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Experimental Demonstration of Non-Local Connectivity Between Fixed Halves of the Same Human Brain Which Was Not Evident for Brain Sections of Different Origins

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ABSTRACT

Macroscopic displays of entanglement can be observed experimentally as excess correlations between specific manipulations of clusters of matter that have shared space-time. It has been hypothesized that brains as well as other biological systems express signal processing capacities characteristic of non-locality. In the present experiment, transverse sections of fixed human brains were stimulated with a variety of low frequency, low voltage (2 μV) applications of electrical current. Microvolt fluctuations from which spectral profiles could be inferred were simultaneously recorded within transverse (horizontal) sections that were either from the same (matched) or different (non-matched) brain origins. Only the 7 Hz spike-train stimulation produced enhanced theta (4 Hz – 7.5 Hz) activity within the matched brain halves. This was not measured for the non-matched halves. The most conspicuous loci which displayed excess correlation were the internal capsules and insular cortices. Cingulate and frontal cortices did not display similar features. The right hemisphere displayed the most powerful theta profiles for matched sections only. These results suggest that brain sections of common origin are functionally responsive to stimulation at a distance in ways unobserved in brain sections of non-common origin.

***Keywords*:** excess correlations; entanglement; fixed human brain sections; gray matter; white matter; insula

1. INTRODUCTION

The human brain is a mass that occupies a defined subset of space. The constituent cells, whose average somatic width is about 10 μm, number somewhere between 10^{11} and 10^{12} whereas the average number within the cerebral cortices is about 25 billion (Pakkenberg and Gundersen, 1997). The individual cells of the brain interface with various populations of other cells within the cerebral volume through structurally determined connections such as axon-dendrite interfaces as well through passively diffuse couplings to concentration gradients of ions and other molecules. Consequently, a plethora of "excess correlations" between single neurons and groups of neurons within the same cerebral volume would be expected. These very strong correlations are considered causal and local because there is a structural and proximal mechanism by which the connections occur. Temporal contiguity of activity between groups of cells within different subsets of the cerebral volume as they respond to sensory inputs sets the conditions for these paired regions, separated by inactive regions, to be functionally associated. This is considered the basis of conditioning (associative learning) as well as intermodal integration, and the integration of function with the human brain.

Biophotons or quanta of photons generated within cells are pervasive phenomena (Popp, 1979) that have been measured across the phyla of animals and plants (Gurwitch and Gurwitch, 1959). Biophoton emissions within the visible and paravisible range, whose flux densities are typically in the order of 10^{-12} $W \cdot m^{-2}$, may operate as neural communication signals (Sun et al., 2010) as well as mediators of processes that access information from subcellular (Salari et al, 2016) and subatomic (Persinger, 2016) sources. The identification of increased photon emissions from the right hemisphere of human subjects who engaged in imagery (Dotta et al., 2012) supported Bokkon's (2005) theory that visual experiences and perhaps consciousness in general occur as photonic fields within the cerebrum rather than only the subjective representation of spatial and temporal patterns of axonal discharges and somatic steady potential shifts.

Photons are the primary entities by which entanglement occurs and can be easily demonstrated experimentally within quantum contexts (Mair et al., 2001). According to Aczel's (2002) interpretation of Schrodinger, "when the quantum system contains more than one particle, the superposition principle gives rise to the phenomenon of entanglement". The superposition principle indicates that an emergent state of a system may be composed of two or more states and that a new state shares some of the properties of each of the combined states. One inference from the approach that a given human brain continually generates photons within its volume (Bokkon et al., 2010) is that all cells in the same human brain could be entangled assuming functionally relevant neuron-photon interfaces. Consequently when sections of the same human brain were separated by non-traditional spaces they might exhibit the type of excess correlation that is displayed for non-local effects. This would imply that different spatial portions of the same brain, because of their shared photonic history, would have the capacity to show similar responses even though they were not spatially adjacent.

We developed an experiment to test this hypothesis. We reasoned that if two horizontal sections from the same fixed human brain were separated by non-traditional distances the long history of conditions compatible with the production of entanglement would result in a similar response in both sections when only one section was stimulated. On the other hand, mismatched samples that are the same level of section obtained from two different brains,

should not display this proclivity. Previous calculations have shown that based upon the inductance and capacitance of gray matter (primarily cell bodies and dendrites) for frequencies associated with the duration of an action potential (1 ms, 1 kHz), the resonance frequency for brain tissue was about 7 Hz (Rouleau and Persinger, 2016). Our detailed histomorphical studies (Rouleau et al., 2016) indicated that appropriately fixed human brains still contain substantial somatic and (microscopic) structural detail. Here we present data demonstrating that the stimulation of one half (transverse section) of a fixed human brain with a 7 Hz, 2 μV, spike-wave produced enhanced theta (4.5 Hz to 7 Hz) power within the other half of the same brain (matched) when separated by 1 m. This did not occur when the non-local half brain was of a different origin (non-matched) with respect to the half brain that was stimulated.

2. EXPERIMENT I PROOF OF PRINCIPLE: METHODS AND MATERIALS

Experimental Procedure

A Mitsar 201 amplifier was equipped with 5 needle electrodes. Four needle electrodes were inserted into the Middle Cerebral Artery (MCA) of a transverse section of fixed human tissue. Collectively, these needle electrodes constituted the electrical reference. The fifth electrode served as the primary probe and was inserted into one of 7 locations: the internal capsule, external capsule, frontal polar cortex, insular cortex, head of the caudate nucleus, putamen, or cingulate cortex (Figure 1). Microvolt fluctuations (μV) were recorded as raw values within the WinEEG 2.93.59 (07.2013) interface on an HP ENVY laptop computer running a Windows 8 operating system.

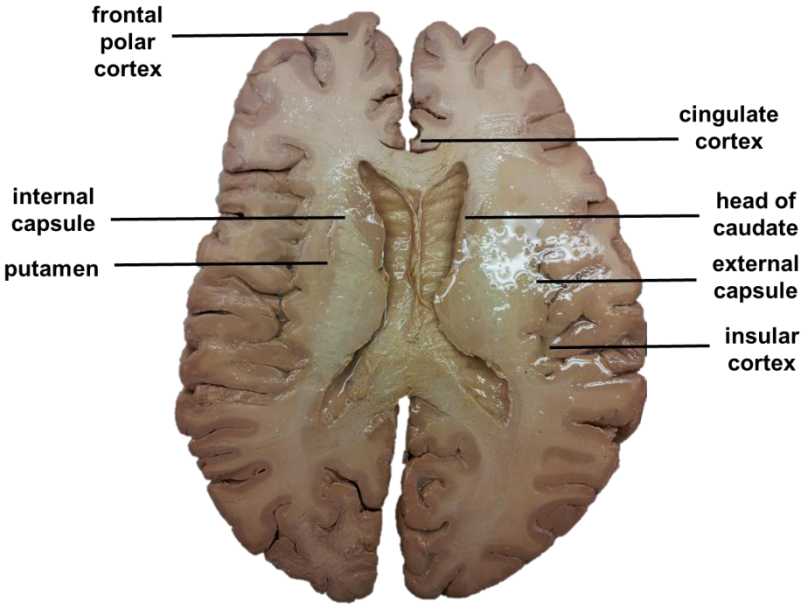

Figure 1. Transverse (horizontal) section of fixed human brain tissue. Probed loci include the frontal polar cortex, internal capsule, putamen, cingulate cortex, head of caudate nucleus, external capsule, and insular cortex.

Simultaneous to the measurement of one transverse (horizontal) slice, the same laptop computer delivered spike-wave potentials into an adjacent brain from the laptop's soundcard via a coaxial cable coupled to an electrical alligator clip and standard breadboard jumper cable. The needle of the jumper cable was inserted into the tissue of the second transverse fixed section of human brain tissue (the adjacent brain) and delivered 2 μV patterned current at 1 Hz, 7 Hz, 10 Hz, 20 Hz, and 30 Hz. Consequently, the stimulated tissue was never measured directly by the electrophysiological equipment.

Similarly, the brain halves which were measured using the electrophysiological equipment were never stimulated directly. Finally, the same brain half was measured for all trials. That is, only the stimulated tissue varied from trial-to-trail. A 1 meter space of separation was maintained between the two transverse sections at all times. The origin of the transverse section was manipulated experimentally such that certain trials involved matched brains (i.e., sections from the same brain) and non-matched brains (i.e., sections from different brains). There were three trials per condition for each condition. Figure 2 demonstrates the basic paradigm in schematic form.

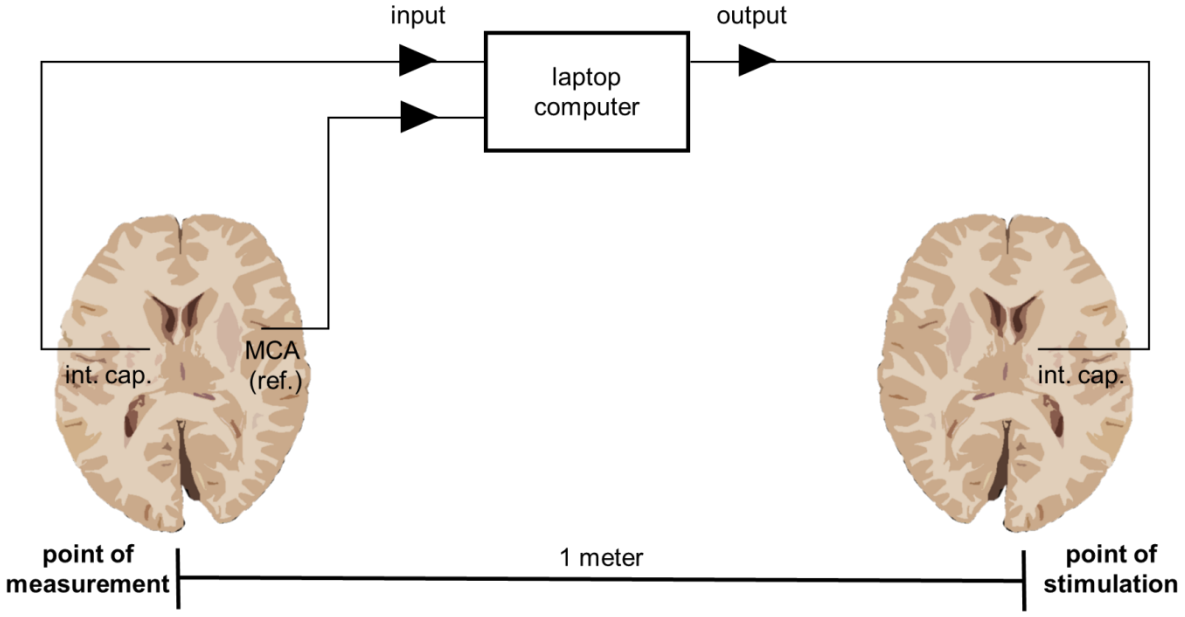

Figure 2. A laptop computer sends outputs of current to the internal capsule of one transverse section of fixed human brain tissue at the point of stimulation while microvolt fluctuations within a matched or non-matched transverse section are collected within the same locus and hemisphere at the point of measurement. The hemispheric representation of the two sections in the figure are reversed due to a common brain origin such that one half of the brain is rested on the dorsal surface of the cerebrum whereas the other is rested on the ventral surface. The two brains were separated by 1 meter. The middle cerebral artery (MCA) served as the electrical reference at the point of measurement.

We were cognizant that even repeated measures for limited numbers of samples might be considered a limit to the methodology. We attempted to attenuate this problem by depending upon frequency-dependence and the differential effects within various loci of the

tissues. The History of Science, as exemplified by Broca's seminal observation of expressive aphasia from one person and Alzheimer's single case study that documented the histological bases of dementia, has shown that powerful phenomena that represent general properties can be inferred by appropriate limited measurement. In order to appreciate effect size, that is the amount of variance in the measure accommodated by the experimental treatment, r^2 or η^2 were calculated. All statistical analyses involved SPSS software.

3. EXPERIMENT I: RESULTS

The results were quite conspicuous across all replications. An ANOVA revealed no statistical difference in spectral power expressed by the non-matched transverse brain sections as a function of the frequency of the applied current ($p > .05$). However, for matched transverse brain sections, stimulus-frequency-dependent effects were noted for theta power, $F(5,503) = 3.77$, $p < .005$, $\eta^2 = .04$. The sources of variance involved increased theta power within matched brain sections during 1Hz ($r^2 = .04$), 7Hz ($r^2 = .06$), 10Hz ($r^2 = .03$), 20Hz ($r^2 = .06$), and 30Hz ($r^2 = .05$) stimulation relative to baseline (no stimulation). These results are presented in Figure 3. Other spectral power bands were unaffected by all forms of stimulation for matched brains ($p > .05$). These results suggested that matched brain sections were generally responsive to stimulation of the other brain half. Further analyses were conducted in order to identify the specific structure which contributed to the most robust effects.

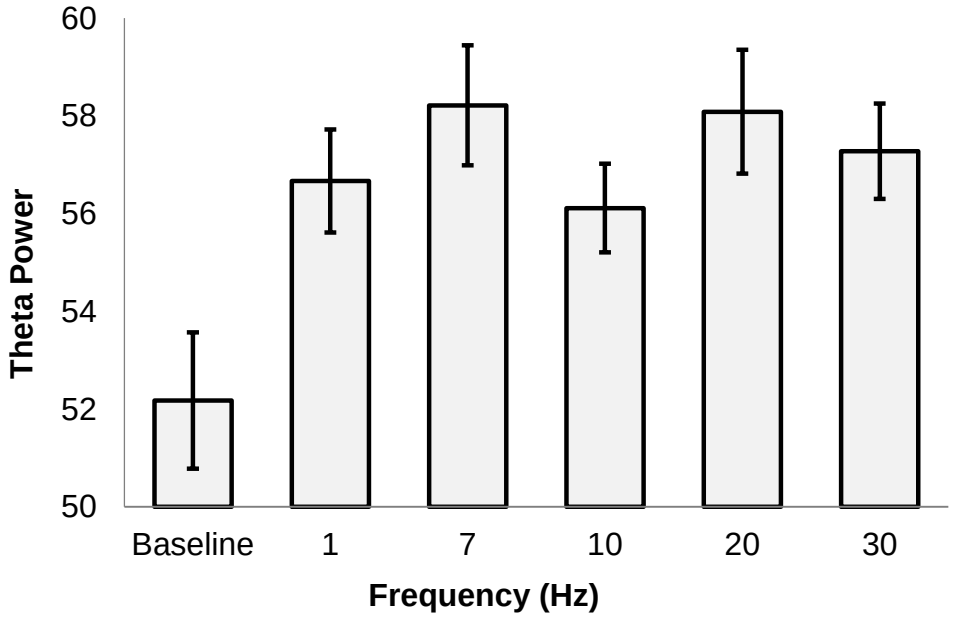

Figure 3. Mean theta (4 Hz – 7.5 Hz) power for matched transverse sections (all structures combined) as a function of the frequency of the applied current to the other brain half.

When one half of a brain was stimulated by a 7 Hz spike-potential wave within the anterior limb of the internal capsule, the other half of the same brain exhibited enhanced theta

power (4.5 Hz to 7 Hz) within the right anterior limb of the internal capsule even though the two halves were separated by 1 m, $t(10) = 3.86$, $p < .005$, $r^2 = .60$. On the other hand, if the two half cerebrums were non-matched – that is, from two different brain origins – this effect was not observed ($p > .05$). In addition, the mismatched sections displayed increased measures of power variability as reflected by standard deviations.

In other words, the matched brains were more consistently responsive and less influenced by the type of stochastic environmental fluctuations that typify the usual laboratory environment. The quantitative results are presented in Figure 4. It may be relevant that the effect of 10 Hz stimulation on one half of the brain did not elicit any statistically significant power increases compared to no stimulation for specific structures ($p > .05$). The specificity of the effect minimizes the likelihood that the finding was spurious.

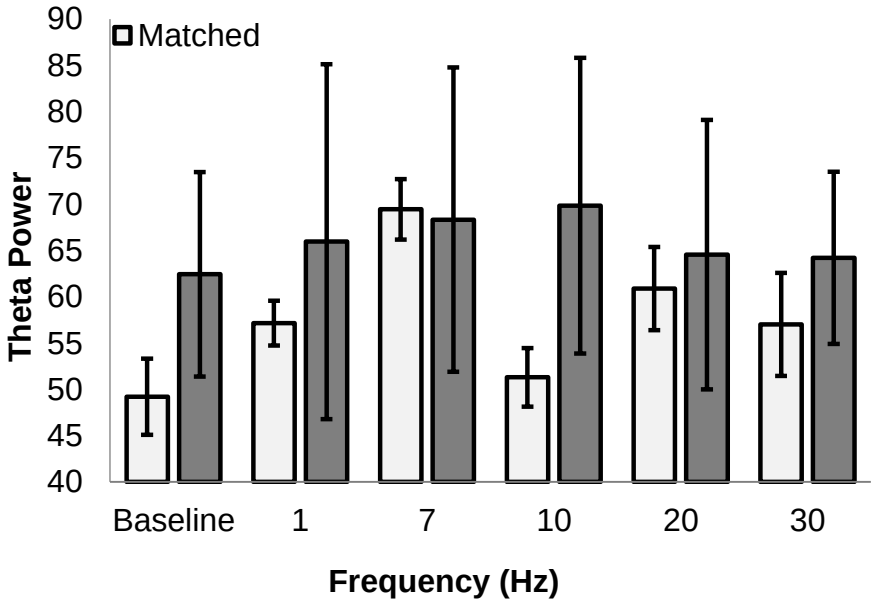

Figure 4. Mean theta (4 Hz – 7.5 Hz) power of the right anterior limb of the internal capsule of non-stimulated transverse brain sections while matched (light) and non-matched (dark) transverse sections were stimulated by 2 μV spike wave potentials 1 meter away from the point of measurement The X-axis represents frequencies of the applied stimulus. Error bars are SEMs.

We also compared different structures within the matched and non-matched brain sections. As can be seen in Figure 5, there was no statistically significant differences in theta power between matched and non-matched sections for the internal capsule, external capsule, frontal pole, or cingulate cortex. However the section matched with its other half displayed 40% more theta power within the insular cortices than did the non-matched pairs ($r^2 = .32$). Compared to the non-matched reference, the matched section displayed less theta power within the head of the caudate and the putamen ($p < .05$).

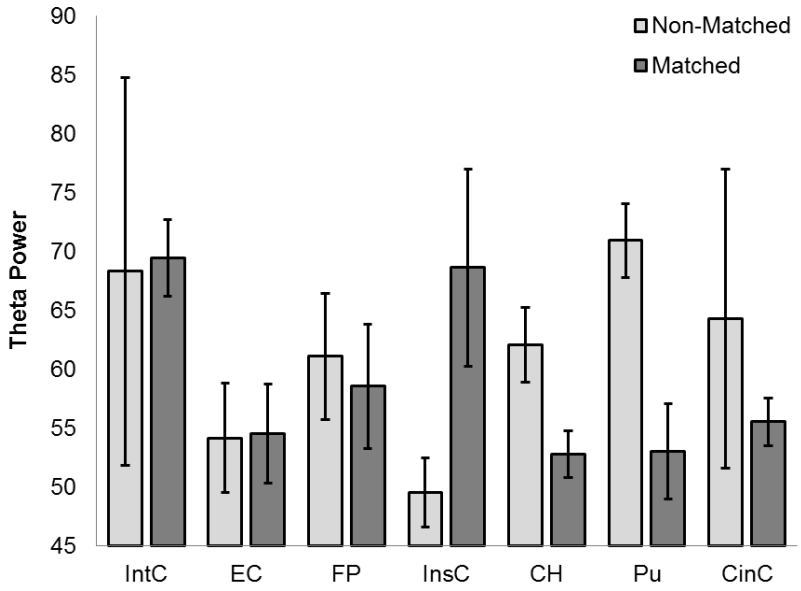

Figure 5. Mean theta (4 Hz – 7.5 Hz) power within right hemispheric structures of the non-stimulated transverse brain sections during 7 Hz spike-wave stimulation of non-matched (light) and matched (dark) transverse sections positioned 1 meter away. Structures include internal capsule (IntC), external capsule (EC), frontal pole (FP), insular cortex (InsC), head of caudate (CH), putamen (Pu), and cingulate cortex (CinC). Error bars are SEMs.

4. EXPERIMENT II: EFFECTS OF DISTANCE

Experimental Methods

Having identified the insular cortex and internal capsule as regions of interest expressing matched-brain effects, further trials were completed wherein the distances between matched or non-matched brain specimens were systematically decreased (0.5 m) or increased (2 m or 4 m). All procedures for measurement and replications were the same as those performed in Experiment I.

5. EXPERIMENT II: RESULTS

An ANOVA revealed that theta power differed by distance for the right internal capsule in matched specimens where the non-measured specimen received 7 Hz spike-wave stimulation, $F(3, 11) = 4.29$, $P < .05$, $\eta^2 = .62$ (Figure 6). Other frequency bands were unaffected ($p>.05$). The major source of variance was a difference between the 0.5 m and 4 m conditions, $t(4) = 3.01$, $p < .05$, $r^2 = .69$. The linear positive relationship between theta power and distance between brains upon stimulation was equivalent to a correlation coefficient of .94. Effects were not observed for non-matched structural pairs exposed to the same stimuli (Figure 7) or the insular cortex whether matched or non-matched ($p > .05$).

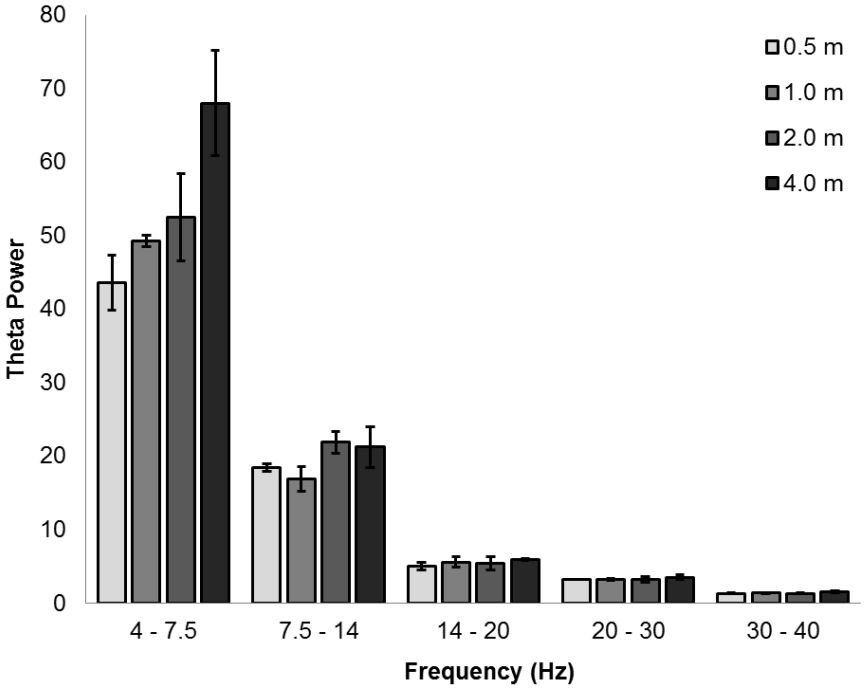

Figure 6. Mean spectral power within theta to gamma frequency bands expressed by a non-stimulated, transverse human brain section sharing a common origin with a paired half brain positioned at 0.5 – 4 m away which received 7 Hz spike-wave stimulation. Error bars are SEMs.

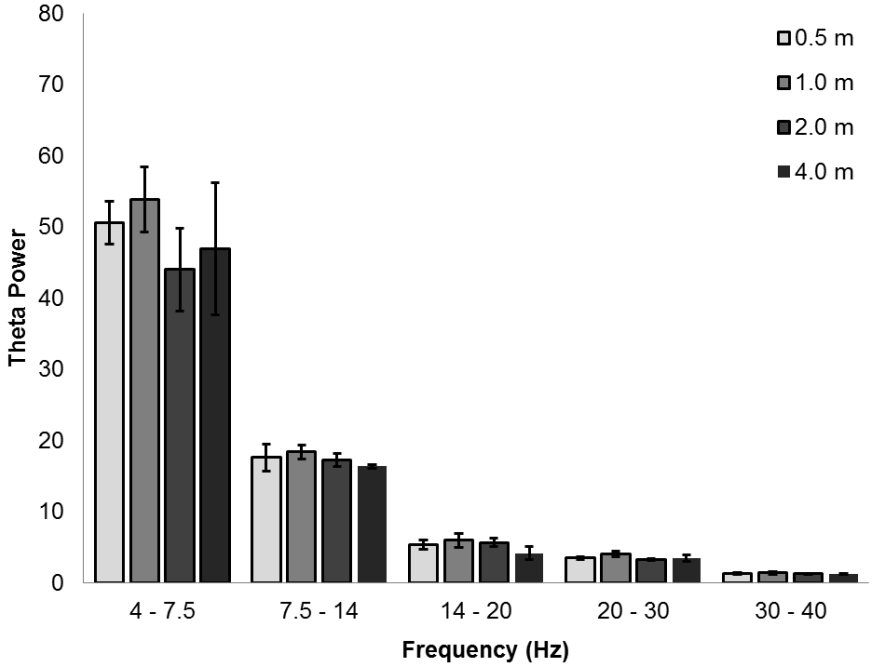

Figure 7. Mean spectral power within theta to gamma frequency bands expressed by a non-stimulated, transverse human brain section which did not share a common origin (non-matched) with a paired half brain positioned at 0.5 – 4 m away which received 7 Hz spike-wave stimulation. Error bars are SEMs.

Examining differences between non-matched and matched brain pairs, theta power was observed to increase within right hemispheric structures within transverse sections 4 meters away from a section of matched-origin during 7 Hz spike-wave stimulation relative to non-matched counterparts, $t(10) = 2.22$, $p = .05$, $r^2 = .33$. The effect size is within the range observed for the insular cortex alone at diminished distances as reported elsewhere. Figure 8 demonstrates the essential finding where *left* hemispheric equivalents did not display analogous effects ($p > .05$).

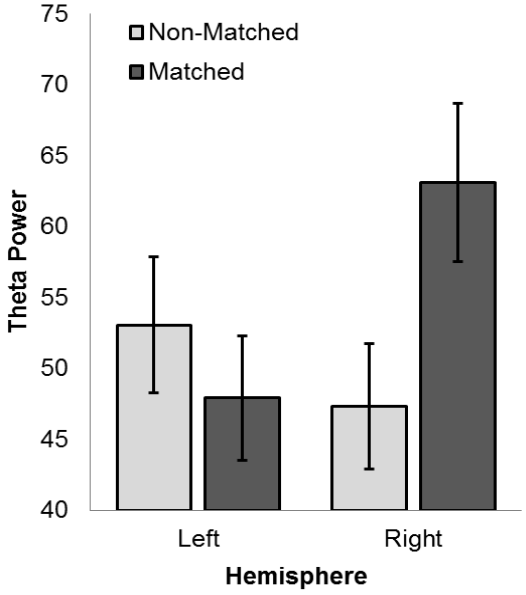

Figure 8. Mean theta (4 Hz – 7.5 Hz) power within left and right hemispheric structures (insular cortices and internal capsules) as a function of whether the paired brain halves were origin-matched or non-matched.

6. DISCUSSION AND CONCLUSIONS

Our perspective predicts that a shared history of photon emissions within a volume of brain matter produces the "entanglement" conditions to promote excess correlations within different portions of that matter despite being detached from the original shared space. Such non-locality suggests that clusters of cells, such as the human brain, can be separated by substantial functional distances and still respond as they still persist within the original state. The results of the present experiments indicate that when the optimal dynamic parameters are applied stimulation in one section with 7 Hz, 2 μV spike-wave stimuli elicit the intrinsic resonant frequency of fresh gray mater (cortices) in the other section separated by 1 m assuming both halves originated from the same brain. The absence of effect during lower or higher frequencies of stimulation despite their predominance during normal brain functions, indicates that the phenomenon required the values of inductance and capacitance that define (gray) matter within brain tissue. The fact that this was fixed brain tissue and not physiologically-typical brain tissue indicates that the characteristics of the latter might still be present in some form.

We selected the 2 μV value for stimulation because is a typical peak to peak amplitude for electroencephalographic activity that is associated with cognition in the living brain. We reasoned that if excess correlations were to be optimal, the actual intensities associated with the original environment in which the entanglement occurred should be employed. In addition, the current associated with this discrete voltage divided by the range of resistivity in the fixative multiplied by the length of the cerebrum was about 10^{-7} A. When this was divided by the diffusivity term derived from magnetic permeability ($1.26 \cdot 10^{-6}$ $N \cdot A^{-2}$) and median value for conductivity, the resulting magnetic field would be in the picoTesla range. This is the range associated with cognition in living human brains as well as the most natural source of the theta band periodicity on the planet: the Schumann Resonance (Nickolaenko and Hayakawa. 2014). Discrete peak components (8 Hz, 14 Hz, 20 Hz, 26 Hz, etc) of this band are generated within the spherical waveguide between the earth and ionosphere. Hence, it is possible we did not demonstrate "entanglement" in a pure sense but instead measured the influence of the global Schumann Resonance-like field within which all matter is exposed.

If the results of this experiment are generalizable then only specific regions of the human cerebrum are prone to excess correlations. The insular cortices, the core of the Island of Reil, displayed a conspicuous effect. The insula is the cerebral substrate for the representation of the internal organs, gestation, cardiac control, and regulation of the viscera. Interestingly the internal capsule traversing the temporal cortices to form the temporal stem is directly above the insula suggesting that it would have had a history of proximal exposure to massive axonal input between cortical areas. Although our specimens had been clinically dead for decades and had been fixed in ethanol-formalin-acetic acid, the insula appears to have sufficient residual microstructure such that the display of the effects of entanglement could still be measured.

The concept that when two organizations of matter share a complex morphology a change in one organization results in very small change in the other organization that simulates the initial change has been superbly articulated by the original thinker Sheldrake (2006). His morphogenic field principle indicates that structural similarity can resonate over distance because of this hypersimilarity. A similar process is known in the manufacturing of electronic communication devices (such as "walkie-talkies") where, for reasons that are still unclear, units that are derived from the same batch creation exhibit the clearest reception over the longest distances.

In the present experiments, injection of 2 μV patterned electrical potential into one half of a brain at 7 Hz resulted in an enhancement of about 10 spectral units within the theta range within the insular region of the other half of the same brain. This would be equivalent to about 1 μV for the theta band. This means that for the 7 Hz band (only) the non-local value would have been approximate to the voltage applied to the other half of the brain. Distal secondary inductions would not explain this strength given that only the 7 Hz stimulation and not frequencies above or below produced the effect.

The measurement of an opposite direction of relationship between matched and non-matched sections in the caudate-putamen compared to the insular response may appear contradictory. From the perspective of "entanglement" some parity would be expected. If this is valid then the intrinsic system that composed this "entanglement" process involves the insula and the caudate-putamen. We did not measure the claustrum which is lateral to the caudate-putamen and is considered the "subcortical" component of the insula by traditional

neuroanatomists. Such parity between subcortical and cortical connections that compose circuits and reverberating pathways reflects the general organization of the human brain.

Although all of the phenomena we measured in these experiments are consistent with contemporary understanding of non-local effects but at macro rather than micro- or quantum levels, there was one anomaly. One would not expect a distance effect if non-local processes were operative. In this experiment there was a significant enhancement of theta power only within the matched brain sections when they were separated by 4 m (the width of the laboratory). The effect was not observed when the non-matched brain halves were separated by 4 m. Consequently the likelihood of artifact is minimal. Both the matched and non-matched sections demonstrated that the most general spectral power was within the theta range which suggests that this band within the paradigm employed here with fixed human brain tissue may be intrinsically enhanced.

Although the pursuit of these phenomena may appear eccentric to the general investigation of the physical properties of the human brain as matter and structure rather than a living, dynamic process the elicited questions may provide important answers to more complex phenomena. The associative capacity for neurons within the living brain has been attributed and explained by the neuronal doctrine as due to the actual physical connections through axons and dendrites between the units. Our observations that a section of fixed human brain tissue from the same person (source) exhibits mutual responsiveness when the other section is stimulated by specific physiological temporal parameters indicates that there may be an intrinsic, passive property within the brain space that exists independently of direct synaptic connections. This might satisfy the condition for non-locality.

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