Article

Experimental Demonstration of Potential Entanglement of Brain Activity over 300 Km for Pairs of Subjects Sharing the Same Circular Rotating, Angular Accelerating Magnetic Fields: Verification by s_LORETA, QEEG Measurements

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ABSTRACT

In order to test the presence of excess correlation, or entanglement, pairs of subjects separated by 300 km were either exposed or not exposed to specific configurations of circular magnetic fields with changing angular velocities that dissociated the phase and group components. When one person in the pair was exposed to sound pulses but not to light flash frequencies within the classical electroencephalographic band, there were discrete changes in power within the cerebral space of the other person even though they were not aware of the stimulus times and separated by 300 km. The intracerebral changes that only occurred if the magnetic fields were activated around the two cerebrums simultaneously were discrete and involved about single, punctate volumes of about 0.13 cc (125 mm^3). The potential energy from the applied magnetic field within this volume was calculated to be about $6 \cdot 10^{-14}$ J and with an average brain power frequency of 10 Hz would result in $6 \cdot 10^{-13}$ W. Assuming $\pi \cdot 10^{-2}$ m^2 for the surface area of the cerebrum, this is equivalent to $\sim 2 \cdot 10^{-11}$ $W \cdot m^{-2}$. This power density is the same order of magnitude as that associated with photon emission during cognition. Given the average of $6 \cdot 10^6$ neurons per 125 mm^3, the induced energy is equivalent to about 10^{-20} J per neuron. This value can be considered a quantum of universal energy and would be congruent with a condition that could promote non-locality.

Key Words: entanglement; brain; s_LORETA; transcerebral magnetic field stimulation; 10^{-20} J

1. Introduction

For many decades the operation of non-locality was assumed to be restricted to the quantum level of space-time reactions. However experimental demonstrations of this phenomenon within macroscopic objects have been reported. Julsgaard, et al (2001) found the maintenance of spin states for about 0.5 msec for two volumes of caesium gas each containing about 10^{12} molecules. Dotta and Persinger (2012) exposed simultaneous reactions that generated photon emission to

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shared rotating magnetic fields whose angular velocities and phase velocities were dissociated. This condition would arise if the photon displayed a non-zero mass as argued by Tu et al (2005). Dotta and Persinger reported clear experimental evidence of entanglement, defined as the doubling of photon emissions from the spatially separated reactions when both shared the same magnetic field configurations. The functional number of molecules involved with the reactions, $\sim 10^{18}$, would have been expected to produce entanglement about a million times longer than the Julsgaard et al (2001) effects. As predicted the duration of the "entanglement" was about 500 s (about 8 min).

Entanglement between two cultures of cells separated by non-traditional distances but sharing specific types of circularly rotating magnetic fields with changing angular velocities was demonstrated by Dotta et al (2011). They found that exposure of one population of cells to bright flashing light was temporally contiguous with increased photon emissions from the population of cells housed in the dark several meters away. The increased photon emission from these cells, when cells sharing the same magnetic field configurations were receiving light stimulation in another room, was about 10^{-11} $W \cdot m^{-2}$ or when accommodating the width of the cell culture dish and the numbers of cells, about 10^{-20} $J \cdot s^{-1}$. When pairs of subjects were exposed to these magnetic field configurations while one of the pair was exposed to flashing light significant increases in photon emissions from the right hemisphere of the other person in the pair, sitting in the dark in another room, was clearly measured; this effect did not occur when the fields were not operating or when the light was not presented. These studies were systematic replications of a previous paradigm (Persinger, et al, 2010) when correlated electroencephalographic cerebral events between physically and sensory isolated pairs of subjects were observed over the right parietal regions when the other member of the pair was exposed to different frequencies of light flashes but only if both were yoked to the same circumcerebral magnetic fields.

In unpublished experiments Dotta and Persinger demonstrated that the "double photon" emission, when injections of the same amount of reactant occurred simultaneously and both chemical reactions were exposed to the changing angular velocity circular magnetic fields, was still clearly evident when the separating distance was about 3 km. In this instance two different computers operated the rotating magnetic field equipment, thus minimizing the potential role of instrumental artefact. In order to test the potential distance by which entanglement between human brains might be demonstrated, the following experiment was designed to discern if there was potential proof for this principle. We reasoned that the effects should be sufficiently strong to be discerned by the most sensitive complex measure of intracerebral activity. This measure, s_LORETA, or standardized Low Resolution Electromagnetic Tomography, reveals the power of different incremental frequencies within regions of the cerebral volume. Although the spatial resolution is 5 mm, the patterns of activation have shown strong validity and concordance with measurements by fMRI (functional Magnetic Resonance Imaging).

The basic procedure was to expose one of a pair of subjects for brief periods to various frequencies of sound or flashes of light while the other member of the pair was unaware of these presentations. Quantitative EEG measurements required for the s_LORETA analyses would be taken from that second member, approximately 300 km away, continuously. Both members of the pair would be exposed to a rotating, circular magnetic field whose frequency modulation would also undergo changing angular rotation (velocity). If entanglement, that is excess correlation, occurred between the two brains that when one person was being exposed to the stimulus there should be a discrete change in power within the brain of the other person, 300 km away, but *only* if the fields were activated. We report here data that support this effect.

2. Methods and Materials

In order to investigate macroscopic entanglement between pairs of strangers separated by 300 km, four adult participants between 20 and 25 years of age were recruited (3 male, 1 female). Two participants were located in Sudbury, ON while the other two were situated in Timmins, ON. Participants located in Timmins were designated as stimulus persons while those residing in Sudbury were considered response persons. Consequently there were two pairs of stimulus-response persons.

Stimulus persons were seated in a dark and quiet room. They were exposed to alternating audio and photo stimulation for periods of 30 seconds. Each interval was followed by 30 seconds during which time no stimulus was presented. There were three audio stimuli (6Hz, 8Hz, 15Hz), and three photo stimuli (7Hz, 10Hz, 40Hz) which were selected because they represent frequencies that can be measured using quantitative electroencephalography (QEEG). Audio and photo stimuli were presented with an Apple iPhone 4 using Nature Scenes v3.2 (audio) and Flashlight v2.0.3(photo) applications.

Response persons were situated in a similar environment. Their brain activity was monitored using a 19-channel cap with electrodes (Mitsar-201) placed according to the 10-20 monopolar system throughout the experiment. The data were recorded with a Lenovo ThinkPad laptop (Intel Core i3 CPU M 380@2.53GHz, 2 Cores, 4 Logical Processors). Communication was maintained by cell phone between experimenters in order to ensure accuracy of time stamps on the EEG data. To reduce experimenter bias, the investigators in Sudbury were instructed when to mark the EEG output, but were not aware of the type of stimulus being presented in Timmins. The response persons were not aware of what was occurring but sat quietly in the room.

Both the stimulus and response persons wore a toroidal magnetic field device ("the halo") on their heads such that the rostral-caudal plane was just above the dorsal ear. The device is shown in Figure 1. Each toroid consisted of 225 turns of 16 gauge stereo wire wrapped around a 10 inch plastic ring. The shape of the magnetic field was modulated using an Arduino Uno microcontroller. The specific field was a frequency-modulated pattern, similar to the one employed by Dotta and Persinger (2012) to create entanglement between photon emissions from chemical reactions. Effectively this contained 230 amplitude-modulated points (333 Hz, 1.45 Hz cycle), with an average strength of approximately 1 μT, that was phase modulated in 2 ms increments (20 ms delay to 8 ms delay) such that an increase in angular velocity occurred within the circular device worn on the heads by the pairs of subjects.

The experimental procedure was repeated two times. During one sequence of 6 stimulus trains (3 visual, 3 auditory) both participants in a pair received the complex, physiologically-patterned magnetic field. During the other sequence, the participants did not receive any field but received the same 6 stimuli in a different order. One pair of subjects received the no field condition first while the other pair received the field condition first.

Figure 1- Halo system consisting of 225 turns of 16 gauge stereo wire around a ten inch diameter plastic ring. The toroids were placed around the heads of the stimulus person and the response person who were separated by 300 km.

The QEEG data was exported for the 15 second segments for each stimulus and the comparable time immediately preceding each stimulus. The data were analyzed by classical sLORETA software. This software displays 3-dimensional, sagittal, horizontal, and coronal representations (resolution 5 mm) of the cerebral volume for 1 Hz frequency increments between 1 Hz and about 30 Hz. The analyses examined the significant changes in brain activity in the response person while the stimulus person was being presented with the sound or visual stimuli compared to the 15 seconds immediately prior to the presentation. All analyses involved SPSS PC software.

3. Results

The results were very conspicuous qualitatively. There was a significant change in very focal cerebral activity *only* during the magnetic field condition for *only* the auditory stimuli for both pairs of participants. There was no significant change in activity within the cerebrums of the response persons between the stimulus periods compared to the previous interval when there was no field in operation. There was also no significant change for any of the periods involving visual stimulation.

As can be seen in Table 1, the changes occurred within the cerebrum of the response persons at the same time the stimulus persons were being presented with the auditory sequences. In Table 1, F refers to the presence of the shared field pattern, NF indicates no shared field pattern, BA refers to Brodman areas of the cerebrum, and the various Greek letters refer to classic frequency bands, such as beta (13-20 Hz), theta (4-7 Hz), delta (1-4 Hz) and alpha (8-13 Hz). The most obvious pattern noted for both pairs of subjects is the involvement of sensory integration (secondary projection) areas of the cerebral cortices.

Table 1- Significant differences in brain activity of the response person when audio stimuli were presented to the stimulus person, compared to the 15 seconds immediately preceding the stimuli, were observed for all stimuli only during the field conditions. (A= audio stimulus, PA=pre-audio stimulus, F= field, NF= no field, SUB= subject pair)

SUBJECT/CONDITION	RESULTS
SUB1	
A-PAθ (F)	Increased β_3 over left BA9 ($p<0.001$)
A-PAθ (NF)	n.s.
A-PAα (F)	Decreased α_2 over right BA19 ($p<0.001$)
A-PAα (NF)	n.s.
A-PAβ (F)	Increased β_1 over left BA7 ($p<0.001$)
A-PAβ (NF)	n.s.
SUB2	
A-PAθ (F)	Increased β_2 over the right BA47 ($p<0.001$)
A-PAθ (NF)	n.s.
A-PAα (F)	Increased δ over the left BA22 ($p<.001$)
A-PAα (NF)	n.s.
A-PAβ (F)	Decreased δ over the left BA3 ($p<0.001$)
A-PAβ (NF)	n.s.

Table 2- Results from the light stimulation were not consistent to those observed for the audio stimulation. From the 12 conditions (6 field, 6 no field), only 1 reached significance with the field and 1 without the field. (P= photo stimulus, PP=pre-photo stimulus, F= field, NF= no field)

SUBJECT/CONDITION	RESULTS
SUB1	
P-PPθ (F)	n.s.
P-PPθ (NF)	n.s.
P-PPα (F)	n.s.
P-PPα (NF)	Increased δ over the right BA10
P-PPγ (F)	n.s.
P-PPγ (NF)	n.s.
SUB2	
P-PPθ (F)	n.s.
P-PPθ (NF)	n.s.

P-PPα (F)	n.s.
P-PPα (NF)	n.s.
P-PPγ (F)	Decreased γ over the right BA8
P-PPγ (NF)	n.s.

The second major observation for all of the periods in which there was a significant change in activity within the space of the response person's brain at the same time the stimulus person was hearing stimuli 300 km away when both shared the same magnetic field configuration was the extremely focal nature of the effect. S_LORETA analyses for all cases displayed a punctate change in power within specific frequency bands in one voxel whose resolution width is about 5 mm. An example of this phenomena that was noted in both response persons from the two pairs is shown in Figure 1.

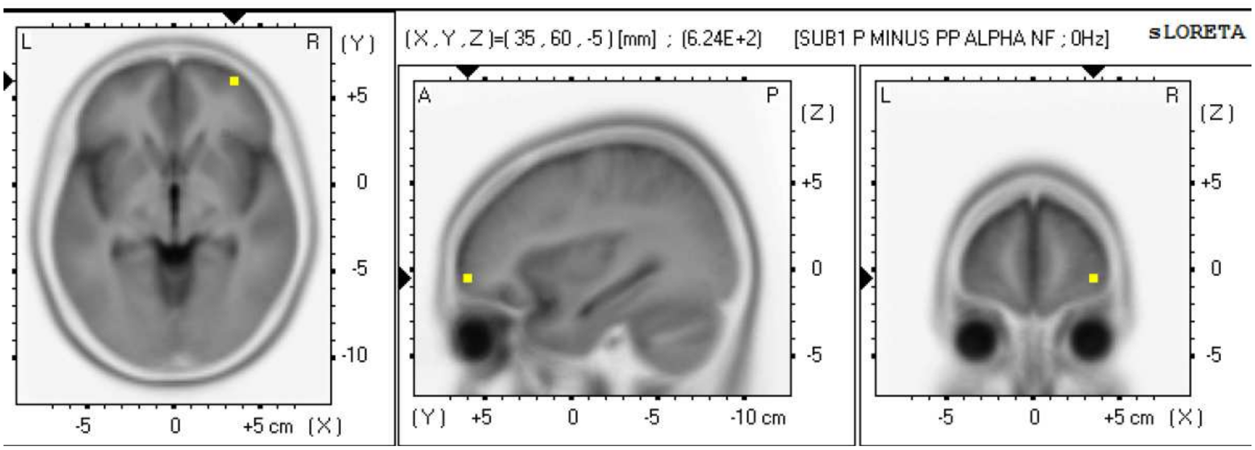

Figure 1. Punctate activation of theta power within the right frontal region of response person 1 while the stimulus person listened to sounds 300 km away but both were exposed to the same circular magnetic field with changing angular velocity.

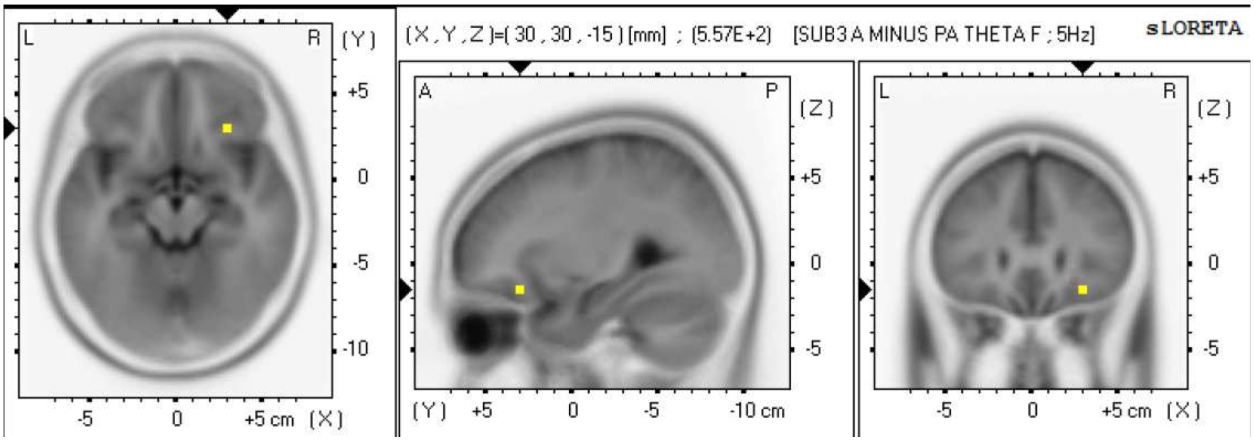

Figure 2. Punctate activation of theta power within the right frontal region (different area than response person 1) of a second response person while the stimulus person listened to sounds 300 km away but both were exposed to the same circular magnetic field with changing angular velocity.

4. Discussion

To our knowledge this is the first demonstration of experimentally-induced, "excess correlation" or entanglement between two macroscopic objects, in this case human brains, over a distance of approximately 300 km. The effect was sufficiently robust to be evident in two different pairs of participants. That change in power within the brain of the response persons was evident only when the magnetic fields were present but not when they were absent and for the auditory stimuli but not for the visual stimuli indicates the effects were not spurious but specific to the condition. Because even the experimenters attending to the response persons were not aware of which conditions were being conducted by other experimenters with the stimulus persons the role of subtle cueing appears minimal.

The effect within the response person's brain during the "entanglement" when the stimulus subject was being exposed to the sound stimuli and when both the stimulus and response persons were exposed to the magnetic field configuration was very focal. This change in power from the previous reference period occurred, for the most part, in only one voxel as shown in Figures 1 and 2. The resolution of s_LORETA is about 5 mm. Such single "pixel" effects are not common during cerebral responses to various physical stimuli or cognitive tasks when dozens of proximal pixels share the same activation or clusters of pixels, with each cluster containing dozens of pixels, are clearly discernable.

However such discrete and singular changes would be more congruent with entanglement. The magnetic energy within a volume can be calculated as $J=B^2 \cdot (2 \cdot 4\pi \cdot 10^{-7}\ NA^{-2})^{-1} m^3$, where B is field strength, the second unit is μ, and m^3 is volume. For a cubic volume with a width of 5 mm, the magnetic energy is $(10^{-12}\ T^2) \cdot (2 \cdot 10^{-6}\ NA^{-2})^{-1} \cdot 1.25 \cdot 10^{-7}\ m^3$ or $6.25 \cdot 10^{-14}$ J. Assuming the average of 48 neurons per .001 mm^3 (Blinkov and Glezer, 1968), then there would be $6 \cdot 6 \cdot 10^6$ cells per 125 mm^3 or one voxel. This would be equivalent to $\sim 10^{-20}$ J per neuron associated with the entanglement effect. This is a fundamental neuroquantum associated with the action potential as well as the resting membrane potential (Persinger, 2010).

If we assume that the average frequency of neurons within the voxel was 10 Hz, then the power would be $6.25 \cdot 10^{-13}$ W. The equivalent power density, assuming a surface area of the cerebrum to be $\pi \cdot 10^{-2}$ m^2, would be $2 \cdot 10^{-11}$ $W \cdot m^{-2}$. This value is within the same order of magnitude and within error measurement of the coefficient for the energy associated with photon emission from the right hemisphere during specific types of imagining (Dotta et al, 2012). The congruence between the energy intensity associated with the strength of the simultaneously applied magnetic fields at the two separate distances, the specific number of neurons occupying the voxel that is matched with the 10^{-20} J solution, and the equivalent power density to photon emission during cognition indicates the importance of this quantum.

The 10^{-20} J quantum may have universal prevalence and significance. As calculated by Persinger et al (2008), one solution for the total force within the universe is 10^{164} N which is derived from the product of its mass ($\sim 10^{52}$ kg) width ($\sim 10^{26}$ m) and intrinsic vibration (zitterbewegung) squared (10^{86} Hz^2). The equivalent numbers of Planck's length volumes within the volume of the universe (assuming it's a cube) would be 10^{78} m^3 and when divided by 10^{-105} m^3 would be 10^{183}. Consequently there would be 10^{-19} N per Planck's voxel. If this force within the domain of zero point potential oscillations were distributed over the wavelength of the precession for neutral hydrogen (10.8 cm), the equivalent energy would be $\sim 10^{-20}$ J. Such convergence obviously does not prove that the entanglement we observed involved a universal energy. However the solution that an average of 10^{-20} J per functional unit may exist throughout the universe in specific geometric domains may be useful for pursuing procedures that could allow the isolation of mechanisms.

We were surprised that visual stimulation did not produce the excess correlation over 300 km. Persinger et al (2010) had found that different light-flash frequencies applied to stimulus persons were reflected in the coherence of quantitative EEG values in response persons sitting in the dark in another room. However in that study the optimal coherence occurred when the rates of change of the angular velocity for the yoked circumcerebral magnetic field conditions were different than those employed in the current study. In the yoked study there were increases in power over the right parietal region for frequencies that were similar to the ones to which the stimulus person was being exposed at the same time.

In the present study, the "excess correlation" was noted when sounds or beat frequencies were presented to the stimulus person. Sound stimuli affect more central components of the temporal lobes and may convey more emotive information because of the contributions from the amygdala and hippocampal formation. The involvement of the latter would require the engagement of the entorhinal cortices and parahippocampal region which are the major loci for the afferent and efferent information for these mesiobasal structures. The parahippocampal gyrus is a multimodal integrator that exhibits pervasive connections to and from the entire neocortices.

If we assume a holographic like organization of the electromagnetic patterns that are manifested within the cerebral volume then information from the central integrator (the parahippocampal cortices) could be represented any where within the volume at any given time depending upon as yet unknown algorithms. Consequently "excess correlation" could occur within different punctate regions but would maintain the same quantum of energy and power. This was observed in the present experiments. There are clearly other interpretations.

One major question is at what critical mass would a person be aware that "something" is occurring within conscious awareness? There is convincing evidence that a critical mass of neurons is required for awareness of events to be reported. For example, in the phenomenon of "psychic blindness", whereby the person with a caudal cerebral injury is technically blind but avoids objects within his or her walking path, there are still residual neurons operating. At some critical number "awareness" of what is registered by sensory systems occurs.

Berns et al (1997), employing positron emission tomography (PET), showed that brain regions are responsive to novelty in the *absence* of awareness. Subtle changes in grammar during a reading task were associated with decreased blood flow within the right dorsolateral prefrontal cortices (Brodman area 45/46), the inferior parietal lobule, and, the superior temporal gyrus. The duration of the right prefrontal changes was consistent with the maintenance of contextual information, without awareness. It may be relevant that in many studies the right prefrontal region, particularly when activated, is associated with the reconstruction of memories including autobiographical references. The spatial regions involved with Berns et al (1997) were more extensive than the single voxel effects we measured and also included increased blood flow in the left premotor region, left anterior cingulate, and right ventral striatum.

Based upon our experience with s_LORETA, the typical numbers of voxels that are activated during normal daily experiences of thinking, solving neuropsychological tasks, or even relaxation that engages in the Default Mode Networks, several tens of voxels within a cluster or sometimes several clusters with these numbers of voxels display either increased or decreased power within specific frequency bands. The single voxel effect reported here would appear to be negligible in comparison and would be obscured by background activity or the "analytical overlay" of consciousness to employ a phrase from the protocol of Ingo Swann.

We suggest that this single voxel is non-trivial. Experimental evidence by Li et al (2009) has shown that repetitive high-frequency burst firing of a *single* neuron within the rat cortices can trigger the switch between cortical states as distinct as slow wave sleep and rapid eye movement ("dream") sleep. The energy associated with a single action potential is $\sim 10^{-20}$ J (Persinger, 2010) and with burst firing of ~100 Hz, this would be equivalent to 10^{-18} J. Li et al (2009) found that repeated burst spiking at 50 Hz for about 3 min resulted in a switch in state that could persist for more than 20 minutes. If a comparable process occurred in the human brain, this would indicate that only $(1.8 \cdot 10^2 \text{ s}) \cdot (5 \cdot 10^{-19} \text{ J} \cdot \text{s}^{-1})$ or $\sim 10^{-16}$ J would be required to shift the global cerebral state. Even if we assumed some recondite mass effect because the human brain is about 10^3 greater in volume than the rat brain, the equivalent energy would still be well within the magnitude of energy that we infer was associated with the single voxel changes in the response persons.

References

Berns, G. S., Cohen, J. D. and Mintun, M. A. Brain regions responsive to novelty in the absence of awareness. Science, 1997; 276: 1272-1275.

Blinkov, S. M. and Glezer, I. I. The human brain in figures and tables: a quantitative handbook. Basic Books: Plenum Press: N.Y., 1968.

Dotta, B. T., Buckner, C. A., Lafrenie, R. M. and Persinger, M A. Photon emissions from the human brain and cell culture exposed to distal rotating magnetic fields shared by separate light stimulated brains and cells. Brain Research, 2011; 1388: 77-88.

Dotta, B. T., Saroka, K. S. and Persinger, M. A. Increased photon emission from the head while imaging light in the dark is correlated with changes in electroencephalographic power: support for Bokkon's biophoton hypothesis. Neuroscience Letters, 2012; 513: 151-154.

Dotta, B. T. and Persinger, M. A. "Doubling" of local photon emissions when two simultaneous, spatially-separated, chemiluminescent reactions share the same magnetic field configurations. Journal of Biophysical Chemistry, 2012; 3: 72-80.

Julsgaard, B., Kozhekin, A. and Polzik, E. S. Experimental long-lived entanglement of two macroscopic objects. Nature, 2001; 413: 400-403.

Li, C-y.T., Poo, M-m. and Dan, Y. Burst spiking of a single cortical neurons modifies global brain state. Science, 2009; 324:643-645.

Persinger, M. A. 10^{-20} Joules as a neuromolecular quantum in medicinal chemistry: An alternative approach to myriad molecular pathways? Current Medicinal Chemistry, 2010; 17: 3094-3098.

Persinger, M. A., Koren, S. A. and Lafreniere, G. F. A neuroQuantologic approach to how human thought might affect the universe. NeuroQuanology, 2008; 6: 262-271.

Persinger, M. A., Saroka, K. S., Lavallee, C. F., Booth, J. N., Hunter, M. D., Mulligan, B.P., Koren, S. A., Wu, H-P., and Gang, G. Correlated cerebral events between physically and sensory isolated pairs of subjects exposed to yoked circumcerebral magnetic fields. Neuroscience Letters, 2010; 486: 231-234.