display increased signs of specific anomalous perceptions that are thought to be associated with paroxysmal-type neural discharge (Blanke et al., 2002, 2004; Blanke and Metzinger, 2008; Blanke and Thut, 2007; De Ridder et al., 2007; Makarec and Persinger, 1987; Mohr and Blanke, 2005; Mohr et al., 2006; Persinger and Makarec, 1993; see Persinger, 2001).

7. General discussion

The present study reports the first empirical investigation of the cognitive correlates of the OBE in the psychologically normal population, as assessed by the CAPS (Bell et al., 2006). An additional standard measure of hallucination proneness (the revised LSHS) was also employed. Study 1 showed that despite the OBEers having no known history of epilepsy, seizure or migraine, they reported significantly more perceptual anomalies (as measured by the CAPS) relative to the non-OBEers. In addition to this, the revised LSHS also revealed that OBEers had a tendency to be more hallucinatory-prone (generally) compared to non-OBEers.

A central prediction of the present study was that OBEers should provide elevated scores for perceptual anomalies related specifically to (i) temporal-lobe disturbances/instability, and (ii) body-based distortion experiences. Findings from both Study 1 and Study 2 confirmed these predictions. This is consistent with accounts positing that the OBE is a consequence of transient impairments in multi-sensory integration that are crucial for the constant processing of embodiment and the 'self' (Blanke et al., 2002, 2004; Blanke and Metzinger, 2008; Blanke and Thut, 2007; De Ridder et al., 2007; Mohr and Blanke, 2005; Mohr et al., 2006).

As noted earlier, the findings from the CAPS measure also challenge the notion that significantly elevated scores on measures of hallucination proneness merely reflect a generic response bias in certain groups. However, such basic notions of a response bias are not convincing arguments against measures like the CAPS that are more multi-dimensional in nature and show selective effects on a minority of subscales. Only two dimensions (from a total of nine) on the CAPS reliably distinguished between OBEers and non-OBEers. This is not consistent with a generic response bias type explanation for the OBE sample as arguably this should impact across all subscales to a level that reliably distinguishes the OBEers from controls. This did not happen. Instead, we suggest the present findings show that certain perceptual anomalies which are known to be associated with paroxysmal-type discharges in temporal-lobe function and biases in body representation appear more prevalent in OBEers.

The findings from Study 2 show that OBEers and participants with high combined scores on the temporal-lobe/body-distortion subscales of the CAPS were significantly impaired, relative to controls, at carrying out mental OBTs. These findings are also consistent with the notion that OBEers display a bias or disturbance in the processes underlying body transformation tasks (see Blanke and Metzinger, 2008; and Persinger 2001, for reviews). Finally, it is also important to note that these findings complement and extend those reported in Study 1 and the presence of significant interactions between perspective and group (both OBE and TL–BD scores) go against the notion that the present findings can be explained as a simple response bias from hallucinatory-prone individuals.

7.1. *Temporal-lobe instability, body-distortion and multi-sensory integration*

The present findings from psychologically normal individuals are consistent with prior studies investigating (i) the experiences and performance of temporal-lobe epileptics; (ii) the relationship between temporal-lobe disturbance and general anomalous experiences; (iii) schizoptypes showing elevated scores of perceptual aberration and impaired performance at carrying out OBTs and (iv) that OBEs reflect disturbances in multi-sensory integration processes that are crucial for supporting the concept of embodiment and the 'self' (Blanke et al., 2002, 2004, 2005; Blanke and Metzinger, 2008; Blanke and Thut, 2007; Easton et al., 2009; Mohr and Blanke, 2005; Mohr et al., 2006; Makarec and Persinger, 1987, 1990; Neppe, 1983; Persinger and Makarec, 1993).

However, while previous studies have shown a link between paroxysmal discharges in the epileptic brain and OBE-type aura experiences, the present study implies that such neural events may also take place (albeit in attenuated form) in the non-epileptic brain. As a consequence, the implication is that these findings from epileptic patients can now be extended to accommodate individuals grouped on the basis of non-clinical predisposition to specific anomalous perceptions (i.e., the OBE). The present study helps to bridge the explanatory gap between the comparative models derived from epileptic patient studies and those from normal populations. It is also interesting to note that on average, around 28% of participants (averaged across both studies) reported having had at least one OBE and many others reported experiencing anomalous perceptions of a different nature. If the existence of specific anomalous perceptions (such as those represented on the temporal-lobe instability subscale of the CAPS), are reliably associated with underlying disruptions in neural processing, then such disruptions appear reasonably prevalent in the psychologically normal population.

Furthermore, it is important to point out that the presence of experiences related to temporal-lobe disturbance and body-distortion may not be functionally unrelated. For example, if neural instability is present in brain regions which support body processing, body-image, and multi-sensory integration, then these mechanisms may suffer transient impairments which may themselves trigger OBEs and/or be responsible for the phenomenological content of them. Although the impairment at OBT reported in Study 2 is in direct line with previous studies (Blanke et al., 2005; Easton et al., 2009; Mohr et al., 2006) – one might expect that OBEers would be better at adopting the perspective of a Facing figure. Intuitively it would seem more likely that individuals prone to exocentric hallucinations of the self would show a bias for exocentric processing per se. Overney et al. (2009) make a similar argument based on a single case study of a tetraplegic patient and cannabis user who, they argued, showed improved body transformation/perspective-taking performance at the OBT task for Facing figures. This is in contrast to previous research and our present results here. However, the patient in this case study only showed beneficial performance on accuracy – there were no beneficial effects at all for Facing figures in the RTs. Indeed, the overall RT data showed a small bias in the same direction as that presented here and in previous studies. As such, it becomes difficult to interpret such findings and integrate them into a wider functional account.

More generally, it remains an open question as to how the body transformations in the OBT task are carried out. Although the popular idea is that performance at this task involves exocentric perspective-taking mechanisms (as opposed to object rotation processes: Blanke et al., 2005), it is conceivable that performance could still reflect impairments in the re-mapping of the Facing figure back into the observers egocentric reference frame. As such, the impairments seen for OBEers could reflect a problem with using one's own egocentric co-ordinates to re-map the Facing figure and make accurate left/right decisions. This would suggest, rather counter-intuitively, that egocentric processes are important in the mediation of the RT costs seen for OBEers. It would also explain why OBEers are hampered at this task as opposed to being benefitted, as the necessary processing may rely on coherent egocentric reference frames in order to support such re-mapping processes and OBEers may suffer from transient instability in egocentric processes. While such suggestions remain tentative, it is important to note that the functional interactions between egocentric and exocentric processing mediating performance at these tasks and those which might be impaired in OBEers are currently underspecified. Irrespective of the actual neurocognitive mechanisms underlying performance at the OBT task, the present results demonstrate that OBEers show selective impairments, relative to controls, at carrying out OBTs.

7.2. Limitations and future research

The current study demonstrates that the CAPS, as a measure of anomalous perceptions in the normal population, is well suited for use with investigating OBE samples in the psychologically normal population. Indeed, the CAPS may be more helpful than previous measures which have been typically cast within the context and language of clinical/psychiatric frameworks (see Bell et al., 2006). To our view, assessing predisposition to anomalous perception in the normal population via a measure liberated from the concepts, language, and views of clinical and psychiatric fields is an important development. However, although the present study provides questionnaire evidence for specific factors being associated with the occurrence of the OBE – questionnaire measures are perhaps not the most direct demonstrations of underlying anomalies in neural function. As such, the intermediate link between specific forms of anomalous experience and underlying signs of temporal-lobe instability would be empirical demonstrations of anomalies in the underlying neurophysiology. The indirect assumption underlying questionnaire approaches is that aura-like perceptual experiences in the non-epileptic brain reflect paroxysmal-like discharges in non-seized neural systems. This is not an unwarranted assumption and is based on direct evidence from epileptic patients. However, if such attenuated discharges do exist in the non-epileptic brain, then the underlying neurophysiology of these paroxysmal discharges are currently obscure.

Modern methods in exploring the time-varying properties of quantitative electroencephalography could offer the potential to reveal either (i) constant though subtle anomalies that are prevalent in the general background EEG of OBEers, or (ii) more transient and fleeting anomalies that, for whatever reason, do not propagate through enough neural landscape, with enough intensity, to present themselves as fully apparent seizure. Nonetheless, these instances may well be sufficient to destabilize or at least temporarily challenge the current mental model of coherent embodiment. Recent developments in modern EEG measuring techniques, coupled to the advancements in statistical analyses may now increase the prominence of these ideas and it may well be appropriate to revisit these issues in the non-pathological brain.

An additional interesting aspect for further investigation would be to investigate differences in processing between OBEers that report seeing visual representations of themselves in the hallucination relative to those that do not. This has been suggested previously as being an important aspect of the experience – though it has received little empirical investigation (see Cheyne and Girard, 2009; Gabbard and Twemlow, 1984; Murray and Fox, 2005; Terhune, 2009, for a similar discussion). Evidence from Study 1 here suggests marginally increased scores on measures of body-distortion (see Table 3) for those that do see representations of themselves relative to those that do not which is nothing if not suggestive (a mean score of 2.33 relative to a score of 1.81, respectively). In addition, it would also seem important to further explore those individuals that report having multiple or even regular OBEs to those who only report having one or a few. One prediction might be that the former group would show increased signs of temporal-lobe disturbance relative to the latter and may represent a sub-group with the best chances of revealing neurophysiological anomalies. Again, tentative suggestions from Study 1 show a small bias in this expected direction (3.0 for those who report multiple OBEs compared to a score of 2.85 for those who reported only one OBE) – though such differences here are very small and caution should be expressed with their interpretation. Low numbers of these sub-divisions within the OBE group leading to low power, and the high variability within the groups, are two factors that prevent a formal assessment of these issues here (even via a single case methodology: see Crawford and Howell, 1998). These issues remain as fascinating avenues for future research.

8. Conclusion

The present study investigated specific factors associated with propensity to report an OBE. We employed a newly devised questionnaire measure which revealed a significantly increased role of (i) temporal-lobe instability and (ii) body-distortion processing in OBEers (relative to non-OBEer controls). In addition, OBEers also showed a selective impairment for carrying out a mental OBT task – when the stimuli did not share the same perspective as the observer. Collectively these results are consistent with the notion that OBEers report perceptual anomalies that are consistent with a specific impairment in temporal-lobe function and the processes underlying OBT which may, in turn, be important factors for predisposition to temporary breakdowns in embodiment and hallucinations of the self.

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