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Research Report

Photon emissions from human brain and cell culture exposed to distally rotating magnetic fields shared by separate light-stimulated brains and cells

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ABSTRACT

Light flashes delivered to one aggregate of cells evoked increased photon emission in another aggregate of cells maintained in the dark in another room if both aggregates shared the same temporospatial configuration of changing rate, circular magnetic fields. During the presentation of the same shared circumcerebral magnetic fields increases in photon emission occurred beside the heads of human volunteers if others in another room saw light flashes. Both cellular and human photon emissions during the light flashes did not occur when the shared magnetic fields were not present. The summed energy emissions from the dark location during light stimulation to others was about 10^{-11} W/m^2 and calculated to be in the order of 10^{-20} J per cell which is coupled to membrane function. These results support accumulating data that under specific conditions changes in photon emissions may reflect intercellular and interbrain communications with potential quantum-like properties.

1. Introduction

All living tissues exhibit very weak photon emissions (Popp, 1979, 1988) with cross-sectional densities in the order of 10^7 photons/s/m^2. Biophotons as candidates for signals for neural communication have been suggested both theoretically (Popp et al., 1988) and by direct measurement (Sun et al., 2010). Considering the inferential evidence that photons may not be massless (Tu et al., 2005) and the results of several experiments by physicists demonstrating entanglement between photons from shared sources (Smith and Yard, 2008; Jin et al., 2010), the potential for such "excess correlations" between pairs of aggregates of cells or pairs of brains separated by non-conventional distances was considered a reasonable possibility. Recently we (Persinger et al., 2010a) reported that pairs of human subjects whose separate cerebral spaces were exposed to the "same" circumcerebal magnetic field and changes in angular velocity displayed evidence of "macroentanglement" as inferred

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by electroencephalographic power spectra. In the present series of experiments we demonstrated that cell cultures or human brains housed in darkness displayed photon emission while being exposed to the same rotating (circumcerebral), phase-modulated magnetic field as yoked equivalents (cells or brains, respectively) when they were stimulated by light flashes.

The role of the photon in macroscopic biological processes is not a new discovery. During the 1920s and 1930s when quantum mechanics was being applied to understand and to produce atomic fission more than 500 papers were published on the subject of mitogenetic radiation (Gurwitch, 1988; Quickenden, 1974; Scott et al., 1991). The general observation was that living cells emitted photonic radiation with wavelengths within the 190 nm to 5000 nm range at between 10^5 and 10^7 photons/m^2 s which could stimulate other cells to divide. More recent data indicate photon emissions also reflect other physiological states, such as heart rate variability (Yoon et al., 2005). They appear to arise from excited singlet oxygen ($^1O_2$) and excited triplet state carbonyls (Tilbury and Quickenden, 1988) that are derived from lipid peroxidation, phagocytosis, enzymatic reactions and interactions with oxygen radicals (Vogel and Suessmuth, 1988). The first experimental demonstration of spontaneous and visible light-induced photon emissions as predicted by Bokkon et al. (2010) from rats' eyes was reported by Wang et al. (2011).

Ultraweak photon emissions, or biophotons (Inaba, 1988) have been measured in the range of 10^{-12} W/m^2 from the exposed cortices of rats (Kobayashi et al., 1999) and 10^{-11} W/m^2 from sliced preparations of hippocampal sections (Isojima et al., 1995). In the latter study the emissions were coupled to theta activity. For comparison the typical background energy levels for cosmic rays is about 10^{-13} W/m^2 (Koenig et al., 1981). There may be a neuroquantal basis to these emissions (Persinger, 2010). The energy available from an action potential (1.2×10^{-1} V) upon a unit charge (1.6×10^{-19} A s) is about 2×10^{-20} J, a value that also emerges for the biophysical substrates that contribute to resting cell membrane potentials. Direct measurements of photon emissions from mouse melanoma cells that have been subjected to "stress" by removal for several hours from the incubator reflect this quantal value (Dotta et al., submitted for publication). Under these conditions the total energy output from photon emission was the systematic sum of the 10^{-20} J per cell for the total population of cells (about 1 million).

Photon emissions from more integrated neural function have been measured during meditation and states of consciousness (Schlesbusch et al., 2005). Dotta and Persinger (submitted for publication) measured significant increases in biophoton emission by a photomultiplier tube (PMT) near the right hemisphere but not the left for most volunteers when they sat in a dark room and imagined light compared to simply casual thinking. The energy increase was about 10^{-11} J/s and was convergent with the estimated number of neurons (from functional Magnetic Resonance Imaging studies) displaying about 10 action potentials/s (10 Hz) each with an energy emission in the order of 10^{-20} J. These empirical measurements were remarkably congruent with the calculations by Bokkon (2005) who has suggested that visual experiences, particularly dreams, may actually be awareness of a matrix or field of biophotons within the cerebrum rather than only a psychophysical equivalent of action potentials and line codes.

There is ample evidence of photon storage within biological systems that may be much higher than expected (Bokkon et al., 2010). Popp (1979) argued that glucose contains stored virtual photons whose ultimate origin was the sun. Popp's model is that each cell corresponds to a quantum state of the system under study. One manifestation of quantum is the principle of superposition of states where a new state of a system shares properties of the composing states regardless of space or time (Aczel, 2002). This entanglement or excess correlation (Arnesen et al., 2001) allows quantum communications (Ambjorn et al., 2004) such that a change in polarity of one previously proximal photon results in reverse polarity of the other at any distance. Experiments have demonstrated such effects in free-space at distances greater than 10 km (Jin et al., 2010).

The photon may display a rest mass with an upper limit about 10^{-52} kg (Tu et al., 2005). The most direct consequence of this "finite mass" for brain function is the frequency-dependence of the velocity of the electromagnetic (EM) fields moving through space. As a result the phase velocity differs from the group velocity. Group velocity refers to the movement per unit time of the modulation or envelope of the overall shape of the wave pattern's amplitudes. Phase velocity refers to the spatial-temporal displacements of or within the entire envelope. Both properties have been implicated in the cerebroelectromagnetic bases of consciousness (Llinas and Ribardy, 1993).

A second feature of a potential nonzero rest mass for the photon is the emergence of a third state of polarization in which the vector of the electric field points along the line of motion. The most obvious general implication for neuroscientists if there are non-massless photons is that new properties may be responsible for behavioral-correlated brain phenomena previously ignored or not pursued (Jahn and Dunne, 1987; Radin, 1997). If photons are entangled between cells separated by significant distances then different perspectives for the operation of the syncytium or glial matrices and even metastases of cancer cells might be considered.

The concept of coherent long-range interactions in living tissue was developed by Froehlich (1980) to provide a basis for the spatial and temporal order of biological system. The question that arises from this concept is: what is the absolute spatial distance this coherence could occur if the space–time structure of two spaces were very similar? In traditional physics the Tesla effect occurs when an electromagnetic pulse is induced in one coil and an induction occurs at significant distances in a second identical coil. Another related more quantum-like concept, developed by Sheldrake (1981) is that two near-identical morphogenic fields can interact through resonance at very large distances because of the intricate shared spatial complexity and organization (Persinger et al., 2008a,b).

We have previously shown that an effect that appears to meet some of the criteria of "macroentanglement" occurred when two people have a history of shared spatial proximity (Persinger et al., 2008b). When pairs of individuals were separated by about 5 m to 10 m but exposed simultaneously to the same circumcerebral magnetic field (controlled by the same computer) with specific second and third derivatives (acceleration and rate of change in acceleration), changes of power within the theta range occurred in one person while the

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other person imagined spatial proximity. This did not occur with randomly selected individuals without a shared past. The effect was more objectified recently (Persinger et al., 2010a) in this "double, shared field" procedure by showing that when one person was exposed to different frequency light flashes the other person sitting in the dark in another room showed comparable peaks in brain frequency bands as measured by quantitative EEG (QEEG). The change in QEEG power was not elicited when the shared magnetic fields were not generated.

For the present study we designed equipment that allowed the simultaneous presentation of identical spatial-temporal configurations of weak (~1 μT) rotating magnetic fields to either coupled cell cultures or coupled human beings. We called this procedure the double field method (Persinger et al., 2008b, 2010). One person or one dish of cells was placed in a closed acoustic chamber (which was also a Faraday cage) while a second person or dish of the same cells were placed in dark room about 10 m away. Photon emissions were recorded by a PMT (Photomultiplier Tube) in the dark room while the subjects or cells in the acoustic chamber were exposed to light flashes (1, 4, or 7 Hz) in a 60 s on 60 s off protocol with complex fields present for 6 min or absent for a similar period.

We selected mouse melanoma cells because of the reliability of their photon emissions to pharmacological interventions related to plasma membrane resting membrane potentials, which in these cells is around 30 mV (Dotta et al., submitted for publication). About an hour after removal from incubation (37 °C to between 21 to 22° C) aggregates (10^6) of these cells in culture medium display very conspicuous increases in photon emission. This is a departure from many approaches where biophoton emissions are measured within the incubated (37 °C) environment. Often such emissions require the addition of an exogenous energy source such as radiation to produce the effect.

As shown in Fig. 1, the output can be experimentally and reliably altered in a predictable manner by reducing the cell numbers or removing glutamine from the medium. We interpreted this persistent emission of photons as indicative of the membranes' more or less continuous responses to the decreased ambient temperature by generating intrinsic processes to maintain membrane potential (Dotta et al., submitted for publication). When there were half the numbers of cells the total photon energy output was half as much. When there was no source of energy, such as in the glutamine-deprived cells, there was minimal photon emission. Its magnitudes were similar to when only the dishes (no cells) containing medium were measured. That the major source of the photon emission is very likely to be the plasma cell membrane is suggested by the rapid and brief duration of emission within 85 s when 1 M KCl is delivered to the plates. The total output is about 10^{-14} J which is the energy equivalence of the summed membrane potentials for the 10^6 cells. A second injection did not produce a response (Fig. 2) presumably because the membranes were depolarized. Addition of 2 M KCl (to fresh cell cultures) produced the same energy output (at least within measurement error) but within half of the time (about 42 s).

On the bases of previous research we selected circular rotating magnetic fields produced by eight solenoids separated by 45° and secured to a circular strip of Velcro with a perimeter of between 55 and 60 cm. As shown in Fig. 3, the devices were placed around the heads or around the cell dishes for subjects or cells in the stimulus (chamber) room and the "response" or PMT room. We selected circularly rotating magnetic fields because they are always accelerating.

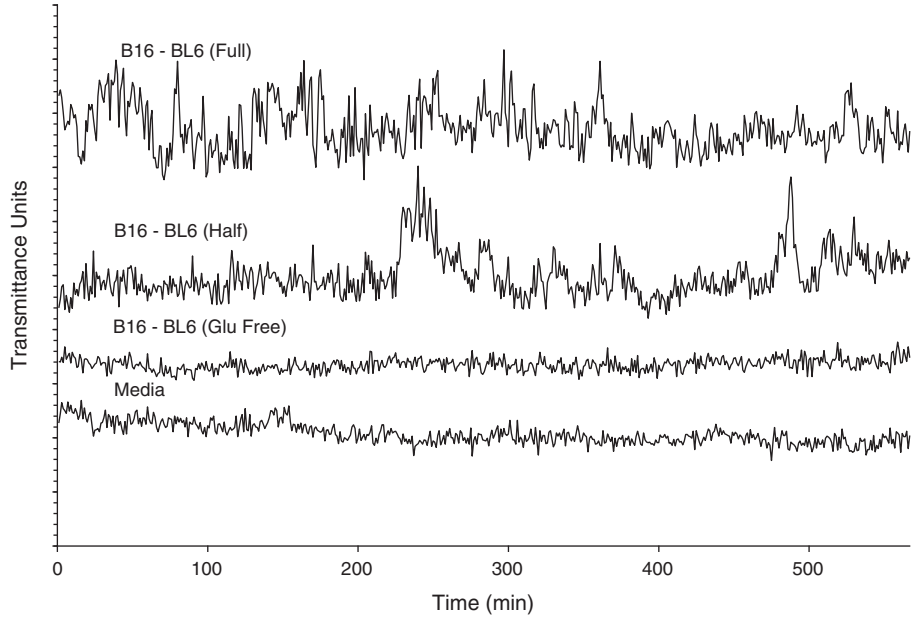

Fig. 1 – Units of photon emission over about 8 h for B16-Bl6 mouse melanoma cells maintained in darkness after removal from incubation (37 °C) and placed at room temperature (21–22 °C). The first line is full or 10^6 cells/dish. The second line is half or 5×10^5 cells/dish. The third line is 10^6 cells in glutamine free medium. The fourth line is simply the media without cells. 1 unit is about 10^{-11} W/m^2.

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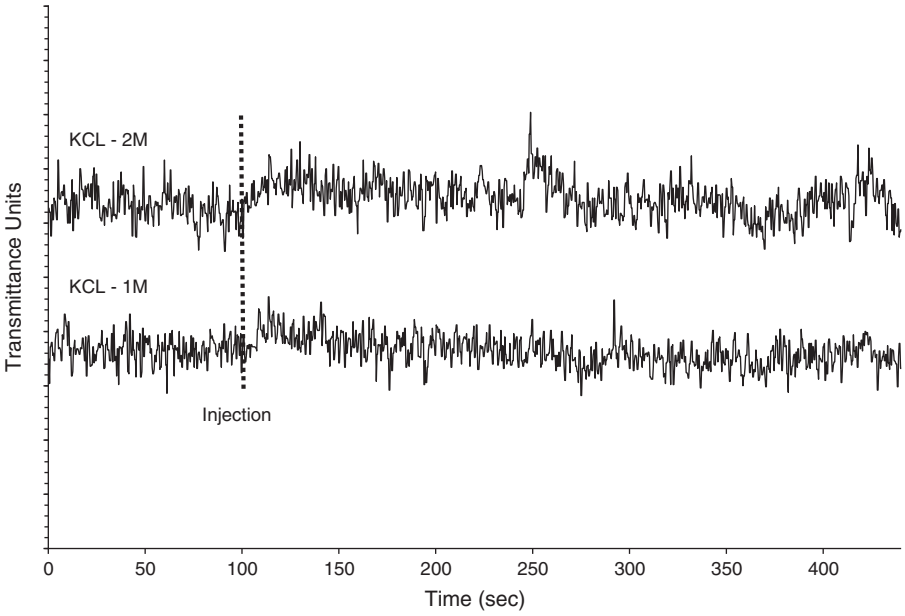

Fig. 2 – Sample energies of photon emissions (vertical axis) during the first 300 s (5 min) after injection (vertical dotted line) of either 2 M or 1 M potassium chloride (~0.4 cm^3) into the 2.5 cm^3 volumes in the plates each containing 10^6 melanoma cells. 1 unit is about 10^{-11} W/m^2.

There were two complex patterns that were used as the base frequency-modulated fields. Depending upon the block of the experiment they were continuously generated at different rates of rotation in a counterclockwise (as seen from the top) direction. The first pattern was an accelerating frequency modulation ("Thomas" pulse). The second pattern was a slowing frequency modulation ("burst pattern"). Their shapes and methods of production have been published elsewhere (Martin et al., 2004). At the level of the organism (rats), 30 min of whole body exposure to these fields at strengths of 1 μT (10 mG) produces analgesia to electric and thermal stimuli that is equivalent to a subcutaneous injection of about 4 mg/kg of morphine.

Based upon concepts of the neurobiological bases of consciousness and re-entry processes (Edelman, 1989; Llinas and Ribardy, 1993) the initial duration of the field presentation at each solenoid was 20 ms with either a +2 or −2 ms change. This meant that (starting over the left frontal region), moving counterclockwise, the durations would be 20, 18, 16, 14, 12, 10, 8, and 6 ms (sum = 104 ms or 9.6 cycles/s) for 20 + 2 ms and 20, 22, 24, etc. (sum = 216 ms or 4.6 cycles/s) for 20 − 2 ms.

External applications of 36 GHz to 55 GHz EMF (electromagnetic fields) have been reported to decrease bioluminescence in bacteria while geomagnetic activity is correlated with increases in these phenomena (Berzhanskaya et al., 1996). During strong geomagnetic storms photon emissions increased by 350% and were synchronized for about 20 min with periodicities of about 10 mHz (Berzhanskaya et al., 1995). We appreciated that the temporal patterns of magnetic fields are as multipotent as the spatial patterns of molecules that determine their function and that all systems are constantly immersed within the static and solar-driven, time-varying component of the earth's magnetic field. Consequently we decided to directly compare the photon emissions during the experimentally time-varying magnetic fields with the natural variations of intensity in the earth's magnetic field proximal (<1 m) to the cells or volunteers.

2. Results

2.1. *Increased photon emission of cells housed in darkness when exposed to the same spatiotemporal magnetic configuration as cells in a separate room stimulated by light*

The first major observation was the occurrence of a "priming" effect. The results of four replications (with a total of eight different plates of cells) showed that when both sets of one million B16 cells were exposed to the double field paradigm when the decreasing frequency modulated field was rotated first for about 6 min (360 s) no changes in energy emission was measured from the response cells when the stimulus cells in the other room (the closed, acoustic chamber/Faraday room) were exposed to flashing light stimuli for 60 s on and 60 s off sequences. The intensity of the flashing lights applied directly over the closed plates containing the cell cultures in this "stimulus" room was about 10,000 lx.

However subsequent presentations of the base accelerating frequency field for 6 min resulted in statistically significant [$F(1,7) = 67.91$, $p < .01$; $eta^2 = .92$] increases in photon emission from the cells in the dark when the cells in the chamber received light flashes. The mean net increases in photon emissions (sampled once per second) compared to when there were no light flashes but the same field was present are shown in Fig. 4. This increase was equivalent to 2.5×10^{-11} W/m^2, or, given the aperture of the photomultiplier unit, about 10^{-15} J/s.

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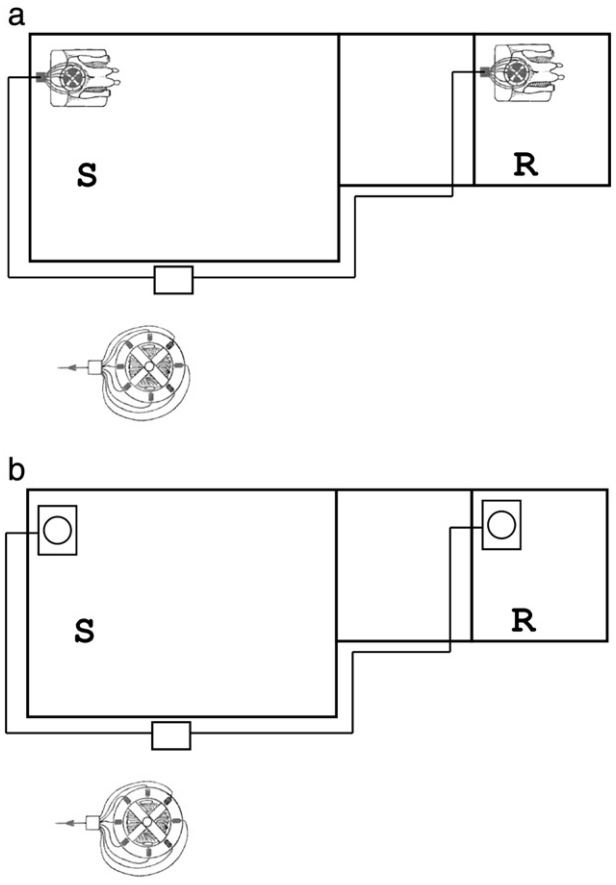

Fig. 3 – Schematic of paradigm where one aggregate of cells (b) or one person (a) was located in a closed chamber and exposed intermittently to light flashes while another aggregate of cells or another person was localized in a dark room about 10 m away. The two people or two plates of cells shared the same circularly, rate changing, rotating magnetic field configuration that was controlled by the same computer.

This robust effect did not occur when the reverse order of base frequencies were presented to the cells. There were also no significant differences in increased photon emissions between the frequencies of the light flashes which were 1 Hz, 4 Hz, or 7 Hz. Similarly, if there was no field present, there was no significant difference between photon emissions from the dark room cells when the cells in the chamber received or did not receive light stimulation. An example of this result is shown in Fig. 5.

Each B16 cell's membrane potential is about 30 mV. The correlative quantum of energy would be 3×10^{-2} V * 1.6×10^{-19} A s or 4.8×10^{-21} J per cell. With 10^6 cells per dish, the total output for the culture was 10^{-15} J/s which is what we measured. The energy contained within the magnetic field from the circularly rotating magnetic field intensities can be derived from the equation $J=(B^2/2*4\pi*\mu)*$volume (Halliday and Resnick, 1962) of the cell (melanoma cells are about 20 μm in diameter). With an average intensity of 1 μT, there would be $(1\times10^{-6}\ T^2)/2.5\times10^{-6}\ N/A^2)$ * the volume of a cell $(4\times10^{-15}\ m^3)$ or about 2×10^{-21}J per cell volume. This means that the

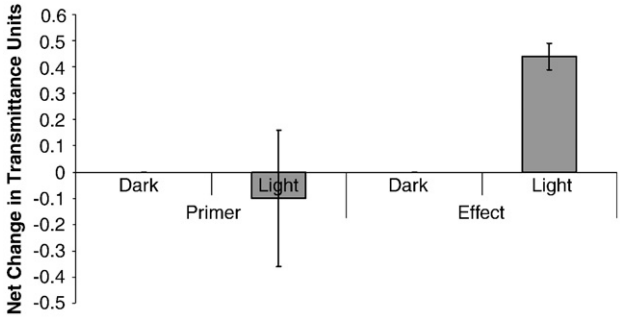

Fig. 4 – Means and standard errors of the mean (SEM) for net changes in photon emission from cells in the dark room when those in a second room received light flashes for the first (slowing) and second (accelerating) base frequency pattern. The time required to complete one rotation was either 104 or 206 ms. One unit in transmittance = 5×10^{-11} W/m^2.

amount of energy available to the cells in both the light-flash and dark rooms from the simultaneously rotating magnetic fields would have been in the same order of magnitude as that emitted from the dark cells when the other cells were being exposed to light flashes.

2.2. *Experimental and natural magnetic field effects on photon emission*

We also found a significant increase in photon emission from the dark room cells when the shared, experimentally generated magnetic fields were on vs. off and with no light stimuli. This global increase [$F(1,1222)=765.21$, $p<.01$, eta$^2=.39$], which exhibited a much smaller effect size than the changes associated in the previous section with the light flashes to the other coupled cells, only occurred when the plates containing cells were over the PMT. If the plate contained only medium or nothing (barren plates), this increase in photon emission from the changing rate, rotating magnetic fields did not occur. The absence of significant difference between the field-on vs. field-off conditions without the

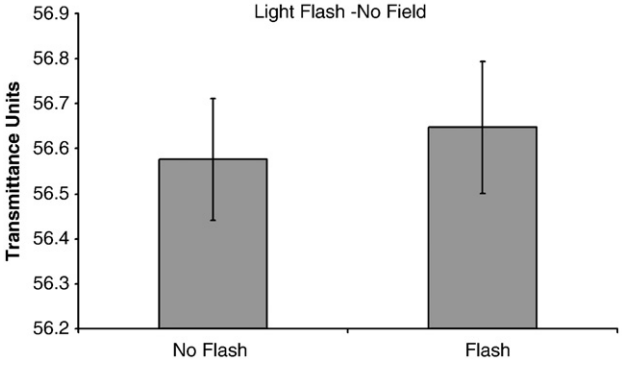

Fig. 5 – Means and SEMs for units of photon emissions from a cell culture during the no flash and flash conditions when the double shared field was not activated but only a low-level d.c. static field was present during the "idling" period between shared (yoked-presentation) rotating field generations.

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presence of cells strongly indicated our observations were not due to instrumental artifacts.

During post hoc analyses of the data we found that the slowing rate (20, −2 ms) of circularly moving magnetic fields produced significantly [$F(2,1772) = 182.8$ $p < .001$; $eta^2 = .20$] more photon emission than the accelerating (20, +2) field. As can be seen in Fig. 6, this meant that the a single rotation that required 216 ms generated more photons than the same field configuration being rotated within 104 ms. We reasoned this was a very interesting phenomenon that was not likely due to Faraday induction-type effects within the cells because it is dependent upon the rate of change of magnetic field intensity over time. Our measurements indicated that slowing this particular field (and hence reducing the numbers of pulses from the base field per unit time) increased photon emission.

To discern if accelerating or slowing fields, per se, were important we ran additional experiments where the initial duration of the base frequency fields at each solenoid was either 200 ms, 100 ms or 20 ms and the rate of change was either ±20 ms, ±10 ms, or ±2 ms (our original pattern), respectively. Again, the + means that this value was serially subtracted from the duration at each solenoid and – means that value was serially added. Fig. 7 shows the results of three replicates. Quite clearly, regardless of the duration the slowing rotations were associated with about 60% more photon emissions than accelerating rotations [$F(6,244) = 30.60$, $p < .001$].

In order to accommodate the reports that cells, like bacteria, emitted more photons during increased geomagnetic activity, we measured the correlation between the changes in the ambient geomagnetic field and photon emissions. On three separate days (12 h each day) over a 3 month period when there were no cells in the dish over the PMT aperture and on three separate days when there were viable cells in the dish over the PMT aperture photon emissions were recorded synchronously once per min. At the same time intensities of the north–south (X), east–west(Y) and vertical (Z) components of a magnetometer whose sensor was less than 1 m from the PMT were recorded once per minute.

When the cells were not present there were weak but statistically significant ($p < .01$) negative correlations ($df = 719$) between the PMT measures and the Y and Z components of geomagnetic intensity. The means and standard deviations

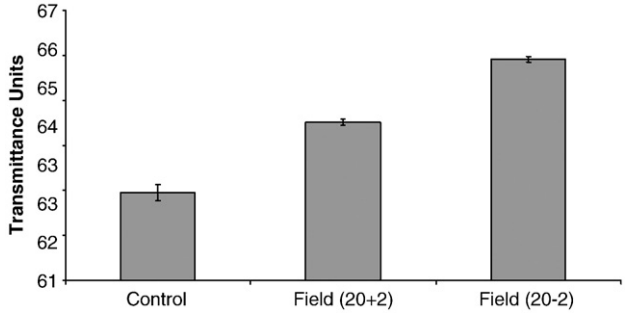

Fig. 6 – Means and SEMs for net increases in photon emission from B16 cells while other cells received light stimulation when the accelerating base pattern's rotation velocity was slowing (–) from an initial 20 ms at the first solenoid by 2 ms per solenoid or accelerating (+) from an initial 20 ms by 2 ms.

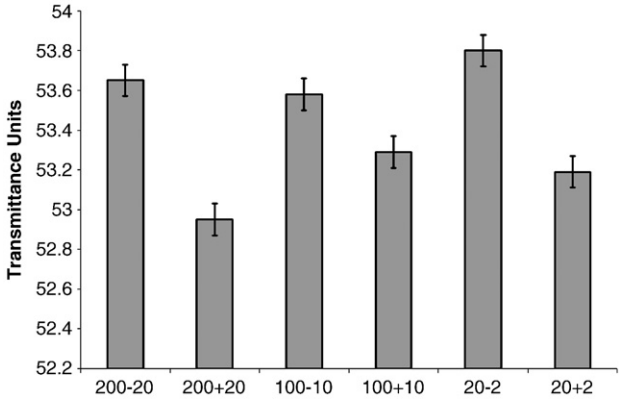

Fig. 7 – Means and SEMS for net increases in photon emission from B16 cells for various changes in rotational velocities. The times required for one complete rotation were 2160 ms (200–20), 1040 ms (200+20), 1080 ms (100–10), 520 ms (100+10), 216 ms (20–2), and 104 ms (20+2). Note the slowing variable rotations produced the greatest photon emission.

for the correlation coefficients (*r*s, Spearman rhos were similar in magnitude) for the three dimensions were X (.03, .22), Y (–.12, .16) and Z (–.16, .08), respectively. However when the cells were present there were statistically significant positive correlations between photon emission and intensity particularly within the vertical (Z) axis. The means and standard deviations were X (–.04, .10), Y (.22, .09) and Z (.33, .07), respectively. Consequently for 12 h increments the changes in the immediately proximal natural magnetic fields explained not more than about 10% of the variability in cell-generated photon emission.

The means and SDs (in parentheses) of the slopes for the regressions for the increase in energy emission when cells were present with increases in local magnetic field intensities were X: –.001 (.03), Y: .06 (.003) and Z: .12 (.03). Consequently, on average, for every 8–16 nT increase in intensity for the Y or Z component during the course of the observations there was a 1 unit (5×10^{-11} W/m^2) increase in energy output from the cells. This meant that our experimental fields, with intensities in the order of 1 μT presented for about 10 min were producing the same effects that required about 100th the magnitude (10–15 nT) from natural variations when present for much longer periods of time. In fact the natural:experimental duration ratio was about 100:1.

The most conspicuous difference between our experimental 1 μT fields that were rotating between 4 and 10 times per second and the natural fields which traditionally change within the mHz range (Bubenik et al., 1983) was timing. Spectral analyses of the periodicities in the magnetometer data verified the results of other researchers of a wide-band peak in power with the greatest amplitudes within 1–10 mHz (10–15 min to 1.6 min). In other words a smaller change over a longer time produced energy emissions when the cells were present that were similar in magnitude to a stronger experimental field changing more quickly.

To discern if the spectral pattern of cells during our 12 h observations were related to the contemporary changes in the natural magnetic field intensities, cross-spectral analyses

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were completed between the power peaks for the cells and each of the three magnetometer coordinates. The cross-spectral correlations (*r*) for three samples (SDs in parentheses) were X: .46 (.13), Y: .48 (.13) and Z: .45 (.13). A sample scattergram is shown in Fig. 8. The coefficient of determination, or shared variance, was 40% (r=.63, p<.001). Obviously this strong correlation does not eliminate the potential presence of a third variable that caused both.

2.3. *Photon emission increases from brains during shared circumcerebral magnetic stimulation when the others are light stimulated*

The results for the double field applications to three separate pairs of unrelated human brains were similar to those found for the cells. During the first 6 min (on–off frequency equivalent to ~3 mHz) of exposure to the slowing base frequency field, there was no significant increase in photon emission as measured by the PMT at 15 cm from the right side of the head of the person sitting in the dark while the person in the acoustic chamber was being stimulated (60 s on) or not simulated (60 s off) with diffuse, whole room 1 lx light flashes.

During the next field exposure (6 min) when the accelerating base field was rotating around the heads of both pairs at the same changing rate, there were statistically significant increase in photon emissions. Fig. 9 shows the means and SEMS for the net changes in photon emission for all trials from all persons sitting in the dark when the persons in the chamber were stimulated with light flashes during the "primer" (Thomas pulse) and the burst presentation phases.

The increase in energy was about half (0.25 units) of that observed for the cells but was comparable for each of the three pairs of individuals. Fig. 10 shows the pattern for one pair of individuals. When the shared fields were not present the increase in photon emission from the head of the person in the dark did not occur when the person in the chamber was watching the light. The strongest photon emission occurred when the rotational parameters were 20–2 or the average rotational frequency was 4.6 Hz.

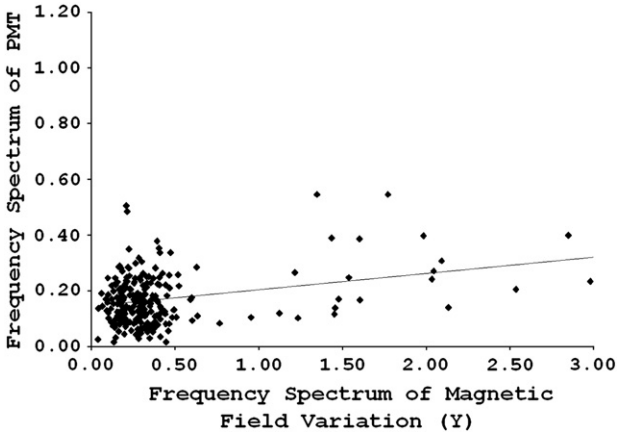

Fig. 8 – Sample cross-spectral correlation between temporal variations in the Z component of the earth's magnetic field and the variations in photon emission at the same time from B16 cells with no experimental fields applied.

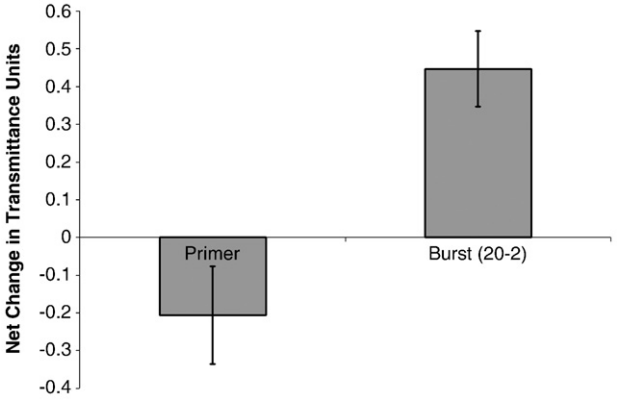

Fig. 9 – Means and SEMS for the net change in photon emission from the heads of people sitting in the dark while others saw light flashes compared to periods of no light flashes during when the base pattern was slowing (Thomas) or accelerating (Burst). The effect was similar to those induced in cell cultures.

3. Discussion

The human brain can be defined as a volume of highly organized matter composed of about 10^{26} proton mass equivalents that occupy 10^{-3} m^3 of space for about 2 Gs. Concepts of neuroQuantology (Persinger et al., 2008a), derived from the application of quantum mechanics (Bohr, 1958) to cerebral function, have begun to be applied to neuroscience in general (Jibu and Yause, 1995) and more exotic functions in particular (Jahn and Dunne, 1987; Radin, 1997). Matter can be defined as particles or as waves (de Broglie, 1962), or, in terms of spatial structures or as temporal patterns. This duality is present in molecular organization vs. electromagnetic configurations, respectively.

That photons as discrete quanta are emitted during shifts in orbits by electrons is a fundamental assumption in modern physics and chemistry. If macrocosm reflects microcosm or levels of scientific discourse share similarities (Persinger and Koren, 2007; Persinger, 1999), photon emissions as sources of potential information between cells, including neurons, would also be expected. There is now empirical evidence to support this inference (Isojima et al., 1995; Sun et al., 2010).

In the present study both pairs of cell dishes or pairs of human brains displayed comparable effects suggestive of "excess correlation" which is one definition of entanglement. We had selected the initial duration for the first solenoid to be 20 ms because of previous success with modifying conscious states (Persinger et al., 2008b; Persinger and Koren, 2007). It is considered within the range of emergent patterns from recurrent re-entrant pathways (Edelman, 1989) and both the phase-modulation and rostral-caudal latencies of the continuously "recreated" transcerebral electromagnetic fields (Llinas and Ribardy, 1993).

There are two important implications from our results. First, temporal derivatives are important for this phenomenon and there may be an important influence from the differentiation of group velocity vs. phase velocity, one of the consequences of

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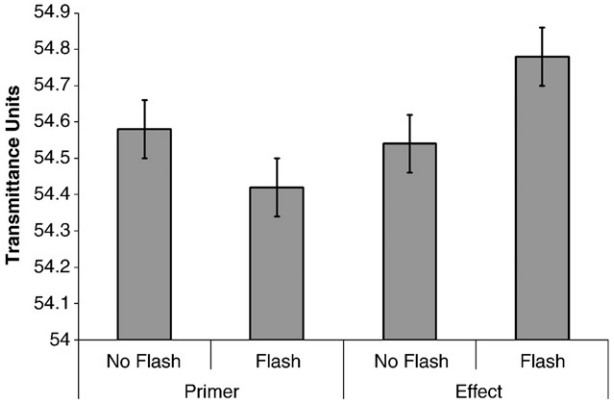

Fig. 10 – Means and SEMs for raw transmittance from the PMT for one subject's head during the "primer" trial 1 and "elicitation" trial 2 when the person in another room sharing the same circumcerebral rotating magnetic field were observing light flashes vs. no light flashes.

photons displaying a very small but nonetheless quantifiable mass (Tu et al., 2005) if this were ever verified experimentally. Second, the phenomenon is not a simple Faraday effect ($\partial B/\partial t$) from current induction because if the latter were correct, then the accelerating (9–10 Hz) field should have produced more current-driven energy emissions.

We also measured a reliable increased change of .25 unit or about 1×10^{-11} W/m^2 (~10^{-12} J/s) near the head of the person sitting in the dark when the yoked person in another room was exposed to light flashes. An action potential with a net change of 1.2×10^{-1} V exerts upon a unit charge ~2×10^{-20} J (Persinger, 2010) which would be equivalent to action potential-coupled photon emissions from about 100 million neurons. If one assumes only a 10% transmittance through the skull, then the original number approaches 1 billion neurons.

Such numbers of photons and neurons would meet the criteria of Bokkon (2005) and Bokkon et al. (2010) for the role of biophotons in actual experience. It may be relevant that one of the three subjects in the three pairs we tested reported experiencing "diffuse white light" while sitting in the dark during five of six intervals when the yoked person in the chamber was being exposed to diffuse flashing light. Although this experiential correlate has significant ramifications for Bokkon's model, we must design more precise experiments to answer these questions.

In addition to the conspicuous enhancement of biophoton emission by applying extracellular K+, there was additional evidence of a plasma membrane source. If glutamine- or glucose-based reaction energies were the primary source, the photonic output would have been much larger. For example, the metabolic energy from 10^6 cells with each cell's metabolic energy in the order of a pJ/s would have been a microJoule. For the human cerebrum, the output (if within the visible photon range) would have been in the order of 10 J/s (or ~60 W/m^2 assuming a surface area of .15 m^2) or similar to day light if total transmission occurred.

The effect did not occur immediately but appeared to require a "priming exposure" for about 6 min before subsequent presentations of light flashes during a second 6 min period produced the phenomena. Such "temporal sequencing" has been noted in our studies involved with the sensed presence (Persinger et al., 2010b; St-Pierre and Persinger, 2006) when burst-firing magnetic fields with asymmetric gradients ranging from 10 to 100 pT/μm originated over the right hemisphere (Meli and Persinger, 2008). We suggest this time was required to stimulate the processes, like "charging" capacitors, before a threshold was reached. The critical question is, once this threshold was reached and the conditions for "entanglement" had been met, would the presentation of photons to one locus result in an instantaneous emission of photons from the other locus?

The most parsimonious source of the photon emissions from the cells or people in the dark are at present presumed to emerge from the membranes of the "stressed" B16 cells or neurons of the brains housed in the dark room in response to the presentation of light flashes to the "stressed" cells or cerebral neurons within the brains of the subjects in the other room. A more exotic explanation is the photons measured by the PMT are fractions of photons presented to the cells or to the people in the chamber that were then "manifested" within the cells or people in the dark room.

This might be considered a variant of entanglement (Aczel, 2002) such that what occurs in one entangled space must be balanced in the other space in a manner similar to the simultaneous alteration of spin or polarity in coupled pairs of particles or energy packets. In either situation a membrane was required (as cells in a dish or neurons in a human brain) because the effect was not measured when only space was present during the light stimulation. We suggest that the experimental production of very complex spatiotemporal magnetic fields in two separate spaces allowed the two loci, within the realm of the photon, to be the "same space".

4. Conclusion

Our results suggest that when two aggregates of genetically similar cells are "stressed" by removal from 37 °C (to 21–22 °C) or two aggregates of highly organized cells (human brains) are experimentally induced to be coherent by simultaneous application of temporally complex, circularly rotating weak magnetic fields, the stimulation of one of the pair by light results in the emission of photon energy from the other. The energy emission was within the order of 10^{-11} W/m^2. For the plates of cells, this meant an energy emission of about 10^{-20} J/s per cell which is comparable to that coupled to the cell's plasma membrane electrical potential. The cumulative energy storage from the intensity of the applied magnetic field within the cell volume matched that value, at least in order of magnitude. For the human brains the energy emission was similar in order of magnitude and equivalent to the estimated value for action potentials of several hundreds of millions of neurons.

The importance of the presence of a living system with a functioning membrane was shown by the absence of any change in photon emission when there were no cells present and the fields were presented. The discrete band of energy that was emitted when cells were present and light stimuli were presented to others was within the range expected for

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energy equivalence of the plasma membrane. Even natural variations in the geomagnetic field resulted in weaker and opposite polarity (negative) correlations when no cells were present.

Because only a few 10 s of seconds of changing rate, circular 1 μT magnetic fields were required to produce photon emissions whereas several thousands of seconds were required for the same increment of photon change to be associated with natural variations in the geomagnetic field, there is a realistic possibility that under special conditions "excess correlations" could occur "spontaneously" when pairs of units separated by distance are exposed to identical weaker configurations magnetic fields (natural or synthetic) for more protracted periods.

5. Experimental procedures

5.1. *Cell culture and treatments*

B16-BL6 mouse melanoma cell cultures were maintained in 150×20 mm tissue culture plates (Sarstedt, Laval, Qc) in Dulbecco's Modified Essential Medium (DMEM, Hyclone, Logan, UT) supplemented with 10% fetal bovine serum, 100 μg/m streptomycin, and 100 U/ml penicillin (Invitrogen, Burlington, ON). The cells had been incubated at 37 °C in 5% CO_2. For experiments, the cell monolayers were harvested by incubation in 0.25% trypsin-EDTA, collected by centrifugation and seeded onto 60×15 mm tissue plates to a final concentration of 10^6 cells/plate each containing a total volume of 2.5 cm^3.

5.2. *Experimental detection of photon emissions*

Between 30 min and 60 min after removal from the incubator the single plate of 10^6 cells was placed directly over the aperture (12.56 cm^2) of the sensor of a PMT. A Model 15 Photometer with a separate meter housed in another room containing a unit scale that ranged in single units from 1 to 100 from SRI Instruments (Pacific Photometric Instruments) detected photon emissions. The PMT housing (BCA IP21) for the RCA electron tube (no filters) was located in a box whose inner surface had been painted black which was covered by 10 layers (8 cm) of thick cotton cloth.

There were two methods employed for calibration. At higher intensities (> 1 lx) values were calibrated by comparison to a digital luxmeter while calibration for lower intensities was determined by responses to a 600 nm LED at 10 mA (5 millicandella; 2 millilumens/45°) at various distances. The lux values were transformed to W/m^2. Calibration indicated that a change of 1 unit of the photometer was equivalent to 5×10^{-11} W/m^2 or about 10^{-14} J/s per group of cells within the area of their containers.

The output was transformed to mV (millivolt meter) and sent to an IBM ThinkPad laptop (Windows 95) set to obtain three samples per second for the quicker (<30 min) experiments including the double, shared field procedures for cells and subjects. For the experiments designed to compare local changes in the earth's magnetic field and the demonstration of the duration of photon emission from cells over 6 h, photon emission values were sampled once per minute. Both measurements were converted to the equivalent of J/s. The average (mean) values for the outputs were computed for the temporal increment associated with the specific experiment.

For the KCl injections that were employed to illustrate the likely membrane source of the photons (in addition to the many signaling experiments by Dotta et al., submitted for publication), 1 M or 2 M solutions were delivered to the cells in plate through a small caliber intramedic tubing whose tip was inserted into the 2.5 cm^3 of fluid containing the cells within the plate and held in place by the wooden component of a Q-tip. 0.4 cm^3 amounts of the KCl solutions were injected into the plate over a 10 s interval once the baseline had been taken.

5.3. *Magnetometer measurements*

The sensor of a MEDA Fluxgate magnetometer was placed 0.5 m from the PMT sensor. The outputs for the X (north–south), Y(east–west) and Z (vertical) magnetic field have been recorded once per minute 24 h per day for the last 3 years within our laboratory. The data for the present experiment were collected and stored by MEDA software on a second IBM laptop. For experiments involving this instrument for longer-term measurements over several hours of collection of data it and the PMT were started within 5 s of each other to insure the match between successive 1 min increments for comparison analyses.

5.4. *Design of the experimental apparatus*

The equipment and procedure were similar to those described in more detail elsewhere (Persinger et al., 2010a). The two identical circular arrangements of 8 equally space solenoids (45° separation) were housed in two locations in different rooms and were separated by 10 m. The circumference of the circular arrangement formed by the eight solenoids was 55–60 cm. Each solenoid was a reed switch that was connected to custom constructed equipment (Canadian Patent 2,214,296). The two circular arrangements of solenoids were connected to the same 286 Computer that was housed in a room separate from the two rooms containing the two coils. This computer controlled the delivery of the timing and amplitude of the current delivered to the solenoids that generated the magnetic fields. This model of DOS-based computer displays reliable point durations ("time pixels") to insure that the current durations (and hence magnetic fields) are not affected by competing software operations and are always based upon actual 1 ms intervals. Computers constructed after the 286 and involving Microsoft software are less consistent with delivering exact pixel durations and require additional software to adjust for each computer's intrinsic discrepancy.

The software was programmable to generate the applied pattern at each solenoid for different durations. For example a temporal configuration of 20–2 indicated that the 1st (over the left prefrontal regions for the human experiments) solenoid received the field pattern for 20 ms, the next solenoid received the pattern for 22 ms, etc., until the last (8th) solenoid received the pattern for 34 ms before the cycle began again in the 1st solenoid (sum=216 ms or 4.6 cycles/s). For the 20+2 configuration, the duration of the pattern at each solenoid decreased by 2 ms with each successive solenoid until the final duration in

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the 8th solenoid was 6 ms (sum=104 ms or 9.6 cycles/s). The base duration of 20 ms was based upon the theoretical assumption of the "cohesive binding" factor for consciousness as described by Edelman (1989) and Llinas and Ribardy (1993). On the basis of the Cook et al. (1999) study, which showed that counterclockwise (as viewed from the top) circumcerebral magnetic fields produced the most significant distortion of subjective time estimation, all studies involved this rotational direction.

The two patterns that were generated to each solenoid were selected from the two shapes that have been most robust in producing changes in the behaviors of rats (Martin et al., 2004) and both the experiences and quantitative EEG patterns in human subjects (Persinger et al., 2010b; Booth and Persinger, 2009; Tsang et al., 2009). These two patterns were the decelerating frequency modulated pattern ("Thomas pulse," named after a previous student) and the accelerating frequency modulated pattern ("burst firing"). Their shapes have been published elsewhere (Martin et al., 2004; Persinger et al., 2010b). These patterns were generated by converting a series (columns) of numbers between 0 and 256 (below 127 is negative polarity, above 127 is positive polarity) within the Complex Software© to between – 5 and +5 V through custom-constructed digital-to-analog converters (DAC). The strength of the magnetic fields as measured by a Metex meter coupled to a magnetic field sensor (EFM 140-3-60-1499) along the inside of each solenoid was 1 to 5 μT with the average within the cross-sectional area of approximately 1 to 2 μT.

5.5. *General procedures: Cells*

For the cell studies, identical plates containing cells form the same source were placed about 1–2 h after removal from the incubator in each of the two circular arrangements of solenoids separated by 10 m. One set of plates were placed within the circular array within an acoustic chamber which was also a Faraday cage (Persinger et al., 2010a) while the other set of plates was placed over the sensor of the PMT in a dark box in a dark room. Once the PMT measurements had stabilized, the experiments began.

Photon output was recorded for 2 min before the 20+2 or 20–2 angular rotating configuration and the decelerating (Thomas pulse) or accelerating (burst pattern) fields were generated by the computer to the two arrays. In six sets of experiments half of the time the accelerating field was presented first while in the other half the decelerating field was presented first. The total duration for either was 6 min per pattern.

During the presence of the patterns and either the 20+2 or 20–2 rotating configuration, 7 Hz light flashes from a flashlight (Nextech, China, 6118952) controlled by a Heath Schlumberger function generator (EU-81A) outside of the chamber were delivered to the cell plates in the acoustic chamber. The face of the light was 9.4 cm^2 and delivered 10,000 lx during the flash. The on-off protocol was 60 s off and 60 s on for the light flashes during each 6 min of a given configuration and field pattern. Photon emission during the on and off periods were delineated by recording the time (within 1 s) when one experimenter activated or stopped the light flashes. The experiments were completed with 6 different pairs of cell plates over a 2-month period.

5.6. *General procedures: Human subjects*

The procedure for the human subjects was effectively identical to the cell study. Pairs of subjects, approximately 18–25 years of age, volunteered from a pool of university subjects to participate for points in various courses or because of interest in consciousness research. One of the pair sat within a comfortable chair within the acoustic chamber while the other member of the pair sat in a comfortable chair within the dark room and was blind folded as well. The PMT was placed ~0.15 m along the right side of the "response" subjects' heads at the level of the temporal lobes. Intervals of baseline photon emission for before the activation of the magnetic fields and during the presence of the magnetic fields during the light on–light off conditions were delineated for subsequent analyses.

The same combination of counterbalanced 20–2 ms and 20+2 ms configurations and decelerating (Thomas) and accelerating (burst) patterns were presented to both pairs of a total of three pairs. The light flashes were generated from the same equipment as in the cell component of the experiment except the light was flashed behind the head of the subject so that it illuminated the entire wall which was about 2 m away from the subject. The ambient reflected intensity was about 1 lx. Without the subjects' a priori knowledge the 1–7 Hz flashes were presented for successive 60 s on and off intervals reported for the cells. Because there was only one experimenter in the human studies sitting in third room away from the rooms containing the stimulus and response persons, coordination of the times of the light off–on conditions with increments of photon emissions from the response person was completed by synchronizing clocks of the equipment in both rooms.

5.7. *Statistical analyses*

Data from the laptops for the various increments of sampling from the PMT and where appropriate the magnetometer were transported to a VAX computer or PC. All analyses, including bivariate correlations, repeated measures, and main effect comparisons involved appropriate versions of SPSS software. Plotter software (R. L. Wells, 1405 Lynn Ave., Clearwater, FLA 33755) was employed for spectral analyses.

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