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Deficient mental own-body imagery in a neurological patient with out-of-body experiences due to cannabis use

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ABSTRACT

In the present work, we report repeated out-of-body experiences (OBEs) in a patient with tetraplegia and severe somatosensory loss due to multiple sclerosis and predominant involvement of the cervical spinal cord. OBEs were experienced on a daily basis and induced by cannabis treatment that was started for severe spasticity with painful cramps and cloni. In order to investigate the link between OBEs and mental own-body imagery, the patient was asked to imagine himself in the position and visual perspective that is generally reported during OBEs, using front- and back-facing schematic human stimuli. Performance was measured before and after cannabis consumption. First, our data reveal that the patient was less accurate for back-facing than front-facing stimuli. This was found before and after cannabis consumption and is the opposite pattern to what is generally observed in healthy participants and in our control subjects (who did not use cannabis). We refer to this as lesion effect and argue that this relative facilitation for stimuli reflecting the position and visual perspective that is generally reported during OBEs might be due to recurrent and spontaneous own-body transformations during the patient's frequent OBEs. Secondly, we found a cannabis effect, namely a performance improvement in the back-facing condition while performance in the front-facing condition remained unchanged, after cannabis administration. We argue that cannabis administration may interfere with own-body imagery when reflecting the actual body position and only when associated with brain damage. Based on these data we propose an extended neurological model for own-body illusions including multisensory and sensorimotor mechanisms, cannabis consumption, and cortical and subcortical processing.

1. Introduction

An out-of-body experience (OBE) is defined as the experience in which a person seems to be awake and to see his body and the world from a location outside the physical body. Closely related experiences are autoscopic hallucinations, which are characterized by the experience of seeing one's body in extrapersonal space. Both experiences are classified as autoscopic phenomena (Devinsky et al., 1989; Brugger et al., 1997) as, during an OBE and an autoscopic hallucination, the person sees himself as a part of the extrapersonal world. Yet, during the OBE, the person appears to see himself and

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the world from a location other than his physical body (parasomatic visuo-spatial perspective), whereas the person during the autoscopic hallucination remains within the boundaries of his physical body (physical visuo-spatial perspective) (Green, 1968; Blackmore, 1982; Irwin, 1985; Devinsky et al., 1989; Brugger, 2002). During an OBE, the sense of spatial unity between self and body is thus abnormal, because the self is not experienced as residing within the limits of one's body (Blackmore, 1982; Irwin, 1985; Blanke et al., 2004). Moreover, the self seems to be located in a second body that hovers above the physical body (abnormal self location). It is from this elevated visuo-spatial perspective that the subject has the impression of seeing his body and the world during an OBE (abnormal egocentric visuo-spatial perspective) (Blackmore, 1982; Irwin, 1985).

Understanding how the brain generates the abnormal self during an OBE is particularly interesting because OBEs are not only found in clinical populations (Brugger et al., 1997; Brugger, 2002; Blanke et al., 2004) but also appear in approximately 5% of the healthy population worldwide (Blackmore, 1982; Irwin, 1985). It has been proposed that illusory own-body perceptions result from a failure to integrate sensory information in personal space (due to conflicting tactile, proprioceptive, kinesthetic, and visual information) and a second disintegration between personal and extrapersonal space (due to conflicting visual and vestibular information) (Blanke et al., 2004; Bünning and Blanke, 2005; Mohr and Blanke, 2005). Moreover, it has been suggested that OBEs are mostly vestibular experiences giving rise to the "floating" and "flying" sensations as well as the elevated visuo-spatial perspective. OBEs may also be accompanied by kinesthetic hallucinations or illusory perceptions of limbs (Blanke et al., 2002; Wade, 2009, this issue). Based on these neurological data, it has been suggested that a double disintegration of body-related information and vestibular information is the main causal factor in OBEs (Blanke et al., 2004; Blanke and Mohr, 2005). Lesion location in patients with OBEs highlighted the role of the right temporo-parietal junction (Blanke and Mohr, 2005), in proximity to the vestibular cortex (Guldin and Grusser, 1998).

Several authors have linked OBEs to deficient multisensory own-body processing (Blanke et al., 2004) and visuo-spatial perspective taking (Brugger, 2002). More specifically, some authors proposed that spontaneous OBEs rely on functional mechanisms similar to those used voluntarily during mental imagery with respect to one's visuo-spatial perspective and body (Brugger, 2002; Blanke et al., 2005). Here we present a patient with multiple sclerosis who experienced repeated OBEs (under the influence of cannabis) with a prominent lesion in the cervical spinal cord leading to tetraplegia and severe somatosensory loss. As previous studies had revealed an important implication of the temporo-parietal junction in OBEs (Blanke et al., 2004, 2005) this allowed us to investigate the importance of sensorimotor mechanisms, spinal cord damage, and cannabis in OBEs. Thus, the presence of OBEs has been found to correlate with the vividness of imagined scenes (Alvarado and Zingrone, 1994). Other authors found that subjects with OBEs are better at visualizing scenes and objects than control subjects (Blackmore, 1987; Terhune, 2009, this issue), although other studies could not confirm these findings (Irwin, 1985; Blackmore, 1982). Moreover, previous authors have suggested that the abnormal illusory visuo-spatial perspective and self location during OBEs may facilitate mental imagery to different extracorporeal positions and perspectives in subjects with OBEs, especially for front-facing figures (Cook and Irwin, 1983; Brugger, 2002).

In order to investigate the link between OBEs and own-body mental imagery, we tested this patient in an own-body transformation task before and after cannabis consumption. The patient had to imagine himself in the position of a front-facing (Front condition) and a back-facing (Back condition) schematic human figure. Since the transformation of his own body into the body position of the Front figures (as compared with the Back figures) mentally simulates the body position and the visuo-spatial perspective that is experienced during OBEs (Blackmore, 1982; Irwin, 1985; Brugger, 2002), we hypothesised that the patient would show facilitation in the Front condition compared to the Back one, due to his lesion and/or cannabis use which induced multiple OBEs. We therefore expected to find a different pattern of results than what is generally found in healthy participants, i.e., better performance for the Back condition compared to the Front one. Further, we also hypothesised that, due to cannabis, the Front condition would generate even more facilitation since cannabis consumption induced OBEs in the patient and as it is the Front condition that reflects the imagined position and perspective that is experienced in OBEs. The symptoms, neurological deficits, and performance in this mental transformation task of the patient were analysed.

2. Methods and case study

The patient was 59-years old at the time of testing. He is an ambidextrous interiors architect with a slight advantage for the right hand (Oldfield, 1971). He has a 26-year history of multiple sclerosis and had entered the chronic progressive phase 13 years before experiencing the OBEs reported here. For the last 13 years he has suffered from a spastic tetrapyramidal syndrome predominating at the lower limbs. Due to spastic plegia of his lower limbs he has been, for the last 9 years, confined to a wheelchair. For the last year, due to severe spastic upper limb paresis, he has not been able to eat independently anymore. No distal upper limb movements were possible. Shoulder movements were possible, but arm flexion and arm extension at the elbow were severely impaired. Hypoesthesia and loss of position sense was severe at the lower limbs and moderate at upper limbs. He had a central scotoma of the left eye (for the last 26 years) and a mild deficit in horizontal smooth-pursuit eye movements and nystagmus (since last year). Otherwise, cranial nerve function was normal. In 2004 his Kurtzke score (expanded disability status score) was at 8.5 without major mental impairments (pyramidal signs, 5; cerebellar signs: not testable; brainstem, 1; sensory functions, 5; sphincter function, 3; vision, 1; mental functions, 0; other, 0). The expanded disability status scale goes from 0 (no neurological deficit) to 10 (death of patient due to multiple sclerosis). Somatosensory evoked potentials (that were carried out 16 years before the present investigation) revealed altered potential morphology after right and left median nerve stimulation as well as right tibial nerve stimulation, but normal latencies.

Stimulation of the left tibial nerve showed delayed and diminished responses. Auditory evoked potentials were normal. Visual evoked potentials were normal for the right, but pathological for the left eye. Several magnetic resonance imaging (MRI) examinations (15, 11, 5 years prior testing) revealed multiple small (<1 cm) periventricular white matter lesions and a lesion of the splenium of the corpus callosum. No lesion was described in proximity to the temporo-parietal regions. A cervical MRI revealed a lesion at the level of C5/C6. These lesions were hyperintense in T2, hypointense in T1, and showed no enhancement after gadolinium injection compatible with multiple sclerosis. Due to severe claustrophobia of the patient no high-resolution MRIs have been carried out and all imaging was done on a low-resolution MR scanner (0.4 T). At the time of testing, we proposed to the patient to repeat an MRI, but due to severe claustrophobia and his severe medical condition (wheelchair) he was not willing to undergo further neuroimaging examinations. His treatment during testing consisted of clonazepam .25 mg/d, tizanidine 24 mg/d, baclofen 70 mg/d, tetra-hydrocannabinol 5 times/day and clomipramine 75 mg/d. Tetra-hydrocannabinol (THC) was started in 2003 due to increasing painful spasticity persisting with tizanidum and baclofen (either tea infusions or inhalation).

The patient was addressed to us by a colleague for recurrent OBEs. The interview was done in accordance with Blanke et al. (2004). The information about the nature of the patient's OBEs was collected by means of a detailed semi-structured interview, which recorded detailed phenomenological information about the OBE (visual, vestibular, auditory, tactile, proprioceptive and motor characteristics). We also inquired about the visuo-spatial perspective from which the experience was seen (embodied or disembodied visuo-spatial perspective) and the visual characteristics of his own seen body (completeness: whether all body parts were seen; body position: standing, sitting, supine; eventual actions; Green, 1968). We asked explicitly for simple and complex visual, auditory and tactile hallucinations, the presence of visual field loss, and visual and nonvisual body-part illusions (Hecaen and Ajuriaguerra, 1952). With respect to vestibular manifestations, we inquired about the sensation of rotation, vertigo, falling, elevation, flying, floating, lightness and heaviness (Smith, 1960). For all manifestations, we asked whether they appeared before, during, or after OBE or at different instances.

The first OBE of the patient occurred in 2003 when tetra-hydrocannabinol (tea infusion) was started. Since then, many OBEs have occurred on a daily basis when consuming tetra-hydrocannabinol (either tea infusion or smoking). OBEs never occurred before this treatment or without tetra-hydrocannabinol. The patient noted that OBEs occurred more frequently and regularly during tetra-hydrocannabinol inhalation. During these OBEs he has the impression of being outside his body and above several people whom he sees from above. He sees his body as static, always in supine position (even though he was actually sitting up in his wheelchair at the time) and as facing him. The entire scene is in color. He experiences his "spirit" to be above his body in an elevated visual perspective, at varying positions and distances. He has the impression of having no body at this elevated position ("I don't feel my body"), but only eyes. He described that OBEs occurred independent of his actual body position. The elevation may also be very high, i.e., kilometres away and he then experiences seeing the whole world. The visual scene is mostly static, but can also vary. He often has the feeling of being at a great distance from the scene and of being outside his present room elevated above streets or fields. He experiences at least one OBE per day and describes them as peaceful positive experiences. Associated sensations are vertigo, colored flashes, and nausea without vomiting.

A brief neuropsychological examination revealed a well-oriented patient without major signs of aphasia and dysarthria. There were no major signs of frontal lobe dysfunction or attentional deficits. Memory was not tested. Few more detailed tests were carried out with respect to visual perception and cognition: He showed no signs of visual agnosia ("Screening Test" and "Incomplete Letters" of the Visual Object and Space Perception Battery; visual recognition of superimposed figures and illusory drawings). There were no signs of autotopagnosia (indication of body parts on his own body and on the examiner's body on verbal command). He made two errors in the first part of the Benton facial recognition test (4/6) which he did not wish to complete and for which therefore we do not have a specific score. In the Culver test (showing right or left hands and feet in different orientations) his performance was in the lower normal range.

Five control subjects took part in the experiment. They were all males, aged between 59 and 62 years (mean $= 60.2 \pm 1.1$). They were all healthy, without any neurological deficit, and recruited from our lab's pool of subjects.

3. Task and procedure

Stimuli in the OBT task (own-body transformation task) consisted of a schematic black and white human figure either facing toward or away from the patient (Fig. 1). Front and Back figures had the same outline and were therefore scaled to the same proportions (dimensions: $5.0^\circ \times 6.1^\circ$). They differed only in the clothing details and the presence of a face (Front) or the back of a head (Back). One of its hands was marked as if it were wearing a grey glove and a black bracelet around the wrist, either on the right or left hand. Thus, there were a total of 4 figures: 2 (Front or Back) $\times$ 2 (right or left hand marked).

In this OBT task, the patient and the control subjects were asked to imagine themselves in the position and orientation of the human schematic figure displayed on the screen and to indicate which hand was marked. Stimuli were presented for 200 msec in the centre of a computer screen. The next stimulus was only displayed after a response was given. The subjects had to answer as quickly and as accurately as possible whether the marked hand was the left or the right one. Because of quadriplegia, the patient gave his answer verbally and the experimenter pressed the corresponding keys, and so did the control subjects. We presented the subjects with three blocks of 20 randomised trials (10 repetitions of the Front picture and 10 repetitions of the Back picture; total of 60 trials).

The patient was administered the OBT task before (Test 1) and after (Test 2) inhalation of cannabis that led to the induction of a habitual OBE. Several such OBEs occurred

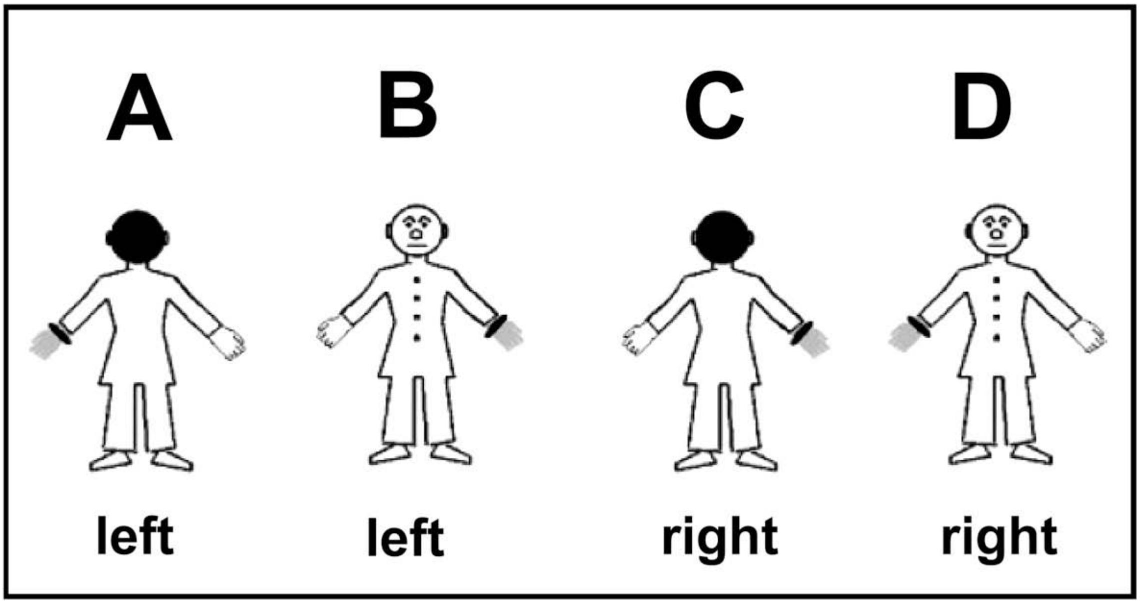

Fig. 1 – Stimuli for the OBT task. Two versions of the front view and two versions of the back view are shown. Correct responses are indicated below each stimulus.

during a period of ∼10 min (the patient reported of having "left and re-entered his body" several times during that period). The OBEs were characterized by an elevated visuo-spatial perspective, feeling of lightness, weightlessness and seeing himself in extrapersonal space. The self was described as a "spirit" and localized in the air at a distance of ∼3 m from his actual body in the chair. He described his body as inert and his spirit as being in a "volume". During all OBEs he experienced seeing his body from above, immobile and somewhat paler than other human bodies around him (there was actually only one of the experimenters sitting in the room). He could not detail or identify these humans, but mentioned that he saw himself on a stretcher. The patient did not see the experimenters during these OBEs. He estimated the period of OBEs to be of a total duration of ∼3–4 min with the last OBE being longest. The OBT task was repeated ∼30 min after the first session (∼5 min after the end of the cannabis-induced OBE period). Therefore, the control subjects also performed the task twice with a 30-min break in between. However, they did not use cannabis.

Reaction times (RTs) and error rates (percent) for the correct trials in control subjects were analysed using a 2×2 repeated measures ANOVA with Side (Back and Front) and Test (Test 1 and Test 2) as within-subject factors. Moreover, performance was evaluated using a *t*-distribution since our sample was small. Upper 99% prediction intervals were derived. Values outside the 99% prediction intervals were judged as pathological.

4. Results

RTs and error rates of the patient and the control subjects are shown in Fig. 2 and are plotted separately for Test 1 and Test 2. In both tests, the patient's RTs were well outside the 99% prediction interval of the control subjects for both Front and Back figures (see Table 1), revealing pathological RTs in all conditions. Regarding error rates, however, the patient only showed pathological error rates for the Back condition in both tests. In the Front condition error rates fell within the 99% prediction interval of the control subjects (see Table 1). This suggests that the Front condition was easier for the patient if compared to the Back condition (Front–Back difference of 40%).

A 2×2 repeated measures ANOVA carried out on the control subjects' RTs with Test (Test 1 *vs* Test 2) and Side (Front *vs* Back) as within-subject factors revealed a main effect of Side ($F(1,4) = 17.5$, $p < .05$) with higher RTs for the Front than the Back condition. However, there was no effect of Test ($F(1,4) = 3.87$, $p = .12$), indicating that there were no significant differences in RTs between Test 1 and Test 2 which in turn suggests that there were no practice effects. Further, no significant Test × Side interaction was observed ($F(1,4) = .06$, $p = .82$). The same ANOVA carried out on the control subjects' error rates showed similar results: a main effect of Side ($F(1,4) = 12.5$, $p < .05$), with higher error rates for the Front than the Back condition, but no effect of Test ($F(1,4) = .09$, $p = .77$) and no significant Test × Side interaction ($F(1,4) = .24$, $p = .64$). Thus, all control subjects had smaller RTs and error rates in the Back condition than the Front condition. As far as error rates are concerned, the patient thus showed the opposite pattern of responses as the present control subjects as well as compared to previously reported results in healthy subjects (Zacks et al., 1999; Blanke et al., 2005; Mohr et al., 2006).

The patient's error rates slightly increased in the Front condition (between Test 1 and Test 2 from 9% to 13%, respectively) but strongly decreased in the Back condition (from 49% to 26%, respectively). This led to a diminished Front–Back difference

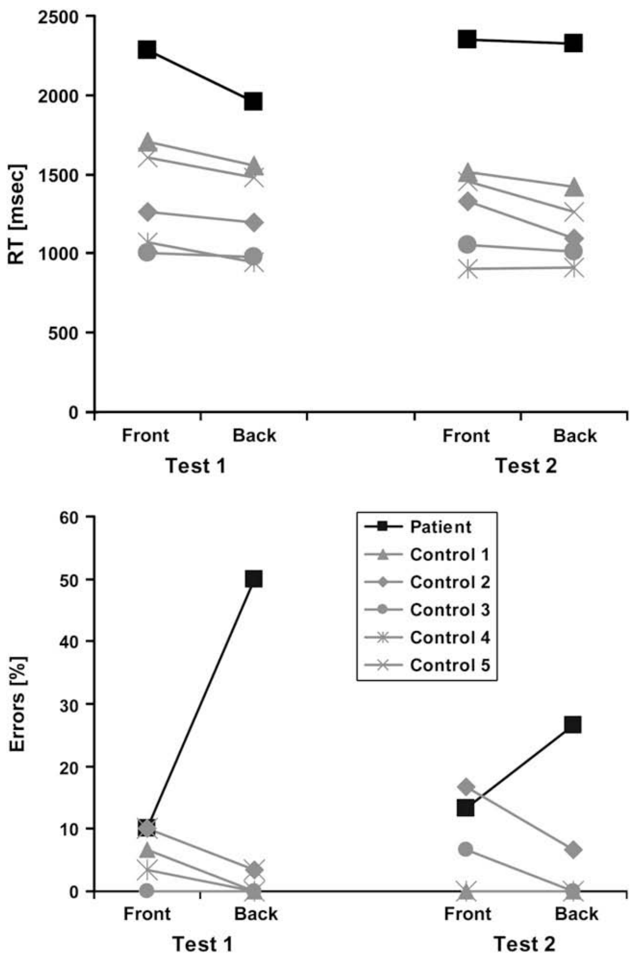

Fig. 2 – The RTs and error rates for the patient (black lines) and the five control subjects (grey lines) are shown for both the front and the back conditions and both Test 1 and Test 2 situations.

of 13%. A 2 × 2 Chi-square analysis on error rates with the variables Front–Back and Test 1–Test 2 turned out significant ($\chi^2_{(1)} = 4.22$; $p < .05$). During briefing after Test 2 trials the patient reported spontaneously that he had felt as if he were actually displaced at the position of the schematic human figures, whereas this was not the case before inhaling cannabis or in Test 1 (“It felt much more real than in the session before”). He did not notice any difference in projection with respect to the Front or Back conditions, but stated that the Back condition was more difficult. We note that this is quite contrary to what control subjects usually report after this task. Indeed, they generally find the Back condition easier because no rotation is required.

5. Discussion

The present patient suffered from multiple sclerosis with severe tetraplegia and severe somatosensory loss of trunk and limbs due to a cervical spinal cord lesion leading to OBEs. Importantly, his OBEs were induced medically and reported to occur in a daily fashion through the administration of cannabis, an adjunct treatment for multiple sclerosis. The patient had a large lesion in the cervical spinal cord leading to tetraplegia with an almost complete absence of voluntary movement (except some proximal movements of the upper limbs) and a severe loss of somatosensory function. This was confirmed by abnormal somatosensory evoked potentials already 16 years prior to the present investigations. Distorted signals related to both types of information (motor and somatosensory) are key constituents of OBEs and related experiences (Brugger, 2006; Blanke et al., 2004). Indeed, it has been suggested that a double disintegration of body-related information and vestibular information is the main causing factor for OBEs (Blanke et al., 2004; Blanke and Mohr, 2005). The present case is concordant with this proposition suggesting that pathological or largely absent somatosensory signals and abnormal motor signals from the entire body may facilitate the occurrence of OBEs through conflicting information of bodily information in personal space (tactile, proprioceptive, kinesthetic, and visual information).

Other clinical observations are in agreement with this proposition. It has been observed that OBEs frequently occur during dreams (Muldoon and Carrington, 1951; Green, 1968) that generally occur in a state of general bodily paralysis. Accordingly, it has been hypothesised that generalized paralysis during REM-sleep dreams might be a precipitating factor of such OBEs (Bünning and Blanke, 2005). The data of Girard et al. (2007) also show that OBEs and autoscopic hallucinations are related to sleep paralysis and recent studies found that subjects with near death experiences that include OBEs more commonly have sleep paralysis (Nelson et al., 2006, 2007; see also Blanke and Dieguez, in press). More studies are needed to investigate the association between OBEs, dreaming, REM phase, and sleep paralysis in greater detail. It has also been speculated that bodily mechanisms related to abnormal motor and somatosensory signals may lead to OBEs during general anesthesia (Bünning and Blanke, 2005). In general anesthesia, somatosensory and motor signals from large parts of the body are disturbed through the application of muscle relaxants while the patient may be in a state of partial awareness due to insufficient levels of anesthetic. The resulting state (partial awareness combined with abnormal somatosensory and motor signals) has been proposed as a main pathomechanism for awareness during general anesthesia (Blacher, 1975; Moermann et al., 1993; Sandin et al., 2000; Spitellie et al., 2002) and might also account for OBEs in these circumstances (Bünning and Blanke, 2005). Thus, disturbed somatosensory and sensorimotor signals from large parts of the body in (1) tetraplegia with severe somatosensory loss (as in our patient), (2) during general anesthesia (Moermann et al., 1993), and (3) during sleep paralysis (Nelson et al., 2006; Girard et al., 2007; Cheyne and Girard, 2009, this issue) seem to disturb integration of multisensory body-related information in personal space due to interference with brainstem, spinal cord and peripheral nervous system signalling information from the somatosensory and motor systems. As REM intrusions or sleep paralysis have been linked to damage or interference with brainstem mechanisms, the present observation suggests the implication of mechanisms in the cervical spinal cord. OBEs during general anesthesia and in

Table 1 – 99% prediction intervals for RTs (msec) and error rates (%), both tests (Test 1 and Test 2) and Front–Back conditions

	RTs (msec)				Error rates (%)			
	Test 1		Test 2		Test 1		Test 2	
	Front	Back	Front	Back	Front	Back	Front	Back
−99%	683.56	651.98	708.54	723.60	−2.95	−2.42	−10.36	−4.80
+99%	1974.72	1808.81	1794.70	1556.25	14.94	5.08	19.69	7.46
Patient	**2278.61**	**1958.36**	**2346.24**	**2323.71**	9.99	**49.99**	13.33	**26.66**

The patient's values are indicated in the bottom line. Values falling outside the prediction intervals are indicated in bold.

patients suffering from Guillan–Barré syndrome (Cochen et al., 2005) also point toward the implication of the peripheral nervous system. Given the importance of tactile cues in calculating the body's position and orientation in space (Lackner and DiZio, 2001) these latter changes may not only lead to disintegration in personal space, but also to an additional failure to integrate information from personal and extrapersonal space. Missing or abnormal tactile cues from the foot soles, for example, may play a critical role for inducing tactile-vestibular bodily information that conflict with visual bodily information. OBEs and double disintegration [in personal space and between personal and extrapersonal space (i.e. orientation and position of the body in space)] may accordingly follow damage to cortical structures, especially at the right temporo-parietal junction (Blanke et al., 2002, 2004; Blanke and Mohr, 2005) as well as subcortical structures (including brainstem and spinal cord) and the peripheral nervous system. This implication of non-cortical brain structures and the peripheral nervous system in illusory own-body perceptions and OBEs was already suggested by the observation of OBEs and related illusions following damage to subcortical vestibular pathways (Bonnier, 1893; Skworzoff, 1931; Tiliket et al., 1996; Lackner, 1992).

Yet, OBEs in our patient were only observed subsequent to cannabis consumption suggesting its important contribution. Drug use has been reported as being related to a higher prevalence of autoscopic phenomena such as OBEs (Tart, 1971; Blackmore, 1982; Aizenberg and Modai, 1985; Grusser and Landis, 1991; Shermer, 1998) suggesting that frequent use of cannabis increases the probability of experiencing an OBE. Moreover, Block et al. (1992) have shown that the use of cannabis may result in an alteration of sensory, motor and cognitive functions. More generally, Vollenweider and Geyer (2001) reported that the application of psychotomimetic drugs can lead to a range of experiences including body and self disturbances, illusions and hallucinations, thought disorders, paranoid ideations, and changes in mood and affect (Vollenweider and Geyer, 2001). Yet, in none of these studies in healthy subjects cannabis consumption immediately and recurrently induced OBEs as reported in the present patient with cervical spinal cord damage. Our observation of cannabis-induced OBEs, but not other illusions and hallucinations, suggests that, at least in the present patient, multisensory and/or sensorimotor bodily disintegration due to cervical spinal cord damage might have been facilitated by cannabis intake in a patient with tetraplegia and severe somatosensory loss. Thus, cannabis consumption does not seem to be sufficient for the induction of repeated OBEs, yet this might be the case if additional brain damage exists. At present we do not know whether differences in the induction of OBEs due to cannabis consumption exist depending on whether brain damage occurs at cortical structures, peduncular, cerebellar, or spinal mechanisms as cannabis consumptions have been shown to interfere with brain processing at these various regions (Mathew et al., 1997; Volkow et al., 1996; O'Leary et al., 2000; for review see Bünning and Blanke, 2005). Especially, we cannot exclude that additional white matter lesions in temporo-parietal areas might have been present. Also, the splenial lesion might play a pathophysiological role in this patient's OBEs and functional deficits. Finally, another potential mechanism might be related to psychoreactive mechanisms (i.e. increased medical care due to his OBE report) in a patient who is severely physically disabled. Although we cannot exclude such a mechanism, it seems quite unlikely since the patient has been followed by a colleague of us for over a decade and had never spoken of OBEs before his cannabis consumption. Moreover, his description was comparable to those of other patients with OBEs that we have seen. We conclude that OBEs in the present patient were due to altered multisensory and/or sensorimotor bodily integration due to cervical spinal cord damage that was further enhanced by cannabis consumption. This is also compatible with our findings on mental own-body imagery.

With respect to mental own-body imagery, the patient responded generally slower than healthy control subjects. Yet, his error rates revealed a selective deficit. He performed normally when asked to imagine himself in the position that is spontaneously reported in OBEs (Front condition), but when asked to imagine his body at a disembodied and merely translated position and perspective (Back condition) he made more errors than control subjects (Zacks et al., 1999; Blanke et al., 2005; Mohr et al., 2006). This pattern was found before (Test 1) and after (Test 2) cannabis administration. Therefore, his error rates depended differently on the position of the shown human figure than those of control subjects, independent of cannabis: he made fewer errors for Front than Back figures, whereas the opposite pattern was observed in all control subjects and many previous studies using this paradigm (Zacks et al., 1999; Blanke et al., 2005; Arzy et al., 2006; Mohr et al., 2006). Extending speculations by previous investigators on OBEs (Blackmore, 1987; Cook and Irwin, 1983; Brugger, 2002) we argue that this might be due to a relative facilitation of mental imagery for Front with respect to Back figures as these correspond to the perceptualized position and perspective that is spontaneously reported by most people with

OBEs. Lower error rates for Front figures was not observed in any of the present control subjects (without OBEs) or in any of the previous studies using this paradigm. As predicted, this pattern of results (better performance in the Front condition than the Back condition) seems to be linked to the patient's lesion in the cervical spinal cord since this lesion effect was independent of cannabis consumption. We accordingly propose that this relative facilitation for stimuli reflecting the position and visual perspective that is generally reported during OBEs (Front condition) might be due to spontaneous own-body transformations during OBEs. Blanke et al. (2005) have described a neurological patient with epileptic OBEs due to a temporo-parietal lesion that showed a normal pattern with respect to Front and Back conditions, as found in healthy participants. Yet, this latter patient had a cortical lesion and only experienced very few epileptic OBEs. It therefore seems that relative facilitation for stimuli reflecting the position and visual perspective during OBEs (Front condition), as found in the present patient, is only found in neurological patients with frequent OBEs. Alternatively, there might be differential influences whether the damage is at the cortical or subcortical level or with respect to the neurological aetiology. Further clinical research is needed to answer these points.

Another result obtained is that under the influence of cannabis, the patient's performance improved, but only in the Back condition. One might argue that practice effects led to this difference. However, in the case of practice, we would expect all conditions to improve, whereas in the present results, performance only improved in the Back condition. Moreover, our control group did not show practice effects for RTs and error rates. The patient's data therefore suggest that cannabis improved mental own-body imagery in the Back condition (cannabis effect). We speculate that this cannabis effect was due to a deficit for imagining the actual body position (corresponding to the Back condition). This cannabis effect is in line with recent data by Easton et al. (submitted for publication) who studied performance in two mental own-body imagery tasks (with front-facing and back-facing human stimuli) in a group of healthy university students comparing performance in subjects with and without OBEs. This study showed that switch costs between two mental own-body imagery tasks in subjects with OBEs were higher when the target stimulus matched the participants' actual body position. Further studies, especially in healthy subjects, are needed to test this issue in more detail. One could also speculate that subjects with autoscopic hallucinations would not show this compensatory effect for Front bodies because they experience seeing a double of themselves in extrapersonal space but, contrary to subjects with OBEs, without having a disembodied perspective. Arzy et al. (2006) argued that the own-body transformations as used in the present study are related to OBEs since it requires subjects to imagine themselves at an extracorporeal position (or disembodied self location) whereas a control own-body transformation task (using the same stimuli as the OBT task but subjects had to imagine that the schematic figure represented their reflection in a mirror) requires subjects to imagine themselves at their usual embodied position. Therefore, we hypothesise that subjects with OBEs could show better performance for mental own-body transformations employing disembodied self location whereas subjects with autoscopic hallucinations would rather show better performance for mental own-body transformations employing embodied self location.

6. Conclusion

We have presented a patient with tetraplegia and severe somatosensory loss due to multiple sclerosis and predominant involvement of the cervical spinal cord who experiences frequent OBEs, induced by cannabis. Whereas neither the presence of a cervical spinal cord lesion nor cannabis consumption alone seem to be sufficient to lead to OBEs, their combination seems to facilitate the occurrence of frequent, daily, OBEs. Our behavioural analysis revealed two further effects: a lesion effect and a cannabis effect. We show that the patient was less accurate for back-facing than front-facing stimuli. This was found independent of cannabis consumption and is the opposite pattern to what is generally observed in healthy participants and in our control subjects (who did not use cannabis). We argue that this relative facilitation for stimuli – reflecting the position and visual perspective that is generally reported during OBEs – is due to recurrent and spontaneous own-body transformations during frequent OBEs. We also show that cannabis consumption may lead to selective performance improvements thus interfering with own-body imagery, but probably only in the context of brain damage. Based on these data we propose a neurological model for illusory own-body illusions including multisensory and sensorimotor mechanisms, cannabis consumption, and cortical as well as subcortical processing.

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