Interaction Between Virtual (Computer Gaming) Environments, Brain Activity, and the Schumann Resonance as the Next Evolutionary Step in Adaptation: Teilhard de Chardin's Noosphere

by

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Abstract

The interactions between the brain of the participant and the temporal flow of events within computer games could reflect a new type of consciousness-machine interface that could reveal novel options for biological-electronic evolution. The flow state which is defined as an inclusive, immersed affect state can be considered a component of and contribution to the interface computer (machine) simulations of real life events. Complex analyses during interactive gaming revealed two parent clusters of topographical quantitative electroencephalographic activity (QEEG) that emphasized the two cerebral hemispheres. A conspicuous peak around 40 Hz (25 ms) occurred upon the declining power gradient of cerebral output. The interactive flow state was more involved with right caudal hemispheric activations within relatively narrow frequency bands that overlapped with the earth-ionospheric Schumann resonances which are also found with normal spectral densities of QEEGs. Independent Component Analyses and Linear Discriminant Analyses for components of QEEG during reward and skill segments of computer game involvement verified the importance of the duration of a percept (around 130 ms). The results were consistent with the possibility that two successive percepts, one of them preceding awareness, might be influenced by extracerebral factors strongly correlated with Schumann Resonance properties. When two experienced or non-experienced gamers shared the same circumcerebral magnetic fields with 20 to 25 ms phase modulations as a second derivative, evidence of excessive correlation, the basis of entanglement, was evident. Application of these results and integration with a biological theory developed by Teilhard de Chardin that the next stage of evolution involve the “noosphere” within which collective experiences would direct subsequent developments in life suggest the feasibility is much greater than previously anticipated.

Keywords

consciousness, electroencephalography, independent component analysis, linear discriminant analysis, digital games, flow state, Schumann resonance, magnetic fields, excess correlation, entanglement noosphere, de Chardin, digital culture, transhumanism, technology, transformative technology

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CHAPTER 1

INTRODUCTION

The experiments conducted for the purposes contained in this document were to begin an objective understanding of the question "What is the response of complex biological systems to applications of advanced human technology, and how may they be applied?" It was of the author's discretion to begin this exploration with simple measurement of brain activations during various conditions of digital game play (Chapter 2), a refinement of the tools necessary to collect optimal data (Chapter 3), and an application of current advancements in related fields to expand the brain/digital environment dynamic to a larger, functional purpose (Chapter 4). Integrated within the universality of the scientific disciplines and the realm of human consciousness, Chapter 5 explores alternative viewpoints on the meaning of digital stimulus interaction as an interface between our biological substrate and energetic properties of emergence within the larger volume of the biosphere. The concepts and applications are then summarized in Chapter 6.

The rise of digital media has provided a unique opportunity to study the effects of these media on the human biological form (Bainbridge, 2007). Traditionally, the advent of the electroencephalograph (EEG) itself by Hans Berger in 1924 is considered one of the first occurrences of brain-computer interface (BCI) (Haas, 2003). BCI research and EEG as well as event-related potential (ERP) use has continued in various forms since then, from the early neurofeedback studies. It has been applied to aiding prostheses in monkeys and for training paralysis patients to control computers (Fetz, 1969; Farwell & Donchin, 1988; Keubler, et al., 1998; Guger, Ramoser, & Pfurtscheller, 2000; Qin, Ding, & He, 2004). Current branches of BCI research now interface with the biological sciences which involves exploring intra-brain cognitive states such as the flow state and inter-brain states utilizing the methods of excess correlation (Dietrich, 2004; Dotta, Buckner, Lafrenie, & Persinger, 2011).

Studies undertaken for this project were organized to integrate these areas of research. Investigations began with simple empirical observation of neurophysiology using EEG during normal immersive video game play. Analyses of these data revealed a novel method for detecting and categorizing millisecond timescale signals using computational and statistical methods. Finally, brain activity associated with video game play was applied to expand the scope of the excess correlation phenomenon, and to begin to experimentally elucidate the dynamics between brains "linked" by a common task. The compatibility of these measurements and observations with a biological theory developed in the early 20th century that postulated the evolution of life forms into the level beyond the biosphere may have significant implications for the human species.

LUDOLOGY AND RELEVANT NEUROSCIENCE

As the primary focus of this project was to integrate the concepts of biology and interactive digital media, the foundations of the theory at hand begin with the study of the stimuli: in the case of video games - *ludology*, or game studies. Academic interest in video games and interactive media began in the 1980s with both social analysis, testing perceptions and reactions, and applying their use to rehabilitation (Malone, 1981; Sedlak, Doyle, & Schloss, 1982; Lawrence, 1986). Even these early studies reported the improvement of hand-eye coordination, reduced reaction times, and improved self-esteem in players. Current research in ludology continues this trend. Much work focuses on the qualitative basis of game design, and measuring the experience this design produces in players (Jennett, et al., 2008; Swink, 2009; Williams, 2014; Landers & Bauer, 2015) and the effects of gaming on neurocognitive ability, in particular their ability to enhance temporal processing capacity and executive function (Donohue, Woldorff, & Mitroff, 2010; Green, Pouget, & Bavelier, 2010).

The concepts of immersion and dissociation in video game environments, referring to a player's capacity to attain a feeling of being outside of one's own body, are particularly studied in reference to what creates these states, how they may be reproduced, and how they affect the player (Williams et al, 2010). Results of these studies indicate that one's experience of the body representation can be overridden in a bottom-up, perceptual alteration by a virtual reality paradigm (Slater, 2010). The neurocognitive mechanisms underlying this phenomenon have been described as belonging to the cognitive, bottom-up "implicit" brain pathways involving the hippocampal formation, and the parietal, temporal, and occipital cortices. These breakthroughs have opened the door for the use of digital environments to study nuances of brain function and perception previously unattainable by the restrictions of equipment and their artifacts.

Digital Environments

A *digital environment* is a computer-based simulation of an environment, which can range from text to 3D graphics (Bartle, 2004). It allows the player to explore and interact with the environment in some way, through actions or events. This paradigm may be referred to as a virtual world in the context of multiple players engaging within a singular environment (Bartle, 2004). There is much literature on the design of digital environments, ranging in context from video games to application and software user interface. Particular attention has been given to the design of video games with respect to eliciting particular behaviours and reward responses (Swink, 2009). The core of a digital environment experience in this context is built on a framework of goal-oriented objectives at various levels of discourse within the environment, each with a task to achieve the goal. This establishes meaning and context within the digital environment, much like Maslow’s hierarchy of needs describes this establishment for a human being in society (Maslow, 1943) and other aspects of ethology for other animals (Huxley, 1942).

The metric of *presence*, or *telepresence*, provides the means to define and measure the effectiveness of an environment’s design (Williams, 2014). It can infer the level of realism and believability a digital space can provide. Presence is formally defined as “a psychological state or subjective perception in which even though part or all of an individual’s current experience is generated by and/or filtered through human-made technology, part or all of the individual’s perception fails to accurately acknowledge the role of the technology in the experience” (International Society for Presence Research, 2000).

Should a sufficient state of presence be reached by an organism in a particular environment, be it digital or otherwise, the organism and its biology associated with those perceptions will activate as they would in “normal” scenarios. It follows then that biological adaptations to perceptions within these environments are relevant for study as these environments become more complex and ubiquitous. The concept of immersion and the flow state in the video game context, as described earlier, can be used synonymously with the concept of presence and states of consciousness relevant to these phenomena should be discussed.

States Of Consciousness

There is a multitude of "states of consciousness" concepts that are discussed in the literature. Most refer to their own neural correlates and philosophical framework. Of foremost interest to the present series of experiments is that of the "**flow state**" and the *out-of-body experience* (OBE) and the manner in which they relate to immersion and presence in digital environments. Discussions on the flow state begin with the work of Csíkszentmihályi (1990) who describes the cognitive state of being immersed in a task, or *flow state*, as the feeling of complete and energized focus in an activity, with a high level of enjoyment and fulfillment. This early conceptual model falls along the axes of ability versus challenge, and the "flow zone" arising from a constructive interference of the two.

Dietrich (2004) provides a concise overview of the neurocognitive mechanisms which would underlie the phenomenon of flow, describing them as belonging to the cognitive, bottom-up "implicit" brain pathways involving the hippocampal formation, and the parietal, temporal, and occipital cortices. These neural correlates contribute to conscious states often explored under the label of OBEs, which are often reported with similar neural correlates and reports (Booth and Persinger, 2009; Blanke, Ortigue, Landis, & Seeck, 2002; Blackmore, 1982). A number of studies have established the fact that virtual experiences can elicit an OBE (Aspell, Lenggenhager, & Blanke, 2012). In computer science research, presence is a prevalent concept with defines the participant's belief that they are present in the environment of computer generated objects and stimuli (Slater, Usoh, & Steed, 1994).

Theories range from the experiences of simple user interfaces to fully realized virtual environments. Many models of immersion in games have been examined - in particular the sensory, challenge-based, and imaginative (SCI) model of Ermi and Mäyrä (2005). The SCI model outlines the predominant components of a game experience necessary to achieve an immersive state: the sensory (audio, tactile, visual, etc), challenge (reason for the player to want to play), and imaginative (allowing the player's own imagination to colour the experience of the provided narrative and design). This contemporary model adds a third axis to Csíkszentmihályi's original concept of challenge and ability. This involves the area of cognition, or the player's interpretation of their senses in the environment and how that translates into imagination. Further, a number of congruencies arise with concepts of cognitive states in meditation (Raffone and Srinivasan 2010).

Davidson and Goleman's (1977) proposal that meditative practice techniques fall along the continuum of concentrative on one end and mindful on the other leads to the deduction that individual challenge my provide a moderating factor to the meditation experience. In summary, the two poles along the linear continuum are often modulated by an exogenous third factor, creating a triadic structure and introducing noise into the system. This conceptual metaphor is seen in both the cases of immersion, through the interaction of ability, challenge, and cognition, and meditation where concentration, mindfulness, and challenge interact. This connection of the well-established set of cognitive states involved in video game immersion to alternative states of consciousness and those involved with meditative practice might be considered compatible with the concepts of Teilhard de Chardin and the sphere of human thought as well as contemporaries such as Sheldrake and the theory of morphic fields and their resonance (Sheldrake, 1981). These ideas have been further tested at the quantum level with experiments surrounding excess correlation.

Excess Correlation

Excess correlation is a frequently employed as an analogue of the physical phenomenon of entanglement, where the experimental treatment of non-local spaces results in a condition as if the two loci were superimposed and become the "same space" (Dotta, Buckner, Lafrenie, & Persinger, 2011). This "entanglement" has traditionally been a phenomenon studied exclusively within the atomic and subatomic levels of discourse but has recently been demonstrated in macroscopic applications at non-traditional distances (> 10m) of these interactions, such as pH shifts, chemiluminescent reactions, cell cultures, and human brains (Rouleau, Carniello, & Persinger, 2014; Dotta, Koren, & Persinger, 2013; Dotta, Buckner, Lafrenie, & Persinger, 2011) Experimental enhancement of these excess correlations can occur with specific types of magnetic fields.

The facilitation of this effect requires two loci simultaneously exposed to frequency (phase)-modulated electromagnetic (EM) fields, displaying changing angular velocity within either a circular array of single solenoids or a wire-wrapped toroid apparatus. Excess correlation effects are seen when the sequences of changing angular velocities are opposite to the increasing or decreasing frequency or phase modulation of the rotated EM fields. The theoretical approach applied here suggests the rotation of the Earth and its magnetic field should contribute to the conditions that produce these effects (Persinger, 1999). Therefore a component of this "excess" correlation requires a change in the subtle magnetic intensities along the axis of rotation.

Expansion of this phenomenon to the realm of human brain function was demonstrated by Persinger, et al (2010) who, using this paradigm, paired untreated participants and presented a series of light flashes to the local participant while the non-local participant remained in a separate sensory isolated room. QEEG demonstrated correlated activations in areas associated with spatial perception (right parietal region) between the participants, despite their separation. A next logical step in testing the boundary of this phenomenon is to engage the participants in a more complex task to explore the dynamics of integrated cortical brain function and the transferability of activity within these regions through the paradigm.

NEUROIMAGING AND COMPUTATIONAL BIOLOGY

Within the last decade a multitude of methods have become available by which one may analyze EEG data. Among these includes the EEGLAB toolbox for MATLAB computational software (Delorme & Makeig). This toolbox provides a robust and simple way to analyze EEG data using advanced computational techniques such as Independent Component Analysis (ICA), cluster analysis, and spectral profiling. ICA is particularly suited to the complex, multivariate nature of EEG signals. The analysis deduces the component independence from the whole signal by minimizing the amount of information shared by components, while maximizing the non-Gaussianity, or statistical normalcy of each component.

ICA algorithms used in EEGLAB pre-process source signals using a centring method of subtracting the mean to create a zero-mean signal. EEGLAB utilizes the Infomax iterative algorithm, a learning algorithm which functions to map a set of input values to a set of output values by maximizing the Shannon entropy and hence maximizing non-Gaussianity (Bell & Sejnowski, 1995). Shannon entropy refers to the expected value of information contained in each message received, and is central to the sampling of cortical activation through the skull (Shannon, 1948). Through this, ICA of electrophysiological data from multiple electrode sites can be statistically compared for shared variance, generating topographs.

Topographs, or scalp maps, of cortical activation can be generated of individually separated components of any particular task. This isolation of individually relevant cortical activations provides a significant advantage when analyzing response to complex stimuli such as video games. These computational methods especially show their usefulness in electrophysiological data collected with many electrodes, but low electrode equipment provides a more than sufficient data source for useful analysis. This is evident with further statistical analysis on ICA computed data, providing opportunity for cost-effective analysis of these data traditionally reserved for high electrode count equipment.

EVOLUTIONARY CONSIDERATIONS

The evolution of the earth has been often considered in large epochs. They begin with the solidification of the earth followed by the formation of a gaseous environment that is compatible with the formation of living systems. The emergence of the biosphere has been considered the third state. With the markedly acceleration evolution of the homo sapiens sapiens and its proclivity to create a secondary environment of electromagnetic instrumentation and related tools there is now the potential for a fourth state of evolution. This state of organization could involve the integration of the biological bases of the cognitive states of all members of the species, integrated with the earth’s resonances within which all members are typically exposed, mediated through this new electronic technology. This thesis explores the quantitative evidence that could support this possibility.

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CHAPTER 2

NEUROPHYSIOLOGICAL DYNAMICS OF THE FLOW STATE IN VIDEO GAME PLAY: EMBODIED COGNITION AND IMPLICATIONS FOR CONSCIOUSNESS

ABSTRACT

The “flow state” is an integrated, positive subjective experience often associated with an expansive perspective during which time the person experiences extension of his or her influence or consciousness into machine environments whereby intermittent convergence (or unity) within the environments can be experienced. Quantitative electroencephalographic (QEEG) measurements were completed while experienced gamers accessed “The Elder Scrolls V: Skyrim” and partitioned according to baseline, skill, reward and planning segments. Independent Component Analyses (ICA) and pre-clustering employing the Principal Component method demonstrated reliable activation of left hemispheric (temporo-occipital, orbitofrontal) regions during personal intention and planning. However, during the “flow states” of active engagement right hemispheric activation dominated within the right occipital, temporooccipital junction, parietal and orbitofrontal region while decreased activation dominated within the left inferior frontal region. The primary frequency bands that were differentiated during the flow state were centralized to the gamma (38-42 Hz) range. There may be some similarity to the “dream state”. The specific activation during flow state planning activities within the right orbitofrontal and temporal regions but decreased activity within the bands that occupy the Schumann Resonance harmonics within the left temporal lobe suggests that the flow state may increase the probability of coherence with weak external magnetic fields within which most human beings are immersed.

KEYWORDS

Flow state, Principal Component Methods, Cluster Arrays, QEEG, Computer Games, Brain-Computer Interface

INTRODUCTION

The cognitive state of being immersed in a task, also termed the "flow state", is described in psychology as the feeling of complete and energized focus in an activity, with a high level of enjoyment and fulfillment (Csíkszentmihályi, 1990). Dietrich (2004) provides a concise overview of the neurocognitive mechanisms which would underlie the phenomenon of flow. In the context of video games early anecdotes about the phenomenon date back to the early 1980s and much of this theory has since been adapted to interactive media. Further studies by Holt (2000) and Sweetser & Wyeth (2005) demonstrate the validity of the phenomenon in video game settings from a psychological and sociological standpoint, respectively. Authors and game designers Chen (2006) and Swink (2009) have demonstrated optimal methods by which to practically implement the phenomenon into games. Studies by Salminen & Ravaja (2007) have outlined the neurophysiology of game events. In general there is very little research in quantitatively exploring the neurophysiological effects of the flow state phenomenon utilizing video games, and especially so in exploring their implications for consciousness.

From a philosophical standpoint, the notions of embodied cognition and extended cognition provide a theoretical mechanism by which an immersive game experience may interact with the player, and vice versa. Rowlands (2010) describes the forms of mental processes under this model as: (1) embodied in the sense that mental processes involve more than the brain, and include a general involvement of the body and its processes, (2) embedded in the sense that mental processes function only in a related external environment, (3) enacted in the sense that mental processes involve not only neural processes but also the player's actions, and (4) extended in the sense that mental processes extend into the player's environment.

These ideas have been applied within the game space by philosophers such as Arjoranta (2013) who extend the work of Dourish (2001) and Antle, Corness, & Droumeva (2009) by describing how embodiment relates to experiences of spatiality and how embodied cognition affects game play interpretation. The interaction of video game play, flow state, and consciousness has been explored from a psychological perspective by Gackenbach (2009), outlining how video game players show increased incidences of lucid dreaming and conscious development with experience, as a function of flow.

With respect to video games, quantitative electroencephalography (QEEG) is currently the ideal neuroimaging candidate to explore the short temporal window in which many game mechanics function, in addition to other factors such as relative ease of data collection and low cost of materials. Highlight of much of the past research combining EEG technology and video game contexts has focused on human-computer interaction and ergonomics, analyzing entire game sessions (Smith, Gevins, Brown, Karnik, & Du, 2001), adolescent aggression (Salminen & Ravaja, 2008), and epilepsies (Hughes, 2008), without focusing on video games in and of themselves. Analyzing data based on entire game sessions (Smith, Gevins, Brown, Karnik, & Du, 2001) and on a per-event basis (Salminen & Ravaja, 2007) have both been completed and each are associated with their own limitations of averaging out event-specific activation detail and removing larger picture context, respectively.

Conceptual models exploring the nuance of video game immersion have been explored by Calleja (2007). In a similar way to how EEG analyses may be completed, Calleja's Digital Game Involvement Model describes two temporal phases: (1) macro-involvement, involving motivational attractors to games that influence sustained engagement, and (2) micro-involvement, involving moment by moment involvement in the game scenario. Six involvement factors contribute to the structure between macro and micro, and include spatial awareness, tactical considerations, affective context, narrative relevance, shared responsibility, and performance requirement.

Sampling each of these factors is essential in capturing the optimal involvement of a player in a game. In addition, these factors are based upon a model presented by Fine (1983) describing table top role-playing games, and a suitable digital equivalent was chosen for the present study as such. Limitations of digital games to test the flow state do present themselves, and contribute to the quality of data collected. As these stimuli are not a true virtual reality, graphical and gameplay limitations establish a boundary by which the environment may become unbelievable to the player. This is especially true with games which are not adequately tested, either from a technical or design standpoint, and these factors must be taken into account.

From a neuroscientific standpoint, Dietrich (2004) bifurcates the neurocognitive model of the flow state into two groups: (1) the explicit system, associated with flexible, high order frontal and medial temporal lobe functions, and (2) the implicit system, associated with efficient, skill-based knowledge involving the basal ganglia. From this the flow state is described on the sliding scale of cognitive flexibility/efficiency where highly practiced skill represented within the implicit system is implemented without interference from the explicit system. Through secondary connections, maintaining activity in the explicit system can stimulate the elicitation of an out-of-body experience (OOBE), where the attribution of personal cognition to another consciousness or sentient being is strongly correlated with theta band (4-7 Hz) activity within the frontoparietal or frontotemporal regions (Booth & Persinger, 2009).

Persinger et al (2010), employing s_LORETA (Low Resolution Electromagnetic Tomography) showed that when participants experienced a "sentient being" or sensed presence during bilateral cerebral stimulation from externally applied weak magnetic fields the activation occurred from the right temporal to left temporal regions. During experiences of OOBEs the current density increased from the left temporal-frontal to the right prefrontal region. They interpreted this reliable dynamic as representative of the reported subjective experiences. For the sensed presence the intercalation in the right-to-left temporal lobe direction was associated with the experience of the right hemispheric equivalent of the left hemispheric sense of self, i.e., the sense of another or a presence. For the left fronto-temporal-to-right prefrontal pattern, the sense of self intercalated with the right prefrontal region which is classically associated with spatial orientation and allocentric space. Consequently the person felt as if they were "in another space". These metaphors require further examination and are potentially applicable to gaming experiences.

Frontotemporal regions have also been implicated in the reimagining of past events and pre-experiencing future events (Lavallee & Persinger, 2010), and provide a basis upon which to group relevant game mechanics for individual study. EEG video game studies by Salminen & Ravaja (2007) explored event-specific activation including reward-type game mechanics. With collection of game items, they found decreased theta and alpha band (8 – 14 Hz) activation over the central and frontal regions, respectively, with increased beta band (15 – 35 Hz) activation over the frontal regions. Reaching a goal increased parietal region theta activity, frontal low alpha (8 – 10 Hz) activity, frontal, central and parietal high alpha (11 – 14 Hz) activity, and frontal and central beta activity. These activation patterns suggest item collection to induce an arousal state, while reaching a goal induces a relaxed state. These studies provide three such types of game mechanic which will be explored in conjunction with the flow state in the present study. The goal of this study was to explore the neurophysiological dynamics of the flow state in video games by consolidating the current social and conceptual frameworks surrounding the phenomenon. Our approach was if this effect was robust and reliable, it should be evident with repeated measures of a small sample of human brain activity from which the massive data base was extracted.

MATERIALS & METHODS

Participants

Four subjects (3 identified males and 1 identified female, aged 20–27 years old) participated in the experiment. All subjects were experienced with the gaming environment and the task therein to eliminate effects of learning and confusion with the controls. All participants provided informed consent for their participation in the experiment, as approved by Laurentian University's Research Ethics Board.

Stimuli and experimental procedures

The gaming task involved a roughly 20 min segment of the commercially available game The Elder Scrolls V: Skyrim (Bethesda Game Studios, 2011). The segment was a reproducible section of the game, where events would occur along the same course for each participant (the dungeon "Bleak Falls Barrow"). This segment, or 'dungeon,' early in the course of the game was chosen to allow players to choose their individual play style so as to generate optimal immersion (Dietrich, 2004). The game was presented on the 15.6" LCD monitor of a Lenovo Y580 gaming laptop at 1920 x 1080 resolution.

The experiment took place in an enclosed and darkened acoustic chamber and Faraday cage. Participants were seated in a comfortable chair and provided with a choice of Xbox 360 controller (3 participants) or a keyboard and mouse (1 participant) for controls. EEG recordings were taken for the entire duration of the session. In-game event timings were recorded manually by keeping view of the play screen from a position behind the participant, and matching to the timing markers of the EEG record.

Prior to data collection sessions, a video of the primary author playing the selected dungeon was made for the passive segment; a positive control of the dungeon as a stimulus. The video was made using Fraps (Beepa Pty Ltd, 2014) screen capture software at equal screen resolution and frame rate to the gameplay. Video for passive segments were equal in length to active gameplay segments. The passive video involved the participant watching another person playing the game and engaging in similar movements that were or would be displayed by the participants.

Game immersion experiment

Sessions consisted of two segments: an active gameplay segment, and a passive video segment. Sessions began with alternating presentations of segments in ABAB fashion. Prior to either the first active game or passive video segment, a 60-second eyes open and 60-second eyes closed measure was taken for baseline comparisons. For the duration of the eyes-open measure, participants were instructed to focus on a point of the game screen.

Prior to the start of active gameplay segments, participants were allowed to move the game character around the ‘dungeon’ area entrance to familiarize themselves with the controls, the particular environment, and organize in-game items. They were told to enter the ‘dungeon’ when they were ready, asked to keep their heads as fixed as possible to avoid recording artifacts, and instructed to save their game regularly. If beginning with a passive segment, participants were verbally briefed on artifacts and saving, and were later given time to familiarize before the next session. Upon entry of the dungeon, both actively and passively, recording of EEG data began and the participant played the game in accordance with their own preferences and plays styles or observed the video.

In-game events and their timings were recorded at the primary author's discretion and during both active and passive segments under the categories of skill, reward, and planning. Skill events were defined as an event where the player was controlling the avatar in a technical manner, and completing an action that would contribute to the game's mechanic of character experience level. Examples of this event type in the context of the experiment include active combat and picking locks. Reward events were defined as an event where the player was rewarded for their continued gameplay, and contributions to improving the player character. This would involve acquiring new items, improving the character's experience level, and completing objectives. Planning events were defined as an event that would require the participant to consider future actions. These events include deciding among dialogue options, choosing character items, and assigning experience points to the characters attributes. Participants were debriefed after the completion of both segments and asked to rate their level of immersion in the game on a 10-point Likert scale of 1 ('not immersed at all') to 10 ('completely detached from my body').

EEG recordings and data extraction

EEG data were recorded with WinEEG software using a Mitsar 201 (© Mitsar Co. Ltd. Saint Petersburg, Russia, 2013) 19-channel QEEG amplifier at 500 Hz in the standard 10-20 montage. Bandpass filters were set at 0.1 – 50 Hz and notch filters at 50-70 Hz. A 5 min segment of EEG data after the first 10 min of gameplay (gradient of increasing immersion) and gameplay video was extracted from the record for each participant. Eye blink artifacts were removed using the WinEEG artifact correction algorithm prior to extraction.

Data processing and ICA

Data was imported into the EEGLAB v13 toolbox (Delorme & Makeig, 2004) for MATLAB R2013b (The MathWorks Inc, 2013). Combined event timing data for each participant was also imported into EEGLAB via text file, and each dataset was then segmented into three further datasets. Segmenting datasets into each of the event types extracted ±1 sec of the event marker for a total of 3 sec extracted per event. Eyes open baseline data was also imported as a standalone dataset. Both the complete datasets (6 total; 3 active, 3 passive), event aggregate datasets (12 total), and baseline datasets (4 total) then underwent Independent Component Analysis (ICA) using the Infomax ICA algorithm (Delorme, Sejnowski, & Makeig, 2007). Infomax ICA returns one IC for each electrode, giving a median of 18 ICs for each dataset. Additional artifactual component correction was performed as needed using standard EEGLAB functions; rejecting and removing artifactual components, performing the ICA decomposition again on the new dataset, and saving the corrected file separately.

Table 2.1: Organization of datasets for analysis

Dataset	Segment	Event	Baseline
1	Active and Passive	All included	No
2	Active	All included	Yes
3	Passive	All included	Yes
4	Active and Passive	Planning	Yes
5	Active and Passive	Planning	No
6	Active and Passive	Reward	Yes
7	Active and Passive	Reward	No
8	Active and Passive	Skill	Yes
9	Active and Passive	Skill	No

Cluster analysis and study statistics

Datasets were combined into studysets for active game and passive video segments and event groups including all participants and baseline datasets as outlined in Table 1. Pre-clustering was performed using the standard Principal Component method; selecting to process the power spectra and scalp map measures for all components of the included datasets. A pre-clustering array was computed for the same measures, defining a power spectra frequency range from 2 - 50 Hz for the parentcluster, the main cluster of all components. Studysets were sub-clustered using the Neural Network method (MATLAB Neural

Network toolbox), computing the default number of clusters. Analysis yields scalp maps and spectral profiles for the parentcluster and any sub-clusters as the data permits. After sub-clustering, comparisons were performed between the clustered component spectral profiles of the study groups with built-in parametric and permutation EEGLAB statistical algorithms with a p-value threshold of 0.05. These methods utilize both t-test (paired and unpaired) and one-way ANOVA (repeated-measures and balanced) as necessary. Comparisons employ the parametric method unless otherwise specified.

RESULTS

Whole-segment measures

Active/passive segment comparisons

Comparison of active gameplay and passive video segments of all participants combined returned 3 sub-clusters, in addition to the parentcluster. The parentcluster outlines parentcluster activation profile A, with activation of the left temporo-occipital junction and left orbitofrontal cortex, combined with a decrease in activation of the right inferior frontal area. Power measures of the parentcluster were significantly higher in the active game condition at frequencies between 23 and 50 Hz (paired t-test). Sub-clusters involve (unpaired t-tests): (1) increased activation in the left temporo-occipital junction alone, with significantly higher power at 40-42 Hz, (2) increased activation across both the caudal and rostral sides of the left central sulcus with no significant difference between active and passive conditions, and (3) decreased activation in the right postcentral region with significant decreases in power during the passive segment at 5 – 9 Hz and 11 Hz compared with the active segment.

Active/baseline segment comparisons

Comparison of active gameplay and eyes open baseline segments of all participants combined returned 5 sub-clusters, in addition to the parentcluster. The parentcluster outlines activation profile A: activation in the left temporo-occipital junction and left orbitofrontal cortex, combined with a decrease in activation of the right inferior frontal area. Power measures of the parentcluster were significantly higher in the active game condition at all frequencies except between 9 and 11 Hz (paired t-test). Sub-clusters involve (unpaired t-tests): (1) increased activation in the left posterior parietal and medial prefrontal regions, with no significant difference between conditions, (2) increased activation bilaterally of the superior parietal lobule, with significantly higher power in baseline conditions at 9 – 10 Hz, (3) decreased activation in the right inferior/middle frontal and right occipital regions, with activation in the left temporal pole and left orbitofrontal area displaying no significant differences, (4) increased activation caudal to the superior parietal lobule, with significantly higher power in active condition at 15 Hz, and 20 – 50 Hz, and (5) increased activation of the left temporal region, with significantly higher power in the active condition at 7 – 8 Hz, 27 – 28 Hz, and 42 Hz.

Passive/baseline segment comparisons

Comparison of passive video and eyes open baseline segments of all participants combined returned 3 sub-clusters, in addition to the parentcluster. The parentcluster outlines activation profile B: activation in

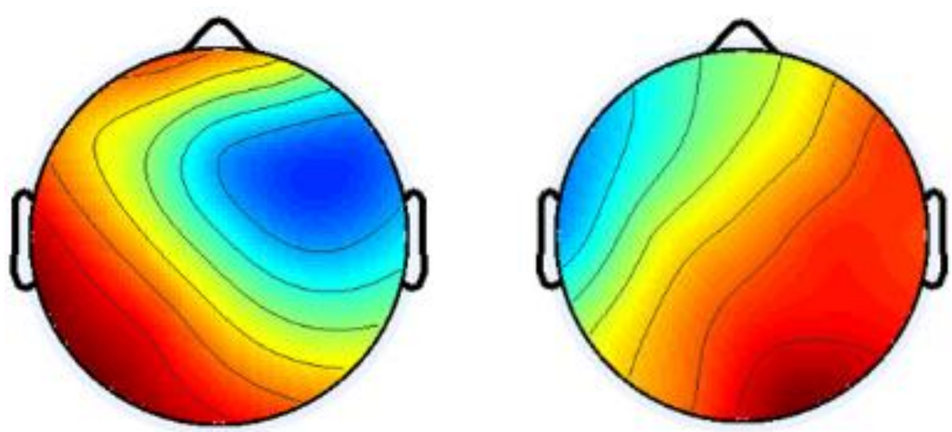

Figure 2.1: Scalp maps of the parentcluster activation profiles. The left map shows the left hemisphere-dominant pattern (pattern A), and the right map shows the right hemisphere-dominant pattern (pattern B).

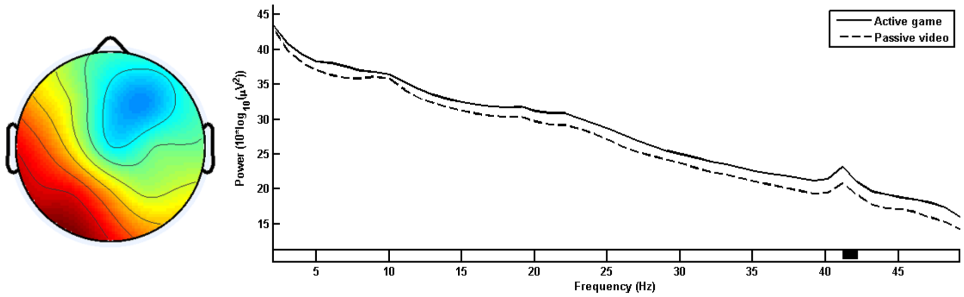

Figure 2.2: Scalp map and power spectra of left caudal region activation in whole-segment measures, with gamma band (41-42 Hz) power increases in active game over passive video conditions.

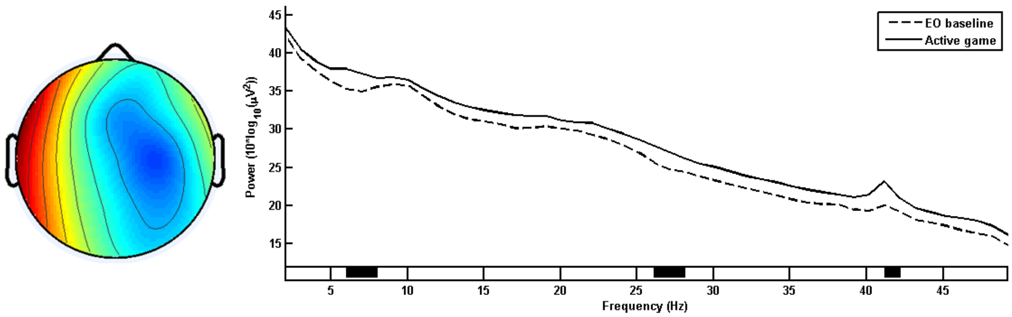

Figure 2.3: Scalp map and power spectra of left temporal lobe activation in whole-segment measures, with theta (6-8 Hz), beta2 (26-28 Hz), and gamma (41-42 Hz) band power increases in active game over eyes-open baseline conditions.

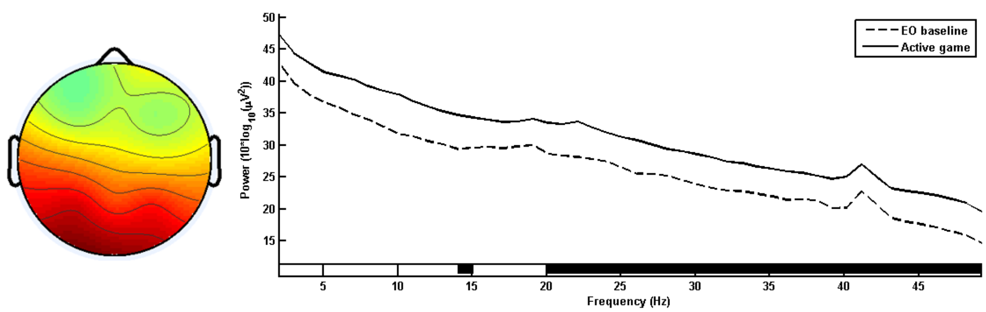

Figure 2.4: Scalp map and power spectra of bilateral caudal area activation in whole-segment measures, with beta1 (14 Hz), and beta2 to gamma (20-50 Hz) band power increases in active game over eyes-open baseline conditions.

the right occipital, temporo-occipital junction, parietal, and orbitofrontal cortex, combined with a decrease in activation of the left inferior frontal area. Power measures of the parentcluster were significantly higher in the passive video condition at frequency ranges of 2 – 8 Hz, 12 to 36 Hz, and 40 – 42 Hz (paired t-test).

Sub-clusters involve (unpaired t-tests): (1) decreased activation over the right superior parietal region, with no significant difference between conditions, (2) increased activation of the middle frontal lobe, with no significant difference between conditions, and (3) increased activation in the bilateral occipital and left orbital frontal regions, with no significant difference between conditions.

Event-specific segment comparisons

Planning active/passive/baseline segment comparisons

Comparison of active gameplay, passive video, and eyes open baseline segments of all participants combined with isolated planning event data returned 3 sub-clusters, in addition to the parentcluster. The parentcluster outlines activation profile B: activation in the right occipital, temporo-occipital junction, parietal, and orbitofrontal cortex, combined with a decrease in activation of the left inferior frontal area. Power measures of the parentcluster were significantly lower in both the active game and passive video conditions at all frequencies compared to baseline (repeated-measures one-way ANOVA). Sub-clusters involve (balanced one-way ANOVA): (1) increased activation in the right temporal and right orbital frontal regions with decreased activity in the left temporal pole, displaying significantly lower power than baseline at frequencies 2 – 15 Hz, 17 – 26 Hz, 32 – 35 Hz, and 42 Hz, (2) increased activation of the right occipital

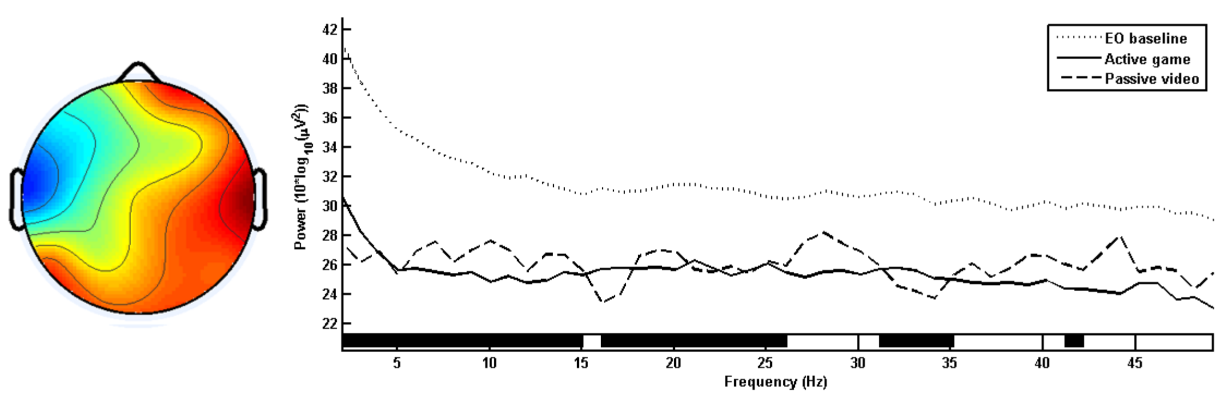

Figure 2.5: Scalp map and power spectra of right temporal and frontal lobe activations during planning-type events, with lower delta to beta1 (2-15 Hz), beta1 to beta2 (17-26 Hz), beta3 (32-35 Hz), and gamma (41-42 Hz) band power in active game and passive video compared to eyes-open baseline conditions.

cortex, with significantly lower power in active and passive conditions from baseline across all frequencies, (3) decreased activation in the left occipital regions, with power in the active and passive conditions significantly below baseline at 2 – 26 Hz and 28 Hz, and active game condition power being significantly lower than passive and baseline conditions at 30 – 45 Hz and 48 – 50 Hz.

Comparison of active gameplay and passive video of all participants combined with isolated planning event data returned 1 sub-cluster, in addition to the parentcluster. The parentcluster outlines activation profile B: activation in the right occipital, temporo-occipital junction, parietal, and orbitofrontal cortex, combined with a decrease in activation of the left inferior frontal area. Power measures of the parentcluster are significantly lower the active game condition at frequencies from 2 – 21 Hz, compared to the passive video condition (paired t-test). Sub-clusters involve (unpaired t-test): (1) decreased activation in the bilateral occipital and right temporo-occipital regions, displaying significantly lower power in the active condition at frequencies 2 Hz, 13 – 23 Hz, 24 – 25 Hz, 27 – 29 Hz and 30 - 50 Hz.

Reward active/passive/baseline segment comparisons

Comparison of active gameplay, passive video, and eyes open baseline segments of all participants combined with isolated reward event data returned 2 sub-clusters, in addition to the parentcluster. The parentcluster outlines activation profile B: activation in the right occipital, temporo-occipital junction, parietal, and orbitofrontal cortex, combined with a decrease in activation of the left inferior frontal area.

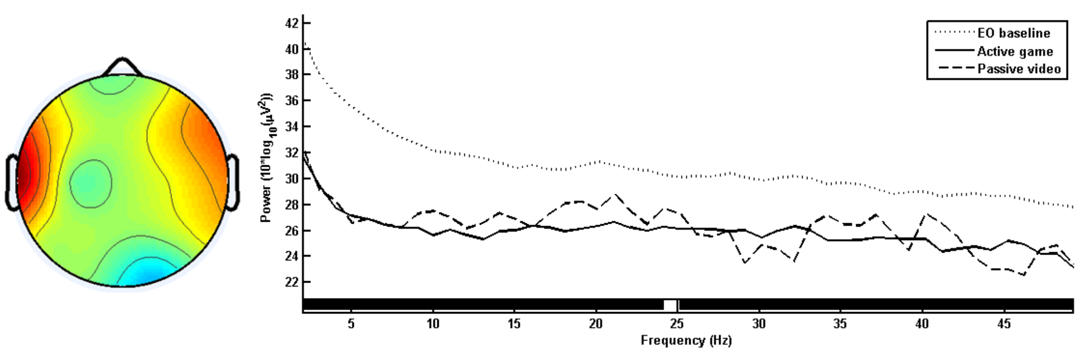

Figure 2.6: Scalp map and power spectra of left temporal lobe activation during reward-type events, with power in all bands (except 24 Hz) lower in active game and passive video compared to eyes-open baseline conditions.

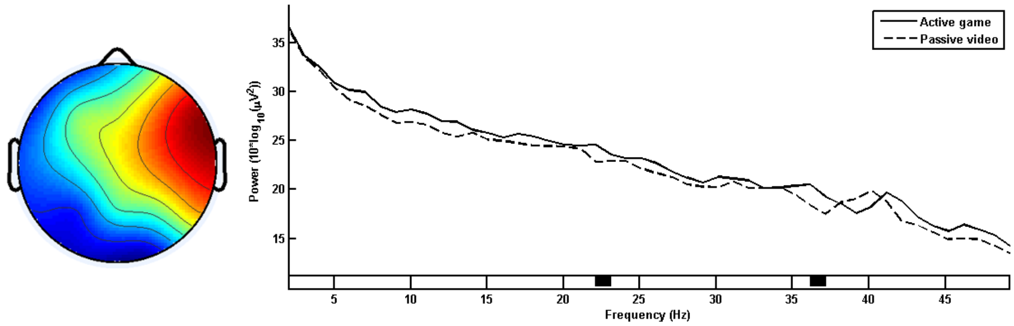

Figure 2.7: Scalp map and power spectra of right temporal and inferior frontal lobe activations and bilateral occipital lobe deactivations during reward-type events, with beta2 (22-23 Hz), and beta3 (36-37 Hz) band power increases in active game over passive video conditions.

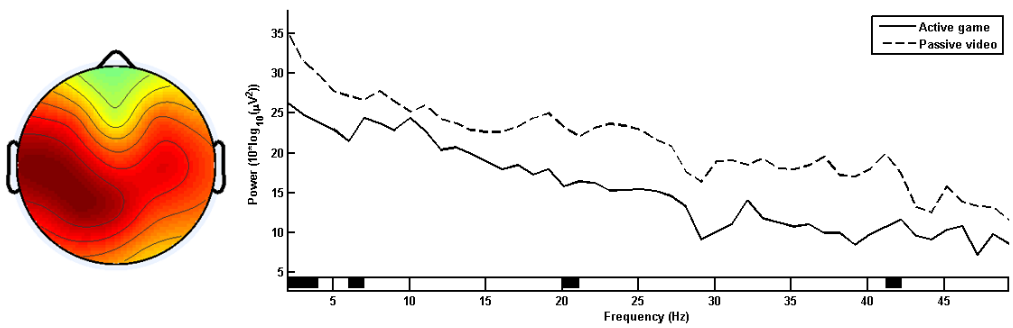

Figure 2.8: Scalp map and power spectra of left temporal and temporoparietal region activations during reward-type events, with lower delta (2-4 Hz), theta (6-7 Hz), beta2 (20-21 Hz), and gamma (41-42 Hz) band power in active game versus passive video conditions.

Power measures of the parentcluster are significantly lower in both the active game and passive video conditions at all frequencies compared to baseline (repeated-measures one-way ANOVA). Sub-clusters involve (balanced one-way ANOVA): (1) increased activation in the left temporal and right inferior frontal regions, with active and passive conditions displaying significantly lower power than baseline at frequencies 2 – 33 Hz, 35 – 36 Hz, 39 – 40 Hz, and 42 – 49 Hz, and (2) increased activation of the right occipital and medial prefrontal cortices, with significantly lower power in active and passive conditions from baseline across all frequencies.

Comparison of active gameplay and passive video of all participants combined with isolated reward event data returned 4 sub-clusters, in addition to the parentcluster. The parentcluster outlines activation profile B: activation in the right occipital, temporo-occipital junction, parietal, and orbitofrontal cortex, combined with a decrease in activation of the left inferior frontal area. Power measures of the parentcluster were significantly lower the passive video condition at frequencies from 29 – 30 Hz, 32 Hz, 37 – 39 Hz, and 42 – 50 Hz, compared to the active game condition (paired t-test). Sub-clusters involve (unpaired t-test): (1) increased activation in the right temporal lobe with decreases in activity from the bilateral occipital lobes including the left occipito-parietal and occipito-temporal junctions, the left temporal and left inferior and orbital frontal areas with significantly lower power in the passive condition at frequencies 22 and 38 Hz, (2) increased activation in the left temporo-parietal junction and bilateral post-central areas, displaying significantly lower power in the active condition at frequencies 2 - 3 Hz, 6 Hz, 21 Hz, and 42 Hz, (3) increased activation in the right orbital and inferior frontal regions as well as bilateral caudal regions, displaying significantly lower power in the passive condition at frequencies 31 and 33 Hz, and (4) increased activation in the bilateral temporal lobes, displaying significantly lower power in the active condition at frequencies 9 Hz, and 41 Hz.

Skill active/passive/baseline segment comparisons

Comparison of active gameplay, passive video, and eyes open baseline segments of all participants combined with isolated reward event data returned 2 sub-clusters, in addition to the parentcluster. The parentcluster outlines activation profile B: activation in the right occipital, temporo-occipital junction, parietal, and orbitofrontal cortex, combined with a decrease in activation of the left inferior frontal area. Power measures of the parentcluster are significantly lower in both the active game and passive video conditions at all frequencies compared to baseline (repeated-measures one-way ANOVA). Sub-clusters involve (balanced one-way ANOVA): (1) increased activation in the left temporal and right inferior frontal regions, with active and passive conditions displaying significantly lower power than baseline at frequencies 2 – 33 Hz, 35 – 36 Hz, 39 – 40 Hz, and 42 – 49 Hz, and (2) increased activation of the right occipital and medial prefrontal cortices, with significantly lower power in active and passive conditions from baseline across all frequencies.

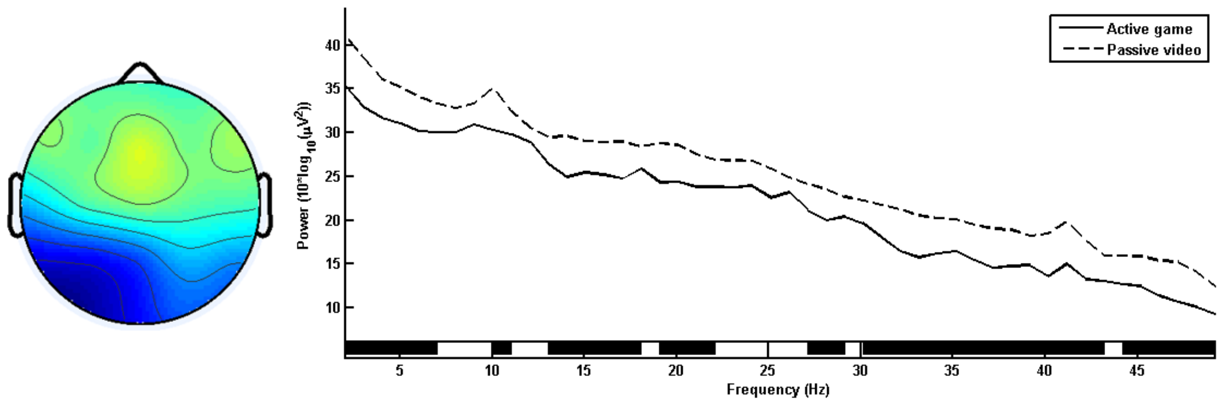

Figure 2.9: Scalp map and power spectra of left temporo-occipital region deactivations during skill-type events, with lower delta to theta (2-7 Hz), alpha to beta2 (10-11, 13-17, 19-22, 27-29 Hz), and beta3 to gamma (30-43, 44-50 Hz) band power in active game versus passive video conditions.

Comparison of active gameplay and passive video of all participants combined with isolated reward event data returned 4 sub-clusters, in addition to the parentcluster. The parentcluster outlines activation profile B: activation in the right occipital, temporo-occipital junction, parietal, and orbitofrontal cortex, combined with a decrease in activation of the left inferior frontal area. Power measures of the parentcluster were significantly lower during the passive video condition at frequencies from 29 – 30 Hz, 32 Hz, 37 – 39 Hz, and 42 – 50 Hz, compared to the active game condition (paired t-test).

Sub-clusters involve (unpaired t-test): (1) increased activation in the right temporal lobe with decreases in activity from the bilateral occipital lobes including the left occipito-parietal and occipito-temporal junctions, the left temporal and left inferior and orbital frontal areas with significantly lower power in the passive condition at frequencies 22 and 38 Hz, (2) increased activation in the left temporo-parietal junction and bilateral post-central areas, displaying significantly lower power in the active condition at frequencies 2 - 3 Hz, 6 Hz, 21 Hz, and 42 Hz, (3) increased activation in the right orbital and inferior frontal regions as well as bilateral caudal regions, displaying significantly lower power in the passive condition at frequencies 31 and 33 Hz, and (4) increased activation in the bilateral temporal lobes, displaying significantly lower power in the active condition at frequencies 9 Hz, and 41 Hz.

DISCUSSION

The primary assumption of cognitive neurobiology is that structure dictates function. Typically this is applied to stable architecture such as the organization of neuronal arrays and their interconnections. This is the spatial component. However the cerebrum is also a dynamic system whereby temporal transients allow changing and often unique organizations or "fields" of connections. These temporal arrays are often labelled as "states". There are three traditional states that include the waking state, REM (rapid eye movement) or dream state, and the slow wave sleep state.

As indicated by Llinas and colleagues (1993), the primary difference between the waking and dream state, both of which exhibit enhanced coherence within the 20 to 25 ms range (40 Hz), is the primary pathways that mediate their presence. For the waking state the mediation is primarily thalamic-cerebral cortical in nature and hence is exteroceptive (externally) oriented. For the dream state the dominant pathways also includes the hippocampal region and is more interoceptive (internally) oriented. Assuming that the cerebral substrate of consciousness is a closed system of intrinsic neuronal interactions for approximately 90% of the cortical input, the exteroceptive sources would only modulate the ongoing stream of consciousness.

The results of the present study indicate that the flow state associated with the interaction between the consciousness of the gamer and the imagery and activities of the game displays a clear cerebral topography. The state is primarily right hemispheric and involves many of the patterns associated with the dream state. There is also deactivation of the left prefrontal region with which intention and the feeling of self-monitoring and control are often associated. Dream states are also defined by active inhibition of the prefrontal regions concurrent with activation of more right hemispheric frontotemporal and limbic structures. However unlike dream states the flow state, as inferred in the present study, involved deactivation of only the left prefrontal region. This would suggest that "structural" organization associated with the sense of "other" or the "presence" was maintained while the structural organization associated with ideation and self-monitored thinking would have been diminished. The consistency was found within even this small sample.

There was copious evidence of these effects as shown within the topographic maps that were consistent for all of the subjects. First, parentclusters (combined activation of all components of all datasets included) of all groups and conditions fell into one of two profiles. The first profile (profile A) was characterized by a left hemisphere-dominant pattern including the temporo-occipital junction. This profile was found to occur in comparisons of whole dataset measures, and only during active conditions. The second profile is characterized by a right hemisphere-dominant pattern, including the temporo-occipital junction, occipital, parietal, and orbitofrontal cortex. This profile was found to occur in all other comparisons, including specific event types.

The results indicated that for true “immersion” or flow-state conditions to occur, as inferred by involvement of the right hemisphere, simply providing the general conditions for immersion are not enough. There must be tasks in which to engage to provide a complete experience. Traditional out-of-body experiences tested in laboratory settings have the participant imagining himself or herself out of their body, with this separation as the defining feature while the sense of self remains. In this instance, however, while the traditional report may be occurring as an intermediate step (as indicated by parentcluster profile B), the noteworthy feature is the redefining or transfer of the participant’s sense of self into the player character. This condition provides a unique opportunity to study the extension of consciousness and theory of mind, as described in experiments by Lavallee and Persinger (2010).

Analysis of planning type event sub-clusters yielded results that were consistent with previous findings by Lavallee and Persinger (2010) who explored the cortical activation of imagining future events during ‘mental time travel.’ They found activation in the left temporal lobe when the person was imagining oneself in the future. This aligns with the activation of profile A. Profile B in this context may be explained by imagining the future of the avatar within various spatial contexts – an effect consistent with the function of the respective hemispheres.

Reward sub-cluster profiles indicate that as both game conditions differ from baseline, a difference emerges between active game and passive video. Higher values in active game over passive video where the right temporal and inferior frontal lobes are active are consistent with classical reward responses and activation of the medial temporal lobes (Squire & Zola, 1996). However, higher values in the passive video where the left temporal lobe was active may be related to the phenomenon seen with planning events where meaning and context is ascribed to the action for the context of the avatar.

The emergence of the two parent clusters involving the left and right hemispheres was not likely to be an artefact of the software. One approach to human brain activity is that there are two simultaneous processes occurring, a type of dual parallel system, that are strongly correlated with the left and right hemisphere. That the left and right hemispheres operate more or less exclusively with only a small proportion of direct interaction would be supported by the structural determinants. Although there are an estimated 25 billion neurons within the cerebral cortices of the human being there are only about 250 million fibers that cross and compose the corpus callosum. This means that less than about 1% of the total potential fibers within either hemisphere directly intercalate with the hemisphere.

Transient conditions, which may exist within the duration of one “wave” of the integrated transcererbral field that reoccurs along the rostral-caudal axis every approximately 20 to 25 ms of both hemispheres simultaneously could be one mode by which intercalation could occur. The other major transient condition would be the primary microstates (Koenig et al, 2002), each occurring between 80 and 120 ms, or the duration of a percept. Under conditions where the right frontal-left occipital and left frontal-right occipital diagonals switch serially, there would be potential for inclusion or “functional fusion” of the dynamics of both hemispheres. As noted by Persinger et al (2010) the primary correlate of the sensed presence was the vectorial hemisphericity moving from the right to left temporal lobes while the feeling of the “self” being out of the body (out-of-body-experience) in another space was associated with the vectorial hemisphericity from the left temporal to right prefrontal region. Both experiences have been associated with flow state of gaming and cerebral configurations with these states were clearly evident in this study.

The 40 Hz Factor

During the conditions associated with the execution of skill and interaction within the game, including the flow state, there was increased power density within a narrow range of ±3 Hz around the centroid of 40 Hz. This inflection was found during the passive video and active game conditions and would be consistent with the “40 Hz” band of consciousness. The quantitative value for this increase compared to the declining power gradient (for example Figures 2.2 and 2.3) was approximately 2 μV. During the active game procedures, changes occurred within the right caudal hemisphere within the same basic range.

Assuming an average bulk velocity of 4.5 m/s and a skull circumference of about 55 cm to 60 cm, the standing wave frequency would be 7.5 to 8 Hz. This value is similar to that calculated by Nunez (1995). If cohesive waves were moving in the rostral-caudal direction at that velocity the frequency associated with moving over the distance of an average length of the cerebrum (12 cm) would be about 38 Hz. Consequently for the standing wave of 7 to 8 Hz associated with the cerebrum the frequency associated with the recurrent rostral-caudal process associated with consciousness would be about 40 Hz. From that perspective the 40 Hz peak would be expected and was measured.

It is relevant that active engagement and the “flow” states exhibited shifts in the power densities that were different than passive observation. The passive condition in this experiment involved the participant simply watching (on video) another person engaging in the game. The distinction of cerebral profiles during the active-engagement-flow condition compared to the passive observation indicates that intent and overt (motor) sequences coupled to the game may be a necessary condition for the experience when the machine and the sense of self become one. The player experiences the “flow state” during a period in which there is the anticipation of “knowing” what do and this “knowing” is realized by the consequences of the self-game interactions.

Potential Schumann Interactions

The "fusion" between the cognitive state of the participant and the condition of the machine may be considered a modern extension of the "flow" reported by those in high performance and highly skilled environments engaged in changing spatial contexts and feel they can anticipate the next move of "another" or the environment while "time slows" or becomes more fluid (Young & Pain, 1999). One could argue that the brain has integrated the interactive activity as if it were one of its own extensions rather than something to be manipulated in the detached environment.

The means by which this connection occurs or the experiences associated with its production can be considered to be local in origin. However there is accumulating evidence that the flow state may be influenced or even actively interact with yet another environment within both the players and the machines are immersed. This is the Schumann Resonances (SR) which are generated by global lightning strikes between the earth's surface and the ionosphere (MacGorman & Rust, 1998). These resonances saturate the biosphere. The average frequency of these pulses is about 40 Hz which is the same peak as the integrated electroencephalographic activity associated with consciousness (König, et al, 1981). Spectral power measurements indicate these signatures can be measured anywhere on the earth's surface (Persinger, 2014). This means that everyone on the surface of the planet could be potentially "connected" to anyone else.

Because the earth is 40,000 km in circumference and the electromagnetic discharges from the lightning as well as the light flashes propagate at the velocity of light ($3\cdot10^8$ m/s), the fundamental resonance is between 7 and 8 Hz. Harmonics emerge in increments of 6 Hz at 13-14 Hz, 19-20 Hz, 25-26 Hz, 31-32 Hz, 37-38 Hz, and 43-44 Hz and perhaps even at higher increments. Persinger & Saroka (2015) have shown these same peaks occur within the (right) caudal portions of the spectral density of the quantitative electroencephalographic activity of most people measured for only a few minutes within quiet conditions within the laboratory. The relative peaks are within the equivalence range of 2 to 10 μV between the rostral-caudal domain with an estimated magnetic field strength of 1-3 pT. These fluctuating potential differences over the length of the cerebrum would be equivalent to about 10^{-4} V/m and when divided by the strength of the magnetic field (10-12 T), results in a velocity term that is within the range of the velocity of light.

The difference of approximately 2 μV that was noted at the 40 Hz enhancement when the interstitial resistivity of 2 Ω·m is assumed results in 10^{-6} A/m. The relationship between this quantity and magnetic field strength is 1 μA/m = 0.4π pT, that is 1.2 pT (10-12 T). This is the fundamental value of the primary and harmonic values of the SR as well as the magnetic component associated with cognition. Llinas and Ribardy (1993) found that the duration for the "refreshing" wave associated with 40 Hz was about 25 ms and the phase shift or modulation was about 12 to 13 ms. The phase shift in the SR between 7.0 and 9.0 Hz is equivalent to about 13 ms while the time required for the electromagnetic wave from the discharge of a lightning strike within the earth-ionospheric cavity to return to the source point is about 125 ms (Nickolaenko and Hayakawa, 2014). This is within the range of the duration of a percept (Koenig et al, 2002).

There is theoretical evidence as well as empirical evidence (Persinger & Saroka, 2015) that there is representation of the SR within the quantitative electroencephalographic profile of most human beings. Coherence analyses indicates that statistically significant enhancement of frequency profiles between human brain activity within the SR bands and the simultaneous real-time values local to the brain measurement as well as thousands of miles away at other stations. The durations of the coherence are about 200 to 300 ms, or the duration of two successive percepts, and occur every approximately 30s. This does not prove that the experiences of the flow state could be generated within the SR band. However, considering the sensitivity of the right hemisphere to very subtle magnetic fields the possibility that this exists, even intermittently, may have significant implications for interactions between the brain, the machine, and the environment. One could predict a future where the three factors result in an emergent property that may be qualitatively different from the currently constructed biosphere.

If there is the occasional interaction between the SR and the human brain that is generalized within the population and similar frequency bands occur involving the same regions of the cerebrum are enhanced during the flow state of modern computer gaming-operator engagement then there is the potential for interaction between all three sources. Quantitative demonstration of this interaction would support

Sheldrake's morphogenic field theory which states that once one member of a group that shares the same structure acquires a task the same task can be acquired more quickly by other members of the group in successive order (Sheldrake, 1981). This tri-source convergence could also indicate that with a critical mass of participant-video game dyads operating within the Schumann environment, the conditions could arise for a cohesive field with emergent properties that reflects the characteristics of the gamer-game but exhibits properties and behaviours of its own that control the array of gamer-game dyads.

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CHAPTER 3

QUANTIFICATION OF THE TEMPORAL DOMAIN OF "EVENT RECORDINGS" OF THE FLOW STATE

ABSTRACT

In order to discern the specific temporal profile of cerebral activity sampled at 500 Hz during immersion in a computer game compared to reference conditions independent component analysis and linear discriminant analyses were applied to 4 s increments of key events from the averages of 4 experienced gamers. Component clusters that discriminate conditions such as skill vs reward events were examined. There were three peaks of shifts in power that were represented within the cerebral profiles before and after the event which was reflected in specific QEEG features that could be discerned within 2 ms increments. The most conspicuous temporal displacement was an enhancement whose median value was about 130 ms (M=108, SD=35 ms) after the event and was interpreted to represent the subsequent percept of the experients. A second cluster of discriminant indicators occurred about 1 s before the actual event and was considered similar to the anticipatory bereitschaftspotential reported in other studies. Less clear peaks about 300, 800 and 1250 ms after a rewarding event were considered to be consistent with "delayed" activation of reward networks. These results verify the observations of the discrepancies between the time of the event as experienced by the conscious person and the correlative quantitative brain activity. The similarity of the general results to those obtained by more laborious average evoked potential methods suggests this present technique might be employed as a supplement procedure.

INTRODUCTION

Electroencephalography (EEG) records of any kind, and at any spatial scale, are a representation of the emergent partial coherence of electrophysiological events occurring at smaller anatomical scales. The particular advantage of QEEG over other neuroimaging techniques is a high ratio of temporal-to-spatial resolution. Techniques, such as the event-related potential (ERP), serve to highlight these smaller scale activities and to reduce the temporal resolution of EEG measure in response to a single stimulus (Nunez, 1981). The ERP results of many trials are averaged together allowing the noise to be removed and the relevant activation to remain. Noise in the system presents the third factor in this equation, and the extraction of a reliable ERP signal is a function of the signal-to-noise ratio, in contrast to the variance in the overall noise. This averaging, however, does remove much of the information in the acquired individual signal, and other methods of single-trial analysis may be used in conjunction (Rousselet & Pernet, 2011).

Independent Component Analysis (ICA) is becoming increasingly more established as a tool in the EEG signal processing toolbox (Makeig, Bell, Jung, & Sejnowski, 1996). ICA is designed to decompose a multivariate signal (i.e. multi-stimuli brain activation) into its linearly independent signals. The focus of the ICA is to reduce overall complexity first, and then determine the relative entropy of each group of signals in order to discern their independence. Noise variance is not directly accommodated for with this method (Makeig & Onton, 2011). The ICA involves software that extracts from the 500 samples per second (2 ms) of each of the 19 channels (in the case of this study) the shared similarities with a quantitative value similar to a factor score. These values were obtained for reward, skill, baseline and related conditions.

Linear discriminant analysis (LDA) is a computation to find linear combinations of features which separate two or more classes of events (McLachlan, 2004). In this case the classes of events included skill vs reward or combinations of these during different intervals (early, middle, and later) of the sampling period. While similar to component analyses, LDA characterizes the signal-to noise ratio using calculated variance of the included distributions where the between-distribution and within-distribution variances are compared. When projected onto the discriminant hyperplane's normal vector, the optimal threshold separating the distributions is returned. When the distributions included in this analysis have already undergone a reduction in complexity such as by ICA, discrimination of data at the LDA time scale returns the exact point where the signal was strongest - an independent activation.

The standard ERP method for decomposing brain signal data, in comparison, provides a “brute force” method of deducing a pattern - completing many trials to expose a commonality. A two-stage processing technique requires much less data to return a significant difference in brain activation data from noise, and does so with a much more robust and refined technique. The target signal and noise variances are accommodated as well as the relative entropy and complexity of each component prior to the signal-to-noise comparison. The motivation behind this novel analysis method is to reduce the complexity and cost of EEG equipment required to perform these robust and essential statistical techniques. The ability to produce reliable millisecond-scale activations from low-channel EEG equipment provides many researchers with the ability to expand the scope of their research and to access powerful conclusions.

These simplified methods of recording EEG have led to findings critical to current understandings of neurophysiology, such as the readiness potential, or bereitschaftspotential (BP). The introduction of the concept that cortical activations in the motor and supplementary motor cortices precede volitional acts by Kornhuber and Deecke (1965) led to the research of free will by Libet and colleagues (1983) to firmly establish this phenomenon. In the original research, the BP has two components – the BP1 component lasts from about -1.2 s to -0.5 s, with the BP2 component lasting from -0.5 s to just before 0s. Traditionally, the very small voltages involved with the BP (<5 μV) were quite difficult to measure accurately. However modern high-sensitivity equipment makes this phenomenon quite easily accessible with the correct analysis.

Much research has also been undertaken in understanding free will and readiness potentials utilizing functional magnetic resonance imaging, finding that the brain begins to form models of potential outcomes in the prefrontal and parietal cortices up to 10 s before the decision enters awareness (Soon, et al, 2008). Further work by Mossbridge, et al (2014) has generalized the anticipatory response to the physiology of the whole body, a phenomenon termed predictive anticipatory activity (PAA). This “sensing of the future” is described as an unconscious physiological phenomenon that may provide a preview of conscious awareness of future emotional or arousing events.

Edelman (1989), in the quintessential description of “the remembered present”, summarized the concept of recurrent pathways. From this perspective the “present” once it is realized is functionally a representation of that which has already occurred. The awareness of the events within the present is because of this “reflection of a reflection”. This suggests two potential properties that might emerge from precision quantification of brain activity which has been presumed to be the source of cognitive experience. First there may be a widening of the functional “now” such that events might be recorded from the brain before a person experiences the event within their “now”. Secondly under conditions where the serial boundaries between successive reconstructions of personal consciousness (which has been assume to have average durations of about 20 to 25 ms with phase shifts in around one half-that value) become more fluid, the person might experience “imminence” and “immanence” (Bem, 2011). It might be reported as “pre-cognitive” or a “feeling” that the direction of experiences, especially so while playing within the defined set of a computer game, are predictable and even that one’s thoughts are controlling the outcomes or sequences because of a unified presence.

The current study, with its novel approach to exploring the temporal aspects of event-based activations, may provide some insights into the neurophysiology of this and similar phenomena. In particular, the fact that events in the present study take place within a state of sustained “flow” as described by experienced computer gamers provides a unique and optimal environment within which to trigger emotional and arousing events. The quantitative purpose was to discern if employment of lag/lead multiple regression could simulate many of the phenomena more frequently measured by event potentials that required large, multiple averages. We assumed that if these effects were very robust reliability within a small sample size should be sufficient to demonstrate the proof in principle.

MATERIALS & METHODS

Participants

Four subjects (3 identified males and 1 identified female, ages 20–27 years old) participated in the experiment. All subjects completed the gaming task in a similar way. All subjects were experienced with the gaming environment and the intrinsic tasks to eliminate effects of learning and confusion with the use of the controller. All participants provided consent for their participation in the experiment, after approval by Laurentian University’s Research Ethics Board.

Stimuli and experimental procedures

The gaming task involved a roughly 20 minute segment of the commercially available game The Elder Scrolls V: Skyrim (Bethesda Game Studios, 2011). The segment was a reproducible section of the game, where events would occur along the same course for each participant. A segment, or ‘dungeon,’ early in the course of the game was chosen to allow players to choose their individual play style so as to generate optimal immersion (Dietrich, 2004). The game was presented on the 15.6” LCD monitor of a Lenovo Y580 gaming laptop in a darkened environment at 1920 x 1080 resolutions. Participants were seated in a comfortable chair and provided with a choice of Xbox 360 controller (3 participants) or a keyboard and mouse (1 participant) for controls. EEG recordings were taken for the entire duration of the game play session. In-game event timings were recorded manually by keeping view of the play screen and matching to the timing markers of the EEG record.

Game immersion experiment

Prior to the start of each session, and during the time which EEG caps were being applied, subjects were allowed to move the game character around external to the ‘dungeon’ area to familiarize themselves with the controls, the particular environment, and organize in-game items. The subjects were told to enter the ‘dungeon’ upon completion of the set-up, and asked to keep their heads as fixed as possible to avoid recording artefacts. Upon entry, the recordings were initiated and the subject played the game in accordance with their own preferences and play styles. In-game events and their timings were recorded, according to the expert's discretion, under the categories of skill and reward.

Skill events were defined as an event where the player was controlling the avatar in a technical manner, and completing an action that would contribute to the game’s mechanic of character experience level. Examples of this event type in the context of the experiment include active combat and picking locks. Reward events were defined as an event where the player was rewarded for continued game play, and contributions to improving the player character. This would involve acquiring new items, improving the character’s experience level, and completing objectives. Participants were debriefed after the experiment and asked to rate their level of immersion in the game on a 10-point Likert scale of 1 (‘not immersed at all’) to 10 (‘completely detached from my body’).

EEG recordings and data extraction

EEG data were recorded with WinEEG software using a Mitsar 201 19-channel QEEG amplifier at 500 Hz in the standard 10-20 montage (© Mitsar Co. Ltd. Saint Petersburg, Russia, 2013). Bandpass filters were set at 0.1 – 50 Hz and notch filters at 50-70 Hz. A 10 min segment of EEG data after the first 5 min of game play (gradient of increasing immersion) was extracted from the record for each participant.

Statistical analysis

Game play and eyes-open baseline data for each participant was imported into MATLAB from WinEEG using the EEGLAB toolbox (Delorme & Makeig, 2004). Combined event timing data for game play data per participant was also imported into EEGLAB via text file and each dataset underwent Independent Component Analysis (ICA) and artifact correction, and was saved separately. Game play datasets were then segmented into two datasets isolating each of the event types, with data extracted ±2s of the marked second of the event for a total of 4 sec extracted per event to capture as much of each event as possible. Aggregate datasets of extracted events underwent additional ICA. 4 seconds of eyes-open baseline data was sampled from the 30-second mark of the 60-second record.

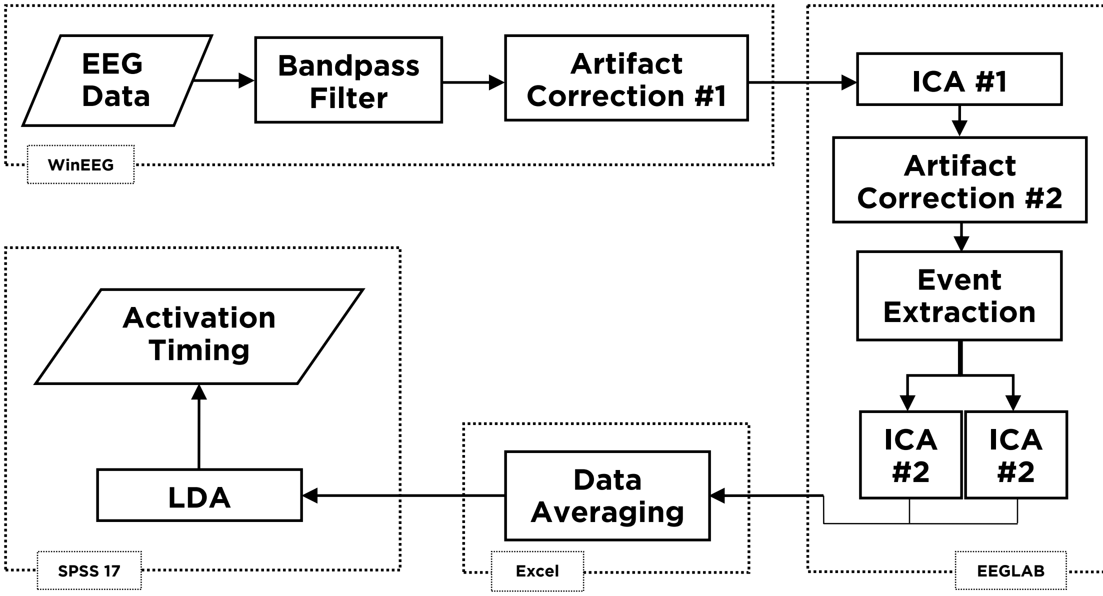

Figure 3.1: Processing pipeline.

Component activation data was then extracted into Microsoft Excel 2010 where component data from each participant was averaged as necessary according to the groups outlined in Table 1. Averaged data for discriminant analysis involved one event; that is, 4 s of in-game time or 2000 data points, as the sampling rate of the EEG was 500 Hz. Early segments involved the first event, middle segments the median event, and late the final event so as to sample the complete course of the flow state game play experience. Each group was imported into SPSS 17 where linear discriminant analyses (LDA) were performed as per the outline in Table 1 to discern standout millisecond-scale component activations during different conditions.

RESULTS

Linear discriminant analyses

Results of the series of LDAs are presented in Table 1. While there were a multitude of results, a select three will be reported for brevity. Generally speaking, the LDAs classified variables after the event, as well as prior to the event taking place. With a few exceptions, nearly all groups returned an initial post-event classification, commonly arising around the 2130 ms variable (median=130 ms post-event) across all

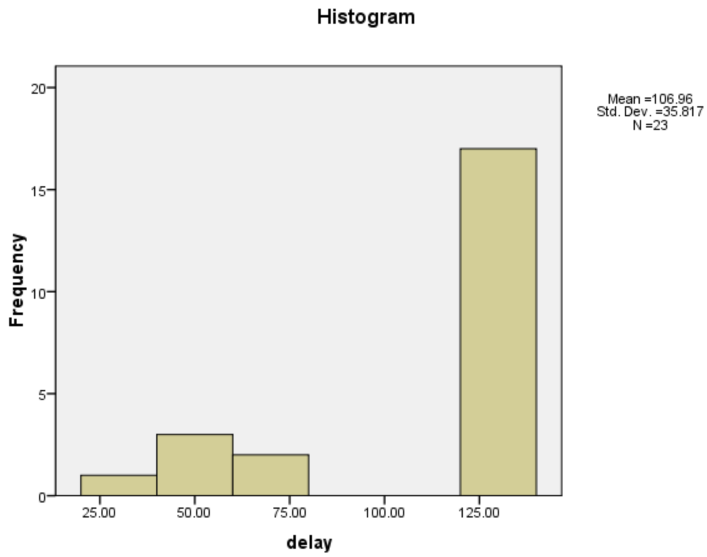

Figure 3.2: Histogram of frequency distribution of delay of event (LDA) values that entered the analyses for all conditions. Note the major proportion at 125 ms or ~8 Hz.

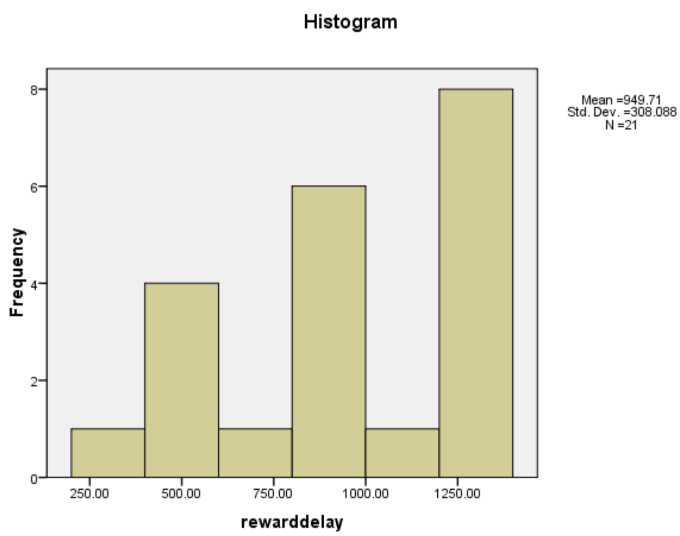

Figure 3.3: Frequency distribution of statistically significant delays following the reward component of the gaming experiences.

3 major levels of the analysis. The mean and standard deviation for all of the latencies was 107 ms and 36 ms, respectively (Figure 3.2). This overlaps with the values for a percept as well as the peak power frequency (about 10 Hz) for the cerebral cortical electrical activity.

The results of the pre-event analyses are shown in Figure 3.3. Except for the extreme values about 2 s before the key interval, there was a distribution of “anticipatory” events about 1 s before the event.

Additional initial post-event classifications included the 2560 ms variable in discriminating average eyes-open baseline from average timing intervals. In addition to these initial post-event discriminations, classifications around 3200 to 3250 arose from discriminations of average skill and reward, as well as discriminating late-game skill from both early and mid-game reward.

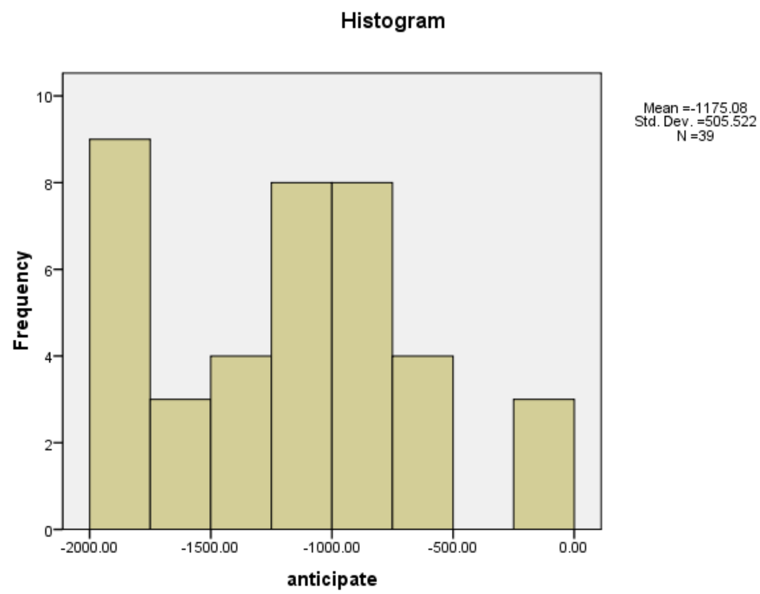

Figure 3.4: Frequency distribution of the statistically significant components of the discriminant analyses for event entering the function before the actual event.

Table 3.1: Pre-event timing variables entering LDAs comparing event groups. Variables from the analysis have been multiplied by 2 to convert them to real time (500 Hz sampling rate of EEG).

Level			Group		Pre-Event Significant Time (ms)									
			1	2	0	2	4	6	8	10	12	14	16	18
I	1	A	EO	skill avg										
				reward avg				744						
		B	EO	skill early										
				skill mid										
				skill late					950	1002				
		C	EO	reward early*	92			744	910	1002				
				reward mid*		236 268				1002				
				reward late*		340		746	910 950					1992
	2	A	EO	P1 skill avg										
				P2 skill avg										
				P3 skill avg										
				P4 skill avg										
		B	EO	P1 reward avg										
				P2 reward avg										
				P3 reward avg										
				P4 reward avg										
II	1	A	skill avg	reward avg					856					
		B	skill early	reward early	82				814					
				reward mid	82									
				reward late										
		C	skill mid	reward early										
				reward mid										
				reward late										
		D	skill late	reward early*										1858
				reward mid*		386								1858
				reward late					954	1002				
III	1		EO	early*	196					1186	1250			
				mid*				726		1186	1250 1288			
				late	196					1186	1250			
	2	A	skill avg	early										
				mid										
				late										
		B	reward avg	early	194									
				mid	194									
				late										
	3	A	skill early	early										
			skill mid	mid										
			skill late	late										
		B	reward early	early										
			reward mid	mid	194									
			reward late	late						1186				

Table 3.2: Post-event timing variables entering LDAs comparing event groups. Variables from the analysis have been multiplied by 2 to convert them to real time (500 Hz sampling rate of EEG).

Level			Group		Post-Event									
					Significant Time (ms)									
			1	2	20	22	24	26	28	30	32	34	36	38
I	1	A	EO	skill avg	2130									
				reward avg										
		B	EO	skill early										
				skill mid										
				skill late	2042									
		C	EO	reward early*	2038									
				reward mid*	2042 2132									
				reward late*	2122									
	2	A	EO	P1 skill avg										
				P2 skill avg										
				P3 skill avg	2130									
				P4 skill avg	2130									
		B	EO	P1 reward avg										
				P2 reward avg	2130									
				P3 reward avg	2130									
				P4 reward avg	2130									
II	1	A	skill avg	reward avg	2120					3000	3328 3256			3898
		B	skill early	reward early	2130						3328			3900
				reward mid	2130									
				reward late	2130									
		C	skill mid	reward early				2776						
				reward mid										
				reward late										
		D	skill late	reward early*		2320			2834		3254 3220			
				reward mid*							3256 3202		3764	
				reward late	2044						3310			
III	1		EO	early*			2560		2864					
				mid*			2560							
				late			2560		2864					
	2	A	skill avg	early										
				mid										
				late										
		B	reward avg	early	2122				2964					
				mid	2122				2964					
				late	2122									
	3	A	skill early	early										
			skill mid	mid										
			skill late	late										
		B	reward early	early	2128 2062									
			reward mid	mid	2128 2066				2964					
			reward late	late			2560							

DISCUSSION

The purpose of the present study was to discern if advanced computer software technology could differentiate states of reward or skill while interacting with computer (game) programs through appropriate analyses of second and third higher order configurations from extractions of large data bases in real time and relatively high resolution. The Independent Component Analyses involved extracting, in a factor-analysis like manner, the shared sources of variances for the microvolt values for each of the 500 samples (2 ms) from each of the 19 channels across the 4 s of total record sample. Although this is a massive amount of data the program contains intrinsic accommodations for the 9,500 data pieces per second by extracting only those most cogent shared sources of variance.

When these extracted components were then subjected to Linear Discriminant Analysis in order to differentiate events, defined as discrete occurrences of skill involvement or reward, specific clusters reflecting specific times of integrated cerebral activity entered the functions. Although the specific weightings of the locations of the integrated cerebral activity were not examined in the analyses, these sources were considered less important to the dynamics. Future examination could involve adding a separate level of analyses where by the contribution from different spatial sites contribute to the moment-to-moment values.

The most conspicuous result of the LDA was the reliable occurrence of component clusters occurring within discrete times about 130 ms after the event particularly when rewards or skills were differentiated either from each other or as a function of time. Even though the discernment of when the event occurred was determined by visualization of the conspicuous shift in QEEG profiles as well as the observation of the event during the protocol, the effects were remarkable stable. This consistency suggests that the values were not artefacts. In addition there was a range in this delay.

The specific delay was approximately 130 ms, which was the mode, and would be equivalent to 7.7 Hz. If 68% of the range based upon the mean and SD are considered the actual duration of delay would be 71 to 143 ms or 7 to 14 Hz. This includes the major power range of cerebral activity. However it also defines the duration of a percept (Koenig et al, 2002). Regardless of the technical aspects of the extraction of the data the fact that states can be discriminated by one percept could be argued to indicate that the function unit of cerebral cortical processing is about 80 to 120 ms as proposed by Koenig et al (2002) and reflects the basic building blocks of thought as argued by Lehmann et al (1988). Lehmann and his colleagues found that the average microstates were about 121 ms. This is quantitatively relevant. If there are four basic microstates, each with durations of about 100 ms, then there would be 410 or 1,048,576 possible combinations per second. If each combination were a bit, then there would be about 0.13 MB of information within those configurations per second.

The prominence of the 7.7 Hz delay associated with 130 ms, if it is not a confounding variable, may reflect more unified properties. Persinger and Saroka (2015) have shown that the Schumann Resonance generated between the earth's surface and the ionosphere are also reflected in the normal human QEEG power spectra, particularly within the caudal right hemisphere. The fundamental of the Schumann Resonance is ~7.8 Hz and is due in large part to the 125 ms phase delay associated with the return (collision) of the propagating field that ripples from a singular lightning discharge. The numbers of discharges globally is about 40 Hz. If this unit of time constitutes a percept then the delay noted in the present study might suggest that events that occur in the previous percept, the pre-conscious percept, might guide or direct the characteristics of the conscious percept.

That events occur within the QEEG before a person experiences an anticipated or likely anticipated event defines the bereitschaftspotential. This occurs between -0.5 to -1.2 s before events. Persinger (2009) found that the simple reaction time to realization of the inference of a conflicting conclusion concerning the person's belief about the existence of personal deities often occurred several seconds before the confrontational statement. The person was not aware of the inferential consequence. However concurrent measurements of dichotic word listening accuracy suggested that the right hemisphere was assessing the affective or emotional meaning of the imminent conclusion before the person was "left-hemispherically" aware of that end point. These effects emerge during a stream of stimuli that were interconnected, such as the game playing scenario or conversation where within a flow state there may be some degree of unexpectancy but participation in the process allows variable accuracy of prediction with respect to the content within that future process.

The results of this study indicate that two well-established software procedures that process massive databases can be applied to the "stream of consciousness" for participants who are engaging in interactive states with computer game video systems. Unlike traditional evoked potential approaches that require hundreds of presentations of the same redundant stimuli, the present approach requires fewer samples and allows the person to extract the components of the stream of real-time increments of brain voltages to discern event conditions and their correlates before, during, and after the event.

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CHAPTER 4

THE POTENTIAL FOR EXCESS CORRELATION "ENTANGLEMENT" BETWEEN FLOW STATES IN PAIRS OF GAMERS SHARING SPECIFIC CIRCUMCEREBRAL ROTATING MAGNETIC FIELDS

ABSTRACT

Excess correlation between the activity or properties of two particles separated by non-local distances has been demonstrated for photons, shifts in relative proton and hydroxyl ratios, and the distribution of random number generators if both loci shared a specific type of rotational magnetic field. Previous experiments had shown that pairs of people who shared circumcerebral magnetic fields with changing angular velocities revealed significant excess correlation. Light exposed to one of the pairs was associated with the emission of photons from the second person sitting in the dark 10 meters away. The most significant differences occurred during the component of the field exposure that has previously been associated with "excess correlation". In the present experiments evidence of excess correlation of performance (serial scores in-game) occurred between pairs of experienced gamers during the relative measures for the central portion of the protocol but was diminished when the "excess correlation" electromagnetic fields were activated. The results are consistent with the interpretation that shared video systems and activities may enhance excess correlation of responses. This can be simulated in novice players by experimentally inducing excess correlation through appropriate application of changing, circumcererbal angular velocity magnetic fields that were similar in magnitude to those associated with computer systems and time frames that define human consciousness.

INTRODUCTION

According to Aczel (2002), entanglement is one of the greatest mysteries in physics. The empirical demonstration of entanglement requires an excess correlation between the responses of two units in non-local space. Non-local space means that the mutual responses of the two units occur over any distance (and potentially any time) and hence are not limited to the mechanisms required for locality. The latter can only occur if there is a medium through which a force or energy can be mediated and consequently diminishes in some systematic manner as a function of the distance between the two units. Excess correlation means that over the measured time increments the correlation between the properties such as magnitude or variations of frequency (including phase modulation) occurs when only random relationships should exist according to the assumptions of locality.

The general consensus is that excess correlation, or by inference entanglement, can occur anywhere in space and primarily involves photons. For example, changing the parity of one photon in a pair that has been entangled, usually because of initial proximity from their shared source, results in the opposite change in the other photon within the pair. There is also evidence of excess correlation at the macroscopic level. Dotta and Persinger (2012) found that when two chemiluminescent reactions shared the same circular-rotating magnetic fields that exhibited specific uncoupling between the group and phase velocities, the injection of the reactant into both solutions simultaneously resulted in a doubling of the photon emissions. In other words, the excess correlation behaved as if the two non-local spaces and been transiently superimposed into the same loci such that the reaction was twice as intense.

Murugan, et al (2014) later showed that two beakers of water separated by non-local distances but sharing the same “excess correlation” patterned magnetic fields also exhibited entanglement. When a small proton source was introduced into one beaker of spring water, producing an increase in acidity, there was a drift in the other beaker of spring water, within which nothing had been injected, towards the alkaline condition. The shift in pH in the non-local site was proportional to the numbers of hydronium ions that would be effected by the energy available from the intensity of the applied magnetic field within that volume of water. In all of these experiments there were two phases of the entanglement paradigm. The first was considered a “primer” while the second, the “effector,” was considered the actual demonstration of entanglement. If the primer was not delivered there was no evidence of excess correlation.

That human brains can display entanglement has recently been demonstrated by Scott, et al (2015). They showed that pairs of people separated by 6,000 km and exposed to the excess correlation paradigm showed clear evidence of coherence of quantitative brain activity but only during the effective component of the entanglement paradigm. In addition during the presentation of a specific tone to both participants, separated by 6,000 km but sharing the same circumcerebral magnetic fields, the shift in spectral power density within both cerebrums of a pair was in the opposite direction. Although both displayed the 7 Hz power shift associated with pulsing of the sound stimulus, one of each pair displayed increased spectral density power while the other showed diminished spectral density power at the same time.

Entanglement requires conditions in which two units share some property in space-time such that later when the two objects are separated there is a residual of this shared property in each such that they create a functional system (Dirac, 1930). Activation of this system allows both units to interact regardless of distance. By the nature of games, which are relatively repetitive due to their programming, pairs of gamers might be exposed intermittently to entanglement-inducing condition. Consequently, even at great distances the behaviours of one gamer could exhibit excess correlation over time with the behaviors of another gamer. The two might not be aware of this excess correlation. If the events occurred frequently enough one might imagine the extent of the excess correlation to generalize to other aspects of their behavior.

Spontaneous occurrences are difficult to control, particularly when the causal factors are not clear. Experimental manipulations whereby the essential elements of the condition, in this case entanglement, are created in the laboratory can enhance the magnitude of the effect in order to direct discernment to be possible. This procedure might be considered equivalent to isolating the essential ingredient of white willow bark, acetylsalicylic acid, in order to produce reliable analgesia and antipyretic effects. In the present study, the potentially enhancing effects of the excess correlation paradigm that has been shown for pH and photon reactions was applied to the brains of pairs of experienced or novice gamers.

We predicted that the entanglement paradigm should simulate the condition of paired experienced gamers and thus produce coherence in a paired novice similar to that of experienced gamers. On the other hand, if the gamer connection is related to unique entanglement the novel excess correlation field exposure should disrupt this connection much like a competitive antagonist for drug action. For the experimental entanglement between two experimenters to be feasible and practical, we assumed the effect size must be large enough to be evident with a small sample size.

MATERIALS & METHODS

Participants

Following approval of the university's research ethics board, a total of 7 identified male participants (ages between 24 and 32 years) participated in the study. Both A and B field application condition groups and positive control groups involved pairs or either one novice and one experienced player, or two experienced players. Experience was established by the participant reported having played the game prior to the experiment for at least 3 hours. Novice designation was given to participants with no prior exposure to the game used. Negative control groups involved one novice player alone, external to either of the field application chambers (to additionally control for space-memory effects).

Interactive stimuli and performance metrics

Use of a complex stimulus involved play of the video game Super Hexagon (Cavanagh, 2012). The game was played on either a Lenovo Y580 or Asus UX31 laptop. The game involves the movement of a radius-fixed cursor in a circular pattern to avoid obstacles (Figure 4.1) using only the left and right arrow keys.

Obstacles rotate in either clockwise or counterclockwise direction around the centre point of the screen, moving from the outer edges of the screen toward the centre. The shape and pattern of oncoming obstacles increases in complexity as the stage increases, up to 60 seconds, where the speed and complexity increase further. The "death" condition consisted of contacting an obstacle, where the play time of that "run" would be displayed. Pressing the space bar starts a new run, resetting to the beginning. The game was run on the standard "hard" setting.

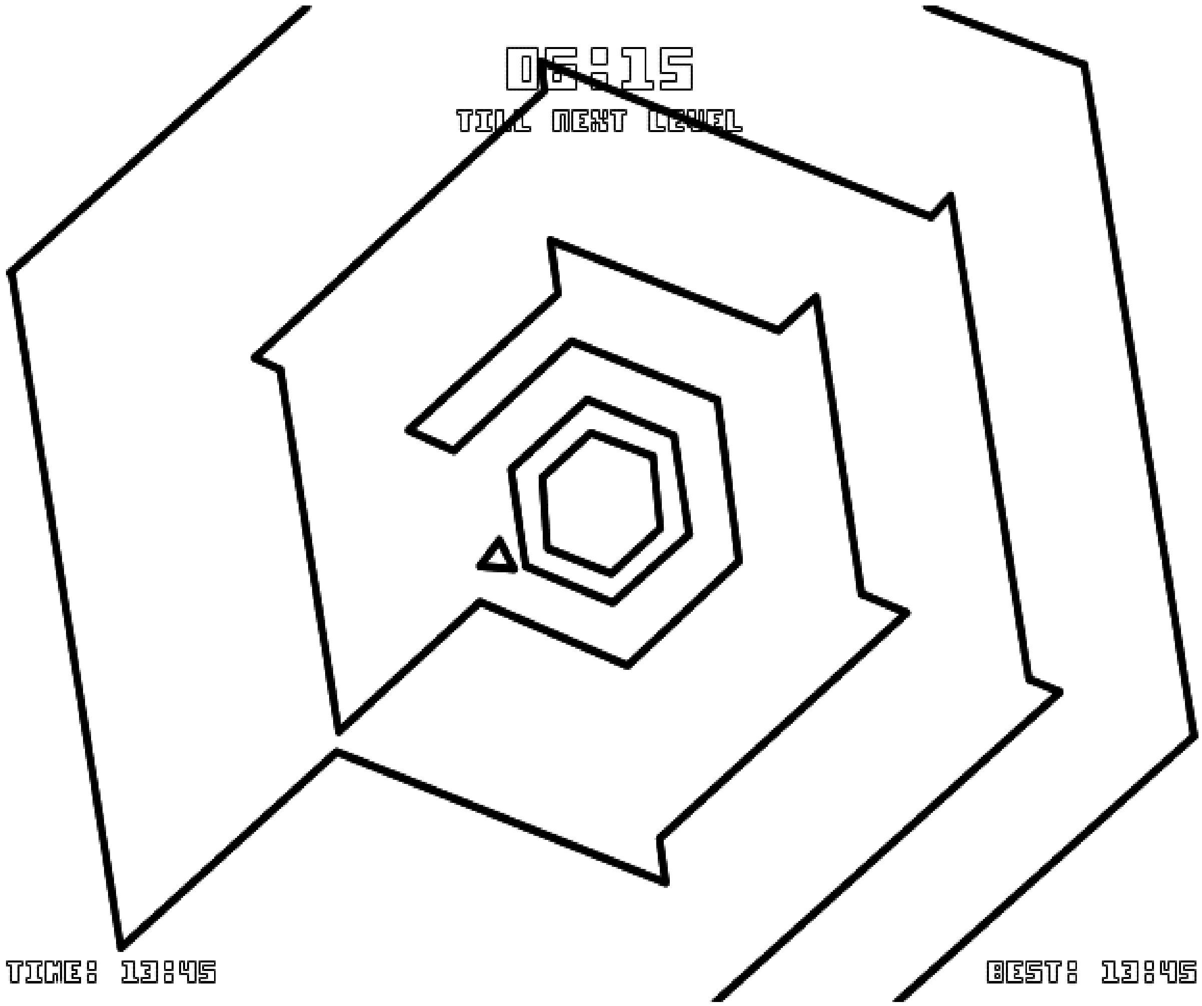

Figure 4.1: Simplified user interface example of *Super Hexagon*. The cursor rotates at a fixed radius from the centre with player input, avoiding oncoming obstacles. The current "run" time is displayed in the top centre with a progress bar to the next stage. The best time is displayed in the top left.

Performance was measured using the game timer, whose large unit counts in seconds and sub-second unit counts up to 60. Each 10 seconds reaches a milestone, where obstacle shape and puzzle complexity increases.

<u>Design of experimental apparatus</u>

The paradigm, as shown in Figure 4.2, utilized the same equipment and procedures used in previous human brain studies (Dotta et al, 2011). Details of exposure procedures have been published elsewhere (Dotta & Persinger, 2012). In summary, two identical circular (55–60 cm circumference) arrangements of 8 equally space solenoids (45° separation) were placed in two separate rooms separated by 10 m. Each solenoid was a reed switch connected to custom constructed equipment (Canadian Patent 2,214,296). The two devices were connected to the same Intel 286 computer housed in a room separate from the rooms containing the coils. This computer controlled the timing and amplitude delivery of the current delivered to the solenoids to generate the magnetic fields. This DOS-based system returns reliable inter-experiment

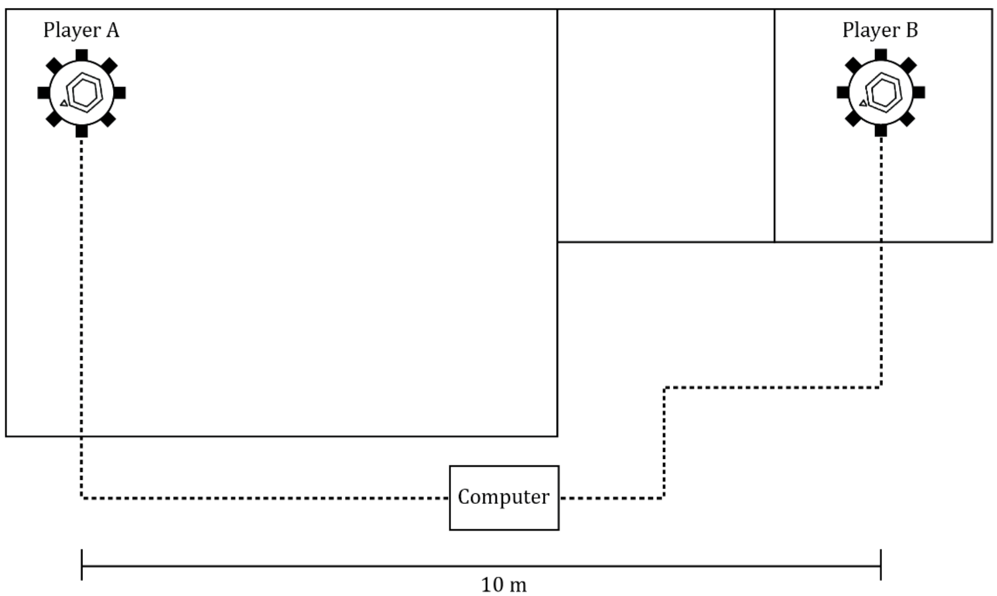

Figure 4.2: Diagram of procedure by which the same magnetic field condition was generated in two separate spaces separated by about 10 m. The two circular arrays represent the 8 solenoids. The magnetic fields were generated as brief pulses whose durations either increased or decreased as the programmable fields were rotated around the solenoids in a counterclockwise direction. The pattern of the magnetic field that was generated reflected either a decreasing or increasing frequency or "phase" modulation.

output point durations 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.

Custom software (Complex Software©) was programmable to generate the applied pattern at each solenoid for different durations. A temporal configuration of "20 - 2" indicated that the 1st (over the left prefrontal regions) 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). The 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). A study by Cook et al. (1999) showed that the most significant distortion of subjective time estimation was produced by counterclockwise (as viewed from the top) circumcerebral magnetic fields, and has remained the standard in this regard.

The two patterns that were generated to each pair of solenoids were selected from the two shapes that have been most robust in producing changes in both the experiences and quantitative EEG patterns in human subjects (Dotta et al. (2011), Persinger et al., (2010) and Booth and Persinger (2009)). Hallmarks of the two patterns were a decelerating frequency modulation (“Thomas pulse,” named after a previous student) and an accelerating frequency modulation (“burst firing”). Their shapes have been published with previous studies (Martin et al., (2004); Persinger et al., (2010)). 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.

Experimental procedure: Field Application

The all field application condition groups consisted of two players. All field application condition groups were exposed in two rooms. The first room was an acoustic chamber and Faraday cage (Persinger, et al., 2010). Players were comfortably seated in a cushioned chair within the chamber with the laptop on their lap, facing in a north/south direction. The second room was a darkened room, the player also seated comfortably in a seated chair, laptop on their lap, and facing a north/south direction. Data collection involved the assistance of two colleagues (one per player), who would record the run time called out by the player after each death. To maintain temporal consistency, the start of each experimental session was synchronized between players, marked with a stopwatch, and a new run was started by the call of the assistant every 2 minutes for the experienced players and 30 seconds for the novice players.

In the event a player remained playing at the end of the 2 minutes, they were instructed to force a death and to restart. At this point the assistant recorded “2 minutes” as the run time. The session ended after 22 minutes (11 experienced runs). Application of field patterns was timed with these increments (changes performed by the chamber assistant); the first 2 runs being a pre-condition baseline (no field), the next 3 runs being the accelerating pattern, the next 4 runs being the decelerating pattern, and the final 2 runs being a post-condition baseline (no field). The A field application group involved two experienced players undergoing 4 trials, and the B group involved one experienced player and one novice utilizing the same procedure as described above for 3 different novices.

Experimental procedure: Control

Control condition groups consisted of a positive and negative type. The positive control condition group was composed of both experienced/experienced pairs undergoing 3 trials, and experienced/novice pairs undergoing 1 trial with a novice from the field application condition group. All procedure for the positive control condition group was identical to the field application condition group with respect to environment, timing, and data collection, except without the application of the magnetic fields. The negative control condition group involved either one novice or one control, paired with one colleague for data collection, and included 1 trial each. This group was situated in a room external to both the field application condition rooms, but adjacent and within the 10 m, and used the Lenovo laptop to play the game as per the standard timing structure on a tabletop.

Statistical analyses

Data collected by assistants were immediately entered and organized into Microsoft Excel for preliminary computation. All raw data was individually standardized using z-scores before any further statistical analysis. Data was detrended by subtracting the linear trend associated with learning (control comparison). Calculation of means, standard deviations, and standard error of the means were performed in Microsoft Excel 2013, and all oneway and correlation analysis was completed in SPSS Statistics 17 on a Windows-based computer.

RESULTS

Direct comparison of field and no field exposure condition performance raw and z-scores for all players combined yielded no statistically significant differences. Comparison of the effects of exposure to magnetic fields on mean individual performance z-score over the length of the exposure paradigm for all experienced players combined returned a significantly lower field condition z-score in the pre-baseline condition and significantly higher field condition z-score in the BurstX condition (Figure 4.3A; $F_{(3,\ 32)}$ =

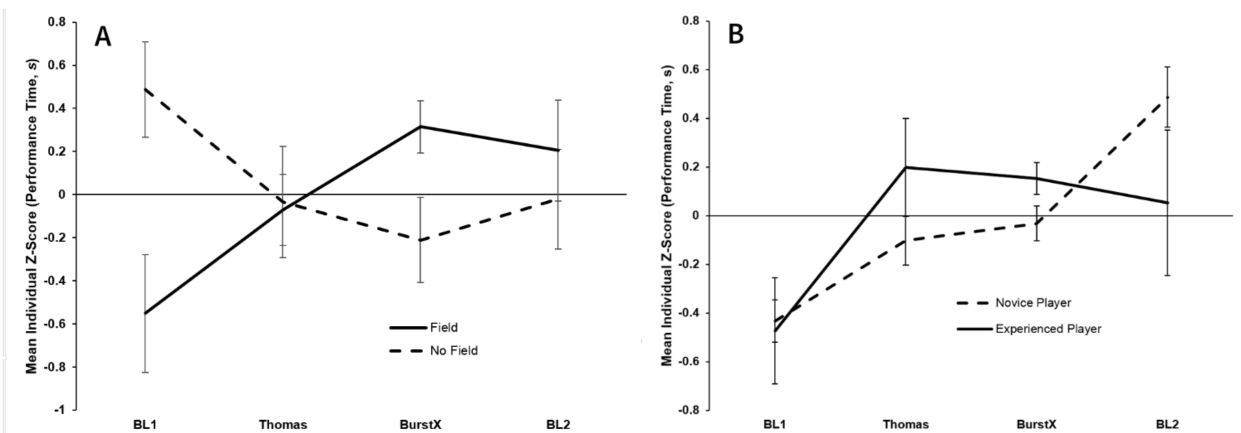

Figure 4.3: (A) Comparison of mean individual z-scores of performance time (in s) between experienced players exposed to fields and experienced players not exposed to fields. Error bars are SEM. (B) Comparison of mean individual z-scores of performance time (in s) between field exposed novice players and their paired experienced players. Error bars are SEM.

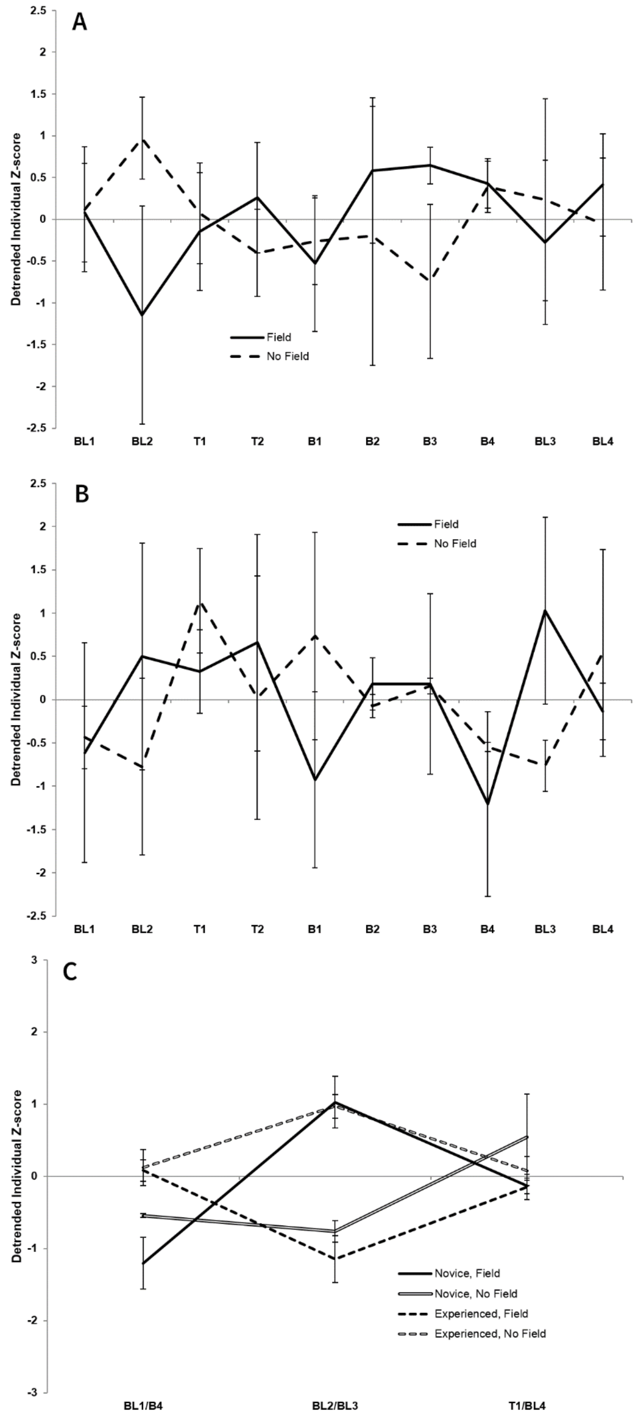

Figure 4.4: "BL" indicated baseline. "T" indicated Thomas, and "B" indicates BurstX (A) Comparison of detrended individual z-scores between experienced players exposed to fields and experienced players not exposed to fields, with additional breakdown of field exposure timeseries. Error bars are SD. (B) Comparison of detrended individual z-scores between novice players exposed to fields and novice players not exposed to fields, with additional breakdown of field exposure timeseries. Error bars are SD. (C) Superimposition of detrended individual z-scores between novice players exposed to fields and not exposed to fields at end of experimental time course (B4 – BL4), with detrended individual z-scores between novice players exposed to fields and not exposed to fields at end of experimental time course (BL1 – T1). Error bars are SEM.

4.58, $p = 0.01$, $\eta^2 = 0.32$). Comparison of all novice players combined returned no significant between field and no field groups. Such analysis of detrended z-scores for all experienced players combined highlighted elevated no field group values over the field group in the pre-baseline condition and elevated field group values over the no field group in the BurstX conditions. These were similar to the standard z-score results (Figure 4.4A; $F_{(9, 29)} = 2.62$, $p = 0.035$, $\eta^2 = 0.54$).

Such analysis for all novice players combined yielded higher field condition scores in the post-baseline condition, as with standard z-score results (Figure 4.3B). However ANOVA indicated no significant difference ($\eta^2 = 0.57$). Combining all players together yielded no significant differences between field exposed and no field groups. Direct comparison of combined field exposed novice and their paired experienced skill group individual performance z-scores yielded significantly higher scores for experienced players during the BurstX field exposure condition, and significantly higher scores for novice players during the post-baseline condition (Figure 4.4B; $F_{(3, 16)} = 3.83$, $p = 0.036$, $\eta^2 = 0.37$).

DISCUSSION

The concept of excess correlation predicts that if two complex systems have shared a space-time condition such that a subset of one is contained in the other as well as vise versa, a subsequent change in one of the two regardless of spatial distance should be associated with a complimentary change in the other. Juden-Kelly, et al (2015) showed that when two RNG (random number generators) were each placed within a circular array of solenoids, identical to the system employed in the present study, a positive drift in one output was associated with a negative drift in the other.

However this only occurred after both systems had been exposed to “primer” pulse which has a frequency modulated (descending frequency or phase modulation) known as the “Thomas pulse” that was contained within an accelerating angular velocity of field activation around the array of 8 solenoids followed by the effector pattern which was frequently modulated (descending frequency of phase modulation) within a decelerating angular velocity system. These effects were evident, even within a small sample within Figure 4.3 for experienced pairs.

As shown in Figure 4.4A, the experienced pairs of players displayed enhanced coherence during the effector phase (when the excess correlation occurred in paired reactions of pH shifts, random number variations, and photon emissions) which was indicated by B3. This was not observed in the novices. In that group, the effects of field occurred during the rebound interval of the post-baseline. One would expect that if excess correlations of the game performance (score) for two people playing the same game occurred naturally within seasoned players that applications of fields that enhance a similar process should be evident in others during the "excess correlation" period. Indeed that was measured.

A particularly intriguing result occurred during the "rebound" periods of the entanglement sequence. As noted in Figure 4.4C, there was a potential manifestation of the "parity" effect often observed in entanglement experiments. This occurs when the property exhibited by one of the properties of the pair is changed and the other member of the pair changes its property so that parity can be maintained. When the immediate pre- and post-baseline were compared with respect to standardized accuracy in the game, there was the equivalent of two standard deviation differences between two mirror conditions. The first was composed of the novice pairs exposed to the field and the experienced pair not exposed to the field. The second that was more than two z-scores less was composed of the novice pairs not exposed to the field and experienced pairs exposed to the field.

It is useful to describe this effect using an equilibrium metaphor. The game performance standard is set by the level of the most experienced player. This energy, by the principles of parity in a classic entanglement setting, moves to create a stasis between the players, and in doing so creates a synchrony (or trend toward it) of performance level and by extension, brain activity. As this is a closed system, however, energy shifts must be accounted for by law that energy is conserved. Due to the nature of the entanglement of quanta, the maintenance of parity across the timecourse of the experiment as indicated by Figure 4.4C may provide evidence for the non-linearity of time during the facilitation of such non-locality in space.

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CHAPTER 5

Convergent Quantification and Physical Support for Teilhard de Chardin's Philosophy Concerning the Human Species and Evolutionary Consciousness

In: OPEN JOURNAL OF PHILOSOPHY

Abstract

Teilhard de Chardin's integration of geobiological phenomena, philosophical, and spiritual perspectives resulted in potentially quantifiable "spiritual energy", the emergence of "sphere of human thinking" (noosphere) as the next evolutionary stage of the biosphere, and the ultimate expansion of consciousness into the galaxy. Transformations of his concepts into contemporary values that effectively define cosmology, quantum biology, and human cerebral parameters could support his interpretations. Scaled quantification of basic universal energies match the magnitudes measured within the human cerebrum during thinking. Superposition of the magnetic fields associated with thinking upon the intergalactic strength fields for induced changes in magnetic moments of elementary electrons solve for durations that approach the age of the universe. The immersion of the human species within both the earth's magnetic field and the Schumann Resonances create the conditions for producing the "noosphere" and for its potential expansion into space. The rapid development of new computer-based technologies that expose the human population to homogeneous energetic patterns and produce cognitive states consistent with "unifying" the noosphere could be sufficient to produce physical changes that could support Teilhard de Chardin's hypotheses.

Keywords

Teilhard de Chardin; spiritual energy; quantum energy; human brain; Schumann Resonances; immortality; sphere of human thinking (noosphere); expansion of consciousness; biophysical evidence; physical philosophy, digital culture, digital games

Introduction

The "dangerous thoughts" of combining traditional religious and philosophical presumptions with human evolution were articulated during the year 1938 in the manuscript entitled Le Phenomene Humain (The Phenomenon of Man) by Pierre Teilhard de Chardin (1959). He was an original thinker who was attempting to integrate the most fundamental philosophical presumptions of Christian Theology with the scientific theory of evolution. Although his nomenclature reflected this time, the prescience of his concepts was extraordinary and anticipated the central thrust of contemporary neuroscience in general and neurotheology and neurophilosophy in particular. His postulations, that evolution is an ascent towards complexity and consciousness that can expand into space and time, has significant ramifications for the future of the human species. The emergence of a sphere of human thought, the noosphere, as the third progression after the geosphere of inanimate matter and the biosphere of animate (biological) matter could manifest unique and different properties. The transformation of his ideas into technologies could contribute to this progression. Like the biosphere affecting the geosphere the noosphere could affect both.

Mertz (1965) discussed the integration of scientific and religious/philosophical perspectives from the late 19th century with regards to "universal" concepts such as energy. Recently Nordlund (2015) applied modern concepts of physics to St. Augustine and Chung (2015) has integrated aspects of quantum physics with Confucian philosophy. We have assumed that, at their essence, the fundamental operations for the substrates mediating the relationships between the words that thinkers have employed to describe concepts for the boundaries of space and time and those moderating relationships between physical units share a common source of variance. Here we apply quantification from contemporary biophysics, the environmental sciences, and quantum concepts (Persinger et al, 2008) to Teilhard de Chardin's fundamental assumptions that attempted to "bind" biology, cosmology, and the essential metaphysics. The latter has been central to all sciences and philosophies. We then describe an emerging technology whose physical properties could lead to the condition that could precipitate the "global consciousness" and expansion of beyond the terrestrial boundaries that he suggested and was described in the 1955 publication of his treatise.

"SPIRITUAL" ENERGY AS "QUANTUM" LEVEL ENERGY

Teilhard de Chardin's consternation with the difference between matter and energy and between the physical and the spiritual (p.67) was similar to many intellects who have grappled with the dichotomous distinctions in general and the mind-body problem in particular. The implicit assumption for this dichotomy is that the differences are qualitative rather than quantitative. His focus was to "connect the two energies of the body and the soul in a coherent manner". He succinctly states "the inner face of the world is manifest deep within our human consciousness and there reflects upon itself…there are dynamic relationships existing between the within and the without of things at a given point in the universe". (Words in italics were indicated in his original work). This perspective that consciousness reflects the universe and it reflects consciousness is remarkably congruent with the phenomenological perspectives of how the human perception (consciousness) affects our measurements of the universe according to Teilhard de Chardin's contemporary and astrophysicist Sir Arthur Eddington (1981).

According to Teilhard de Chardin, "The two energies—of mind and matter- spread respectively through the two layers of the world (the within and the without), have, taken as a whole, much the same demeanor" (p. 69). In contemporary biochemistry and biophysics the two energies are more typically represented as those associated with matter or molecular pathways and those associated with energy or electromagnetic patterns most frequently associated with photons or light. However one interpretation of his comment is that the two are qualitatively the same but differ only quantitatively.

If he were alive today there would very likely be no dilemma. Niels Bohr (1958) one of the primary originators of quantum theory, had stated that the "energy"" of thoughts and cognition were likely to be within the magnitudes of quantum units, very small and very discrete. In other words the primary difference between energies of the machinery of cells and the machinery of "thought" or "spiritual" patterns is the magnitude. They are not "apples and oranges" but rather different sized apples. The apparent qualitative difference is a perception because the contemporary measurements are not sufficiently precise to discern the quantitative difference. One classic illustrative example is a description from the Ancient Greeks. They assumed that "mind" or "soul" moved as "animal spirits" through tubes and hence was "non-physical".

Translated to contemporary language “thoughts” are aggregates of “electromagnetic fields” with measureable intensities that move along axon barrels with discrete lengths. Both are operationally similar and only differ in their quantification.

The matter that occupies the volume of the human brain is organized as cells, primarily neurons and glia cells. The cell is composed of multiple organelles and structures that must be maintained continually in opposition to the forces of “deconstruction”. About 10-12 Joules (the unit of energy, and energy is force over distance) is required per second per cell. The coefficients will vary but the order of magnitude remains more or less similar. This assumes a classic cell with a width of about 10 micrometers.

On the other hand a single action potential, which is a temporally discrete (about 1 millisecond or 10^{-3} s) change in voltage of about 120 mV ($1.2 \cdot 10^{-1}$ V) acting upon a unit charge (of a proton or an electron) of $1.6 \cdot 10^{-19}$ A·s (Amp second) or a Coulomb, exerts an energy of $2 \cdot 10^{-20}$ J (Persinger, 2010). If there were 10 of these spikes per second or 10 Hz (the median peak power frequency of the human cerebrum as measured by electroencephalography as “brain waves”), the energy associated with the “electromagnetic” pattern of neurons would be $2 \cdot 10^{-19}$ J/second or about ten million times less than the energy per second required to maintain the metabolic operation of the neuron as cellular matter.

This small amount of energy per action potential, 10^{-20} J, is the same magnitude of quantum that is required to add a base nucleotide to a ribbon of RNA that will ultimately determine the type of protein sequence within the cell. Proteins are constructed of series of amino acids and determine the structures and functions (enzymes) of the cell. In this manner the pattern of action potentials which reflects the impact of the environment upon sensory input is transformed into more or less stable patterns of proteins that are the representations of experience or memory for the individual. This unit of energy is also the same order of magnitude as many of the complex forces, such as the hydrogen bond, that “hold” the chemical units of the biological machinery together (Persinger, 2010).

The range of energies between 10^{-20} J and 10^{-19} J is within the band associated with visible light. Since the 1930s photon emissions have been recorded from all living systems (Gurwitch, 1926). The rejuvenation of these measurements, primarily stimulated by Popp (1979), has indicated that the photon emissions are not simply metabolic artifacts but are intimately involved with inter-cell and intra-cell communications (Trushin, 2009; Fels, 2009). Popp (1979) has argued that because all (or simply most) of the energy that has contributed to the evolution of biological systems on this planet originates from the sun, “virtual photons” that reflect this history are represented within the matter of the cell.

Relating consciousness and thinking to photon emissions has been an aspiration of many scientists over the centuries. The concept that “light” is an indicator of properties or processes that reflect positive qualities of space and time are represented in many religious perspectives. If “spiritual” energies are actual energies displayed at very low intensities then biophoton emissions are candidates for the physical equivalence. The measurements require photomultiplier units and are usually within the range of 10^{-12} Watts (Joules per second) per meter squared (Dotta et al, 2011a). For comparison this irradiant power density (Watts per meter squared) is about 10,000 times weaker than the “dark” on a cloudy, moonless night.

Dotta and his colleagues (2011, 2012) measured clear, reversible changes in photon emissions from the right sides of the heads of human participants sitting in hyper-dark chambers when they imagined white light compared to when they did not. The increase in photon emissions from the right side of the head was about 10^{-12} W per m^2. Simultaneous measurement of quantitative shifts in electroencephalographic power indicated strong correlations between the activity within the participants left prefrontal region which is associated with personal intent, decision-making and choice, and the irradiant flux density of the photon emissions from the right side of the head (Dotta et al, 2012).

The importance of this connection between imagination and consciousness and photon emissions from the human brain to Teilhard de Chardin’s premises cannot be over-emphasized. These biophotons match his operational description of the essence or evanescent particle (p. 283). They also connect or resolve the dichotomy between matter and energy or mass and spirit in a very quantitative manner (Persinger, 2012a, 2013a). The velocity of light, even when mildly attenuated in water, is about $2.8 \cdot 10^8$ m per second. The width of the plasma cell membrane of a neuron is 10^{-8} m (10 nanometers). Hence, the time required for a photon to pass through the membrane of a neuron would be about 10^{-16} s. The actual value is overlaps with the time required for an electron in the classical Bohr atom to complete one orbit.

This temporal congruence creates the conditions for any photon originating anywhere in the universe to have sufficient time to transpose the information within the packet into an electron orbit and hence the mass within the membrane of a neuron. It also means that the photons generated within the atoms that compose the cell membrane from the shifts in electron orbits would have the potential to be emitted and traverse anywhere within the universe. What is required is a specific technology or process that facilitates excess correlation between great distances, that is, "non-locality". If the photon is timeless or can exist as virtual patterns within space-time for indefinite periods, then both complexity and connectivity within the entire universe could be accessed potentially. The convergence, the "omega point" was Teilhard de Chardin's description of the maximum level of that complexity and consciousness to which the universe is evolving.

The Personal Universe

In the chapter concerning the convergence of the person and the omega point, Teilhard de Chardin states that after the catabolism of all of the forms of synthesis (p. 283) and the ultimate dismantlement of biological machinery, primarily only evanescent particles remain. This is remarkably similar to the concept of entropy when the final distributions of energy into the smallest increment of measurement approach equality. He states "Only one reality survives and be capable of succeeding and spanning the infinitesimal and the immense: energy…" There should be a fundamental unit of energy that can expand or is implicitly present through which the expansion can occur.

The concept of the humanized progression of noogenesis (the sphere of thinking) and space-time is similar to the process of a hologram which is defined in many contemporary terms as when the unit reflects the whole and the whole reflects the unit (Rose, 2006). Teilhard de Chardin expresses this as "…the Universal and Personal…grow in the same direction and culminate simultaneously in each other. (p. 285) and "The conclusion is inevitable that the concentration of a conscious universe would be unthinkable if it did not reassemble in itself all consciousness as well as all the consciousness" (p. 287). The "Omega" concept, in its ultimate principle, can only be a "distinct Centre radiating at the core of a systems of centres; a grouping in which personalization of the All and personalization of the elements reach their maximum, simultaneously, without merging, under the influence of supremely autonomous focus of union" (p. 289).

There are two perspectives that are consistent quantitatively with this concept. If one assumes the individual unit is the human brain and the numbers of neurons within the cerebral cortices is around 25 billion (Pakkenberg and Gundersen, 1997) but that only about 10 million neurons are required for a concept or a percept and each discharge 10 times per second with an energy of 10^{-20} J, the total energy per second would be 10^{-12} J per second. Interestingly this is the amount of energy supplied by the "machinery" of the biological systems through glucose metabolism per second for a single neuron, the unit of thinking. That the activity of only one neuron can affect the organization of the activity of the entire cerebral cortices (Li et al, 2009) or determine the direction of a complex behavior (Houwelling and Brecht, 2008) has been shown experimentally.

From Teilhard de Chardin's perspective what is more critical is the energy density of the human cerebrum during thinking. Assuming a typical volume of $\sim 10^{-3}$ m^3 for the cerebrum, the energy density from the 10^{-12} J (per second) would be about 10^{-9} J per m^3. The value is conspicuous. If the total energy within the universe based upon contemporary estimates of 1069 J (from the mass of 1052 kg) and the volume of the universe is in the order of 1078 m^3, the average energy density of the entire set that defines existence is 10^{-9} J per cubic meter (Persinger, 2014). This convergence would be a condition expected by the premise that "the whole and the individual reach their maximum without merging and that the universal and the personal grow in the same direction and culminate simultaneously in each other".

Any system that is intrinsically connected such that the every element is associated with the whole and the whole is associated with each element, must have some type of operational commonality. For Ernst Mach's concept of the Prominence of the Universe, behavior of any part of the Cosmos is determined by all of its parts (Persinger, 2013a). From that perspective any physical field could be conceived as existing anywhere. Teilhard de Chardin's unifying principle is an energy which he defines as love with a rather exotic definition. It "is a more or less direct trace marked on the heart of an element by the psychical convergence of the universe upon itself (p. 291)". Furthermore, "love alone is capable of uniting living beings in such a way as to complete and to fulfill them, for it alone takes them and joins them by what is deepest within themselves." Effectively he states there is some fundamental smallest (deepest) unit within an element through which all elements could interact and could be represented within the entire or maximum set, the universe.

There is evidence for this uniting principle that is the energy found within the essence of human cognition, thinking, and at the most fundamental spatial fabric of the universe: Planck's Length (10-35 m). One would expect that equations that are applicable to the subset of the universe should be valid when the whole universe is considered. Force is equal to mass times distance times the square of frequency. For the total mass of 1052 kg over the length of 1026 m multiplied by the intrinsic oscillation of the universe, effectively the square of the reciprocal of Planck's time or the actual Zwitterbewegung of the oscillations (Puthoff, 1989) attributed to oscillations for zero point vacuum oscillations (1043 Hz), that is 1086 s^{-2}, the total force would be 10164 N. To obtain this value one adds the superscripts of the powers of 10 for mass, distance and the squared frequency.

The density of this force, to follow Teilhard de Chardin's direction, would require considering the smallest unit of spatial structure or Planck's Length (10^{-35} m). For simplicity if one assume a Planck's voxel or volume unit of 10^{-105} m^3 and the total volume of the universe (1078 m^3), then there would be 10183 Planck's voxels within the universe. Hence the force per voxel would be 10^{-19} N. For energy to be realized this force must be applied over a distance. The most predominant distance throughout the universe due primarily to the fact that about 90% of the composition of the universe is hydrogen (one proton, one electron), is the electromagnetic wavelength associated with the neutral hydrogen line of 21 cm ($2.1 \cdot 10^{-1}$ m) . The multiplication of this distance by the unit force of 10^{-19} N is 10^{-20} J.

This quantum of energy (Persinger, 2010) is the basic unit associated with the action potentials of neurons from which cognition is correlated and from which consciousness is assume to emerge. This unifying factor would presumably exist within the smallest imaginable space, Planck's Length, and the most common element: neutral hydrogen. Such homogeneity of energy could allow the specific form of "connectedness" that Teilhard de Chardin attributed to "love as an energy" that would be capable of uniting not only all living things but all "things". He states, in prose, the essence of this statement in the section reason for love, as "Expressed in terms of internal energy, the cosmic function of Omega consists in initiating and maintaining within its radius the unanimity of the world's reflective particles (p. 295).

THE HUMAN BRAIN AND THE EARTH

The evolutionary continuity of life and consciousness is a central theme within The Phenomenon of Man. Teilhard de Chardin frequently discusses the terrestrial continuity of the evolution of the human "mind" which emerged from the brain. Like many contemporary neuroscientists (Hameroff and Penrose, 2014) he linked the degree of complexity with consciousness. What he did not realize because the technology was not present at the time of his insights is that the fundamental characteristics of the volume occupied by the human cerebrum and that of the earth itself are both complex and remarkably similar. Because the earth is $4 \cdot 10^7$ m in circumference and the velocity of light is $3 \cdot 10^8$ m/s (meters per second) there is a resonance shell between the ionosphere and the earth's surface of about 8 Hz. This has been called the Schumann Resonance (Nickolaenko and Hayakawa, 2014).

Current estimates of the bulk, coherent velocity of fields of action potentials over relatively large areas of the cerebral cortices is 4.5 m per s. These recurrent fields display a phase velocity in the order of 25 ms or "40 Hz" and move in a rostral to caudal direction over the surface of cerebrum (Llinas and Pare, 1991). Assuming the average circumference of a human head is 60 cm, the resonance frequency is about 8 Hz. There are harmonics or higher frequencies which show peaks of power along the frequency continuum separated by about 6 Hz which are found in the human cerebral power spectra and the Schumann domain at 14 Hz, 20 Hz, 26 Hz, etc.

Measurements of the magnetic components of the Schumann resonances at the fundamental frequency are 10-12 Tesla. The typical magnetic field strength for the oscillations within the cerebral cortices from the scalp associated with thinking are 10-12 T (Persinger, 2014). The electric field component of the Schumann resonance is about 1 mV per m; an almost identical potential difference is measured for the human brain. The primary sources of the Schumann resonance are lightning strikes over the entire surface of the earth (but primarily in the equatorial regions). They occur about 44±5 times per second, or 44±5 Hz (Christian et al, 2003). The primary model for human consciousness is electroencephalographic activity around 40 Hz. The current density within a lightning discharge is about 105 A per m^2. The equivalent current distribution for an action potential as it moves along the axon barrel, if it were scaled to a meter, would be 105 A per m^2 (Persinger, 2012b).

Recent measurements by Saroka and Persinger (2014) indicated that several of the power fluctuations within the lower harmonics of the Schumann resonances are coupled in real time with electroencephalographic power of human brains. The concurrence is about 150 to 300 msec, which is equivalent to about 2 or 3 microstates of consciousness (Koenig et al, 2002) on average about once every 30 s. This duration is the classic interval of short-term memory. Consequently the conditions that could promote the convergence of evolutionary properties that contribute to consciousness within human brains exist and would be consistent with Teilhard de Chardin's predictions. There are many themes that "run through evolution". The first three involve "groping profusion, constructive ingenuity and indifference towards whatever is not future and totality". "There is also a fourth heading which embraces all of them: global unity.

TEMPORAL CONTINUITY OF CONSCIOUSNESS: "IMMORTALITY"

Teilhard de Chardin's essential units imply a type of immortality or a temporal duration that approaches that of the age of the universe. There is quantitative support for this potential based upon the specific quantity or intensity of the magnetic field strength found within the human brain during cognition which is similar to that displayed by the Schumann Resonance generated by the earth. This potential is seen by calculating the induced magnetic moment upon an electron which corresponds to a change in angular velocity (the motion of a particle in a circle around a central point). An electron moving in a closed path produces a magnetic field. The induced magnetic moment (Δm) is:

$$\Delta \boldsymbol{m} = -\left[\frac{\boldsymbol{e^2 r^2}}{\boldsymbol{4 m_e}}\right] \boldsymbol{B}$$

where "*e*" is the fundamental unit charge of 1.6×10^{-19} A·s, *r* = the radius of the Bohr atom (5.1×10^{-11} m), m_e is the mass of an electron (9.1×10^{-31} kg) and *B* is the strength of the applied magnetic field.

The solution for this aggregate when applied within the magnetic field strength (10^{-12} T) associated with the 40 Hz pattern of consciousness or of the earth-ionospheric resonance within which all human beings are exposed, becomes 10^{-40} A·m^2 (the unit for magnetic moment) which is the same as Joules per Tesla. To obtain only energy, this ratio must be multiplied again by another magnetic field strength. If either the Schumann intensity is applied, or the average intensity of the intragalactic magnetic fields (Neronov and Vovk, 2010) is utilized, the energy is 10-^{52} J.

This value becomes a potential central point for Teilhard de Chardin's premise for two reasons. First, if the photon, the particle that has been attributed with "timelessness" and may be a source of intercalation between the energies of space and time, is at rest its mass would be about 10^{-52} kg (Tuo et al, 2005). In other words if m^2/s^2 approached unit, 10^{-52} kg would be convergent with 10^{-52} J. Secondly, if this energy of 10^{-52} J is divided into the reference value for quantum solutions, Planck's constant ($6.626 \cdot 10^{-34}$ J·s), the solution is time (seconds). The actually value is about $4 \cdot 10^{17}$ s which is effectively the age of the universe. Although this does not necessarily prove the immortality of the self, it does suggest a temporal continuance for the information associated with the energy that produced the change.

Applying the “Omega” concept, in its ultimate principle, can only be a “distinct Centre radiating at the core of a systems of centres; a grouping in which personalization of the All and personalization of the elements reach their maximum, simultaneously, without merging, under the influence of supremely autonomous focus of union (p. 289)”, the quantification indicates that a representation of the “whole” superimposed upon the individual unit (the electron’s angular motion) without necessarily merging, reflects a central radiating core. The core could be the rest mass-equivalent energy of a photon whose temporal value is the age of the universe.

Expansion of the Noosphere (The Sphere of Human Thought)

Under the section of “The Ultimate” the definition of the noosphere is expanded and articulated more succinctly. He states “we have as yet no idea of the possible magnitude of ‘noospheric’ effects. We are confronted with human vibrations resounding by the million—a whole layer of consciousness exerting simultaneous pressure upon the future and the collected and hoarded produce of a million years of thought” (p. 313). Continuing, “Under the increasing tension of the mind on the surface of the globe, we may begin by asking seriously whether life will not perhaps one day succeed in ingeniously forcing the bars of its earthly prison by getting into psychical touch with other focal points of consciousness across the abysses of space. “...the Universal and Personal…grow in the same direction and culminate simultaneously in each other (p. 285). “Consciousness would thus finally construct itself by a synthesis of planetary units”. If we substitute terms such as “psychical” for “cognitive” and “consciousness” for “electromagnetic or energetic patterns”, the expanding noosphere develops physical characteristics. This physical basis of consciousness is not unique. A mathematical form with specific biochemical substrates, the microtubules, has been thoroughly developed by Hameroff and Penrose (2014).

In previous quantifications, Persinger (2008) showed that the amount of energy contained within the space occupied by the earth’s magnetic field was sufficient to store the energies from all of the action potentials and hence potentially all of the thoughts of every person that has ever lived. The assumption of his model was that during the labile duration, of about 30 min, for the electrical stage of memory before it is represented as newly formed spines (newly synthesized proteins) on dendrites of neurons, there is also the representation of this information in electromagnetic form within the space occupied by the earth's magnetic field through the spherical (earth-ionosphere) waveguide, i.e., the Schumann Resonances.

The physical parameters for the earth's magnetic field as well as the conductivity between the ionosphere and the earth's surface solve for this specific duration. In addition recent measurements by Professor Kevin Saroka showed brief (150 to 300 ms) coherence between Schuman frequency powers recorded a continent away (Italy) as well as locally (Sudbury, Ontario) within the EEG patterns for dozens of human participants. The coherence occurred once every approximately 30 s. This is the first physical evidence that electromagnetic mediated information could be shared between the brain and the entire surface of the earth's shell within which Schumann resonances occur.

Assuming that the functional energy from neurons associated with percepts and thoughts is about 10^{-9} J per second and that each person lives for about 2 Gigaseconds (70 years), the total "pure" energy from simply the individual's lifetime of "cognition" would be about 1 Joule. Even with conservative estimates of 100 billion human beings over the history of the planet, only about 1011 Joules would have been represented within that space. In comparison the energy associated with the earth's entire magnetic field is within the order of 1018 J. Stated alternatively, all of the energy from every thought of every person who has ever existed would only occupy about one-ten billionth of the total potential.

Teilhard de Chardin's concept of expansion of a "human universal consciousness" once a critical threshold had been achieved was prescient. The electric field between the ionosphere and the earth surface within which the Schumann resonances are generated and all humans are immersed is about 10-12 A (amps) per m^2. According to Volland (1982) the total mean on flat ground from these currents is about 2 pA per m^2. The difference between the surface over the oceans or lands is negligible.

Assuming the average of $2 \cdot 10^{-6}$ V (2 microVolts) for the primary 40 Hz activity through the cerebral cortical tissue associated with cognition and consciousness for which the intracellular resistivity is ~2 $\Omega \cdot$m, the current would be 10-6 A/m and when applied across the averaged linear distance of the cerebrum ($\sim10^{-1}$ m), would be 10^{-7} A per human brain. For $7\cdot10^{9}$ human brains, the summed current is $7\cdot10^{2}$ A and when spread over the surface of the earth ($5\cdot10^{14}$ m^2) is about $1.4\cdot10^{-12}$ A/m^2. For comparison the mean of the air-earth current over land is about $2.0\pm0.3\cdot10^{-12}$ A/m^2 (Volland, 1982).

Hence the current density, on average, for human beings in the process of thinking or consciousness over the surface of the planet is beginning to approach the current density of the air-earth current over land. When the values converge which could occur with the addition of only another 3 billion people or a total of 10 billion people, the current density of the earth and the human species of a whole would enter a condition where "...the Universal and Personal…grow in the same direction and culminate simultaneously in each other. (p. 285). Whether or not this is the threshold at which "Under the increasing tension of the mind on the surface of the globe, we may begin by asking seriously whether life will not perhaps one day succeed in ingeniously forcing the bars of its earthly prison" remains to be discerned.

Obviously there are clusters of places where the current density would be less or more. This may not be important. Teilhard de Chardin's premise would require the human species to behave as a unit or a whole. Although each person would contribute their quantification to the whole, an integrator would be required. One of the most likely candidates is the earth's magnetic field within which almost every living system is immersed. The geomagnetic field displays the conditions that would satisfy the noosphere that encircles the earth through evolution of consciousness and complexity. Both the geomagnetic field and the Schumann Resonance have been present since the first amino acids were formed by the lightning discharges through ammonia, hydrogen, oxygen, methane and carbon dioxide (Graf and Cole, 1974).

The physical form for connectivity in space-time is magnetic diffusivity (m^2 per s). The process is defined as the ratio of conductivity of a medium divided the magnetic permeability of a vacuum. For physiological saline within each human brain the conductivity (σ) is 2.1 S/m (Siemens per meter). When divided by magnetic permeability (μ) which is 1.26×10^{-6} N/A^2 (Newtons per square A), the result is a diffusivity term of $1.3\cdot10^{6}$ m2/s. Assuming 7 billion human cerebrums each with a cross-sectional surface area of 10^{-2} m^2, the total surface area of "cerebral surface" connected temporally by the magnetic flux lines of the earth would be 7 x 10^7 m^2 at about one minute. Even if the conductivity varied by several units or the cross-sectional area of cerebrums were slightly larger the potential passive connectivity between any one cerebrum and all other cerebrums would be within the time of less than 10 min (Persinger, 2013b). Such passive connectedness increases the degrees of freedom within the whole aggregate for increasing complexity.

There is also a dynamic component. The product of magnetic flux density measured in Tesla ($kg \cdot A^{-1} \cdot s^{-2}$), current density ($A/m^2$) and magnetic diffusivity (m^2/s) is kg/s^3 or W/m^2. There is one potential process by which brains that share the earth's magnetic field or common current densities might be associated. Assuming the value of 10-12 T for either the functional magnetic field intensity for human cerebral activity or the first harmonic of the Schumann Resonance, a 10^{-12} A/m^2 current density for either the earth-air value or the average for all of the brains of the human population, and 106 $m^{2/}s$ (from $(\mu \cdot \rho)^{-1}$ where μ is magnetic permeability ($4\pi \cdot 10^{-7}$ N/A^2) and ρ = the inverse of $2 \cdot \Omega \cdot m$ or 0.5 S), the irradiant flux density would be $\sim 10^{-18}$ W/m^2.

The significance of this relatively small flux density becomes apparent when it is applied over the cross-sectional area of human cerebrum (cortex), about 10^{-2} m^2 (Pakkenberg and Gundersen, 1997). The resulting value is 10^{-20} W or J/s. This is the unit energy for a single action potential. Energy is also the product of the potential difference (voltage) and unit charge. For the typical voltage associated with the 40 Hz pattern correlated with consciousness, which is 2 μV, the resulting energy would be $3.2 \cdot 10^{-25}$ J. When divided by Planck's constant the frequency is within π of the neutral hydrogen wavelength. This could be the wavelength (connecting the force per Planck's voxel to be 10^{-20} J) that would allow distributions "across the abysses of space".

EXCESS CORRELATION AND NON-LOCALITY

The presumption of locality requires an intricate serial sequence of events that are sufficiently adjacent in space-time for forces to be influential or for a mediating process to affect directly the adjacent events. As a result there is a discrete latency associated with this propagation that can be measured and predicted. This intrinsic process is the basis of cause-and-effect.

However the concept of non-locality challenges this assumption. For example the philosophy of Ernst Mach assumes the prominence of the Universe. From this context any one part of the universe is affected by all of the other parts. For it to be valid an integrating process would be required that includes the entire set (the universe) and occurs more or less instantaneously. There is evidence for brief temporal connections across universal boundaries derived from the fundamental constants (Persinger and Koren, 2013). The presence of non-locality is inferred by the persistence of "excess correlation" between two events at distances that cannot be accommodated by the latencies expected for "locality" and ordinary mechanisms of cause and effect or the properties of the medium (such as the velocity of light) that moderate the effect.

Dotta et al (2011) demonstrated the "proof in principle" of this concept experimentally by exposing the cerebrums of pairs of volunteers to an identical sequence of magnetic field patterns that were rotated counterclockwise in the horizontal plane at the level of the ears. The circular array of point magnetic fields consisted of 8 separate solenoids each separated by 45 degrees that was placed around the head like a laurel. Each member of the pair was separated by about 10 m and sat in comfortable chairs within separate, closed rooms. The fields were generated from this circularly array of eight solenoids where the rate of change of the presence of the field in each of the solenoids (as the field pulses were rotated around the heads) was controlled by computer software. From our perspective this experimental configuration produced the "same" temporal configuration within in two different loci.

Dotta et al (2011) based the conceptual operations of the circularly, changing angular velocities of magnetic fields around the head from the usual behavior of photons when their rest masses were assumed to be non-zero. Tu et al (2005) had summarized the physical theory and mathematical derivation of these different properties. One of these characteristics is that group velocities (the speed of the whole packet of photons) become different from their phase velocities (movement of photons within the packet). Dotta and his colleagues rotated the fields around the heads at different rates than the repetition frequencies of the patterns contained within the field. They found that when one of the yoked pair was exposed to bright light in one room there was increased emission of photons from the right side of the brain of the other member of the yoked pair, separated by 10 meters, and sitting in another room that was hyperdark.

The effect only occurred if there were two stages to the exposure and if the magnetic fields were present. The first involved a circularly rotating magnetic field with an accelerating group velocity associated with a diminishing phase velocity for a few minutes followed by a decelerating group velocity but an increasing phase velocity for about twice that time. No other combinations were effective. A constant velocity of rotation also was not effective. In subsequent studies Dotta and Persinger (2012) found that when two chemical luminescent reactions both shared the same optimal field simultaneous injection of the reactant in both locations doubled the photon emissions. During this specific sharing of fields parameters the two loci behaved as if they were superimposed within the same space. This effect was demonstrated as far as 3 km, which was the furthest distance tested at the time.

Slightly different equipment indicated that complex brain activity could be coordinated when the two subjects were exposed to the same configuration of magnetic fields (a changing angularity velocity around the head was still required) and separated by as far as 300 km (Burke et al, 2013). This “excess correlation” of reactions between two locations when the two spaces share the circularly rotating magnetic field with different rates of angular velocity has been found for the most essential chemical reactions associated with brain function, such as shifts in pH or the relative acid-base levels (Dotta et al, 2013).

Recently Karbowski et al (2015) showed that pairs of dishes containing melanoma cells sharing similar rotating magnetic fields exhibited excess correlation over a distance of approximately 2 km. When one dish in the pair was injected with hydrogen peroxide that diminished cell growth by the following day the cells in the other dish, 2 km away, that had received no injections showed a proportional diminishment of growth. These results indicate that under the appropriate conditions that would imbue photons with additional properties superposition of different loci behave as the same space. This would produce an environment where the noosphere might be maintained.

TWENTIETH FIRST CENTURY TECHNOLOGY AND THE NOOSPHERE

One of the conditions that facilitate the emergence of a complex whole that is greater than the sum of its parts or elements is the presence of a force or energy within which all of the elements are immersed. For example a parallel bundle of a million wires moving through magnetic flux lines or the field moving across the bundle generates a configuration of a changing field (a "tensor") that may reflect the characteristics of the elements. The whole field would also display properties that add to these characteristics as secondary representations. During the evolution of the geosphere and biosphere these immersive forces and energies included the geomagnetic field and the Schumann Resonances.

The biosphere, particularly from the contributions of the human species, has generated additional immersive forces. They include the communication systems defined by relatively restricted GHz bands that are remarkably adjacent to the 1.42 GHz signature that defines the neutral hydrogen line that itself permeates the universe. Although the wavelengths for the hydrogen line and for GHz bands associated with modern communication systems occur within the range of the circumference and diameter of the human cerebrum, the more fundamental effect would occur from beats.

Beats are the differences between frequencies. In the simplest form if a 1000 Hz and 1010 Hz tone were presented simultaneously, the experience would also include the subtraction of the two: a 10 Hz "tone". It would be an emergent property and from some perspectives a "virtual" condition derived from the derivate of the change. The differentiating individual features for cell phone communications primarily depend upon the sub-frequencies or lower frequencies and patterns superimposed upon the carrier. There will be some point in the near future where the density of communication requirements are such that the subtractions will result in near-continuous “beat” patterns that overlap with the range of brain activity, that is, between 1 and 100 Hz.

Although the “energy” levels from global communications systems have been argued to be “too weak” to be cerebrally effective, calculations suggest otherwise. For example if the radiant flux density or power density of a GHz signals was 10 mW per square meter, which is a common intensity within a few meters of kitchen microwave when it is operational, the energy available to just the soma or cell body of a neuron with a cross sectional area of 10^{-10} m^2 would be 10^{-12} Joules per second (or Watts). This is the same order of magnitude as the amount of energy supplied from glucose metabolism within the cell to maintain its organelles and functions.

Within the last two decades the emergence of the World Wide Web has allowed “information” in its electromagnetic form to be present in space-time in a manner never previously possible. This information is accessed visually and through earbud devices, worn more and more frequently by members of the population, which allows direct proximity to the associated magnetic fields within the listener’s brain space. The outer regions (cortices) of the temporal lobes are only about 2 cm away from the spaces in which the earbud devices are placed. We have measured magnetic field intensities in the range of 0.1 to 1 microTesla from these electronic devices (Saroka and Persinger, 2011). The magnetic energy within the volume of the cerebral cortices would be sufficient to affect, potentially at least, millions of neurons.

There is another immersive energy that Teilhard de Chardin may have considered the “precipitant” to produce the conditions to allow the expansion of consciousness into non-local space. This additional energy is that associated with the direct interfacing between computer electronics and human brains. The most productive and expanding forms of this synergism are the escalating numbers of virtual and real-time engagement software or “games” that couple the brain with complex electronics. Many of these conditions produce “the flow state”. It has been defined by Csikzentmihalyi (1990) as a feeling complete and energized focus of activity associated with a high level of enjoyment and fulfillment.

Our laboratory (Lavallee and Persinger, 2010) specializes in relating the quantitative changes in brain activity during typical cognitive states and those associated with “mystical” or “spiritual” perceptions. The array of sensors placed over the scalp according to conventional neurological procedures is effectively an aggregate of small volt meters. The amplitudes of the potential differences between each sensor that fluctuate between about 1 and 40 Hz, although fast transients around 400 Hz can be measured, are about 2 μV to 20 μV per Hz. These “ripples” originate from structural arrangement of the billions of cells in the cerebral cortices and are superimposed upon the “steady potential” or “d.c.” potential for the whole brain which is between 10 and 30 mV (about 1000 times stronger). With appropriate software we can map the transient spatial patterns of voltage changes during discrete increments of time and construct three-dimensional images of the current sources (with resolutions of about 1 cm) anywhere within the cerebral volume.

Direct measurements in our laboratory of the quantitative electroencephalographic activity of people engaging in the virtual perceptions generated by computer technology indicate there are frequent but intermittent occurrences of a “flow state”. This is a specific pattern of activity within portions of the

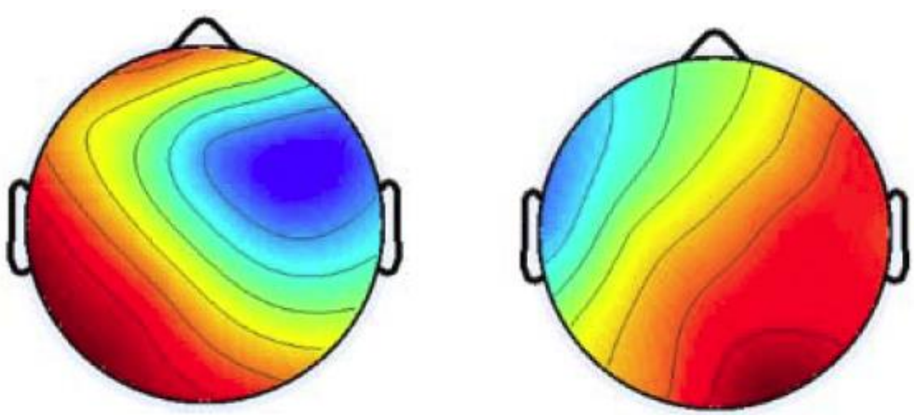

Figure 5.1: An example of the power shift within critical frequencies as measured by quantitative electroencephalography that would allow intercalation with an external field consistent with “the noosphere” that occurs during the “flow state” of interaction with virtual experiences in computer programs. Red indicates maximum power; blue indicates minimum power. The map on the left indicates the activation of the left caudal temporal region while the map on the right indicates the right occipitotemporal region. The condition would be consistent with the “confluence” between the electromagnetic cognitive states of the individual and the physical correlate (Schumann Resonance immersed in the earth’s magnetic field) of Teilhard de Chardin’s noosphere.

brains that could allow access to the Schumann domains and the interfacing with other brains engaging in similar activities. This flow state involves the right hemisphere, which is the region associated with "mystical" experiences (Persinger et al, 2010), creativity, and the feeling of expansiveness in space and time. It is also the region, particularly when the right parahippocampal gyrus is involved, that is likely to mediate the coherence between the cerebral activity of human beings on this planet and the activity within the earth's spherical wave guide within which the Schumann Resonances intercalate. In our experiments more detailed analyses indicated that the right occipital, temporo-occipital junction, parietal region and orbitofrontal cortices are particularly activated during the flow state.

The flow state was maximal when there was a decrease of activation in the left inferior frontal region but increased power within the 7-8 Hz, 27-28 Hz, and 42 Hz bands within the left temporal regions. Activation of this area is correlated with experiences of the self in general and the re-representation of memory specifically. We interpret this pattern as the flow state being a "state of consciousness" where there is a diminished personal intention (the "release" of sense of self to another) and planning in conjunction with more reliance upon experiencing passively the information within the left hemisphere as it is transformed from right hemispheric processes. If large numbers of people on the planet engaged in the technology that produced this configuration within the cerebrums and the specific subjective experiences, the conditions would be met potentially for the creation of a noosphere or the sphere of human thought with specific physical properties, as predicted by Teilhard de Chardin.

CONCLUSION

Three of Teilhard de Chardin's concepts, the prominence of "spiritual energy", the emergence of a sphere of human thinking (the noosphere) and the expansion of consciousness beyond the terrestrial domain can be supported by quantification of known parameters of the human cerebral cortices and the fundamental energies and forces that permeate the universe. There is evidence that what he called "spiritual energies" may be quantifiable to values similar in magnitude to those that operate within quantum levels. There are sufficient physical electromagnetic and temporal similarities between the Schumann Resonances of the earth-ionospheric cavity and the cerebrums of the human population to allow the conditions that could create the "noosphere". The persistence of alternations in magnetic moment by changes in angular velocity of the simplest unit, the electron-proton pairing, by superimposing the magnetic field strength associated with thinking upon the background intergalactic magnetic field, could qualify for the physical foundation required for immortality and the convergence at the Omega Point.

CONFLICTS OF INTEREST

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CHAPTER 6

CONCLUSIONS

The evolution of the earth has progressed through a number of discernable stages or phases each of which were dependent upon the quantity and pattern of the previous organization. The solidification of the terrestrial matter into the crust with a relatively constant temperature for a specific band of chemical reactions encouraged the formation and stabilization of a gaseous envelope covering a harder spherical shape. Warming from solar energy upon this gaseous band produced the differential gradients that stabilized disparity of charges between the ionosphere and the earth surface. Lightning occurred. The different temperature and rotational features of the earth produced electrical discharges that may have contributed to the first amino acids. In other areas where light mixed with formaldehyde and residual cyanide the first purine, adenine, was likely to have emerged.

The transition from the geosphere to the biosphere was associated with a proliferation of life forms whose densities increased in proportion to the duration of the solar constant over billions of years. The quantity of these life forms and shapes spread across the terrestrial surface. For that duration the natural cycles of accessing energy through consumption and removing metabolites by secretion did not produce any residuals of major significance. Biodegradation of end products delivered the source materials to the original forms of chemistry. However, then a species developed, likely augmented by a single point mutation in the FOXP2 gene, that allowed symbolic substitution of experience with shared groups. This primate, homo sapien sapien, began to leave physical traces that were constructed by it and were not easily degradable by natural processes.

Within the last 100 years this species developed the capacity to recreate or simulate the conditions that were strongly correlated with life. Electromagnetic fields from extended communication systems have generated a secondary matrix superimposed upon the natural geomagnetic and earth-resonance patterns that were present during the emergence of life forms. This new matrix is significant because it is constructed like the organ, the human brain, which is correlated with consciousness. Consciousness could be considered a collection of states of simulated representations of the physical world. One of the new components of this matrix is the electronic brain (the computer) and its sensory-efferent systems (input/output) that allow linkage between the organic and the electronic brains.

Because the states of the human brain are immersed within the original Schumann Resonances and both share electromagnetic properties, including intensity and frequency patterns, with the electronic brains generated by the human species, there is the possibility of a new phenomenon emerging. This new phenomenon could be considered a "sphere" much like the biosphere, except the extension of a specific type of biological process, consciousness, exists with the same complexity and the taxonomic life forms within the biosphere. If there is a threshold, much like the threshold that occurred before the solidification of the earth and the conditions that produced the biosphere, and, it has a threshold that occurred before the massive spread of life forms over the surface of the planet, then a threshold could be achieved where this new sphere of "consciousness" suddenly spreads and dominates. Technologies to utilize and access this sphere would be simple and ubiquitous, and could range from handmade external devices to advanced, integrated cranial implants.

The conditions under which this transformation might occur has been described and was demonstrated experimentally, at least in principle. The interaction between the human brain during the experience of a virtual environment produces a quantifiable state, like dreaming, that involves the portion of the human cerebrum that is known to be sensitive to the geophysical environment. This state is associated with a sense of presence and extension of subjective consciousness to other spaces where by a "fusion" or flow with the electronic brain (the computer field) is sensed. The parameters associated with this flow are sufficiently compatible with the properties of the electromagnetic shell between the ionosphere and the earth's surface to allow a connection between all brains that are engaging in that state at any given time. If this condition is like any other physical process, then, either by natural or synthetic means, there will be reached some imminent critical threshold where a qualitative shift to this new state will occur.