

NeuroTheology and Its Convergence with NeuroQuantology

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Abstract

The principles of neuroscience assume and predict that all experiences are generated by brain activity as a consequence of structural patterns. A convergence of methodologies and measurements indicate that religious/mystical experiences and beliefs associated with them are predictable phenomena. The central roles of the right hemisphere, specifically the temporal lobe, and the chemistry, structure, and gene sequences that affect this region's electrical sensitivity and intercalation with the left hemisphere are reviewed. The precarious consequences of the enmeshment between the neuronal networks that mediate the survival of the self and moral judgments are considered. The neuroquantological bases to the cellular activity that mediates these experiences suggest an imminent change in paradigm that will alter the manner in which we perceive ourselves and our relationship to the universe.

Key Words: neurotheology, neuroQuantology, cerebral volume, neurochemistry, sex differences, gene potentials

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Introduction

From either a direct (causal) or indirect (probabilistic) perspective the characteristics and functions of matter are determined by structure. Structure occurs within the organization of atoms and molecules in discrete increments of space. Structure also occurs as the organizations of discrete energies whose patterns change over time. Different structures in space or temporal patterns produce predictable functions and behaviors.

If this approach to the universe is valid, then all molecular characteristics are predictable by quantum processes and all behavioral patterns that include thoughts and experiences are predictable by molecular characteristics. Fundamental processes are reflected through different organizations of human knowledge. The change in the level of discourse, from the smallest set (the quantum) to the largest set (the universe), reflects perspective rather than qualitatively different phenomena.

The essential assumption of *neurotheology* is that because all experiences are directly or indirectly determined by the material structure and the fluctuating energies that integrate their patterns through time in the space occupied by the brain, then the experiences and beliefs there is a Sentient Being that is identified

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with all time and all space is a product of brain function. Like any physical principle the application geometry, in this context the language and the culture in which the person is immersed, will determine the specific characteristics of the experiences and beliefs.

Language, a variant of symbolic experiences, and memory, the representation of those experiences, effectively define the human being's self awareness and sense of self. The anticipation of aversive events, such as self dissolution (*death*), can be minimized by the belief that the person is associated with a concept that displays no boundaries in space or time. When there is no perceived termination, there is no anticipation. Congruent with this inference is the recent demonstration (Wiech *et al.*, 2008) that pain reduction (analgesia) is enhanced by religious belief. That focal region (the right ventrolateral prefrontal cortices) is adjacent to the region associated with moral judgments and decision making (Koenigs *et al.*, 2007).

Challenge to that belief by direct or indirect implication threatens the person's egocentric conviction of immortality. A veridical solution to this dilemma may, at this point in the evolution of the human brain, be critical for the survival of *Homo sapiens sapiens*. Group and social manipulations of religious beliefs and experiences have been either a cause or correlation for the subjugation and death of others more than the most virulent of biological conditions. Even conservative estimates of the "human expenditures" associated with organized killing (war) within the last 500 years because of religious-inspired beliefs exceed 100 millions.

Although modern neurotheology examines the physical bases to religious and mystical experiences and beliefs and may implicitly appear to reduce this rich phenomenology to only neuronal function, the emergence of neuroquantology as a viable area of investigation suggests that the experiences and beliefs in gods may be relatively minor concepts that have masked more fundamental relationships within space and time. In this paper we examine these possibilities.

A Brief Description of the Human Brain

If structure dictates function, then the most conspicuous feature of the human brain is the two hemispheres. The total surface area is about 1570 cm²; the right hemisphere contains about 40 cm² more area. Of the approximately 196 sulci and gyri that can be differentiated in both hemispheres (van Essen and Drury, 1997) only four sulci share clear structural similarity between the two hemispheres. The remainder show significant hemispheric differences. When these qualitative differences are added to the variability of the bulk volume of the cerebrum and the often forgotten fact that during ontogeny different regions mature at different rates, the complexity of structure allows for both tonic and phasic manifestations of experiences and functions.

In general the left hemisphere in most individuals is associated with sequential integration of experiences and consequently is strongly enmeshed with language processes. The sense of self is strongly correlated with language and consequently with the left hemisphere. The right hemisphere which is structurally organized for more simultaneous integration of experiences displays some linguistic properties, whose syntactic and semantic levels are estimated to be at the level of a young child and adolescent, respectively. Information is organized as a function of vigilance, anticipation, emotion, and "the big picture".

The caudal region of the cerebral hemispheres is the general reservoir for the perception and understanding of experiences which are the intermediate representations of neuronal activity generated by sensory patterns evoked by physical stimuli. They are a small subset of the billions of events that penetrate the cerebrum every second. The frontal regions organize and re-represent these caudal experiences and result in the person acting upon the environment. Beliefs, attitudes, fantasies of what will occur within the future and world views about one's self and his or her relationship to others are strongly correlated with the integrity of this region.

Whereas the left hemisphere is more involved with the sense of self as a viable

entity the right hemispheric equivalent to the left hemispheric sense of self is more related to the feeling of “another” that is different yet familiar (Persinger, 2003) that can be evoked experimentally (St-Pierre and Persinger, 2007). We have suggested that when there are intermittent intrusions of the electromagnetic patterns (action potentials of neurons) into left hemispheric processes from the right hemispheric equivalent of the self the person experiences a sensed presence, the feeling of a Sentient Being. The conditions for recruitment of the critical volume within the right hemispheric could be both minute and quantal. Recent experiments have shown that the burst spiking of a single cortical neuron is sufficient to modify the global brain state (Li *et al.*, 2009). The activity of a single neuron can initiate a cascade that changes the probability of the occurrence or non-occurrence of a response.

The labels, acquired through culture, that are applied to these transient experiences actually determine the details of the verbal images and their significance when the occurrences are later reconstructed through the autobiographical processes involved primarily with the right prefrontal regions and mesiobasal (hippocampus and amygdala) temporal lobe structures. The languages of all cultures have “default” descriptors for “everything and everywhere”, the essential operations for gods, with which the experiences are associated. In this manner the sense of the person becomes inexorably intermeshed with the shared beliefs of the culture.

The fundamental characteristics of the Sentient Being reflect its origin, the right hemisphere. It is familiar yet “beyond” or “more” than the self; it may sometimes produce the experience that “the self is now complete”. The themes are dominated by emotional significance, a perfusion of the sense of self with simultaneity (experiences of being “outside” of space and time”) and of conviction that the experience was completely true. From a neuroanatomical perspective, the dominating theme of the experience would reflect which region of the right hemisphere dominates input through the major interhemispheric pathways: the corpus callosum, anterior commissure, or

dorsal hippocampal commissure. Parietal (spatial and location experiences), anterior temporal (auditory, vestibular, “knowing” experiences), posterior temporal (visual “manifestations”) insular (visceral, including sexual experiences) and mesiobasal or hippocampal-amygdala (“remembering” or “intrusive memories”) sources differentially weight the details.

The occurrence of these experiences would be more probable when the right hemispheric intrusions are more frequent such as dreaming or the fluctuating waking states during the early morning hours. During more tonic conditions, such as psychological depression, despondency and loss of hope, the intrusion of right hemispheric processes and subsequent activation of the left hemisphere would be associated with both a sensed presence with powerful personal significance and a “recovery” from the depression. Any electrically labile condition, such as partial complex epilepsy with a focus within the temporal lobes, would facilitate interhemispheric intercalation.

It may not be spurious that the behaviors of many if not all of the individuals who began the contemporary religions meet the criteria for the ictal (during electrical paroxysmal activity) and interictal behaviors of temporal lobe epilepsy. Post-mortem histological examinations have shown a history of electrical seizure-induced proliferative growth of dendrites and axonal endings within the hippocampal formation and its primary input, the entorhinal cortices, for individuals who displayed temporal lobe epilepsy (Eriksson *et al.*, 1998; Cameron and McKay, 2001). The emergence of the “temporal lobe personality” defined by enhanced religiosity, paranormal interests, hypermoralism, altered sexuality, viscosity, a sense of the personal, a feeling of being “selected” and the compelling motivation to proselytize are classic clinical correlates (Dewhurst and Beard, 1970). In many cases, psychotic behaviors emerge about two decades after the onset of the electrical seizures within the temporal lobes.

Although there are myriad anecdotal descriptions in the literature, one file available to us was a middle aged man who did not believe in a god. During various

stages of the subsequent “disorder” he thought he was Jesus who had returned to earth to preach and to spread the word by starting a musical group. Later he believed God was speaking through the radio and experienced a “revelation” that heaven was a secret place hidden in Siberia. Following a partial lobectomy of the right temporal lobe no overt convulsions occurred and his receptive language skills normalized. Although he still pondered the existences of a god, he no longer confused the differentiation between his thoughts and the concept. It is relevant that even the powerful hallucinatory effects of LSD-25 do not occur following removal of portions of the temporal lobe.

Neurostructural Associations

That the sensed presence and its variants such as experiencing the culture’s form of god are associated with paroxysmal electromagnetic activity within (usually the right) temporal lobes have strong spontaneous, clinical, and experimental support. Devinsky and Lai (2008) indicated that up to 3% of partial epilepsy patients reported religious experiences or religious premonitory symptoms. This percentage is within the congruent range of the approximately 7% of first year university students who reported they would kill another person in a god’s name. The capacity to reason about the beliefs of others requires the normal integrity of the left temporoparietal junction (Samson *et al.*, 2004).

This region has been also implicated in the theory of mind (TOM) which assumes neuroelectrical processes within this location that contribute to the understanding of how or why another person is thinking (Blakemore and Decety, 2001). The medial prefrontal cortices, immediately adjacent to the region involved with moral decision making, is also consistently activated by TOM-related tasks in which subjects think about their own or others’ mental states. The labels for what these states mean or imply are strongly affected by the conditioning from the culture and the implicit semantic chains associated with those words.

The dynamic functions of the ventromedial frontal lobe, involving

traditional Brodmann areas 10, 13, 14, 24, 25, and 32 or the gyrus rectus, orbitofrontal cortices, anterior cingulate cortices, and ventral cingulate cortex, have been only recently accessible by modern imaging techniques such as fMRI (functional Magnetic Resonance Imaging). Lesion studies, including the classic case of Phineas Gage, have suggested that damage in this region results in deficits of social conduct and markedly reduced compassion, shame, and guilt, all of which are closely associated with moral values. Despite these diminishment general intelligence, logical reasoning, and the declarative knowledge of social and moral norms are preserved (Farah and Fellows, 2005; Damasio and Saver, 1991; Rudebeck *et al.*, 2008; Bechara *et al.*, 1994).

Damage to the ventromedial prefrontal cortices results in an abnormally “utilitarian” pattern of judgments on moral dilemmas that juxtaposes considerations for the welfare of the aggregate against aversive behaviors. The most typical example of the latter would be killing a smaller subset of people to save a larger number of others. Because of the involvement of the anterior cingulate which is involved with bonding and love, particularly to the group, this affiliation can influence the bifurcation sequences that determine the outcome of the logical argument. The enhancement of this bonding during late adolescence to early adulthood intermeshes the identity of the self with the emotionally bonded group and the verbal behavior. The latter is derived from the essential beliefs that define the group.

The participation of the orbitofrontal region which associates the history of rewards and punishments with the consequences of planned thoughts and actions (functions more correlated with the prefrontal dorsolateral convexity) would create conditions for “moral” justification based upon beliefs in general and religious beliefs in particular. The major input from the amygdala, which is associated with the degree of manifestation of overt (killing others) or covert (self-destructive acts) aggression, into the orbitofrontal regions suffuses the behavior with meaning and potentially moral justification. Because behavior is reinforced by its consequences,

aggression exhibits a low threshold for many individuals for which the belief is maintained and through which frustrations induced by challenge of the belief is expressed.

The “critical mass” that would be sufficient to recruit an entire culture into the same or similar belief system would not require an initial total participation. Considering the strong propensity for human beings to imitate and to respond to the hierarchy of those who control the rewards and punishments within the group, only a small percentage of constituents would determine the cultural vector.

The Importance of Development and Sex Differences

The sense of self is a primary linguistic process that evolves as reiterative integrations of the verbal representations of experiences over the person's life time. If the sense of self and its beliefs of an infinite post-self state are inculcated in early childhood, then by the time the person progresses through the various cognitive stages and exhibits the potential perspicacity to refute the argument even its initiation would be anxiogenic. In one experimental study (Persinger, 2009) normal volunteers who were exposed to progressive statements that would ultimately suggest God was a creation of neuronal function, displayed behavioral indications that the right hemisphere discerned the semantic implicit chain even without the participation of awareness. The cognitive sequence that would have led to the conclusion was avoided or displaced by circumlocution.

If the temporal lobes and their associated parietal regions are primarily involved with most god experiences, then even the subtle differences in their structure are important to consider. There are at least two dozen different brain structures, beginning with the bulbocavernosus nuclei of the spinal cord, that exhibit sexual dimorphism. Adult gender differences in the size of the major structures, such as the corpus callosum, are usually in the order of 0.5 to 1 standard deviations. The primary differences in average brain weight (and implicitly brain volume) are in the order of 100 gm to 200 gm (of the approximately 1.5 kg) when comparisons are made between

genders, races and adult age groups, assuming minimal pathology. The approximately 10% difference is reflected interhemispherically as well; the right hemisphere contains about 10% more white matter and exhibits about 10% greater cerebral blood flow when compared to the left hemisphere.

Direct measurements indicate that males exhibit about 7% more cerebral cortical white matter than do females. This increase in white matter, moderately correlated with testosterone levels, is more strongly associated with an increase in axonal caliber than enhanced myelination. On the other hand the ontogenetic increases in white matter in females actually reflect increased myelination (Paus *et al.*, 2010). These sexual differences, which are manifested predictably in global behavior, included the greater density of white matter in the fornix in women compared to men (Perrin *et al.*, 2009). They are superimposed upon the non-sex specific bilateral increases in white matter during adolescence (Giorgio *et al.*, 2009) within the arcuate fasciculus (superior longitudinal fasciculus) that communicates the information associated with images and emotions from direct experiences and language processing to the prefrontal regions for organization and overt action.

The means and standard deviations (in parentheses) for the right and left temporal lobes are 631 (51) cc and 623 (48) cc, respectively for men and 569 (47) cc and 561 (47) cc, respectively for women. The proportion of white matter within the left and right temporal lobes ranges between 32% and 33% (Nopoulos *et al.*, 1999). During development males exhibit a more rapid increase in white matter volume (Lenroot *et al.*, 2007). Whereas the female brain exhibits a consistent increase in white matter development during adolescence, the changes are more inconsistent in males with the steepest increase evident during the early teenage years (Giedd *et al.*, 1999).

This differential development is strongly correlated with the sex differences in the characteristics of the sensed presence evoked within experimental settings. Although both men and women experienced sensed presences when weak, temporally

structured magnetic fields are applied more over the right temporal lobe than the left, the composition of the experiences are different. For men the sensed presences were associated with the feeling that the experiences were ego alien intrusions. They concluded that the experiences “did not come from their own minds”. For women, the sensed presence was associated with out of body experiences, spatial displacement (being somewhere else), vestibular effects, and fear (Persinger, 2003).

If structure dictates function then qualitative differences in temporal lobe structure in general and hippocampal position in particular would be significant. Barsi *et al.*, (2000) reported a probable new entity of hippocampal malrotation in 6% of patients suspected to display temporal lobe epilepsy. The MRI examinations revealed an incomplete inversion of the hippocampus, an abnormally round shape, an abnormal size and position of the fornix, and an oblique angle of the collateral sulcus. However the corpus callosum and the temporal lobe in which the hippocampal anomaly occurred were normal.

Interhemispheric Connections

The corpus callosum, present only in mammals, is the largest fiber tract in the primate brain. This interhemispheric fiber system is composed of approximately 200 million axons. With the assumption of only one axon per neuron, this means that less than 1% of the approximately 20 billion neurons (19 billion in females; 23 billion in males) in the cerebral cortices are directly connected to the other hemisphere. Effectively the human cerebrum is two separate systems whose intercalation, by necessity phasic, requires a critical mass of input to be represented within the contralateral hemisphere.

There are two other interhemispheric systems. The dorsal hippocampal commissure, situated within the area of the rostral portion of the splenium of the corpus callosum, is the direct interconnection between the hippocampal formation from one hemisphere to the entorhinal region (and ultimately hippocampus) of the other. The entorhinal cortex is the primary route through which the neocortices interact with

the hippocampus (Insausti *et al.*, 1995). The right temporal lobe in general and the hippocampus in particular, in addition to displaying the lowest threshold for electrical excitability and seizure-production, is remarkably sensitive to ambient geomagnetic activity. This occurs particularly during dreaming, which is characterized by an enhancement of activity within the right temporal region. Modification of experiences mediated through the right hippocampus into the left equivalent can modify memory even without the person's awareness.

During adolescence, when the acquisition of religious beliefs and experiences intensify, there is an accelerated rate in dorsal hippocampal commissure maturation (Verma *et al.*, 2005). Between early to old adolescence a significant increase in hippocampal size occurs in males only (Suzuki, 2005). The increase in the volume of the right hippocampus is greater than the left between the ages of 13-14 to 19-21 years. The effect size for the relationship between age (8 to 30 years) and the increased thickness of the dorsal hippocampal commissure is about 6%. The functional significance of this structure is indicated by its strong ($r=0.47$) correlation between its volume and measures of episodic memory (Begre, 2010). Localized left hippocampal electrical seizures result in amnesia for experiences represented as declarative memory during the previous approximately 20 min and open the indirect contribution to later reconstructed memory from information acquired through the right hemisphere.

The anterior commissure is the major interhemispheric connectivity for the ventral portions of the temporal lobes. It interconnects the orbitofrontal cortices, olfactory nuclei, middle and inferior temporal gyri, and the amygdala (La *et al.*, 1981). According to Allen *et al.*, (1992) this fiber tract can be 18% larger for homosexual men than for heterosexual women and 34% larger than for heterosexual men. The anterior commissure has been suggested to be particularly vulnerable to direct impact trauma, myelin degeneration, and progressive axonal injury (Wilde *et al.*, 2006). From a neurofunctional perspective,

whereas anisotropic stimulation within the origins of corpus callosal fibers would contribute to the modality and details of the intrusive experiences such as sensed presences, asymmetric stimulation from anomalous myelin deposition within the anterior commissure would contribute to the type and degree of emotion, particularly aggression, associated with those experiences. The adolescent male would be most vulnerable in any culture.

Neurochemical Asymmetries

Glick *et al.*, (1982) reported that the enzymes associated with the cholinergic (acetylcholine) and dopamine systems were more concentrated within the left hemisphere compared to the right. These two neurotransmitters are intimately involved with positive affect, addiction, and the prefrontal processing associated with intelligence and self-awareness. Their diminishment results in dementia, flattening of affect, and the loss of the sense of self.

On the other hand the distribution of serotonin displays more right side laterality (Parsey *et al.*, 2000). Arato *et al.*, (1991) reported this asymmetry, particularly within the mediofrontal region of the brains of people who had killed themselves. Imaging techniques, such as positron emission tomography (PET), revealed greater receptor (5-HT_{1a}) binding within the superior and middle frontal gyri, as well as the superior and middle temporal gyrus of the right hemisphere (Fink *et al.*, 2009). Norepinephrine was also more concentrated within the right hemisphere (Oke, 1978; Melillo and Leisman, 2004).

This asymmetry is congruent with the reports of Kurup and Kurup (2003). On the bases of serum analyses and erythrocyte membrane enzyme activity, they found that people who were spiritually-inclined as defined by their lifestyles displayed increased levels of tryptophan catabolites such as serotonin and quinolinic acid but decreased membrane Na⁺/K⁺ ATPase activity. This strongly suggested a right hemispheric dominance. On the other hand atheistic individuals exhibited increased levels of dopamine and related compounds with increased ATPase activity.

Chemical stimulations that influence the serotonin system provoke mystical experiences. Griffiths *et al.*, (2008) found that oral psilocybin (30 mg/70 kg) administered once or twice produced phenomenology similar to spontaneous mystical experiences. More than a year later these volunteers considered the experiences among the most meaningful and spiritually significant of their lives. The administration of methylphenidate as the reference substance did not produce these effects. This was one of the first experiments to show such long-term effects from singular events for a compound that has been used as a sacrament for millennia in structured religious ceremonies and reiterates the importance of the neurotheological interpretation of these experiences.

Although classic neurotransmitters are strongly correlated with the major classes of behavior, such as the type of thought and affective disorders relevant to modern civilization, they constitute a small fraction of the function neurochemistry within the human brain. The neuropeptides, which are effective at concentrations within the femtomole rather than micromole range, dominate the infrastructural substrates that maintain the tonic conditions of brain function. Patients who have been diagnosed with temporal lobe epilepsy show reliable alterations of somatostatin within the inferior temporal gyrus (Brodmann area 21) within the same layers (Gonzalez-Albo *et al.*, 2001) whose cellular alterations are associated with altered connections within the hippocampus-dentate gyrus interface.

Neuropeptide Y within the amygdala, which has been associated with decreasing anxiety, has also been associated with suppression of neurotransmission in single hippocampal cells as well as with electrical seizures (Davis, 2002). Autopsy results for temporal lobe epileptic patients indicated that the numbers of neurons expressing this peptide within very specific nuclei of the amygdala was about one standard deviation lower in the patients compared to the reference group (Frisch, 2009).

The quantitative changes within the hippocampus associated with experimentally-induced epilepsy in non-human animals are congruent with the

clinical observations. Rodents in which limbic (temporal lobe) epilepsy was induced exhibited almost (76% more) twice the length of reactive dendritic growth compared to controls and a 31% increased somatic (cell) area. What is particularly important for potential neuroquantum connections is the shift (when voltage clamped at -60 mV) increase in membrane capacitance from 41 (2) pF for controls to 66 (5) pF for epileptic tissue although the resting membrane potential for the later was about 4 mV closer to the firing threshold (Halabisky *et al.*, 2010).

Gene Potentials

It has been established that changes in FOXP2, a gene involved with speech production, and ASPM, which affects brain size, have had a significant influence upon the evolution of the human brain. Point mutations can result in marked diminishment of capacity for overt speech production as well as structural modifications of the regions responsible for these functions. Pollard et al (2006) found that of the approximately 15 million changes in the genome (about 3 billion pairs of nucleotides), the most conspicuous have been those involved with transcriptional regulation and neurodevelopment. HAR1, which lies in the last band of chromosome 20q, is a part of divergently transcribed genes HAR1F and HAR1R. During prenatal development their expressions were found within the neocortex, and, in particular, the hippocampal primordium and dentate gyrus.

Given the genetic determination of all chemical sequences, even accommodating posttranslational modifications, a genetic component to religious or mystical beliefs would be predictable. Hamer (2004) and Silveira (2008) suggested that a variation in the vesicular monoamine transporter 2 (VMAT2) proteins could be associated with a predisposition to belief in the paranormal. This gene transcribes a 514 amino acid sequence that transports dopamine, serotonin, and norepinephrine. According to the Uniprot database the gene is located on chromosome 10 and a single variation of an adenine or cytosine at position 33,050 is sufficient to activate spirituality in human experience. People with cytosine in either

one or both alleles displayed scores (53%) on a self-transcendence questionnaire that were about twice the magnitude as those that did not (about 25%).

That the human genome can be influenced by natural selection is a fundamental assumption of Darwinian theory. However there is now evidence that approximately 5% to 8% of the human genome contains sequences of retroviral origin (Belshaw, *et al.*, 2004). These endogenous retroviruses appear to have accumulated in frame-stop codons and frame-shift mutations that affect expression. The most recently active forms in human beings are members of the HERV-K (HML2) family. In light of the small and quantal energies required to alter the protein sequences that define prions, including those that compose the normal neuronal cell membrane and contribute to seizures and epilepsy (Walz *et al.*, 2002), and the patterns of nucleic acids that define viruses, the potential that energies extraneous to the biological system may have shaped the occurrence of neurotheological behaviors must be at least considered.

Neuroquantal Considerations

The primary unit for the major correlate of thinking is the neuronal action potential. Assuming a net change of 120 mV it imparts a quantum of energy of about 2×10^{-20} J on a unit charge (Persinger, 2010). This is the same magnitude and time (about 1 msec) required to add one base pair to an RNA ribbon. This quantum is the same solution for the energy: 1) between the approximately 10 to 12 nm separation of charges within the single layer along the surface of the plasma neuronal membrane that creates the resting membrane potential, 2) across atomic bonds, 3) for free electrons moving along the DNA backbone, 4) the product of voltage, current, and time across synaptic space, and, 5) that predicts the numbers of molecular reactions within a cell. This value emerges from the narrow range of temperature within which life exists and corresponds to about 9.4 μ m, the width of a cell, and a frequency of 3.2×10^{13} Hz.

Assuming 20 billion neurons within the cerebral cortices, each operating around 10 Hz, the total amount of energy per sec

(watts) associated with “thinking” and cognition would be 2×10^{-20} J* (=multiplied by) 2×10^{10} neurons $\times 10^1$ Hz or about 4×10^{-9} J/s. This nanoJoule magnitude is in stark contrast to the approximately 20 J per sec generated within the cerebrum associated with glucose metabolism which is essential for maintaining the structural and material substrates for this brain activity. The presence of such minute amounts of absolute energy associated with thinking and presumably beliefs and awareness, suggests that the pattern rather than the magnitude of applied energies is more important for influencing the complex matrices of conscious experience and decision making.

The Geomagnetic Connection and Dreaming

All human brains are immersed within the earth’s magnetic field. According to Ivahhoe (1982) there has been a co-evolution of human brain size and Paleolithic culture as a function of the changes in static geomagnetic field intensity. However if all contemporary brains are immersed within the geomagnetic field, then, due to their genetic similarity, they would have the capacity to display the characteristics of a condensate. The average magnetic field strength induced within every brain because of this connectivity would be about 30 pT, which is within the operating range of the average cerebral activity (Persinger and Lavallee, 2010). It is also within the range of the secondary magnetic field strength induced within the cerebral volume by the intensities (about 1 to 10 microTesla) of magnetic fields shown to induce mystical and religious-like experiences (Persinger *et al.*, 2010).

Events occurring within one human brain, such as an intense physiological arousal by a structural enhancement within the hippocampus within the right temporal lobe, would have the capacity to affect, although in a subtle manner, every other brain immersed with the earth’s magnetic field. The magnetic diffusivity time for the total surface of all human brains would be about 4 min, well within the range of a single duration of dreaming. The right temporal lobe and functionally associated prefrontal regions are particularly stimulated during dreaming and exhibit an enhanced

sensitivity to geomagnetic activity. Dream sleep directs the course of brain maturation through the control of neural activity.

Implications of Quantal Extracerebral Representation of the Information Associated with Thoughts

Memory is the representation of experiences. This progressive consolidation process displays an electrically labile period of about 1 to 2 ksec (15 min to 30 min) before the microstructural (spine) changes within the dendrites emerge. Memory is effectively the temporal history of the individual represented as spatial patterns within the dendritic matrix. With approximately 10^{13} synapses within the cerebral cortices alone, the amount of information might exceed the Terabyte range. However when the physical substrate is challenged by disease, hypoxia, or insufficient glucose, this fragile configuration is eliminated and the individual memory and the sense of self are lost. The self, a product of the microconstruction of the left hemisphere, no longer exists.

However Persinger (2008) has suggested that the existence of a duality between matter and energy predicts that for every molecular aggregate there is an electromagnetic equivalent. The essential model is that during the first approximately 20 min of the electromagnetic period of memory consolidation the *information* is represented in extracerebral space. One candidate for this representation is the volume occupied by the earth’s magnetic field. With a dipole moment of 8×10^{22} A m² and an average intensity of 5×10^{-5} T, the total energy storage would be about 4×10^{18} J. Assuming that each person lives for about 2 Gigaseconds, there would be enough storage capacity for every thought of every human being who has lived within the last 5,000 years.

The approximately 15 to 30 min duration is within the range for the current decay within the electric field between the earth’s surface and ionosphere. With a value of about 2 Farads and 1.6×10^2 Henrys involved with the geomagnetic-ionospheric interface, the solution is also about 20 to 30 min if the frequency was 7 Hz. This frequency is the fundamental for the

Schumann resonance generated between the earth surface and ionosphere. It is also the central frequency for the hippocampal formation and the 40 Hz fluctuations, associated with consciousness, that are superimposed upon this range. The “7 Hz pattern”, displayed as repeated aggregates of single bursts followed by a cluster of four or more bursts, may be a central prerequisite for the long-term potentiation that leads to microstructural changes in the synapses.

The extraordinary plasticity of the approximately 10 million cells that comprise the hippocampal formation in the human brain and its physical structure isolate it as an optimal locus of connectivity to energies and sources of information outside of the individual's immediate brain space. Structurally the human hippocampus is two, interlocking C-shaped structures that are geometrically congruous with a smaller spherical condenser wrapped and partially interdigitated by a larger spherical condenser. The net C-shape structure is similar to a toroid with a gap that would allow a discrete leakage of magnetic flux whose polarization can be matched within an order of magnitude to the geomagnetic scalar potential.

The physical property in conjunction with neuroquantal energies might allow a yet to be explored connection with brain-based mystical and religious experiences. For example Persinger et al (2008) calculated that the average force per voxel of Planck's length would be about 10^{-18} N. This force applied across the most prominent wavelength in the universe, the 21 cm hydrogen line, would be associated with an energy that is equivalent to an electromagnetic wavelength of about 10 nm. This is the width of the neuronal membrane which is the basis of the action potential.

The Emergent Brain Volume and the Future

In our pursuit of a theory of neurophysics and quantum neuroscience we (Persinger and Koren, 2007) showed that the optimal time required to solve the four dimensional distance in Minkowskian space for the human brain converged with the 21 cm (1.4 GHz) wavelength associated with neutral hydrogen. However this was most prominent for larger functional cerebral volumes that would include the obvious physical boundaries as well as the surrounding electromagnetic fields. If the average cerebral volume of the *Homo sapiens sapiens* is increasing, this would allow a larger number of individuals to access this fundamental constant until, presumably, some critical mass or number occurs.

The correlation between average brain weight and year for the years from 1872 to 1957 (Blinkov and Glezer, 1968; publication dates of the data) showed a correlation of .58 for men and .60 for women. The slopes indicated an increase of about 1 gm per year and the net differences between the earliest and most recent measures was about 150 gm for both sexes. This is within the range of the differences between genders. Around the year 1920 the female brain weight exceeded the male brain weight from the previous century.

Modern neuroscience assumes that all experiences are caused or strongly correlated with brain activity. However brain activity and brain structure are composed of matter that exhibits quantum characteristics. These characteristics reflect the essential fabric of space and the energies within it. Neurotheology may describe the biological heritage and potential risks of this selected behavior. Neuroquantology could reveal the infinite potentials that could result from the exploration of the sources for these behaviors.

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