Theme Issue: Experimental NeuroTheology

Experimental Elicitation of an Out of Body Experience and Concomitant Cross-Hemispheric Electroencephalographic Coherence

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Abstract

Brief exposure to a counterclockwise global externally applied magnetic field generated from an array of 64 solenoids designed to affect the cerebral fields associated with the left and right hemispheric correlates of consciousness evoked a powerful out of body experience (OOBE) in a single naive subject. The energy available from the applied field within the cortical volume was within the same order of magnitude as that associated with the sum of action potentials in all cortical neurons. During the OOBE there was a marked generalized increase in coherence in quantitative electroencephalographic activity between the left temporal lobe and right prefrontal region with specific abnormally high increases within the 4 to 7 Hz and 15 to 21 Hz band. These results are congruent with the experience of "consciousness" detached from the body and moving through space. The diagonal congruence is more consistent with the existence of two quantized fields or a global field with opposing polarities whose vector determines various emergent states experienced as OOBEs or sensed presences during brief periods of perturbation.

Key Words: out of body experiences, weak magnetic fields, interhemispheric coherence, theta activity, Schumann resonances

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Introduction

Changes in states of consciousness (Jibu and Yasue, 1995) have been considered analogous and perhaps even macroscopic representations of changes in quantum states (Bohm, 1951; Bohr, 1958; Persinger and Koren, 2007). A state can be considered a quantized field composed of zero point energy from which specific properties emerge. Different space-time organizations of this field in localized space would exhibit slightly different properties (Persinger and Meli, 2008). Perturbations of the boundaries between these organizations, such as the protrusion of one field into another, would produce interactions. The relativity of frame of reference, that is which field was invaginating the other, would affect the measurement or the experience in fields that generate this property.

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The human brain is considered the primary spatial localization of human consciousness and its various states. The two cerebral hemispheres have remarkably different structural configurations, even at topographical perspectives (van Essen and Drury, 1997). The approximately 20 to 40 billion neurons (Blinkov and Glezer, 1968; Pakkenberg and Gundersen, 1997) in the cerebral cortices of each hemisphere exist as relatively independent fields whose normal intercalation is constrained by the corpus callosum and anterior commissure. About 1% of the neurons in one hemisphere are directly involved with interhemispheric interaction (Kolb and Whishaw, 2009).

If structure dictates function, then normal left and right hemispheric processes should display specific organizations of conscious states and frames of reference. There is evidence that the left hemisphere is associated with a linguistic-based sense of self with spatial boundaries and persistence in time (Joseph, 1982). The right hemispheric equivalent to the left hemispheric sense of self is the "sensed presence", the feeling of a Sentient Being (St-Pierre and Persinger, 2006). There is both correlational and experimental evidence for this distinction (Persinger, 2003; Persinger and Healey, 2002; Persinger and Makarec, 1992; Suedfeld and Mocellin, 1987). In fact brain dysfunction localized to the temporoparietal junction has been shown to be associated with both OOBEs and autoscopy (Blanke *et al.,* 2004). The latter is characterized by the experience of seeing one's body in extrapersonal space.

The vectorial hemisphericity hypothesis (Persinger, 1993) states that when there is a transient or paroxysmal intrusion of right hemispheric processes (or field) into left hemispheric awareness the person experiences a sensed presence, the right hemispheric equivalent to the sense of self. However if the left hemispheric processes (or field) intrude into right hemispheric space, the sense of self is maintained and the experience is "outside of the body". The self is experienced as dissociated from the body. These phenomena have been labelled historically as out of body experiences (OOBE) in scientific contexts and astral or "soul" travelling within more mystical traditions (Fox, 1962; Twitchell, 1969).

Content analyses of reports of OOBEs by Tart (1967) revealed fundamental elements that included: 1) floating, 2) seeing one's physical body from the outside, 3) thinking of a distant place while "outside" and suddenly finding oneself there, 4) possessing a non-physical body, and, 5) being absolutely convinced the experience was not a dream. Persinger (1974) who analyzed the temporal sequence showed that 38% of experients reported the OOBE suddenly occurred. The remainder reported antecedent experiences that included tingling sensations (10%), vestibular experiences (16%), paralysis or pain (12%), fear (8%) or unusual sounds (8%).

The temporal sequence of the experiences involved a progression from "being pulled by a force", awareness of the "consciousness" looking down on the physical body, floating sensations "like the wind", and movement through space by "thinking" or "willing". Two-thirds of experients found themselves in another place; about one-third of these places were the ones the people were thinking about at the time of the onset of the OOBEs; the remaining places were not "on earth" but in environments that ranged from ancient settings to "other worlds" (usually with religious meaning).

In about half the cases a "bright star" or light was reported in the blackness and approached the experient. This was associated with a sensed presence attributed to culturally appropriate religious figures or dead relatives. A voice, reported in about 70% of the cases, told the person to "go back" or "return" to the body. The temporally contiguous experiences of a sensed presence and the instruction to "return" usually preceded the experient's return to the normal state, i.e., "returning to the body".

Given the limited immediate interhemispheric access through interneuronal communications (the 5 to 10 msec complete latencies through corpus callosal pathways) and the approximately 80 to 120 msec coherence of a microstate over the entire cerebral surface before the next stable state is organized (Koenig *et al.,* 2002), one would expect that neither OOBEs nor sensed presences should occur frequently in a normal person's lifetime. They would occur for brief periods after acute minor functional reorganization of the right hemisphere, such

as mild brain injury (Persinger, 1994), during appropriate electrical stimulation within the temporoparietal regions (of the right hemisphere in particular), or during extreme metabolic states that typically diminish the blood flow or perfusion rates that are approximately 10% higher in the right hemisphere. These suppositions have been supported clinically and experimentally (Bancaud *et al.,* 1994; Persinger and Meli, 2008).

Both OOBEs and the sensed presence frequently occur in a sequential order during near-death experiences (NDEs). From the perspective of the vectorial hemisphericity hypothesis, the enhanced vulnerability to diminished blood flow or hypoxia of the right hemisphere during the conditions associated with near death would encourage the intrusion of the left hemispheric processes into right hemispheric "space". Hence the sense of self and the prominence of "thought" in determining outcomes of experiences would predominate. The content of the perceptions reported by individuals who experience NDEs are compatible with this interpretation.

However the normal compensatory changes in blood flow within the right hemisphere would then occur within the order of tens of seconds and a reversal of the process would ensue. The subjective experiences would be expected to involve the awareness of the sensed presence and "returning" to the body. Acquired verbal labels and associated verbal images, determined by the person's cultural history, would affect the details of the sources and of the attribution for these experiences (Persinger, 1999a).

Such "analytical overlay" would be responsible for the richness and variability of detail which do not always reflect the "classical" forms reported in the popular media. For example one of our patients who sustained a mechanical impact to and subsequent haemorrhage within the right parietal lobe during a snowmobile incident suddenly felt himself detached from his body and riding as a passenger in a white limousine that was speeding down a narrow road. The interior of the car was shining white. The car stopped at a red stop light and the door opened and he was about to exit. However his dead grandmother leaned into the car and said "stay inside you are not ready to get out". The next experience he recalled was awakening in the hospital. This man's passion and profession was working as the clerk of a large company that sold automobile parts.

Tests of various hypotheses are most optimally verified within the laboratory under controlled conditions but without the life-threatening conditions associated with traditional OOBEs. Normal volunteers whose cerebrums have been stimulated by extracerebrally applied weak (1 μT range) magnetic fields whose patterns were designed to simulate natural phenomena, commonly report sensed presences as well as out of body experiences. Both occur, although at various times during the experiences, within 15 to 30 min of continuous exposure while sitting in a darkened, quiet room. However the externally applied fields are focused over a restricted region of the brain volume.

For the following experiment we reasoned the following. If there are two quantum fields representing the left and right hemisphere, then an experimental condition that produces a coherent stimulation over most of the cerebral volume and allows the penetration of the field associated with the sense of self into the right hemispheric condition there should be an associated powerful OOBE. Because the left temporoparietal region is strongly associated with the sense of self (Joseph, 1982) and the right prefrontal region is associated with the reconstruction of the organization of space with respect to the self (Buckner and Petersen, 1996), we predicted increased transient neuroelectromagnetic coherence between these areas. The frequency of coherence should be within the theta (4 to 7 Hz) range based upon previous reports (Tart, 1967; 1968) from people who could voluntarily produce these experiences as well as the theoretical calculations that the general frequency ranges associated with consciousness exist as second and third order derivatives within the 5 to 6 Hz range (Persinger, 1999b).

The brain can be approached as a complex space whose organization serves as substrates for electromagnetic patterns that are the quintessential sources of behaviour, including consciousness. If electromagnetic patterns are the origin for consciousness (McFadden, 2002; 2009; McKay and

Persinger, 2006), then it should be modifiable by the appropriately patterned, applied magnetic field. In the least, the magnitude of the energy from our applied fields should approximate the magnitude of the neuromagnetic correlations of consciousness within the whole of cerebral space so that potential interference or modification could occur. The quantum unit of neuronal function (Persinger, 2010), derived from the action potential, is approximately 2 x 10^{-20} J, the product of 120 mV (peak-to-peak voltage change during an action potential) and 1.6 x 10^{-19} Coulombs (charge per ion).

The energy within the cerebral cortices of the human being exposed to the estimated intracerebral strength of 1 μT magnetic fields is calculated as J=[B^2 (kg/A^2) /2*4pi x 10^{-7} N/A^2] * volume. Because the cerebral cortices are .44 of the cerebral volume (1.1 x 10^{-3} m^3), this means the energy available would be about 6 x 10^{-9} J. If there are on average 40 x 10^9 neurons within the cerebral cortices and each neuron's action potential is 2 x 10^{-20} J and the average firing frequency is 7 Hz, the energy associated with the "electromagnetic activity" of consciousness is 560 x 10^{-11} J or about 6 x 10^{-9} J (Mulligan *et al.,* 2010). The convergence of these values indicates that the energy generated from our applied magnetic fields overlaps with that available within the entire cerebral cortices.

Subject and Methods

The subject was a 27 year old male university student. He sat in a comfortable chair in a small office with normal low lighting (400 lux) and acoustic background (people walking in hallway). The subject wore a custom-constructed (by Todd Murphy) hat containing 64 solenoids (see Figure 1) obtained from Radio Shack. The 64-solenoids were distributed equally around the cerebrum in columns of 8 separated by 45 deg. Consequently there were 8 columns over the left and right frontal, temporal, parietal, and occipital lobes.

Shiva Neural Stimulation Software (Todd Murphy) was used to apply the magnetic field through 4 USB audio devices. This software was custom-designed by Todd Murphy to deliver weak-intensity magnetic fields to each of the 8 columns of solenoids at specified times with the same parameters used in previously published studies (Martin *et al.,* 2004; Richards *et al.,* 2002). The actual signals were audio derivatives of patterns converted to magnetic fields that are used regularly within our laboratory.

Figure 1. Lateral, frontal and topographical views of the custom-constructed hat used in the experiment. The hat contains 64 solenoids arranged in columns of 8 separated by 45 degrees.

An 8-channel Grass Electroencephalograph was used to monitor brain activity. Eight sensors (odd numbers=left hemisphere; even numbers=right hemisphere) were applied with EC2 electrode cream over the frontal (F7 and F8) parietal (P3 and P4) temporal (T3 and T4) and occipital (O1 and O2) regions in accordance with the 10-20 International Standard of Electrode Placement. Eyes open and closed baselines were collected prior to the application of the magnetic fields for comparisons.

The patterns of stimulation used in this experiment were 5-minutes of stimulation, 1.5 minutes of no stimulation, followed by a second period of 5-minutes of stimulation. Such durations are capable of even qualitative EEG entrainment (Persinger *et al.,* 1997). The base pattern of the stimulation was a burst-firing field, designed to imitate amygdaloid-firing patterns, whose temporal structure has been published elsewhere (Martin *et al.,* 2004). It is composed of 289 points each with a value between 0 and 256 that is transformed to between -5 and +5 V. The specific voltage was sent to the strips of 8 solenoids to generate the magnetic field at any given time for any given space around the cerebral perimeter. The point duration of the voltage associated with each point or value was 3 msec; consequently one sequence of the pattern was completed every 867 msec. Point durations that are less or more than 3 msec are less effective from both theoretical (Persinger and Koren, 2007) and experimental (Martin *et al.,* 2004) perspectives.

Application of this pattern for one second every four second across the two hemispheres by separate application geometries at the level of the temporoparietal region has been shown to attenuate markedly clinical depression in patients who have sustained closed head injuries and who are resistant to antidepressant medication (Baker-Price and Persinger, 2003); these physiologically-patterned fields also produce analgesia equivalent to about 4 to 5 mg/kg of morphine in rats (Martin *et al.,* 2004). The effect size (how much variance in the change in clinical depression explained) for the relief in depression is comparable to that from pulsed fields a million times (1 μT) more intense. In the present experiment each of the 8 strips of 8 solenoids from the apex to the most lateral extent of the skull was activated for specific durations in a counterclockwise direction.

During the first 5 minutes the left frontal strip was activated for 20 msec while each of the next succeeding strips of 8 solenoids were activated for 2 msec less. Thus the counterclockwise duration was 20 msec (over the left prefrontal region), 18 msec, 16 msec until the duration of the right prefrontal strip was 6 msec. The range in velocity was 3.75 m/s to 12.5 m/s with the average=5.8 m/s. This temporal configuration generates an average velocity and successive changes in velocity or acceleration. Near the right prefrontal region the acceleration would approach 9.8 m/s^2. Such changes in rates of change or derivatives over the entire cerebral manifold have been considered essential properties of human consciousness (Edelman, 1989; Llinas and Ribardy, 1993).

The second configuration presented for 5 minutes after the 1.5 min no field condition involved a base rate of 100 msec and a change of 10 msec. This means that the duration of the burst-firing field over the left prefrontal region was 100 msec but the duration for each of the successive 8 positions around the head decreased by 10 msec until the duration over the right prefrontal region was 30 msec. Both configurations (20+2 and 100+10) were selected based upon both theoretical calculations and empirical demonstration of effectiveness (Richards *et al.,* 2002).

Statistical analysis was performed on coherence and power measures derived from the raw data according to previous methods. Six 3-second segments were extracted from each condition (eyes open, eyes closed, time of OOBE). The segments were imported into Matlab v.7 where specialized scripts calculated coherence and spectral power for each 1-Hz increment. The data was then grouped by averaging each frequency range according to the classical bands (delta, theta, alpha1 (8 to 10.5 Hz), alpha2 (10.5 to 13 Hz), beta and gamma). All of these derived data were then imported into SPSS for Windows v.17 for statistical analysis.

Results

Elicited Experiences

Within a few seconds after the cessation of activation of the first 64-point magnetic field stimulation for 5 min with the 20+2 configuration the subject reported a mild floating sensation. A feeling of lightness, especially in the limbs, ensued. The feeling of lightness then became a sense of floating as if "my body was oscillating around the place in the chair like a pendulum oscillating around its resting point even though I knew my body was sitting".

The sensation of floating/oscillation continued and was accompanied by intermittent "rushes of anxiety or sensations of falling". During this period the experience was similar to motion sickness. He focused on breathing to avoid the urge to vomit. These "rushes" became more and more frequent and were associated with feelings of dissociation from the body and a loss of body image and awareness.

The experience culminated with the subject feeling his head was floating above the spot where his body was sitting. He could not distinguish between his limbs, his torso, or the surrounding space and objects in the room. During this intense experience, he considered asking the experimenter to terminate the procedure. Following the experience there was noticeable fatigue and a headache developed.

Quantitative EEG Results

The relative power (uV^2/Hz) from eyes-closed baseline associated with 7 of the 8 sensor positions showed peak intensity within the 9 to 13 Hz (alpha region) and an extraordinary enhancement of voltage over the left temporal lobe (T3) at 2 Hz (Figure 2) during the OOBE. There was an overall increased coherence between the left temporal and right frontal region during the OOBE relative to the eyes-closed reference (Figure 3).

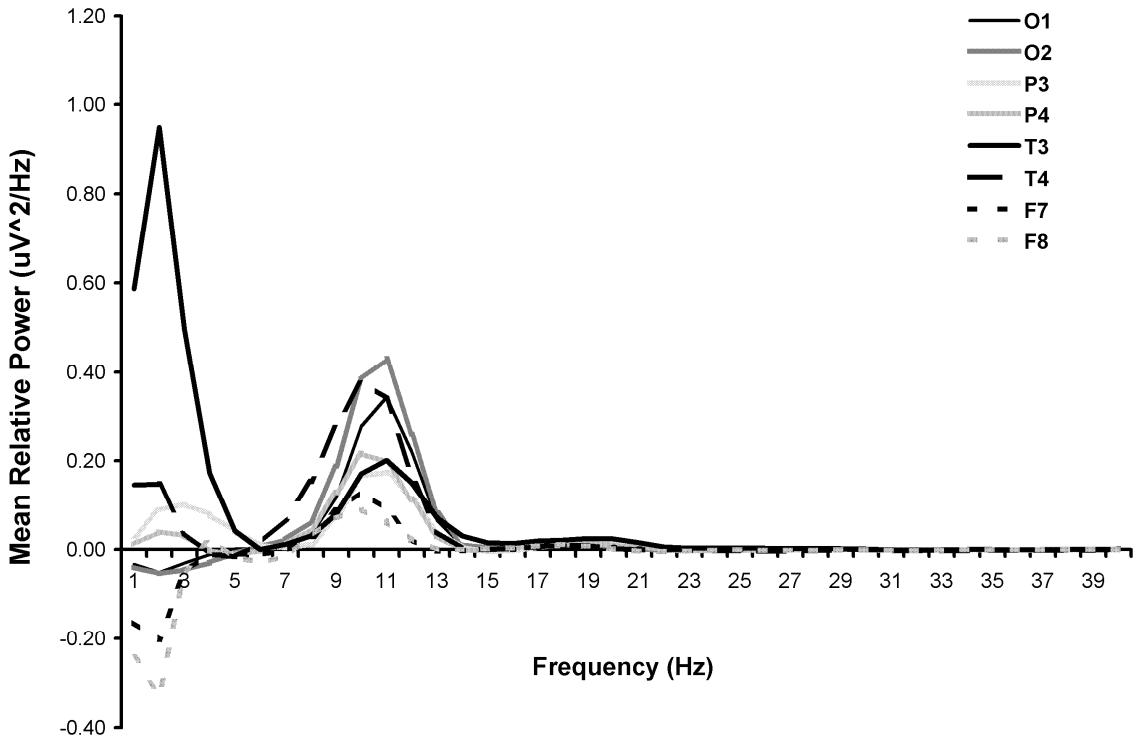

Figure 2. Elevated power at 2 Hz within the left temporal lobe with a concomitant increase in 9 to 13 Hz power at 7 sensor positions during the out-of-body experience relative to the eyes closed baseline. O1-left occipital, O2-right occipital, P3-left parietal, P4-right parietal, T3-left temporal, T4-right temporal, F7-left frontal, F8-right frontal.

However there was an additional "bimodal" peak in coherence (minimum=0; maximum=1) within the theta (3-7 Hz) and low beta (15-23 Hz) range during the OOBE only. These coherences were abnormally high compared to typical waking cerebral activity. The means and standard error of the means for the coefficients of coherence within successive 1-Hz bands within the theta range are shown in Figure 4 for the conditions of eyes-opened, eyes-closed, and the OOBE. The strength of coherence during the OOBE was twice to three times greater on average compared to these values during the eyes-opened or eyes-closed condition.

There was also an enhanced coherence between the left temporal and left frontal regions within the theta band during the OOBE. To control for possible confounding variables, zero-order and partial correlations were completed for the coherence values. The zero order coefficients for the theta band coherence were: T3,F7 vs F7,F8 (.68), T3,F7 vs T3,F8 (.91) and F7,F8 vs T3,F8 (.68). However after partial correlation these values were .21, .84, and .19, respectively, indicating that the source of the left temporal-right prefrontal coherence originated from the left temporal lobe and was not indirectly mediated between the left temporal to the left frontal lobe and then across to the right frontal region.

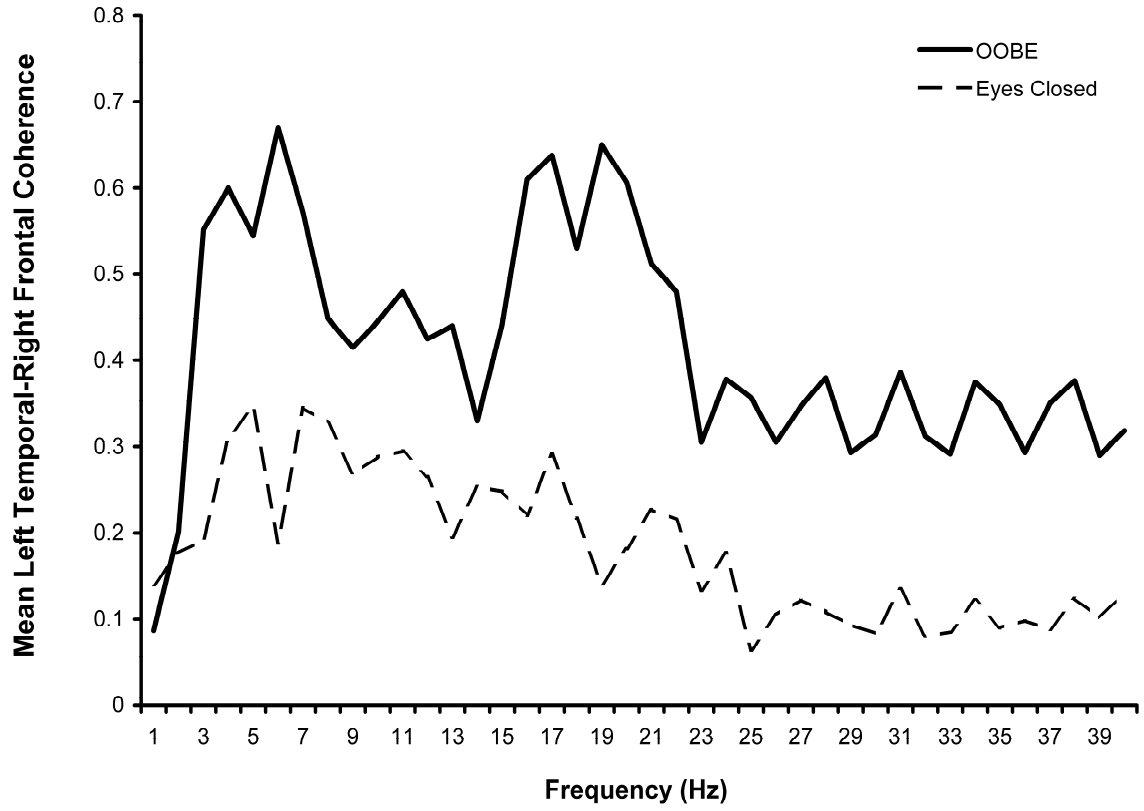

Figure 3. Overall increased interhemispheric coherence between the left temporal and right frontal regions during the out-of-body experience (OOBE) compared to the eyes-closed baseline with bimodal peaks in the theta (3-7 Hz) and low beta (15-23 Hz) frequency ranges.

Discussion

The results of this study indicated that with the appropriate stimulation by a global extracerebral magnetic field generated by an array of 64 solenoids the first stages to a powerful OOBE can be induced quickly in a person sitting in a normally lit room with hallway sounds in the background. In other words, the energy and patterns associated with the globally applied magnetic fields displaced the holistic vectors (Wackermann, 1999) correlated with normal sensory input.

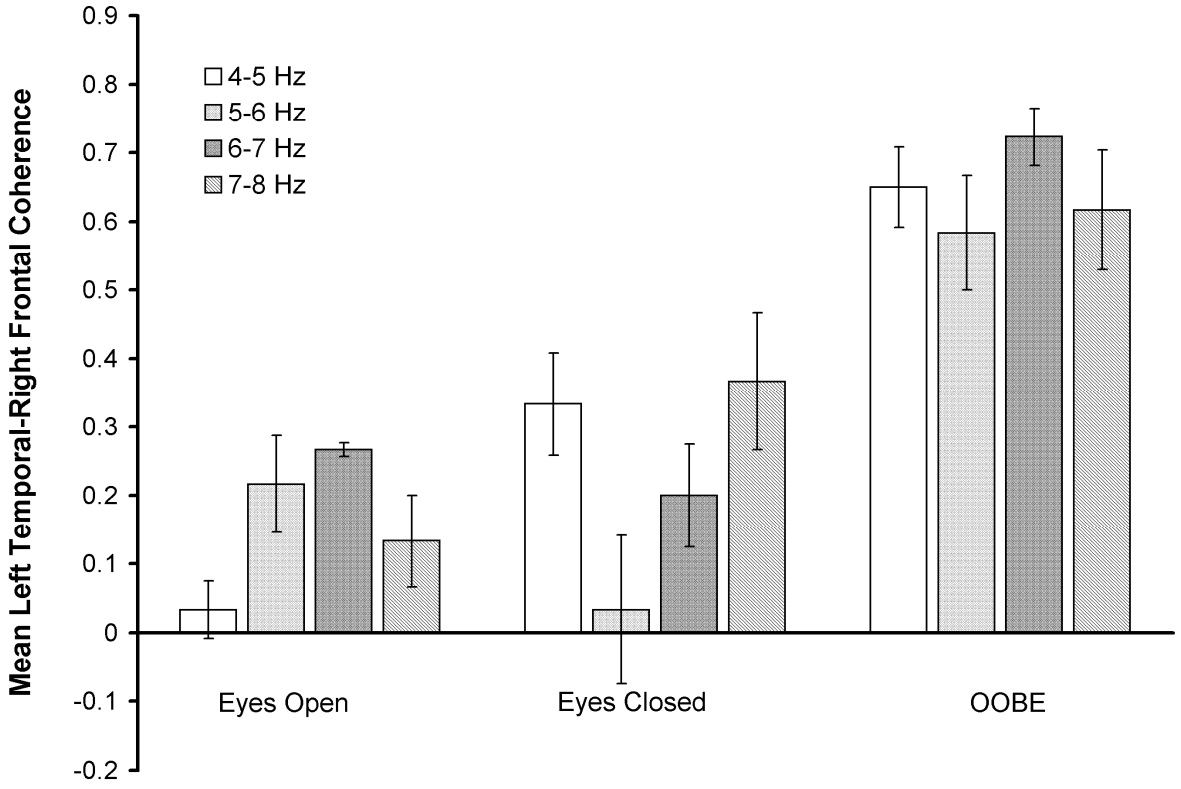

Figure 4. Mean interhemispheric coherence for successive 1-Hz bands within the theta (3-7) range were significantly elevated during the out-of-body experience (OOBE) when compared to eyes-open and eyes-closed conditions. Error bars represent standard error of the mean.

The increased cerebral power within the range of alpha rhythms over most of the cerebrum during the occurrence of the experimentally-elicited OOBE is consistent with reports of other researchers. During partial sensory deprivation subjects reported sensations of the self being detached from the body during increased amplitude of synchronous slow waves with theta-like characteristics (Zubek *et al.,* 1960; Coffer and Appley, 1964). Alphoid activity, defined as synchronous activity 2 Hz lower than the person's fundamental alpha frequency, was displayed in two different special subjects who could voluntarily elicit OOBEs (Tart, 1967, 1968).

The coherence results observed in the present study strongly support the hypothesis that OOBEs are associated with the protrusion of the left hemispheric field into the right hemispheric field. For this diagonal association there was a generalized increase in coherence between the left temporal and right prefrontal region across all major frequencies (3 to 40 Hz) with specific peaks between 3 Hz to 6 Hz and between 15 Hz to 22 Hz. If the left temporal region is associated with the sense of self and consciousness and the right prefrontal region is associated with spatial navigation, the reconstruction of autobiographical memory about when, where and with whom an event occurred (Buckner and Petersen, 1996), and "mental time travel", then this specific coherence could encourage experiences consistent with the classical OOBE.

The left temporal-right prefrontal coherence might be expected to include the feeling of separation of the self from the body, "movement in space", "thought" as the central frame of reference to control this movement, and the feeling of being somewhere else. These are classic features of OOBEs (Tart, 1968). The remarkably enhanced amplitude of power within the 2 Hz band over the left temporal lobe, from this context, could be considered the source of initiation. Partial correlation analyses with the strongest coefficients of coherence support this interpretation. The "left hemispheric field"

would have been directed into the "right hemispheric field".

It is relevant that the OOBE did not occur during the presentation of either field configuration. It began within seconds after the termination of the 20+2 configuration of the counterclockwise rotating, global extracerebral magnetic field to which the subject had been exposed for 5 min. The energy within the cerebral cortices associated with the application of the approximately 1 μT strength burst firing magnetic field that was rotated approximately 9.6 times per sec around the circumference of the head would have been in the order of 10^{-9} J. We selected this intensity because it would be within the same order of magnitude as the energy generated by action potentials of the approximately 40 billions neurons in the cortices. Even if only 10% of neurons' neuropatterns were coherent per second, the approximately 100 msec duration of a percept (Koenig *et al.,* 2002), the energy would be sufficient to interact with the cohesive or "binding" factor (Llinas and Ribardy, 1993) that organizes the cerebral manifold. Theoretical calculations suggest the existence of a recondite second or third derivative contained within the 5 to 7 Hz band (Persinger, 1999b).

We suggest that the global magnetic field generated by an array of 64 solenoids was sufficient to initiate instability within the holistic parameters that define the functional state of the whole brain (Wackermann, 1999). When this field stopped suddenly the compensatory changes in the cerebral magnetic field during this period of stabilization produced the conditions for the left hemispheric field to intrude into right hemisphere space. In fact the holistic measures of complexity decreased over the left temporal and right prefrontal regions concurrent with an increase in coherence during this transience which was associated with the OOBE.

The nature of the hemispheric field interactions might be considered analogous to the transient disruption of the constrained polarity of the geomagnetic field from the penetration of opposite polarity flux lines during shear disruptions from the solar wind before the "reconnections" occur. In the present case, the initial vector for penetration was driven by the marked elevation of voltage originating over the left temporal lobe. This peak would be congruent with the subject's initial vestibular experiences.

If consciousness exists within a narrow band of neuroelectromagnetic activity then stimulation below that threshold would not be effective and magnitudes of stimulation above that threshold would be aversive and potentially disruptive. Some spontaneous cases of OOBE are associated with negative experiences such as dizziness, nausea and fear. In addition, not all NDEs are positive. About 7 to 10% of these cases are extremely negative affectively (Persinger, 1974). The imagery, which involves the culture's labels for aversive sensations, is mood congruent. Such non-linearity between the number and valence of NDEs would be expected based upon the annular-like organization of reward and aversive areas within the limbic system. Aversive areas surround and suppress pleasure centers.

There would be a point where the microcurrent induction from the conditions associated with the NDE would exceed the lower threshold pleasure areas and diffuse into the surrounding aversive areas. If the magnitude of the induction was too high there would be a complete disruption of the process and hence complete amnesia. In other words, most people would remember nothing. It may be relevant that the transition from intrinsic hippocampal patterns that promote normal memory consolidation to those that reflect paroxysmal, epileptic seizure activity (and hence amnesia) occurs mathematically as an all-or-none, catastrophic event.

The occurrences of the left temporal-right prefrontal coherence within the theta and low beta band have two major implications both for OOBEs and for the nature of consciousness within brain space. First the diagonal nature of the coherence would not be consistent with a fixed structuralist model whereby two hemispheres interact laterally through the corpus callosum and anterior commissure. The asymmetry might be considered representative of a fundamental, holistic standing wave derived from the beats or emergent organizations from the rapid alternations from reciprocal inhibitory control between the two hemispheres and the ascending input from the

brain stem. This cohesive field moves in a rostral to caudal direction through the cortical manifold with repetition rates and phase-modulations within the 10 to 20 msec range (Llinas and Ribardy, 1993).

Within an equilibrium system where there are periodically shifting polarities, such as the solar magnetic field, one would expect at least four fundamental states or briefly stable configurations within the three planes. Along the horizontal (x,y) plane the first two would be: left frontal-right caudal and right frontal-left caudal. Along the z-axis or vertical plane one would expect two similar polarities more homogeneously integrating both hemispheres but differing in the focus over the rostral or caudal dorsal frontal pattern. In fact these four patterns are very similar to the fundamental microstates that define the human brain ontogenetically (Koenig *et al.,* 2002). From this perspective the neuroelectromagntic field associated with states of consciousness are cohesive transcerebral fields that occupy the brain's volume.

The second implication involves the two bands of coherence. Both the theta and low beta band are very similar to the first and second harmonic of the Schumann resonance. It defines the essential standing wave, with the usual range of 7 to 8 Hz, between the earth's surface and the ionosphere. This frequency range is shared by the human hippocampus, the "gateway to memory", and has been hypothesized to be a potential mechanism by which the transient 20 to 30 min of electrically labile state of experiences before they are consolidated to protein structures and dendritic spine growths could be represented in extracerebral space (Persinger, 2008). OOBEs are more probable in people with elevated complex (temporal lobe) partial epileptic-like signs during periods of moderately enhanced geomagnetic activity (Persinger, 1995).

Secondly, Minakov et al (1993) have shown theoretically that gravitational waves can be converted into electromagnetic waves. Gravity waves freely propagated inside the earth-ionospheric resonator induce alterations in the boundaries as well as perturbations in the space-time metric. According to these authors, the most powerful region of amplification of a gravity wave is near the second global Schumann harmonic around 14 to 15 Hz. The second peak of coherence between the left temporal lobe and right prefrontal region occurred within this band. Whether or not these similarities could explain the acquisition of information from distal sources during OOBEs remains to be examined. Throughout the last two millennia there have been repeated claims of "projections" into distal spaces. Although most experiences are easily accommodated through the nuances of normal neuronal chemistry and neuropsychological processes associated with fantasy and confabulation, the occasional reports of information not accessible to the experient within this "cerebral noise" may be worth pursuing.

Pursuit of the neuroQuantology component of OOBEs may be revealing. We consider states of consciousness as conditions analogous to quantum states embedded with cerebral fields. The fields contain quantized points. A candidate for this quantum has been the 10^{-20} J associated with the quintessential digital component of information transfer within brain space: the action potential (Persinger, 2010). If the operating intensity of the cerebrum is about 10 pT, then the energy available within the cerebral cortices would be 2×10^{-20} J. That the magnitude of the unit reflects the magnitude of the whole would be an important component for the condition of a field.

In previous research (Booth *et al.,* 2005) we applied the quantum nature of electron energies during the presentation of magnetic fields to the cerebral volume. The Zeeman effect occurs when the application of a magnetic field "splits" the emission and absorption spectrum of the constituents of matter into equally polarized components. One solution for the equivalent Zeeman frequency is the product of the field strength and charge divided by the mass of the electron. For a field strength of 10×10^{-12} T and a unit charge of 1.6×10^{-19} A s, the frequency to produce this effect in an electron with a mass of 9.1×10^{-31} kg is about 2 Hz. Whether or not the extraordinary peak of power at 2 Hz within the left temporal lobe noted in the present case was indicative of this effect requires further examination.

References

Baker-Price L, Persinger MA. Intermittent burst-firing weak (1 microTesla) magnetic fields reduce psychometric depression in patients who sustained closed head injuries: a replication and electroencephalographic validation. Perceptual and Motor Skills 2003; 113: 119-139.

Bancaud J, Brunet-Bourgin F, Chauvel P, Halgren E. Anatomical origins of deja vu and vivid memories in human temporal lobe epilepsy. Brain 1994; 117: 71-90.

Blanke O, Landis T, Spinelli L, Seeck M. Out-of-body experience and autoscopy of neurological origin. Brain 2004; 127: 243-258.

Blinkov SM, Glezer II. The human brain in figures and tables: a quantitative handbook. New York: Plenum Press, 1968.

Bohm D. Quantum theory: New York:Prentice-Hall, 1951.

Bohr N. Atomic physics and human knowledge. New York: John Wiley and Sons, 1958.

Buckner RL, Petersen SE. What does neuroimaging tell us about the role of prefrontal cortex in memory retrieval? Seminars in the Neurosciences 1996; 8:47-55.

Coffer CN, Appley MH. Motivation and emotion N.Y.: John-Wiley, 1967, pp. 169-301.

Edelman GM. The remembered present: a biological theory of consciousness. N.Y.: Basic Books, 1989.

Fox O. Astral projection: a record of out-of-body experiences. N.Y: University Books, 1962.

Jibu M, Yasue K. Quantum brain dynamics and consciousness. Amsterdam: John Benjamins Publishing, 1995.

Joseph R. The neuropsychology of development: hemispheric laterality, limbic language, and the origin of thought. Journal of Clinical Psychology 1982; 38:4-33.

Koenig T, Prichep L, Lehmann D, Sosa PV, Braeker E, Kleinlogel H, Isenhart R, John ER. Millisecond by millisecond, year by year: normative EEG microstates and developmental stages. NeuroImage 2002; 16:41-48.

Kolb B, Whishaw IQ. Fundamentals of human neuropsychology. New York: Worth, 2009.

Llinas R, Ribardy U. Coherent 40-Hz oscillations characterizes dream state in humans. Proceedings of the National Academy of Science. 1993; 90: 2078-2081.

Martin LJ, Koren SA, Persinger MA. Thermal analgesic effects from weak, complex magnetic fields and pharmacological interactions. Pharmacology, Biochemistry and Behavior 2004; 78:217-227.

McFadden J. Synchronous firing and its influence on the brain's electromagnetic field: evidence for an electromagnetic theory of consciousness. Journal of Consciousness Studies 2002; 9: 23-50.

McFadden J. Conscious electromagnetic (CEMI) field theory. NeuroQuantology 2007; 2: 262-270.

McKay BE, Persinger MA. Weak, physiologically relevant magnetic fields disrupt maze performance in seized rats normalized with ketamine: possible support for the neuromatrix concept? Epilepsy and Behavior 2006; 8:137-144.

Minakov AA, Nikolaenko AP, Rabinovich LM. Gravitational-to-electromagnetic wave conversion in electrostatic field of earth-ionospheric resonator. Radiofizika 1992; 35: 488-497.

Mulligan BP, Hunter MD, Persinger MA. Effects of geomagnetic activity and atmospheric power on quantitative measures of brain activity: replication of the Azerbjaijani studies. Advances in Space Research 2010; 45: 940-948.

Pakkenger B, Gundersen HJG. Neocortical neuron numbers in humans: effects of sex and age. The Journal of Comparative Neurology 1997; 384: 312-320.

Persinger MA. The paranormal: patterns (Part 1) N.Y.: MSS Information, 1974.

Persinger MA. Vectorial hemisphericity as differential sources for the sensed presence, mystical experiences, and religious conversions. Perceptual and Motor Skills 1993; 76:915-930.

Persinger MA. Sense of presence and suicidal ideation following traumatic brain injury: indications of right hemispheric intrusions from neuropsychological profiles. Psychological Reports 1994; 75: 1059-1070.

Persinger MA. Out-of-body-like experiences are more probable in people with elevated complex partial epileptic-like signs during periods of enhanced geomagnetic activity: a non-linear effect. Perceptual and Motor Skills 1995; 80:563-569.

Persinger MA. Near-death experiences and ecstasy: an artifact of the organization of the human brain? In S. Della Salla (Ed) Mind Myths. N.Y.: John Wiley, 1999a: 85-99.

Persinger MA. Is there more than one source for the temporal binding factor for human consciousness? Perceptual and Motor Skills 1999b; 89: 1259-1262.

Persinger MA. The sensed presence within experimental settings: implications for the male and female concept of self. The Journal of Psychology 2003; 137: 5-16.

Persinger MA. On the possible representation of the electromagnetic equivalents of all human memory within the earth's magnetic field: implications for theoretical biology. Theoretical Biology Insights 2008; 8:3-11.

Persinger MA. 10^{-20} Joules as a neuromolecular quantum I medicinal chemistry: an alternative approach to myriad molecular pathways? Current Medicinal Chemistry, 2010, in press.

Persinger MA, Healey F. Experimental facilitation of the sensed presence: possible intercalation between the hemispheres induced by complex magnetic fields. Journal of Nervous and Mental Diseases 2002; 190: 533-541.

Persinger MA, Makarec K. The feeling of a presence and verbal meaningfulness in context of temporal lobe function: factor analytic verification of the Muses? Brain and Cognition 1992; 20: 217-226.

Persinger MA, Meli S, Koren S. Quantitative discrepancy in cerebral hemispheric temperature associated with "two consciousnesses" is predicted by neuroQuantum relations. NeuroQuantology 2008; 6:369-378.

Persinger MA, Koren SA. A theory of neurophysics and quantum neuroscience: implications for brain function and the limits of consciousness. International Journal of Neuroscience 2007; 117: 157-175.

Persinger MA, Richards PM, Koren SA. Differential entrainment of electrocephalographic activity by weak complex magnetic fields. Perceptual and Motor Skills 1997; 85: 387-398.

Richards MA, Koren SA, Persinger MA. Circumcerebral application of weak complex magnetic fields with derivatives and changes in electroencephalographic power spectra within the theta range: implications for states of consciousness. Perceptual and Motor Skills 2002; 95: 671-686.

St-Pierre L, Persinger MA. Experimental facilitation of the sensed presence is predicted by the specific patterns of the applied magnetic fields not suggestibility: reanalyses of 19 experiments. International Journal of Neuroscience 2006; 116: 1-18.

Suedfeld P, Mocellin JSP. The "sensed presence" in unusual environments. Environment and Behavior 1987; 19: 33-52.

Tart CT. A second psychophysiological out-of-the-body experience in a gifted subject. International Journal of Parapsychology 1967; 9: 251-258.

Tart CT. A psychophysiological study of out-of-the-body experiences in a selected subject. Journal of the American Society for Psychical Research 1968; 72, 3-27.

Twitchell P. Eckanakar. N.Y.: Lancer, 1969.

Van Essen DC, Drury HA. Structural and functional analyses of human cerebral cortex using a surface-based atlas. The Journal of Neuroscience 1997; 17: 7079-7102.

Wackerman J. Towards a quantitative characterisation of functional states of the brain: from the non-linear methodology to global linear description. International Journal of Psychophysiology 1999; 34: 65-80.

Zubek JP, Sansom W, Prysiaznuik A. Intellectual changes during prolonged perceptual isolation (darkness and silence). Canadian Journal of Psychology 1960; 14, 233-243.