

A TRIPARTITE THEORY OF CONSCIOUSNESS AND MIND: THE NEURAL-MENTON CONJUNCTION HYPOTHESIS*

Richard P. Shank†

Abstract

In this paper we present a theory about the fundamental nature of consciousness and mind. The theory draws upon concepts from three sources, the Writings of Emanuel Swedenborg, modern neuroscience, and the Standard Model theory of particle physics. A central hypothesis of the theory is the existence of a theoretical particle, termed menton, which functions as a force carrier particle. Through the principles of correspondence and influx, a menton is functionally comparable to a photon. However, rather than being assimilated into a recipient electron and thereby adding kinetic energy to the electron, a menton is postulated to conjoin with a recipient electromagnetic field generated by a specific type of neural network within the brain, and thereby add mental energy that confers consciousness or another form of mental activity. The postulated source of mentons is the spiritual sun.

I. INTRODUCTION

Emanuel Swedenborg wrote his theological Writings to fulfill the Lord's purpose of revealing our relationship to Him, what He expects of

* An earlier version of this paper was submitted to the Academy of the New Church Theological School by the author as partial fulfillment for a Master of Arts degree in the Master of Arts in Religious Studies program. I am most grateful to the following readers who gave valuable help in bringing this revised version to press: Rt. Rev. Alfred Acton II for providing a valuable critique of an early version of it and for helpful discussions on the Writings; Linda Simonetti Odhner for her questions, and thoughts from the Writings, about aspects of the content, for her careful copyediting, and for suggestions regarding organization; and Dr. Dewey Odhner who made significant suggestions about the physics portion of the paper.

† Dr. Shank received a Ph.D. in biochemistry at Indiana University. His primary research interests are in various areas of neuroscience. Institutions he has been affiliated with include Indiana University, Temple University, the Franklin Institute, and the pharmaceutical division of the Johnson & Johnson Corporation.

us, the essence of good and evil, and the nature of the Spiritual World, and the role that spiritual and angelic humans serve in that world. Because Swedenborg was given the special privilege of entering into the spiritual realm to meet and converse with angels and other beings there, and to be instructed by the Lord, he was able to accumulate a vast amount of knowledge never available to anyone else while still living in the natural body. Of the vast amount of material that Swedenborg wrote and published, it is not surprising that a considerable portion dealt with the human mind, in both the natural and spiritual worlds. A search of the Writings using NewSearch revealed that the topic “mind” appears more than 5,500 times in more than 2,800 sections of the Writings, and shows up in nearly all of Swedenborg’s published and unpublished manuscripts. The importance of mind as a subject in the Writings is evident from an excerpt of *True Christian Religion* 34.

The human mind, which makes man to be man, and in accordance with which man is man, is formed into three regions in accordance with the three degrees; in the first degree, in which also are the angels of the highest heaven, the mind is celestial; in the second degree, in which are the angels of the middle heaven, it is spiritual; and in the third degree, in which are the angels of the lowest heaven, it is natural. [2] The human mind, organized in accordance with these three degrees, is a receptacle of Divine influx; nevertheless, the Divine flows into it no further than man prepares the way or opens the door.

Swedenborg described in considerable detail the characteristics of the degrees or levels of mind, especially the two primary degrees, the natural and spiritual minds (*AE* 406, *AE* 790, *AE* 1056; *DLW* 263), both of which are divided into several sub-degrees. The characteristics of most of the sub-degrees of the natural mind are intuitively obvious; e.g., the sensual mind and the rational mind. However, some of the sub-degrees of the spiritual mind are rather esoteric. Fortunately for us, Hugo Odhner has organized and explained these sub-degrees of the mind in a book titled *The Human Mind* (1969). The first chapter of Odhner’s book provides a brief account of some prominent theories relevant to the fundamental nature of mind and consciousness prior to the Writings. These early theories were proposed

by philosophers, and were generally dualistic in that they postulated a factor external to physical body (e.g. the soul) that served as the essence of the mind. Although Swedenborg did not develop a systematic theory of the fundamental nature of mind, it is evident that his understanding embodied a dualistic view of the mind. He also recognized that in the natural body the brain implemented the actions of the mind through a process of correspondence.

We are particularly interested in what Swedenborg wrote regarding the fundamental nature of mind. The impetus to develop the theory described in this paper came largely from sections of the Writings pertinent to the question of how the Lord communicates with celestial and spiritual angels, and humans in the natural world. An example of this is the following quote from *Interaction Between the Soul and Body* 4. II.

The internal sight of a man, which is the sight of his mind, receives influx from the spiritual sun; but the external sight, which is that of the body, receives influx from the natural sun; and in operation they unite, just as the soul does with the body.

The terms “influx” and “spiritual sun” are of particular interest in the context of the theory. In the Writings, influx is used either in an operational sense, i.e., it mediates a process, or in a functional sense, i.e., it is the active agent of the process.¹ In the quote above, influx is used in the functional sense, and the “agent” is something received either by the mind, as in the instance of the spiritual sun, or the body (e.g., the eyes), as in the instance of the natural sun. However, in both instances Swedenborg did not describe what is actually received by the mind, or the eyes. With respect to the eyes, it wasn’t known until the early 1900s that vision involved an interaction of photons with electrons in the retina, and only in last few decades of the 1900s that the interaction of photons with certain electrons caused a chemical reaction that opened channels in the membrane of photoreceptor cells in the retina. What is rather remarkable is that

¹ An analogy of the dual meaning we ascribe to influx is a gift and the box the gift is carried in. Influx can refer to either the box or the gift, or both.

Swedenborg did recognize that visual images are received by the brain and subsequently integrated into the mind.

The primary intent of the theory is to apply concepts from modern particle physics and neuroscience to offer a more detailed hypothetical account of the roles that the spiritual sun and influx serve in the process by which the Lord imparts the blessings of Divine love and Divine truth to angels in the spiritual world and humans in the natural world, specifically with respect to mind and consciousness.

II. BRIEF REVIEW OF MODERN THEORIES OF MIND AND CONSCIOUSNESS

The nineteenth and twentieth centuries witnessed a gradual escalation of theories about the nature of mind proposed by people with divergent perspectives. In the late 1800s, William James, who was familiar with the Writings, and a leader in what was then the emerging science of psychology, suggested that “the mind is a process, not a thing.” This may have had a significant influence on the way that many theorists viewed the mind because this appears to be a prevailing premise of theories published during the past 100 years. One postulate of our theory is that the mind is not just a process, it is also a thing. Many modern theories postulate that all forms of mental activity arise (or emerge) solely from the brain, and therefore are intrinsic properties of the brain. An argument used to support this concept is that living things emerged from nonliving matter (Brown, 2004; Torrance, 2004).

In recent years, the phenomenon of consciousness has received much attention, and may be the most challenging aspect of mind to explain (Chalmers, 1995; Seager, 1999). A comprehensive definition of consciousness is not easy. One dictionary definition is as follows: “awareness of thoughts and feelings: the part of the human mind that is aware of the feelings, thoughts, and surroundings” [*Microsoft® Encarta® Reference Library 2003*]. Consciousness includes such things as “reliving” a previous experience, and intentionally relating to life in a subjective way that attributes meaning and value to all experiences.

III. SYNOPSIS OF THE THEORY

As noted above, we have drawn upon concepts from the Writings, the Standard Model of particle physics, and neuroscience to develop a theory that may enhance our understanding of how the Lord communicates and confers blessings to angels in the spiritual world and receptive humans in the natural world. A key hypothesis of the theory is the existence of theoretical particles that have properties functionally analogous to those of photons, but rather than interacting selectively with recipient electrons, they interact selectively with recipient electromagnetic fields generated by certain types of neural networks² within the brain. In order to facilitate the description of these hypothetical particles, they have been termed “mentons.” A menton is defined as a hypothetical particle that acts as a force carrier in a manner analogous to photons.³ Mentons are postulated to interact only with electromagnetic fields generated by certain types of dynamic and complex neural networks. In correspondence with photons, various forms of mentons are postulated to exist in different energy states. Each particular type of menton is postulated to exist in a specific energy state that is matched to the electromagnetic field generated by a particular neural network, which enables the menton to conjoin through influx with that particular electromagnetic field. Hereafter, an electromagnetic field generated by a neural network will be referred to as an NN-EMF. The energy supplied by the menton in this conjunction is postulated to confer a particular form of consciousness or a “higher order” mental function (e.g., a specific thought or emotion, perception, understanding) to the NN-EMF.

The hypothetical characteristics of mentons as force carrier particles are discussed in Chapter IV. Their postulated source or origin, and their contribution to consciousness, perception, cognition and other mental activities are discussed in Chapter V. The mechanistic basis for the hypothetical conjunction of mentons with NN-EMFs is discussed in Chapter VI.

² A neural network may be defined as a group of neurons that collectively function as a unit to mediate or contribute to a specific physiological function. This could be as simple as a reflex or as complex as creative thinking.

³ According to the Standard Model of particle physics, a photon is a “force carrier particle,” which specifically interacts with, and can become part of, an electron, thereby adding kinetic energy to the recipient electron.

IV. PHYSICS AND THE MENTON HYPOTHESIS

Despite the remarkable advances made throughout the 20th century in understanding the nature of fundamental particles, it wasn't until the early 1970s that a coherent theory of particle physics was formulated (Oerter, 2006). The original theory, termed the Standard Model, is not able to satisfactorily explain all known or postulated physical particles and their interactions; consequently the Standard Model is constantly undergoing revision, and may eventually be supplanted by more refined models (Kane, 2000). The menton hypothesis, as presented in this paper, draws primarily upon concepts enunciated in the Standard Model, particularly the origin and nature of photons and their interaction with electrons. To help establish the significance of particle physics in our theory, a brief account of the Standard Model is presented below. A more authentic account is available on the web at <http://CPEPweb.org>.

In the Standard Model, fundamental particles are divided into two types: fermions (matter constituents) and bosons (force carriers). Fermions include leptons and quarks. Leptons can be subdivided into electrons and neutrinos (electrons and neutrinos can be further subdivided). Quarks can be subdivided into at least six types, but they are normally joined together in groups of three to make protons or neutrons, the constituents of the nucleus of an atom.

Bosons are force carrier particles and can be divided into three types: electromagnetic (photons), strong (gluons, mesons) and weak (W^+ , W^- , Z^0).⁴ For our purposes we are particularly interested in the electromagnetic force carrier particle: the photon. Nearly all the energy that makes biological life possible on earth comes from the sun in the form of photons. Photons are created in the sun indirectly by the process of solar nuclear fusion. This fusion process converts two hydrogen atoms to one helium atom near the center of the sun, and in the process generates enormous amounts of energy, primarily in the form of high energy gamma particles (photons). As the gamma particles move away from the center of the sun

⁴ This does not include the graviton, a theoretical particle that mediates gravitational force.

they are trapped by electrons along the way, which subsequently release the energy by emitting larger numbers of lower energy photons. These photons slowly move to the surface of the sun (it takes about 100,000 years), and escape at the speed of light. Many of these photons have oscillating frequencies in the visible or ultraviolet light range, and they travel through space unimpeded until they encounter an electron within an atom in an energy state suited to interact with the photon. The photon may be absorbed into the electron and thereby elevate the energy level of the electron, or it may interact briefly then be emitted by the electron. Absorption (influx) of the photon is the primary means by which energy from the sun is trapped. At the macro level, this energy is felt as heat, and can be utilized to drive chemical reactions, including those that sustain biological life.

A key point relevant to the menton hypothesis is that the sun emits a wide range of photons with different oscillation frequencies (wavelengths in wave theory terminology) and energy levels, each of which interact specifically with an electron in an atom that is in a suitable energy state. In effect, there is a precise matching of a particular type of photon with an electron in a particular energy state, such that when conjunction of the two particles occurs there is a precise change in the energy state of the electron. The same type of conjunction occurs between photons and electrons when radio, television and microwave signals are generated and transmitted to a receiver tuned to the appropriate photon oscillation frequency.

A key premise of the menton hypothesis is that mentons are force carrier particles that carry a form of energy that confers consciousness and other forms of mental function by interacting with a matched NN-EMF. In effect, mentons are postulated to confer mental energy to NN-EMFs in a manner somewhat analogous to the way photons add kinetic energy (momentum) to electrons, enabling them to drive chemical reactions.

V. ORIGIN AND HYPOTHETICAL NATURE OF MENTONS

Although the massive amount of material written by Emanuel Swedenborg during the last thirty years of his life focused on concepts generally regarded as theological and philosophical, many of the novel

concepts he enunciated have implications for scientific consideration. A remarkable feature of the Writings is the number of novel concepts described. One of these is the concept of the spiritual sun, which is discussed extensively in *Divine Love and Wisdom*. The spiritual sun may be described as a celestial body that serves as a vehicle through which the Lord's Divine love and wisdom creates and sustains life (*DLW* 1–4, 84–88, 112, 138, 192).

The existence of the spiritual sun is an essential premise of the theory presented here. However, since its existence has not been established scientifically, it can only serve as another hypothesis of our theory. From a functional perspective, the spiritual sun has correspondence with the natural sun in that they each emit or, in terms of wave theory, radiate energy necessary and sufficient for creating and sustaining life. As discussed above, the natural sun emits photons, which provide the energy necessary for creating and sustaining biological life. The spiritual sun emits particles of a different substantive nature, and serves a greater role than the natural sun in that it is the vehicle by which the Lord, through Divine love and wisdom creates and sustains the natural world and the spiritual world (*DLW* 93). The spiritual sun sustains the material world in part by influences on material bodies, in particular the natural sun. A premise of our theory is that the spiritual sun also has a powerful impact on the natural world by serving as the source of mentons that contribute to biological life by conferring consciousness and other forms of mental function in a living being whose brain generates NN-EMFs of sufficient complexity to be recipients of mentons. The impact of the spiritual sun on the spiritual world is, in some respects, more direct than it is on the material world because it serves as the sole means by which the mind and body of spiritual beings are sustained (*DLW* 90).

In correspondence with photons, mentons are postulated to exist in a wide spectrum of energy levels. Swedenborg's description of the "warmth (heat) and light" that emanates from the spiritual sun indicates that angels in different spiritual states (degrees of heaven) are recipients of different degrees or levels of this radiant energy (e.g., level of consciousness or cognition) from the spiritual sun (*DLW* 85, 132). Angels in the highest celestial heaven are well suited to receive a mental (spiritual) energy level that could not be understood by angels in a lower heaven. But these angels would be able to receive and benefit from a degree of this mental energy

that would be of no benefit to angels at an even lower level of spiritual development. Within the context of our theory, the energy level of mentons that conjoin with NN-EMFs of the natural brain would generally be lower than that of recipients in the spiritual world (*DLW* 85, 132; *AC* 8443). From this it may be inferred that there is a hierarchy of recipients of energy (mentons) from the spiritual sun, with angels in the highest heaven at the top, and humans in the natural world near the bottom.

According to our theory, mentons do not interact with ordinary matter (fermions). Consequently, they are not impeded from being virtually anywhere in the natural world, or the spiritual world. Therefore, we may postulate that mentons of all possible energy states permeate the entire universe. Furthermore, we may infer from the concept of “spheres” (*AC* 6600) the possibility that “high energy” mentons are prevalent in the celestial and spiritual heavens, whereas “low energy” mentons are prevalent in the natural world. Another inference is that mentons cannot be sensed by people in the natural world because the theory stipulates that these particles do not interact with matter (neither photons nor mentons are matter particles because they have no rest mass).

VI. ROLE OF THE BRAIN IN CONSCIOUSNESS AND COGNITION

The brain is essential to the formation and expression of consciousness and other aspects of mind in the natural world, but the physiological processes of the brain that are vital to the brain/mind relationship have not been clearly established. The human cerebral cortex, which is the area of the brain most closely associated with conscious mentation, is an exceedingly complex and highly organized tissue comprised of an enormous number of neurons ($\sim 10^{10}$) (Popper & Eccles, 1977, 228). At the whole organ level, the brain is organized by major physiological functions. A partial list includes the visual cortex, auditory cortex, sensory cortex, motor cortex, language function areas, emotion (limbic areas), areas associated with abstract thinking, mathematical ability, and art and music appreciation. Each of these regions can be further divided based on more detailed anatomy (e.g., neural columns or modules) and more precise function (neural networks). A neural network may be comprised of only a

few neurons (e.g., a reflex pathway) or many thousands. Each neuron within a neural network may have synaptic contacts with only a few neurons or with hundreds of neurons (Popper & Eccles, 1977, 227–249).

The brain has many physiological roles, some of which do not contribute to consciousness and cognition in any obvious way. These include control of the contractile activity of skeletal muscle tissue, and regulatory influences on the functional activity of many other organs in the body, such as the heart, lungs, vascular system, gastrointestinal system, kidney and skin. The lungs and gastrointestinal system also possess their own enteric neural networks, which are not thought to contribute to consciousness or mind. Neural networks that regulate the activity of other tissues and organs do so by precise signaling processes which control the functional activity of cells in the target tissue. These signaling processes are mediated by nerve impulses (action potentials) and synaptic potentials (defined below). In a general sense, the brain serves as a master organ that regulates the activity of other organs through a network of neurons that sends signals via action potentials and synaptic potentials. Most neurons use the same process to communicate with other neurons. The significance of this is that an essential premise of the neural-menton conjunction hypothesis is that action potentials and synaptic potentials operating within specific neural networks underlie the role of the brain in mediating consciousness and other aspects of mental activity.

The significance of the micro and macro anatomical structure of the brain

During early development, stem cells in various regions of the neural crest differentiate and form clusters of neurons. Within each cluster, several populations of different types of neurons form. As the neurons mature, dendrites and axons grow to their mature lengths, and synaptic contacts are made with other neurons. As various regions of the developing central nervous system (CNS) (brain and spinal cord) mature, they each take on characteristic shapes and sizes, and in all cases some neurons in any given region extend into one or more of the other regions and make synaptic contact with other neurons. During embryogenesis, the more

primitive regions of the CNS (midbrain, brainstem, spinal cord) develop rapidly, and at birth in some cases are sufficiently mature to be functional; whereas some areas of the brain do not fully mature until near the end of the second decade of life. Even after full maturation neurons continue to undergo synaptic modifications, and in some areas of the brain associated with memory formation new neurons continue to be generated throughout life.

The most unusual feature of the development of the CNS is the process by which neurites, especially axons, are guided to their target neurons and establish functional synaptic contact. In utero, assuming the fetus receives appropriate nutrition, neural development is driven by a genetic programmed process in which a variety of proteins and other specific chemicals (e.g., hormones and neurotransmitters) serve as cues to help neurons recognize each other, and initiate cellular activities associated with synapse formation. Beginning with newborn babies, the environment through its impact on sensory organs becomes a factor in synaptogenesis in the CNS. As a child develops and the brain matures sufficiently to enable consciousness and focused mentation to occur (e.g., independent and meaningful verbal expression, imagination, independent realization and understanding), the activities of the mind begin to impact synaptogenesis. This in turn must impact the structural and functional characteristics of select neural networks (discussed below). The concept that consciousness and other aspects of mental activity (e.g., cognition) can contribute to the creation of new neural networks in the brain is an essential premise of the neural-menton conjunction hypothesis.

How neural networks contribute to consciousness and focused mentation

Regardless of the type of physiological function served by the brain, the generation and propagation of nerve impulses (action potentials) within a neural network are nearly always key components in the mediation of these functions. Based on the current understanding of how the brain functions, it seems unlikely that synaptic potentials or action potentials generated by individual cells would have sufficient uniqueness or tempo-

ral complexity to form and code specific bits of mental activity (information). This is also presumably true for neural networks that mediate reflex activity. Neural networks that provide spatial and temporal complexity sufficient to form and code specific bits of mental activity may include groups of neurons in multiple regions of the cerebral cortex together with neurons in subcortical regions. The concept that complex neural networks serve as an underlying basis for consciousness and other forms of mental activity seems to be universal among neuroscientists who have seriously considered the nature of the mind/brain relationship and have contributed to the dialogue on this subject (Sperry, 1992; Eccles, 1977; Crick 1993; Edelman, 2004). The human brain may possess millions of functional neural networks, many of which presumably code for memories. A critical question with respect to our theory is how active neural networks can contribute to the formation of consciousness and focused mentation.

The moment-to-moment generation of nerve impulses by neurons within the brain creates an exceedingly complex and dynamic electromagnetic field. Active neural networks generate spatially complex and temporally dynamic electromagnetic fields (NN-EMFs). At any given point in time, a particular neural network generates a unique NN-EMF, which according to the menton hypothesis can be conjoined with a menton possessing an energy (mental energy) profile matched or suited to that of the NN-EMF. It is postulated that this conjunction provides the essential condition required for the expression of consciousness or other forms of mental activity. Notably, this hypothetical conjunction of a menton with an NN-EMF presumably creates a new particle, albeit transient. We have termed this hypothetical particle a neuromenton.

It seems unlikely that the electromagnetic field reflecting the sum total of all nerve impulses in the brain is associated with a particular thought or state of mind. More likely, consciousness or a state of mind is associated with a precise pattern of neural activity associated with a particular group of neurons that function as a neural network. A key concept consistent with our theory is that the temporal characteristics of electromagnetic fields generated by complex neural networks are similar to the temporal characteristics of mental activity. We will elaborate on this later.

Mechanisms involved in the generation of neuronal electromagnetic fields

The biological processes that enable neurons and some other biological cells (e.g., muscle cells) to generate electromagnetic fields differ mechanistically from those generated by photons traveling through space or by electrons flowing over metal wire, and are far more complex. This is an important point with regard to our theory because a key proposition of the menton hypothesis is that only electromagnetic fields generated by neural networks can interact with mentons in a way that confers consciousness and mentation. Therefore, according to our theory, computers and robots cannot experience consciousness regardless of how powerful their computational abilities may be. Several properties of neurons contribute to their ability to generate electromagnetic fields, most of which involve the membrane that serves as the boundary of the neuron (the cell membrane). These properties are each discussed below.

Cell membrane capacitance

The matrix of the cell membrane is a lipid bilayer which functions as an insulator that impedes the flux of electrically charged particles through the membrane. This property makes it possible for neurons to store an electrical charge on either side of the membrane, thereby maintaining a voltage potential across the membrane.

Electrical (voltage) potentials across the membrane of neurons

In common with most biological cells, neurons generate and maintain an electrical potential across their cell membrane. When neurons are not generating action potentials, they are said to be in a resting state. In this state, an electrical potential of nearly constant voltage is maintained. This voltage is negative inside the cell, has a magnitude ranging from about 50 to 70 millivolts (mV) and is termed the “resting membrane potential” (Aidley, 1971). Energy is expended by the neuron to generate and maintain this resting potential, and it is made possible by a group of proteins

embedded in the cell membrane that move (pump or transport) sodium ions (Na^+) out of the cell. Since Na^+ has a positive electrical charge, the inside of the cell membrane becomes negative with respect to the outside. Calcium ions (Ca^{++}) and certain other ions [e.g., chloride (Cl^-) and hydrogen (H^+)] are similarly pumped out of the neuron, but in smaller amounts. Some ions are pumped (actively transported) into cells [e.g., potassium (K^+)].

Action potentials (nerve impulses)

Unlike most types of cells, neurons have the ability to initiate a transient depolarization and repolarization of the membrane in a precisely controlled fashion. Typically, the cell membrane shifts briefly from its resting state potential of -60mV (inside negative) to a potential of $+40\text{mV}$ (inside positive), then reverts briefly to a negative potential of high magnitude (-70 mV) before returning to the resting membrane potential (-60 mV). This brief cycle is made possible by proteins embedded in the cell membrane that serve as “voltage gated” channels (pores) that selectively allow an ion (e.g., Na^+) to flow through the membrane. This flux is driven by the electrochemical gradient of the ion. The means by which action potentials are initiated and propagated down axons are discussed in the next two sections.

Generation of excitatory and inhibitory voltage potentials at neuronal synapses

Signaling between neurons occurs primarily at synapses. It is primarily unidirectional and is mediated mostly by small organic chemicals (usually amino acids or derivatives thereof) termed neurotransmitters or transmitters. Typically, when an action potential propagating down an axon reaches the terminal point of the axon (synaptic bouton), the depolarizing portion of the action potential activates (opens) voltage gated Ca^{++} channels, thereby causing an influx of Ca^{++} into the bouton. The Ca^{++} initiates a series of chemical reactions that cause packets of neurotransmitter molecules to be released from the bouton into the extracellular space (synaptic cleft) between the membrane of the presynaptic neuron and that

of the postsynaptic neuron. The transmitter molecules diffuse across the cleft and bind to receptor proteins in the membrane of the postsynaptic neuron. In some instances these receptor proteins function as gated channels that are opened by the transmitter. These channels selectively allow certain ions to pass through the membrane.

From a physiological perspective, there are two types of transmitters; excitatory transmitters (e.g, glutamate) that decrease the magnitude of the resting membrane potential (i.e., partially depolarize the membrane) and inhibitory transmitters that increase the magnitude of the resting membrane potential (hyperpolarize). The depolarizing effect of an excitatory transmitter is termed an excitatory postsynaptic potential (EPSP), and usually occurs as a result of an influx of Na^+ and/or Ca^{++} into the neuron. As a result of this depolarizing effect, the depolarizing voltage-gated ion channels discussed previously tend to be activated, and when a threshold point is reached (about -50 mV), an action potential is initiated. The hyperpolarizing effect of an inhibitory transmitter is termed an inhibitory postsynaptic potential (IPSP), and usually occurs as a result of an influx of Cl^- and/or an efflux of K^+ out of the neuron. As a result of this hyperpolarizing effect, the depolarizing voltage-gated ion channels are inhibited (impeded) from being activated. Hence, the probability of an action potential being initiated in a neuron is governed by the summation and integration of the relative input of excitatory and inhibitory signals (mediated by transmitters) from many presynaptic terminals, and often from many different neurons.

Propagation of action potentials

During the depolarizing phase of an action potential some of the electrical current carried into the dendrite or cell body of the neuron by Na^+ ions spreads into the axon where it partially depolarizes the axonal membrane. This partial depolarization causes voltage-gated Na^+ channels in the axon to open and allow more Na^+ to flow in, which in turn causes more positive ionic electrical current to spread further down the axon. This repetitive process then cascades down the axon to its terminal, where it activates the release of packets of transmitter molecules from the synaptic bouton. Typically, the time from initiation to termination takes about

one millisecond. Since the depolarized cell membrane returns to its resting potential within a few milliseconds, a neuron can potentially generate and propagate action potentials at a frequency greater than 100 per second.

Role of synaptic potentials and action potentials in the formation of electromagnetic fields generated by individual neurons and complex neural networks

The electromagnetic field generated by individual neurons represents the summation of action potentials mediated primarily by axons, but also dendrites in many neurons, and the synaptic potentials on dendrites and the cell body. The pyramidal cell, which is a prevalent type of neuron throughout the cerebral cortex, is characterized by a long dendrite in which the cell membrane is greatly expanded by outward directed pouches (spines). Numerous axon boutons (>10,000) form synaptic contacts with each pyramidal neuron and initiate a multitude of synaptic potentials (Popper & Eccles, 1977, 235–249). The synaptic potentials generated by synapses on dendrites of pyramidal cells are usually depolarizing potentials (EPSPs) and in some cases initiate action potentials that travel down the dendrite to the cell body. The ion (Na^+ , Ca^{++} , etc.) mediated electrical currents that generate these synaptic potentials and action potentials spread in all directions and form a complex electromagnetic field, which becomes more complex as the current flows into the cell body and down the axon. Since large axons, such as those in pyramidal cells bifurcate several times before making synaptic contact with other neurons, the electrical current and the associated electromagnetic field become even more complex. Hence, the electromagnetic field generated by a single large neuron with dendritic spines can be quite complex. Dendritic spines on cortical pyramidal neurons are necessary for learning and development of normal intelligence (Wong, 2005). Although pyramidal neurons in the cerebral cortex, hippocampus and some other areas of the brain are presumably essential for consciousness and mentation, the electromagnetic field generated by individual pyramidal neurons are not likely to be sufficient to generate consciousness or the simplest unit (quantum) of mental activity. Neural activity associated with consciousness (in its most general sense) may be derived from the activity of clusters of pacemaker neurons and the

target neurons they interact with, particularly those in sensory regions of the brain.

Individual neurons receive and transfer signals in the millisecond range; i.e., they can receive signals from other neurons in the form of synaptic potentials and transfer modified signals on to other neurons within ~2 milliseconds (msec). The shortest time in which people can recognize a visual or auditory signal is ~10 to 20 msec. Consequently, according to this theory a single quantum of mental activity is likely to require an established network of hundreds or thousands of neurons, with a minimum time elapse of about 10 to 20 msec.

How individual neural networks are created and activated

The details of how neurogenesis can create specific and highly complex neural networks are not understood clearly. This is also true of the mechanisms involved in the activation of existing neural networks. As noted previously, some neural networks are formed during the development of the brain in utero. Therefore, it may be assumed that some neural networks are genetically programmed. Most neural networks are likely to be formed, at least partially, by neural signals entering the brain from sensory organs. One of the premises of the neural-menton conjunction hypothesis is that mental activity can provide immediate feedback that impacts the activity of the brain and thereby cause a subtle change in the active, participating neural network(s).

Modern brain imaging techniques that can visualize high neural activity in comparatively small (~1 cm in diameter) areas of the brain have facilitated the mapping of various types of mental activity within areas of the brain. It is well established that neural networks are formed specifically within the areas of the central and peripheral nervous systems that are associated with a physiological function of a particular organ or specific type of mental function. For example, neural networks associated with language occur primarily within the areas of the brain associated with language skills, such as the temporal and parietal lobes of the cerebral cortex. It seems likely that as the brain and mind grow, new neural networks are formed by elaboration and modification of existing networks, probably arising in part from alterations in synaptic densities. For

any existing neural network, activation may be initiated by synaptic transmission of signals derived from primary, secondary or tertiary sensory neurons, or by active pacemaker neural networks or other closely related neural networks that are already active. Neural networks within the brain may be activated by synaptic contacts from neurons that are only a transient component of a newly activated neural network. Consequently, some neural networks may be defined more by their dynamic neural interactions than by a precise group of neurons.

The question arises as to how the first neural network in a train of mental quanta is activated. Most are likely to be initiated by sensory signals entering into the brain from sense organs, especially the eyes and ears. But many thoughts seem to appear spontaneously without any apparent reason. The human mind must have an intrinsic imagination. A possible correlate of this in the brain is the built-in neural networks that are spontaneously activated by pacemaker neurons. Variations of such neural networks might occasionally (perhaps randomly) conjoin with a paired menton that sets off a train of mental quanta that form a coherent thought. This is a particularly fascinating area that has relevance to Swedenborg's concept of "spheres" as discussed in the next section.

VII. THE THEORY IN RELATION TO THE WRITINGS

The primary intent of this paper is to propose and describe a general theory of mind from operational and functional perspectives; i.e., to identify the particular entities (substances) that make consciousness and mentation possible, and how they interact in the natural world. Although Swedenborg focused more on describing the various degrees of mind within the scope of a person's mental and spiritual development, and the particular characteristics and thought contents of each degree of mind, he did give some fascinating accounts of how mental activity arises in humans (AC 5862, AC 5288, AC 5846, AC 2887, AC 2888), and in the process used some key conceptual terms to facilitate understanding of the origin of consciousness and other forms of mental activity. These terms include: correspondence, influx, conjunction, spheres, successives and remains. Here we discuss these terms within the context of the neural-menton conjunction hypothesis.

Neural-menton conjunction in relation to correspondence and influx

Swedenborg emphasized that the spiritual world differs considerably from the natural world, and occasionally states that they are “completely different” (*DLW* 83). As indicated in the passage below, communication between the two worlds occurs only through correspondence. Correspondence, as used in the Writings, typically implies a cause-effect relationship between the two correspondents. In the first of the two examples below, the correspondence appears to have an element of symbolic correspondence as well as a potential cause-effect relationship. In the second example there is an evident cause-effect relationship between the correspondents.

. . . They are completely different worlds, communicating only through correspondent relationships, the nature of which we have shown many times elsewhere. . . . To illustrate this, take the following example. Heat in the natural world corresponds to the good of charity in the spiritual world, and light in the natural world corresponds to the truth of faith in the spiritual world. Who does not see that heat and the good of charity, and that light and the truth of faith, are altogether different in character? (*DLW* 83 Part 2)

. . . [I]t shall be explained what correspondence and also influx are, otherwise it cannot be comprehended what the quality of the Word is, thus as to its life from the Lord, which is its soul. But what correspondence and influx are shall be illustrated by examples. The variations of the face, called the features, correspond to the affections of the mind, therefore the face is varied as to its features just as the affections of the mind as to their states. These variations in the face are correspondences, consequently, also the face itself; and the action of the mind into it, in order that the correspondences may be made evident, is called influx. (*AE* 1080[2])

According to the neural-menton conjunction hypothesis, there is a cause-effect correspondence between a particular menton and its matched NN-EMF. Furthermore, conjunction between the two entities is mediated

operationally by influx, as described on page 3. In theory, the conjunction between a single menton and an NN-EMF forms a new particle, albeit transient, termed a neuromenton, which functions as a single unit of consciousness or other type of mental activity. Although a single neuromenton exists only briefly, others follow along in sequence, thereby creating a continuous process. Along with the sequence of mental activity there must be a cause-effect relationship with corresponding active neural networks that induce subtle changes in the structure of the brain, thereby “adjusting” the corresponding neural network to the mental activity. The postulated changes in the brain caused by mental activity are presumably the basis for learning,⁵ formation of memories and development of various other skills. This cause-effect correspondence between the mind and brain is apparently bidirectional because the activity of the mind is also dependent on the development and state of the brain. For example the mind of a child is limited by the state of development of the brain. Similarly, brain injury, neurological damage and psychoactive drugs can impair mental activity.

Neural-menton conjunction hypothesis in relation to successives

The term successives as used in the Writings embodies the notion of hierarchy. Within the context of the neural-menton conjunction hypothesis, the mentons that mediate influx of consciousness and mentation into angels in the highest heaven carry a higher level of Divine love and wisdom than angels at lower levels of heaven are able to receive. For humans residing in the world of spirits, influx is mediated by mentons with successively lower levels of Divine love and wisdom. This successive decline continues down to humans in the natural world and finally to evil individuals.

⁵ Neural networks not involved in mental activity can also undergo changes; e.g., networks that contribute to motor skills undergo modification as a result of repetitive activity of their component neurons.

Neural-menton conjunction hypothesis in relation to spheres

Another concept given considerable attention in the Writings that the neural-menton conjunction hypothesis is consistent with is “spheres” (*SE* 152; *AE* 707; *CL* 386). As used in the Writings, this term has some analogy to the term “fields” as used in physics. Often in the Writings, this term relates to a form of influence that spiritual beings, either angelic or evil, can exert on other beings, especially humans in the natural world (*AC* 2887). The influence can be, for example, in the form of cognitive thoughts, affections, sympathetic or empathetic feelings, or malevolent desires. Since all of these are forms of mental activity, according to the neural-menton conjunction hypothesis, these spheres of influence are mediated by a neuromenton, the hypothetical particle created by the conjunction of a menton with a neural network. This raises the question of the substantive nature of the hypothetical new entity created by this conjunction. It seems reasonable to postulate that neuromentons have some characteristics similar to those of NN-EMFs. These fields are most concentrated within the brain, but extend beyond the surface of the brain. Although the density of NN-EMFs declines rapidly beyond the surface of the brain, the density of some elements of a neuromenton may decline more slowly and thereby create a field or sphere whose influence extends well beyond that of the NN-EMF. Since there are innumerable postulated forms of mentons, each with its own energy level and oscillation frequency, there will be innumerable neuromenton spheres. Those generated by low energy level mentons typical of humans in the natural world would be expected to create a sphere of low influence. According to the Writings, it would be expected that neuromenton spheres of an individual will have the greatest influence on like-minded beings (*AC* 6600, *AC* 6602).⁶

⁶ A concept that seems to be consistent with the Writings is that the influence of neuromenton spheres may be additive. If so, it should be possible for a group of people who collectively and simultaneously think a specific thought can generate a more influential neuromenton sphere than a single person can. One implication of this possibility is that this may provide a means of testing the neural-menton conjunction hypothesis.

Neural-menton conjunction hypothesis in relation to remains

The Writings seem to imply that some of the “genetic programmed” neural networks, or “frameworks” of immature neural networks, formed in utero or early childhood arise from the influx of Divine love and wisdom (the carrier particle mediating this influx would be an exceptional type of menton). In essence, these incipient neural networks would serve as “seeds” for the eventual development of the spiritual mind, and may be the neural component of the remains that the Lord God gives to infants and children (AC 1905, AC 3494). Since neural networks are unlikely to be fixed and static, they presumably undergo frequent modification, either deterioration or elaboration. Typically, if an established neural network is not used it would be expected to deteriorate over time. Therefore, if the reception of remains by a child is impeded or never allowed to develop or be expressed, the spiritual development of the child would surely suffer.

VIII. GENERATION OF CONSCIOUSNESS, MENTATION AND MEMORIES

The neural-menton conjunction hypothesis appears to be logically consistent with the concept that there is a two-way interaction between the mind and the brain. However, offering a description of the details of what is involved in this interaction seems to take us into the realm of pure speculation. Here we will describe one of what must be several possible scenarios. Suppose a particular neural network is activated by an auditory cue and the associated NN-EMF conjoins with a menton, giving rise to a neuromenton, and within <50 milliseconds confers a quantum of conscious mental activity (e.g. you recognize a friend’s voice). In <50 milliseconds, the mental recognition of the voice has activated a different neural network, thereby initiating conjunction between the associated NN-EMF and a menton, giving rise to a neuromenton, and within <50 milliseconds confers a quantum of conscious mental activity (e.g. you remember your commitment to meet your friend). In this sequence of events the brain receives a sensory cue, which through the activity of a neural network and a postulated menton creates a unit of conscious thought, which in turn activates another existing neural network. In this way a cyclic interaction

between the mind and brain can continue, with each new cycle causing subtle changes in the brain, some of which store memories of the mental experiences. The presumed modification of a neural network caused by mental activity associated with a conscious experience or other mental activity is of interest because it implies that the mind supervenes on the brain. Although this may seem quite obvious, the existence of supervenience between the mind and brain is not a settled issue among people currently publishing on this subject (Mandik, 2004).

Mental activity in a normal person who is fully conscious and has a clear comprehension and appreciation of the mental content of an event, both experientially and cognitively, will normally result in the creation of a memory (i.e., the ability to create a replica or a partial replica of a particular mental event and recall that event at a later time). It is generally taken for granted that the formation of a given memory is associated with a subtle change in the brain. Although the precise nature of the change is not fully understood, it likely involves some synaptic reorganization of the neural network associated with the creation of the memory. This implies that new neural networks arise from previous ones. It would not necessarily follow that the previous one no longer exists. In addition to the creation of memories, there must be a mechanism by which the neural network that stores a given memory can be selectively activated to bring the stored replica into conscious experience.

IX. CRITIQUE OF THIS THEORY WITHIN THE CONTEXT OF SOME OTHER THEORIES

[3] . . . The man of reason, who knows nothing concerning the sun of the spiritual world, easily goes astray in his idea of the creation of the universe, which, when he deeply considers it, he perceives no otherwise than as being from nature; and as the origin of nature is the sun, no otherwise than as being from its sun as a creator. Moreover no one can apprehend spiritual influx, unless he also knows its origin; for all influx is from a sun, spiritual influx from its sun, and natural influx from its sun . . .
(*ISB* 4[3], Whitehead)

A website maintained by Chalmers (http://en.wikipedia.org/wiki/David_Chalmers), lists at least 8,000 articles relevant to the nature of consciousness and mind. Judging by their membership in professional organizations, the background of most individuals publishing on these topics is philosophy or psychology (e.g., American Philosophical Association, Society for Philosophy and Psychology, Association for the Scientific Study of Consciousness, and the German Analytic Philosophy). However, during the past several decades, there has been a gradual increase in interest by individuals with backgrounds as diverse as physics, neuroscience, cognitive science, mathematics, sociology, computer science, artificial intelligence (AI) and psychoanalysis.

Despite the diversity of thought fostered by these different perspectives, the majority of modern theories begin with the premise that consciousness, as we think of it in humans, arises solely from the activity of the brain. Two prevalent concepts that have been developed to explain this include panpsychism (consciousness at some level is a property of all matter), and emergence, i.e., consciousness emerges from the activity of the brain as a result of its unique structural and functional complexity (Seager, 1996; Chalmers, 1996; Torrance, 2004). Both of these concepts are often accepted as fundamental facts that either do not require further explanation, or that it is not possible to provide further explanation because the present understanding of the physical world is not adequate to offer a meaningful explanation. Some theorists take the view that consciousness cannot be explained as a phenomenon and choose to ignore it as a factor in mental activity (Seager, 1996, 60–132). Theories that have postulated that the mind is an entity separate from the brain but interacts with it, e.g., the theories of Eccles and Popper, have not offered an intelligible description of the mind as an actual entity.

Chalmers (1996) has argued that the only thing that cannot be explained solely by the activity of the brain is the conscious experience associated with mental activity. No matter how sophisticated the behavior or “intelligence” a robot or zombie might exhibit, there is no evidence to support the view that these “beings” can ever have a conscious experience. Conscious experience seems to either define or contribute to many human characteristics. Some examples include self esteem, mood, awe, reverence, respect, admiration, affection, anger, fear, disgust, weariness, exuberance,

optimism, pessimism, inquisitiveness, pleasure, anticipation, sensation of pain, emotional pain or hurt, desires, intentions, disappointment, excitement, and music and art appreciation. If we accept that humans (and presumably animals with highly developed brains) can have conscious experiences, the question arises "how can neural activity in the brain give rise to conscious experiences?". The inability of theorists to come up with a widely acceptable explanation has resulted in what has been termed "the generation gap" or "the explanatory gap." One response to this gap at the present time is to invoke panpsychism as a default mechanism (Seager, 1996, 252).

We think it is notable that despite the many widely divergent and clever theories proposed during the last 50 years, few have proposed a theory postulating that an entity external to the brain contributes to the development of consciousness and other mental activity. The principal elements that differentiate our theory from other theories are the postulated existence of mentons, their origin, and their interaction with electromagnetic fields generated by neural networks. The use of the correspondence between mentons and photons served as an established example of how two distinct particles (or substances) conjoin to form either a new particle or at the least a new energy state of the combined particles with unique properties. Our view of the involvement of the brain appears to be quite similar to those of Eccles, Edelman and Crick et al.; however, in their theories the role and nature of neural networks are much more developed and detailed than in our theory.

X. CONCLUDING REMARKS

In a recent issue of *The New Philosophy*, an elegant paper titled "Boundary Issues In Science: An Historical Approach," authored by Dr. Gregory Baker (2006), discusses the emergence and impact of modern science on various facets of the way we think and live, and importantly, its limitations. Notably, those limitations include the fact that scientists, in common with philosophers and theologians invariably have a biased perspective in their search for knowledge and truth. Perhaps there is no area of scientific inquiry that is more fraught with theoretician biases and limitations to scientific methodology than in the pursuit of elucidating the fundamental

nature of consciousness and mind. This, of course, is true for our theory, which is limited by our understanding of the concepts from which the theory is derived, and remains a work in progress.

One of the most striking features of nearly all modern theories is that consciousness and mental activity arise solely from the activity of the brain. The conventional views of most neuroscientists, psychologists and philosophers have no-doubt fostered this perspective. This has created a situation in which virtually everyone developing theories on the origin and nature of consciousness and mind begin with a common premise that guides the theory in a particular direction. The consequence of this is that it stifles debate and creative thinking.

The noted American geologist T.C. Chamberlain (1897), wrote extensively on the stifling effect that this type of “tunnel vision” has on advances in science, education, business and some other human endeavors. Chamberlain introduced a concept he referred to as the “method of multiple working hypotheses” as a more effective approach in advancing scientific knowledge, and in solving any problem for which there is no obvious solution. The value of this approach in advancing cellular and molecular biology and particle physics has been discussed by J. Platt (1964). The theory proposed in this thesis is offered in the spirit of the method of multiple hypotheses. □

BIBLIOGRAPHY

- Aidley, D. J. *The Physiology of Excitable Cells*. London, England: Cambridge University Press, 1971: 13–152.
- Baker, G. L. “Boundary issues in science: an historical approach.” *The New Philosophy*, CIX, 3 & 4 (2006): 395–432.
- Bohm, D. “A new theory of the relationship of mind and matter.” *Philosophical Psychology* 3 (1990): 271–286.
- Brown, W.S. “Neurobiological Embodiment of Spirituality and Soul.” In: *From Cells to Souls—and Beyond*. (Jeeves M., Ed.), Grand Rapids, MI.: William B. Eerdmans Publishing Co., 2004: 58–76.
- Chalmers D. “Facing up to the problem of consciousness.” *Journal of Consciousness Studies* 2 (1995): 200–219.
- Chalmers D. *The Conscious Mind: In Search of a Fundamental Theory*. New York, NY: Oxford University Press, 1996.
- Chamberlin, T.C. “The method of multiple working hypotheses.” *J. Geol.* 5 (1897): 837.

A TRIPARTITE THEORY OF CONSCIOUSNESS AND MIND

- Edelman, G. M. *Wider than the Sky: the Phenomenal Gift of Consciousness*. New Haven, Connecticut: Yale University Press, 2004.
- Goswami, A., Reed R.E. and Goswami, M. *The Self-Aware Universe: How Consciousness Creates the Material World*. New York, NY: Penguin-Putman Inc., 1993.
- Kane, G. *Supersymmetry: Unveiling the Ultimate Laws of Nature*. Cambridge, MA: Perseus Publishing, 2000.
- Mandik, P. Philosophy of Mind website, 2004. <http://artsci.wustl.edu/~philos/MindDict/supervenience.html>
- Odhner, H. L. *The Human Mind: Its Facilities and Degrees*. Bryn Athyn, PA: Swedenborg Scientific Association, 1969.
- Oerter, R. *The Theory of Almost Everything: The Standard Model, the Unsung Triumph of Modern Physics*. New York, NY: Pi Press, 2006.
- Platt, J.R. "Science, strong inference—proper scientific method (the new baconians)." *Science* 146 (1964): 347–353. [This article is available on the internet at: http://256.com/gray/docs/strong_inference.html and http://www.bmb.uga.edu/wschrmidt/bcmb9000_readings/Strong_Inference.pdf]
- Popper, K.R. and Eccles J.C. *The Self and Its Brain: an Argument for Interactionism*. New York, NY: Springer-Verlag International, 1977.
- Seager, W. *Theories of Consciousness: An Introduction and Assessment*. New York, NY: Routledge, 1999.
- Sperry, R. <http://people.uncw.edu/puente/sperry/sperrypapers/80s-90s/273-1992>.
- Swedenborg, E. *Apocalypse Explained*. Trans. John Whitehead. New York: Swedenborg Foundation.
- _____ . *Arcana Coelestia*. Trans. John Elliot. London: Swedenborg Society.
- _____ . *Divine Love and Wisdom*. Trans. N. Bruce Rogers. Bryn Athyn, Pennsylvania: General Church of the New Jerusalem.
- _____ . *A Theosophic Lucubration on the Nature of Influx, as it respects the Communication and Operations of Soul and Body*. Trans. T. Hartley. London: M. Lewis and W. Heard, 1770.
- _____ . *Interaction Between the Body and the Soul*. Trans. Whitehead. New York: Swedenborg Foundation.
- _____ . *True Christian Religion*. Trans. J. Ager. New York: Swedenborg Foundation.
- Torrance, A.J., "What is a person?" In: *From Cells To Souls—And Beyond*. (Jeeves, M., Ed.), Grand Rapids, MI: William B. Ferdmans Publishing Co., 2004, p. 199–222.
- Wong, M., "Modulation of dendritic spines in epilepsy: Cellular mechanisms and functional implications. *Epilepsy & Behavior* 7, 569–577, 2005.