Chapter

Human Consciousness: The Cerebral Cortex and Beyond

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Abstract

Human Consciousness is one of most elusive issues in the scientific history. Its nature created major historical debate started thousands of years ago and still ongoing. Despite the explosive developments in the last 6 decades to explore its nature, the knowledge about it is still deficient. The important advances in the twentieth and 21st centuries in understanding cerebral cortex dynamics fortified by the dominant materialistic philosophical approach of the era dictated its impact on consciousness science, which is understood as sole human brain function. This chapter is a call for holistic perception of human consciousness incorporating the ancient wisdom of the human civilizations with the massive current advances in different disciplines of applied sciences. The description of René Descartes in the 17th century of the Cartesian dualism is timely to revisit with new holistic perspective, in view of the major advances of our understanding of heart brain communications, astrophysical resonances with, human heart and central nervous system frequencies, and signaling between humans and their large environment. Neural and psychological correlates of human consciousness which dominate the consciousness research nowadays should undergo revolutionary conceptual understanding to perceive consciousness as a massive universal event expanding from human genes to galaxies with cerebral cortex as major player.

Keywords: human consciousness, solar geomagnetic activity, heart based resonant fields theory of consciousness

1. Introduction and definition

Consciousness remains the hall mark defining human intelligence and interactive life and the true demarcation line between being and not being. In spite of being the most practical experience of self identity and intelligent life reactions in this life that we live, its nature remains an area of great debate and sometimes conflicting opinions between philosophers, biologist and intellectualists since the dawn of human scientific history. The twentieth century is known as the century of brain as there was exaggerated materialistic inflation of brain role in human functions but mainly consciousness. There is compelling scientific and rational evidence to convince scientific communities that the nature of consciousness involves dynamics inside the skull but essentially much beyond it in extreme dimensions between the skull and the sky. In addition to discussing the sophisticated neurobiological dynamics within the cerebral cortex, the main aim of this chapter is to

open channels for holistic perception and understanding of human consciousness incorporating other scientific disciplines like the central role of human heart contribution to consciousness, quantum physics, as well as astrobiologigcal aspects of consciousness are going to be discussed.

2. Consciousness definition

2.1 The challenges

Since the dawn of humanity the ability of human beings to be alert, responsive and behave intelligently with emotions and identity were the subject of huge concerns in the philosophical, medical, psychological and religious communities. The explosive nature of diagnostic modalities in neuroimaging, medical physics and neurocardiology since world war 2 but more specifically in the last 20 years created revolutionary perspective of our understanding of the nature and origin of consciousness. Those advances were paralleled with numerous publications and selective conferences concerned with the brain and mind. We established unique conceptual congress, the King of Organs for Advanced Cardiac Sciences where heart and brain communications were discussed in unconventional ways in five international conferences (2006,2008,2010, 2012 and 2019) founded and chaired by the author of this chapter. One of the most challenging controversial and still ongoing scientific issues is the debate on how to define consciousness. The words *conscious* and *consciousness* is antique but appeared first in the documented English literature in the17th century followed by the world *self-conscious* and *self-consciousness* [1]. Consciousness is frequently used in different cultures and writings interchangeably with the Mind. In our understanding the term "Mind" is best preserved for psychological states and processes that might or might not be 'conscious'. In addition it is crucial to emphasize that mind and brain are not synonyms. Brain is structural correlates of the mind while mind is functional correlates of the brain. In similar way the tem knowledge is not synonym for consciousness as knowledge can be unconscious, or implicit.

Comprehensive understandings of scientific etymology demands the linguistic power in combination with the practical meanings as it is accepted and understood in the mainstream language. In this regard we suggest approaching consciousness with broad visionary perspective. For this reason we will define consciousness by referring to three major domains: First: the state of alertness and being vigilant, the opposite of which is coma as measured by Glasgow Coma Scale. This is predominantly of neurological nature. Second is the experience or the content of experience from time to time or 'what something looks like' and the inward connotation and feelings. This is predominantly of philosophical nature. Third is referred to the mental state with propositional content like fear, anger or appreciation. Most research in medical literature has natural tendency to neglect this third meaning of consciousness. This state of continuous historical uncertainty and debate about consciousness is in our opinion justified because of lack of knowledge of the origin, dimension and fate of our current life consciousness. The fact that the nature of consciousness cannot be explained as deduction from pathological alterations in the brain led to the fact that the mysterious mission of understanding human consciousness will be impossible without involving dimensions out of cerebral cortex. It can be looked as property of highly complex dependent biological systems which is adaptive, and highly interconnected.

The phenomena of access consciousness where information are accessed to the brain from different energetic cosmic levels is a major gate to explore in the

comprehensive science of consciousness although by itself, it is unconscious. What increase complexity is the historical believe in different civilizations and religions that consciousness will never disappear but transform from one realm to another. Recently consciousness research refers to the **Consciousness Tetrad** which describes four escalating levels of consciousness starting from the **default consciousness** which is the default state that separates the living from the dead, rising to the **aware consciousness** which looks at consciousness as a continuum of states ranging from awake to sleep to drowsiness to semiconscious states like stupor and finally coma. The third level is the **operational consciousness** which is consciousness related to motor, sensory, cognitive, ethical, creative, emotive, and other abilities and capabilities and awareness of all mental operations. The fourth level is what philosophers refers to as the transcendence of human soul called the **exalted consciousness** where the most elite and spiritual experience of a human being can be achieved as the person is getting closer to the thresholds of the highest intelligence ever, who masters the emergence and fate of death and life and all creatures and universes. Our mentor and ex colleague and fellow member in the scientific advisory board of HeartMath Institute the famous neuroscientist the late Karl Pribram simplify the current deficient perception of consciousness saying that there is little c consciousness refed to being awake or sleep and big C consciousness referring to the intelligence and information that organizes the universe and all that is within it.

2.2 Definition of consciousness

Agreement in definition and overlapping terms is important to navigate safely and target the phenomenology of human consciousness as precisely as possible. To recapitulate the wide spectrum of meanings and domains the author define Consciousness as *a state of alertness and being aware, active and vigilant of the self and surroundings with volition, based in memory and personal identity.* **This state is** *ineffable* **and** *intrinsic* **and express itself in presence of soul through activation of different sensing and perceptive body organs but may pass through lighter densities and variable dimensions in quantum nature, if soul leaves the body**.

The following discussions in this chapter will expand the understanding in those directions.

3. Neurobiological basis of consciousness

The level of human consciousness is the collective activity of widespread areas of bilateral association of cortical and subcortical structures and possibly other interconnected biological and astrophysical systems. Due to the complex nature of consciousness origin and dimensions, it would be too artificial and nonrealistic to confined consciousness discussion in cortical, subcortical dimensions as is the product of interaction and connections of complex biological and non-biological networks.

Although much has been learned about the neuroanatomical structures participating in consciousness, there is always great demand to establish the physiological and physical mechanisms through which consciousness is generated in these networks, structures and dimensions. In this section we are going to elaborate with some details about "brain related consciousness systems" including cortical components, as well as subcortical components comprising multiple parallel arousal systems in the upper brainstem, thalamus, hypothalamus, and basal forebrain, cerebellum as well as sensory and motor components and neurotransmitter pathways, interaction of which will determine the amount of alertness, attention, and awareness.

Cortical components consisting medially of the medial frontal, anterior cingulate, posterior cingulate, and medial parietal (precuneus, retrosplenial) cortex. On the lateral surface, it includes the lateral frontal, anterior insula, orbital frontal, and lateral temporal–parietal association cortex. The major subcortical networks that regulate level of consciousness including the thalamus and subcortical arousal nuclei acting through multiple neurotransmitters (glutamate, acetylcholine, gamma amino butyric acid (GABA), norepinephrine, serotonin, dopamine, histamine, orexin) that arise from the upper brainstem, basal forebrain, and hypothalamus are going to be discussed.

The consciousness experience remains more complex than simple understanding of possible structure or network functions. The content of consciousness at certain time period is interdependent on the substrate of structure(s) and network(s) activated during that time to yield the specific conscious experience as will be discussed in this section.

3.1 The correlates of consciousness

In spite of the developments in the field of consciousness in the last two decades it is not clear how any physical process, such as neural activity, can give rise to a subjective phenomenon such as conscious awareness of an experience. For this reason, very important observation for researchers in the field of neurobiology of consciousness is to know that the causal relationship of the objective detection of neuronal activation and the subjective awareness of conscious experience is uncertain. Neuroscientist suggested the idea of the Neuronal Correlates of Consciousness (NCC) to be able to study the possible minimal model or the smallest possible building components of conscious percept or explicit memory.

Gamma-band oscillations around 40 Hz is proposed as the band that correlate conscious processing. Examples of NCC documented in literature are: the intralaminar nuclei of the thalamus [2], re-entrant loops in the thalamocortical systems [3], an extended reticular thalamic activation system [4], neural assemblies bound by N-Methyl-D-Aspartate (NMDA) [5], the inferior temporal cortex [6], visual cortex connections to the prefrontal cortex [7, 8] and visual processing within the visual stream [9]. With the advances of both behavioral sciences and computational engineering consciousness scientists, innovate are under investigations to discover ways to couple Neuronal Correlates of Consciousness (NCC) with Behavioral Correlates of Consciousness (BCC) and Computational Correlates of Consciousness (CCC) in order to promote our understanding of more comprehensive perspective of human consciousness. Building conscious machine through the new understanding of computational models [10] artificial intelligence and cognitive robotics is pursed.

3.2 Ascending reticular activating system and consciousness (ARAS)

Revising history of arousal in modern medicine document (ARAS) as one of the first described structures responsible of enhanced arousal [11]. After decades of researchers efforts we know that what was described as (ARAS) is not a structure of brain stem nuclei per se but is a group of specialized nodes in a complex network and pathways that controls arousal. This network includes the cholinergic nuclei in the upper brainstem and basal forebrain, The posterior hypothalamus histamine projection, and noradrenergic nuclei, especially the locus coeruleus. The dopamine and serotonin pathways that arise from brain stem are thought to be part of (ARAS). The thalamus which constitute crucial synaptic relay for most sensory and intracerebral pathways is located strategically at the apex of (ARAS) and have mediated major control on most of its activities [12, 13]. Thalamic burst discharges

are generated through extensive inhibitory axon collaterals, produced by special thalamic, ARAS coordination. Those discharges are responsible for gating specific reticular information which is in turn transmitted back to the cortex, and this reverts the information back to the brainstem [14]. Positron emission tomography (PET) investigation during slow-wave sleep [15] and anesthesia [16] documented selective thalamic and ARAS hypometabolism through studying functional neuroimaging of normal human sleep and studying the neurophysiologic basis of anesthetic induced unconsciousness.

3.3 Amygdala contributions to consciousness

Amygdala, the brain's center for emotions, occupies major position in the neurology and biology research concerned with working memory, long-term memory, and attention. It is strongly linked with social interactions region in the brain, namely, the orbital cortex. Tight tripartite network constitutes robust pathways from amygdala connected to neurons in the thalamus which in turn connect directly to the orbital cortex. The pathways from the amygdala to the orbital cortex and to the thalamus are dual and distinct by function, morphology, neurochemistry [17]. This highly sophisticated and specialized pathways provide strong evidence that emotions influence higher cortical areas concerned with affective reasoning. In addition, Investigating the neurobiological bases of executive functions suggest that amygdala facilitates cognitive performance during challenging tasks between the amygdala and cognitive systems. For this reason neurotransmitters like dopamine and noradrenaline may contribute important role between the amygdala and higher cognition [18, 19]. In our opinion, the well-established role of amygdala in emotions and the additional relation to cognition are both integral to each other and support the establishment of comprehensive intelligent emotional model as a cornerstone of human consciousness experience.

3.4 The cerebellum and its contributions to consciousness

Functions related to movement, gait, posture and balance were the traditional functions related to cerebellum. In the last two decades cerebellum was found to have regulatory functions concerned with emotion processing, cognition, behavior, and collectively consciousness experience [20, 21]. The cognitive role of the cerebellum can be understood by looking at its afferent and efferent connections. The most important of the central afferent circuits is the corticopontocerebellar pathway which emanates from the motor and sensory cortical areas. The pontocerebellar tracts connect with the pontine nuclei then it connect with the contralateral cerebellar hemisphere in a somatotopic manner -which denotes feeling or consciousness experience- of point to point correspondence of an area of the body to a specific point on the cortex. Peripheral cerebellar pathways originate from the brainstem. Via the red nucleus and ventrolateral nucleus of the thalamus, the cerebellum exerts most of its output to the brain stem and the cerebral motor cortex. [22] Efferent cerebellar pathways are four and ultimately connects to the following critical structures: pons, medulla oblongata a, reticular formation, basal ganglia, corticospinal and reticulospinal pathways and limbic cortices (cingulate and parahippocampal gyri). Those sophisticated networks and connections of afferent (corticopontocerebellar) and efferent (cerebellothalamocortical) pathways, the cerebellum can exert highly complex regulatory role and integrate information to the cortical cerebral areas related to cognition and ultimately the consciousness experience. [23] The ongoing collective data from different discipline in genetics, neuropsychological research, structural and functional brain imaging studies will provide better perspective of the integral role of cerebellum in consciousness. [22]

3.5 The thalamus and its contribution to consciousness

Thalami are pair of large ovoid organs that form most of the lateral walls of the third ventricle of the brain in humans. Thalamic main nuclear divisions and nuclei are: midline thalamic nuclei, anterior nuclear group, medial nuclear group (mediodorsal nucleus), lateral nuclear group, thalamic reticular nucleus and intralaminar nuclei. Nearly all information directed to the cortex first reaches the thalamus. The thalamus transmits this information and reciprocally receives an even greater number of connections back from the cerebral cortex. For this reason, the thalamus is considered as a major player in all forebrain functions including consciousness. The thalamus relays the content of consciousness, and also controls its level via specialized circuits that act as regulator of arousal level and are critical for selective attention. The specific thalamic relay nuclei communicate with the cerebral cortex regarding each sensory and motor function. For this reason the thalamus with its extensive nuclei connections is thought to be responsible for all the individual contents of consciousness [24]. Corticothalamic rhythms are thought to be generated by The reciprocal connections between thalamic relay nuclei and the thalamic reticular nucleus during normal sleep and waking activity, as well as in pathological rhythms such as epilepsy [25]. the intralaminar thalamus plays an important role in transmitting arousal influences from strategic location, namely, the midbrain and upper pontine cholinergic and glutamatergic systems to the cortex. *Lesions in this crucial area of the upper pons and midbrain produce deep coma, whereas in comparison lesions in the lower pons or medulla oblongata do not typically disrupt consciousness*.

3.6 The frontoparietal circuits and its role in consciousness

The contribution of frontoparietal activity to conscious perception was suggested by neuroimaging studies. In addition to visual perception due to activity in the ventral visual cortex, the parietal and prefrontal areas contribution seems to be essential for awareness [26, 27]. The network nodes for correlates of consciousness are thought to be divided to primary and secondary. Early activity in the occipital lobe correlates with the perceptual processes, which is detrimental for later process, namely, the activity in the frontoparietal areas. Access consciousness, in comparison to the phenomenal subjective consciousness due to mainly activation of sensory regions, refers to the direct control of experience through reasoning, reporting, or action. This type of higher functioning needs the involvement of the frontoparietal areas [28].

3.7 The prefrontal cortex (PFC) and consciousness

The PFC constitutes a large portion of the frontal lobe that includes most of the cortical tissue anterior to the central sulcus which can be divided to five main areas. The role of the prefrontal cortex (PFC) as an NCC is the source of debate between prefrontal theories and posterior theories of consciousness. The strongest argument point of posterior theories of advocates is the preservation of consciousness in patients with PFC lesions. Apparently, they limit their definition of consciousness to the state of alertness and vigilance, which is too deficient definition. In our view, adopting our comprehensive definition of consciousness, mentioned earlier, will make both conflicting parties complementary rather than competitive. The five main areas of the PFC –namely The anterior prefrontal cortex the caudal prefrontal cortex; the dorsolateral prefrontal cortex; the ventrolateral prefrontal cortex; and the medial prefrontal cortex -are extensively connected with sensory areas, which conceivably denotes that PFC is essential part of the consciousness experience

although the exact mechanism of how the sensory information could become conscious is still not well understood. NCCs involving PFC might be subtle neurological activity. The fact that common neuroimaging techniques are not sufficiently sensitive to detect subtle differences in neural activity should be considered in future research discussing the role of OFC in consciousness [29].

3.8 Precunues, posteromedial parietal lobe and consciousness

Precumues or the mesial extent of Brodmann's area is a cortical region located in the posteromedial portion of the parietal lobe. It is well known with its widespread connections with both cortical and the subcortical structures. Recent Functional imaging findings in healthy subjects suggest a central role for the precuneus in a wide spectrum of higher functions, including visuo-spatial imagery, episodic memory retrieval and self-processing operations. Precuneus and surrounding posteromedial areas are among the most hot spots of the brain as it is displaying high resting metabolic rates. It is characterized by transient decreases in the tonic activity during engagement in non-self-referential goal-directed actions [28]. It is thought that precuneus is involved in the interwoven network of the neural correlates of self-consciousness, engaged in self-related mental representations during rest. The evidence is supportive of the involvement of precunues in the endogenous signaling function during conscious resting state. This hypothesis is consistent with the selective hypometabolism in the posteromedial cortex reported in a wide range of altered conscious states, such as sleep, drug-induced anesthesia and vegetative states [30].

3.9 Consciousness related neurotransmitter systems and pathways

3.9.1 Glutamatergic arousal systems

The most prevalent excitatory neurotransmitter in the central nervous system is Glutamate. It functions seems to be critical in initiation and maintaining of sleep and wakefulness. Arousal system pathways arising from the midbrain and upper pontine reticular formation that project to the thalamus and basal forebrain as well as the widespread projections from the thalamic intralaminar nuclei to the cortex are thought to be mediated by glutamate [31]. Through interaction with other types of neurons, the glutamatergic neurons can regulate sleep stages. With this type of arrangement, complex sleep–wake regulation network in the brain is made [32].

3.9.2 Cholinergic arousal systems

Acetylcholine, although being, the major neurotransmitter of the peripheral nervous system, plays neuromodulatory function in the central nervous system (CNS). The brainstem pontomesencephalic reticular formation and the basal forebrain are the two main sources of cholinergic projections neurons in CNS. Brain stem arousal is thought to act in a synergistic manner with the noncholinergic putative glutamatergic pontomesencephalic neurons which project to intralaminar thalamus and basal forebrain [24, 31, 33]. The brainstem and basal forebrain cholinergic systems work together to abolish The cortical slow wave activity which is known to be enhanced with pathological brain function as in stroke, schizophrenia, depression, Morbus Alzheimer, and post-traumatic stress disorder are abolished by the brainstem and basal forebrain cholinergic systems and this ultimately will promote an alert state [31, 34] Muscarinic acetylcholine receptors are the major receptor type operating in cholinergic arousal in the CNS, although nicotinic

receptors may also play an important role [24]. The result of pharmacological blockage of cholinergic neurons in the CNS can be deduced from its functional areas connections, resulting in acute state of delirium and memory loss. In the contrary, the miracle of human brain creation is shown in the preservation of consciousness with experimental selective damage to cholinergic neurotransmission [35]. This can be explained by the multiple parallel neurotransmitter systems are participating in maintaining the consciousness.

3.9.3 GABAergic arousal systems

The most prevalent inhibitory neurotransmitter in the CNS is GABA. It is known for its major role in regulating arousal. Several long-range GABAergic projection systems also contribute to controlling arousal. Arousal is promoted by some GABAergic neurons in the basal forebrain as these inhibitory neurons in turn project to cortical inhibitory interneurons. [24, 36] On the other hand the overall effects of basal forebrain GABAergic neurons on arousal process is variable with variable firing patterns on cortex and sleep awake cycle. Long GABAergic projections have their overall function as inhibitors for arousal process. These include neurons like ventral lateral preoptic nucleus which is known for its widespread inhibitory projections to almost all subcortical arousal systems [37]; forebrain and hypothalamus inhibitory neurons namely lateral septal GABAergic neurons [38]; and the GABAergic containing neurons nucleus namely the thalamic reticular nucleus that is projecting to the remainder of the thalamus and projecting to the brainstem reticular formation [39]. Regions of the thalamus including the intralaminar nuclei are inhibited by GABAergic neurons in the globus pallidus internal segment. It is thought that the inhibition of the globus pallidus to remove the tonic inhibition of the intralaminar thalamus with medications like zolpidem in minimally conscious state, or benzodiazepines in catatonia is the possible mechanism for the paradoxical arousal effects of those GABA agonist [24, 40]. The loss of consciousness in partial seizures is thought to be due to activation of these multiple GABAergic inhibitory projections converging on the subcortical arousal.

3.9.4 Noradrenergic arousal systems

In proximity to the fourth ventricle, in the rostral pons the locus ceruleus contains the norepinephrine (noradrenaline) neurons. Inhibition of locus ceruleus neurons with drugs like selective α-2 agonists such as clonidine or the anesthetic agent dexmedetomidine is the possible mechanism of action yielding profound depression of arousal. In contrary selective blockage or removal of noradrenergic neurons will impair arousal but will not end up in deep coma. This can be explained, like the situation mentioned in cholinergic arousal systems, by multiple parallel neurotransmitter systems are participating in maintaining the consciousness. Norepinephrine neurons type are also found in the lateral tegmental area extending into the more caudal pons and medulla. [24, 41] Sleep–wake cycles, attention, and mood are regulated via ascending noradrenergic projections that reach the cortex, thalamus and hypothalamus. Modulation of autonomic nervous system function and pain gating is operated through descending projections to the brainstem, cerebellum, and spinal cord.

3.9.5 Serotoninergic arousal systems

The midline raphe nuclei of the midbrain, pons, and medulla contains most of the serotonergic neurons. Projections to the entire forebrain are received from the

more frontal serotonergic neurons in the midbrain and upper pontine raphe nuclei, participating in regulation of sleep–wake cycle. Serotonergic systems occupies major position in psychiatric practice as dysfunction of which is thought to play a role in a number of psychiatric disorders including, anxiety, depression, obsessive–compulsive disorder, aggressive behavior, and eating disorders. Modulation of breathing, pain, cardiovascular system, temperature control,, and motor function is attributed to the caudal serotonergic neurons in the pons and medulla. The dorsal raphe and median raphe are thought to be the most important rostral raphe nuclei participating in arousal process. [42] The contribution of serotonergic neurons to the arousal process with either promotion or inhibition, is complex due to the wide diversity of serotonin receptors in different regions of the brain. [43, 44] The lifesaving arousal response to hypoventilation and high carbon dioxide tension is thought to be promoted by brainstem serotonergic neurons located rostrally [45].

3.9.6 Dopaminergic arousal systems

The substantia nigra pars compacta and the adjacent ventral tegmental area of the mid brain are the regions where dopaminergic neurons are mostly found. Three ascending dopaminergic projection systems will emanate from those nuclei projecting to vital cortical and subcortical regions with substantial contribution to consciousness process: (1) the mesostriatal (nigrostriatal) pathway (2) the mesolimbic pathway (3) the mesocortical pathway. Those three projections arise from substantia nigra (pathway 1) and ventral tegmental area (pathway 2 and 3) reaching to the caudate and putamen (pathway 1), limbic structures including the medial temporal lobe, amygdala, cingulate gyrus, septal nuclei, and nucleus accumbens (pathway 2), the prefrontal cortex and the thalamus (pathway 3). Dopamine can have dual effect on the thalamus and cortex either activation or inhibitory [46]. Schizophrenia related apathy and the reduction of motivation and initiative, seen in frontal lob pathologies, abulia, and akinetic mutism are thought to be due to impaired dopaminergic transmission to the prefrontal cortex [47].

3.9.7 Histaminergic arousal systems

In the posterior hypothalamusan an important nucleus is called tuberomamillary nucleus where most of the Histamine-containing neurons are found. In addition a few scattered histaminergic neurons can be seen in the midbrain reticular formation. The entire forebrain including cortex and thalamus receives extensive ascending projections emanating from the tuberomamillary nucleus, while the brainstem and spinal cord receives descending projections [48]. Anti-histamine medications are intended to act on peripheral histamine release from mast cells, but are well-known to induce drowsiness presumably through central actions (White and Rumbold, 1988). Anti histamine medications are thought to act centrally inhibiting the arousal function of histamine on cortex [49] and thalamus [50] resulting in drowsness. In addition other hypothalamic nuclei, the basal forebrain, brainstem cholinergic and noradrenergic nuclei may contribute to the arousal actions of histamine. Histamine effect is thought to be receptor specific as activation of H1 receptors will facilitate alertness where H3 receptors activation will result in drowsiness.

3.9.8 Orexinergic arousal systems

Orexin from *orexis,* means "appetite" in Greek; is a neuropeptide produced in neurons of the perifornical, lateral, and posterior hypothalamus that regulates appetitel, wakefulness, and arousal. It projects to cortex and almost all arousal

subcortical systems. Alternatively, in some publications it is called hypocretin. Two research groups in rat brain discovered it in 1998 almost in the same time: Masashi Yanagisawa's lab at the University of Texas and Sakurai T et al. [51]. Deficiency of the orexin systems will result in, a disorder characterized by excessive daytime sleepiness and pathological transitions into rapid eye movement sleep namely, narcolepsy [24]. The beneficial effects of modafinil in preventing the symptoms of narcolepsy, shift work sleep disorder, and excessive daytime sleepiness associated with obstructive sleep apnea is thought to be through activation of orexin neurons.

3.9.9 Adenosine and arousal

Hydrolysis of Adenosine Mono phosphate (AMP) and S adenosyl- homocysteine (SAH) will result in adenosine production which is known as a somnogenic substance that has control on normal sleep–wake patterns. The neuroanatomical sources of adenosine are not well known, but functionally it is well known neuromodulator contributing to the conscious arousal The adenosine system can affect the gating of Slow Wave System-Slow Wave Activity expression. Adenosine affect is through modulating of the arousal level, thereby altering the duration of time during which sleep homeostasis and function can occur. [52] Adenosine receptor stimulation is expected theoretically to act as a potential treatment for insomnia. In spite of the fact that $A_{2A}R$ agonists strongly induce sleep, classical $A_{2A}R$ agonists have adverse cardiovascular effects that restrict its use clinically. In addition the passage of adenosine across the blood–brain barrier (BBB) is known to be poor with evidence of rapid degradation inside endothelial BBB cells. Infusing of selective $A_{2A}R$ agonist CGS21680 increases the release of GABA in the tuberomammillary nucleus (TMN), but not in the frontal cortex and decreases histamine release in the frontal cortex and medial preoptic area. Adenosine arousal effect can be blocked by coffee and theophylline.

4. Brain molecular and cellular events and the neuron firing, is it all the sole source of human consciousness

4.1 Refute of the 20th century doctrine on consciousness origin

The last 7 decades conceptual model of the consciousness scientific dilemma in general human knowledge as well as in scientific specialties in psychiatry, neurology, clinical neuroscience and all related disciplines was based on reductionist concepts that aimed at naturalizing all phenomena of mind including memory and other higher functions, to solely, cellular and molecular mechanisms of the human nervous system [53]. This dogma occupied the scientific understanding of the twentieth century. As a matter of fact those reductionist ideas as well as their opponents extended few thousands of years deep in the human history. Example of the opponents are the phrenologicals as documented by work of the Austrian anatomist Franz Joseph Gall (1758–1828), [54]. In fact in ancient Egyptian wisdom the role of human brain as the source of wisdom and consciousness was not of value. In fact, when creating a mummy, the Egyptians scooped out the brain through the nostrils and threw it away [55]. The ancient Egyptians believed that the heart, rather than the brain, was the source of human wisdom, as well as emotions, memory, the soul and the personality itself. The father of the reductionist theory of brain functioning in todays medicine is Wilder Penfield's (1891–1976) who adopt the concept that electrical stimulations in certain brain areas produce experiential phenomena [56]. The originality and innovative level of Penfield's contributions to

the field of neurophysiological localization of the higher psychological functions in the human cortex as well as the purity of his operational research approaches was questioned and criticized. Now a days, Penfield approach with his neurological and psychiatric patients is of considerable academic debate in the scientific communities [57]. In historical appraisal R. Nitsch and F. W. Stahnisch in the journal Cerebral Cortex challenged Penfield original concept of experiential phenomena elicited by electrical Stimulation of the human cortex. They revisited Penfield clinical work and found that the actual results obtained from electrical stimulation studies of the brain are far less conclusive, than his firm assertions made during Penfield Gordon Wilson Lecture in 1950. They stated clearly "In-depth comparison with the original stimulation map shows clearly that the original stimulation protocol did not support this repetitive account by stimulation at the same point". There was no consistent response of defined experiential phenomena observed upon stimulation of an individual stimulation point of the original work. In addition there was no full memory repertoire could be elicited. Patient's stimulation records did not yield stream of an individual's consciousness [58]. The heaviness of the scientific evidence emphasizing that consciousness is a complex reconstructive process, not merely limited to electrophysiological stimulation and recordings is beyond the stage of simply overlooking the situation. ***There is compulsive stream of scientific power to depart from our current very limited perspective of the process of human consciousness to be limited to the box of the skull and to be expanded as far as the sky. It is justifiable to claim that neuronal reductionism is a failed theory and that the search for an answer to the question about the origin of consciousness has to take a novel turn.***

4.2 Consciousness without a cerebral cortex

The thalamocortical complex does not seem to be critically essential for consciousness experience. Brainstem mechanisms by its own can create adequate consciousness state. This means that Consciousness without a cerebral cortex is possible. [59] Penfield and Jasper note that a cortical removal even as radical as hemispherectomy deprived their patients certainly from of information and discriminative capacities but not consciousness. [60] An explicit reference to the midbrain reticular formation was always included in Penfield and Jasper definition of their proposed centrencephalic system. Sprague in 1966 contribute significantly to consciousness research after performing complete removal of the posterior visual areas of one hemisphere in the cat. Agrees well with the Penfield and Jasper perspective that without cognizance of potential subcortical contributions to cortical damage deficit, the cortical functions will be counterfactually inflated [61]. Striking scientific agreement arguing strongly against the necessity of cerebral cortex for consciousness experience is seen in children born without cortex, namely Hydranenecephalic children. It is a congenital anomaly of the brain where for genetic or acquired reasons the cerebral cortex is drastically under developed and replaced by cerebrospinal fluid (**Figure 1**).

Neurological evaluation reveals they are responsiveness to their surroundings and conscious. Personal observations reported by hundreds of families of affected children stressed on the fact that their responsiveness is most readily to sounds, but also to salient visual stimuli. To the surprise a paradox phenomena in this regard is rarity for any auditory cortex to be spared in those children in spite of their impressive sound responsiveness. Bjorn Merker wrote a unique chapter entitled "Consciousness without a cerebral cortex: A challenge for neuroscience and medicine" which appeared in Behavioral and Brain Sciences and was able to spent seven days of observation with 5 families in a visits to Disney World. He stated that "They express pleasure by smiling and laughter, and aversion by "fussing," arching

of the back and crying (in many gradations), their faces being animated by these emotional states. The children respond differentially to the voice and initiatives of familiars, and show preferences for certain situations and stimuli over others, such as a specific familiar toy, tune, or video program, and apparently can even come to expect their regular presence in the course of recurrent daily routines. "[62] It is woeful that many medical institutes label hydranenecephalic children to be in a vegetative state. On the other hand *the absence of the cerebral cortical tissue with preserved consciousness as well as all normal mental functions and normal neuropsychological testing is not a myth*. In other words, normal human being can be seen conscious and mentally good without brain tissue. Lionel Feuillet et al., published in the Lancet 44 years old French man married, a father of two children, and worked as a civil servant with otherwise normal neurological development and medical history. History revealed ventricloatrial shunt surgery in childhood with two revisions after mild symptoms. He achieved intelligence quotient (IQ) of 75, verbal IQ

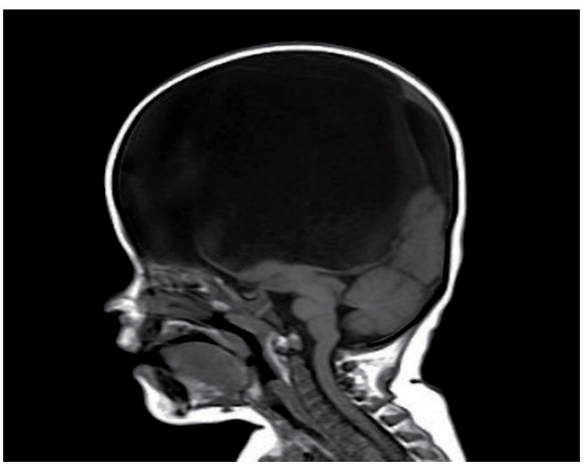

Figure 1.
Sagittal MRI section for a child demonstrating drastic underdevelopment of cerebral cortex with only remnants of occipital and temporal lobes. Cerebellum and brainstem are intact.

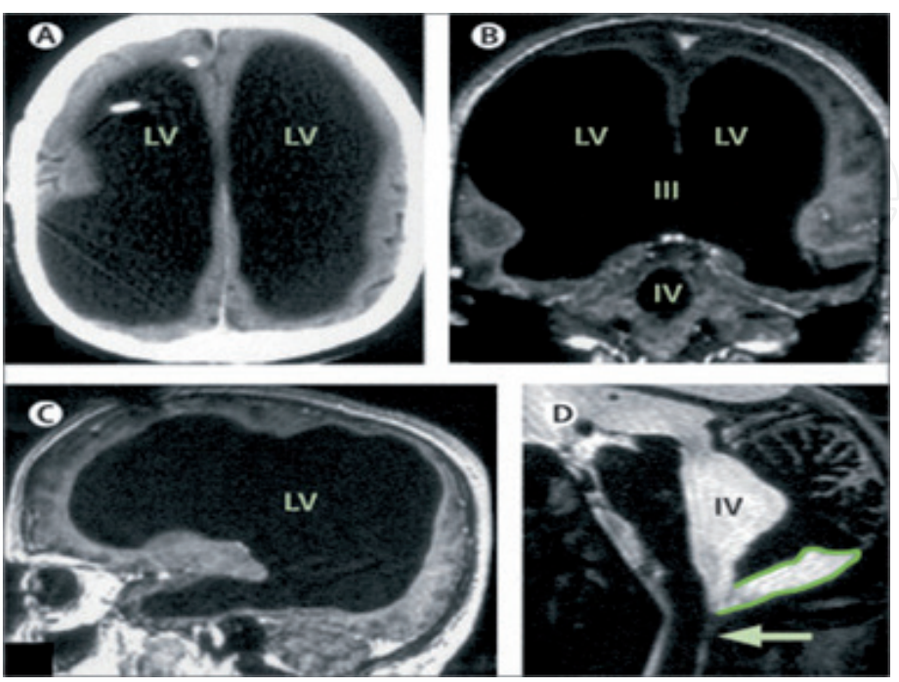

Figure 2.
44 years old french man with 90% absence of his cerebral cortex. His consciousness, mentality as well as social life were otherwise normal. LV=lateral ventricle. III=third ventricle. IV=fourth ventricle. Arrow=Magendie's foramen.

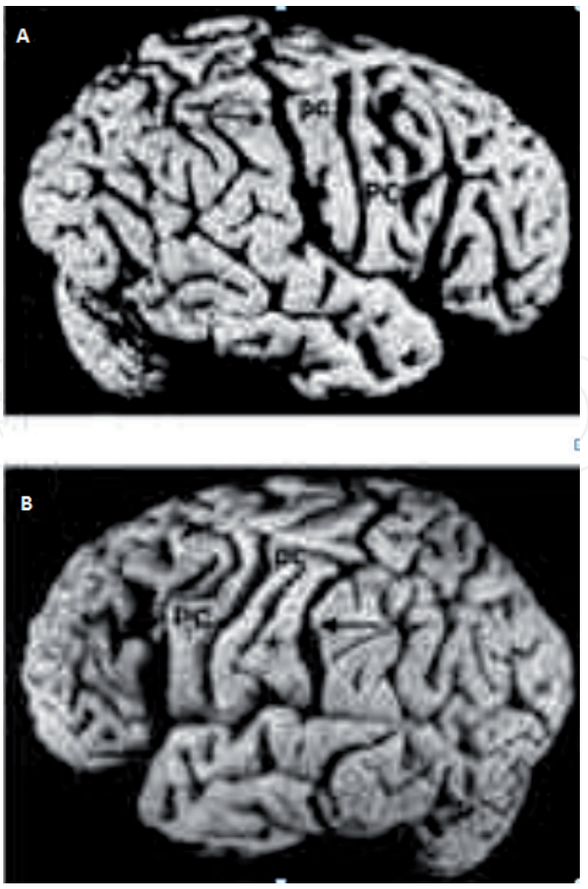

Figure 3.
Einstein's brain is no exception to the most common of patterns, showing (A): Typical posteriorly rising Sylvian fissure on the right (arrow) and (B): A parietal operculum on the left (asterisk).

was 84, and his performance IQ was 70. MRI revealed massive hydrocephalus with all brain ventricles, lateral, third, and fourth were enlarged. 90% of cerebral cortex was absent with remnants of very thin cortical mantle and a posterior fossa cyst (**Figure 2**) [63].

4.3 Structural brain components and human intelligence are they parallel?; the Einstein's brain

Thinking of intelligence from the point of computer and artificial intelligence language will denote the fact that the higher the capacity and intellectual power of a computer requires larger hard ware and more sophisticated computers. The comparisons is not valid in case of human brain as the anatomical study of the most intelligent human in the 20 century Albert Einstein's brain was not showing any convincing anatomical difference than any body brain. Witelson and colleagues' claim that Einstein's brain lacks a parietal operculum on the left and right sides. A M Galaburda from Harvard Medical School -and others- argues strongly against this and documented that Einstein's brain is no exception to the most common of patterns, showing a parietal operculum on the left and the typical posteriorly rising Sylvian fissure on the right (**Figure 3**) [64, 65].

5. Orchestration of the human consciousness from beyond the brain

It is conspicuous for the ingenious observer in the consciousness scientific arena that the inability to explain and match facts and observations and the failure to

reproduce the exact consciousness experience incorporating current knowledge in the field implies presence of deficient rings in the long chain that demand more comprehensive perspective. In this regard we established the King of Organs International Congress for Advanced Cardiac Sciences and held five international congresses (2006,2007,2008,20,101,2012 and 2019). The King of Organs congresses are an international collaborative efforts between international renewed scientists in cardiac sciences, psychologists, astrophysicist, mathematicians, geologists, space engineers, signal analysis specialists and other related disciplines. It is chaired by us in Prince Sultan Cardiac Center (Alhasa, Saudi Arabia). Our academic partners are the HeartMath Institute and the Global Coherence Initiative (Boulder Creek, CA, USA), American Institute of Stress (NY, USA), The Global Consciousness Project (Institute of Noetic Sciences, USA), and other western and eastern reputable universities and collaborators. *Our mission is to decode the great mystery of consciousness away from the traditional neurobiological approach*. Our research areas were: neurocardiology, solar and geomagnetic fluctuations and how it affects human autonomic nervous system, quantum physics of the human heart and brain and other related subjects. The heart as the dominant energetic organ of the human body and the role of heart rate variability (HRV) and its orchestrating symphony in the human body and the universe were the illuminators and the distinguished new scientific arena of the King of Organs Congresses.

5.1 Neurocardiology and the heart brain neurodynamics

The field of neurocardiology is relatively new discipline which was discussed first time in a scientific conference in King of Organs 2006,Saudi Arabia. The meticulous and sophisticated neurological afferent pathways (**Figure 4**) as well as energetic dominance of the heart over the brain was astonishing for the modern scientific communities. The amplitude of the cardiac electrical signal is about 60 times greater in amplitude compared to the brain while the electromagnetic field of the heart is approximately 5000 times stronger than the brain and can be detected six feet away from the body with sensitive magnetometers. Other ways the heart communicate the brain are hormonal and biophysical.

John and Beatrice Lacey during 1960s and 1970s created a massive drift in the modern psychophysiological research with their publications on human heart –brain communication [66, 67]. An important land mark in the field was there observations that afferent input from the heart and cardiovascular system could significantly affect perception, cognitive functions and behavior. This was neurophysiological evidence signifying that sensory and motor integration could be modified by cardiovascular activity. The heart behaves as if it had a mind of its own. In contradiction to Cannon theory of homeostasis, Laceys showed that patterns of physiological responses were affected as much by the context of a specific task and its requirements as by emotional stimuli. A phenomenon called by Laceys the *directional fractionation* denotes paradoxical heart rate response as it decelerated and blood pressure *decreased*, while simultaneously recorded parameters such as, respiratory rate, pupillary dilation and skin conductance all increased as expected. Later, cognitive performance fluctuated at a rhythm around 0.1 Hz was demonstrated by Velden and Wolk and showed that the modulation of cortical function was via the heart's influence was due to afferent inputs on the neurons in the thalamus, which globally synchronizes cortical activity and the consciousness phenomena [68, 69]. A critical observation here is the finding that "pattern and stability" (of the rhythm) of the heart's afferent inputs, rather than the number of neural bursts within the cardiac cycle that will modulate thalamic activity, which in turn has global effects on brain function and ultimately the consciousness experience [70].

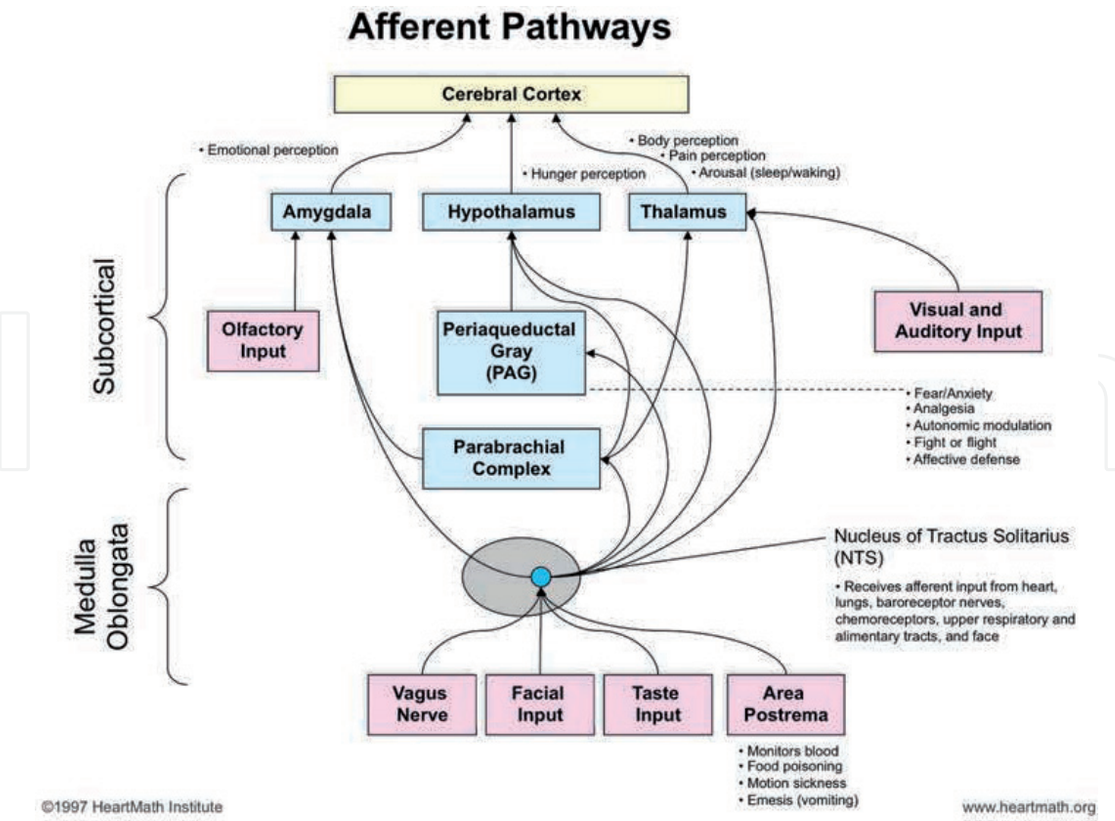

Figure 4.
The currently known afferent pathways by which information from the heart and cardiovascular system modulates brain activity. The nucleus of tractus solitarius (NTS) direct connection to the amygdala, hypothalamus and thalamus is shown. In addition there is emerging evidence of the presence of a pathway from the dorsal vagal complex that travels directly to the frontal cortex.

Growing body of respectful research has since been accumulating indicating that afferent information processed by the intrinsic cardiac nervous system can influence activity in the frontocortical areas and motor cortex, affecting psychological factors and the consciousness experience elements such as attention level, motivation, perceptual sensitivity, and emotional processing [70–72].

5.2 The revolutionary paradigm, the heart detect stimulus before the brain and brain neural events are locked to heartbeats

One of the strategic scientific, philosophical, as well as conceptual turning points that emanates from the basic science and neuroscientific arena is the accumulating evidence of the precedence of the heart detection of sensory stimulus before the brain. Hyeong-Dong Park in nature neuroscience, documented neural events locked to heartbeats before stimulus onset predict the detection of a faint visual grating in two regions that have multiple functional correlates and that belong to the same resting-state network:the posterior right inferior parietal lobule and the ventral anterior cingulate cortex **Figure 5** [73].

There is compelling evidence to suggest the physical heart is coupled to a field of information not bound by the classical limits of time and space [74]. Rigorous experimental study demonstrated the heart receives and processes information about a future event before the event actually happens. The study's results provide surprising data showing that both the heart and brain receive and respond to pre-stimulus information about a future event before it occurs but the heart proceeded the brain by 1.3 seconds which is truly too long time in the scale of neural impulse transmission which is counted with milliseconds (**Figure 6**).

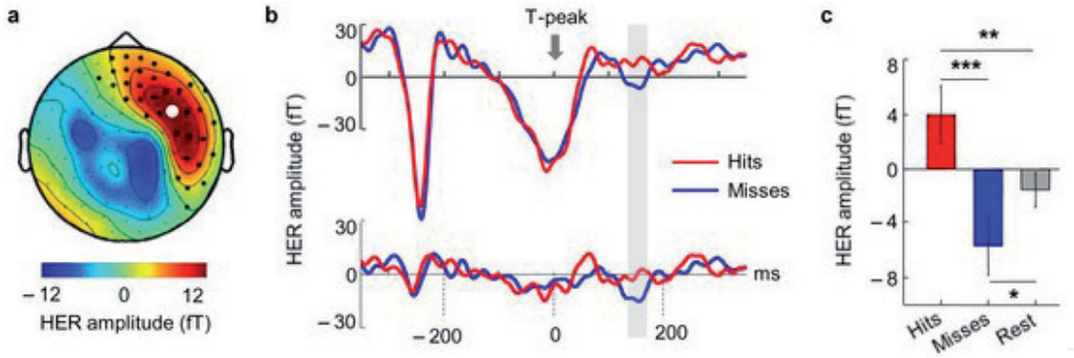

Figure 5.
Neural events locked to heartbeats before stimulus onset predict the conscious detection of a faint visual grating in the posterior right inferior parietal lobule and the ventral anterior cingulate cortex [73]. (HER): heartbeat-evoked response.

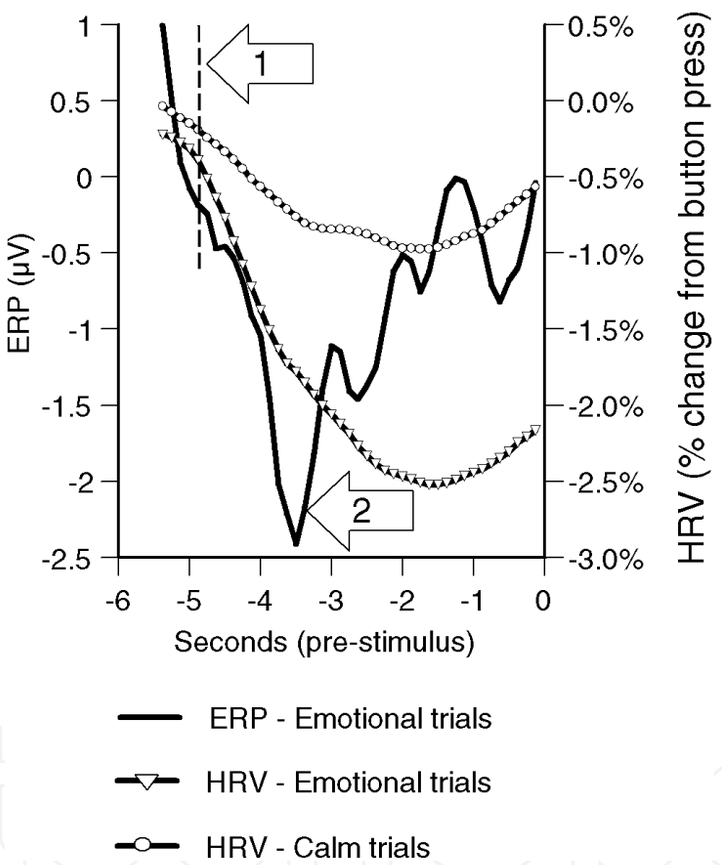

Figure 6.
Temporal dynamics of heart and brain pre-stimulus responses. Sharp downward shift about 4.8 seconds prior to the stimulus (arrow 1) is seen. The emotional trials ERP showed a sharp positive shift about 3.5 seconds prior to the stimulus (arrow 2). This positive shift in the ERP denotes the time the brain "knew" the nature of the future stimulus. The time difference between these two events suggests that the heart received the intuitive information about 1.3 seconds before the brain. Heartbeat-evoked potential analysis confirmed that a different afferent signal was sent by the heart to the brain during this period. (ERP) is event-related potential at EEG site FP2. HRV is heart rate variability [74].

5.3 *The vagal nerve is never vagal*, the afferent cardiac neuronal traffic and consciousness

Astonishing fact of the vagus nerve (means the nerve with unknown role) called sometimes, the tenth cranial nerve is the fact that it has very significant afferent neurons beside what we taught about its efferent neurons in our medical schools. 85–90% of the fibers in the vagus nerve are afferent [75]. The majority of higher

brain centers, as well as emotional experience and cognitive processes are operated by Cardiovascular related afferent neural traffic [76]. Numerous brain centers including the thalamus, hypothalamus, and amygdala are connected to cardiovascular afferents. Range of frequencies of complex afferent information related to mechanical and chemical factors is continuously sent to the brain and is over time scales ranging from milliseconds to minutes [77]. Vagal afferent nerve stimulation causing increases traffic over the normal intrinsic levels in the thalamic pain pathways in the spinal cord will inhibit those pathways. In addition, vagal afferent nerve stimulation was shown to reduces migraine and cluster headaches and to improve cognitive processing and memory [78]. Activating afferent input with vagal nerve stimulation (VNS) is apparently heralding a new era in medical therapeutics as it proves effective in many psychophysiological disorders including epilepsy, obesity, depression, anxiety, autism, alcohol addiction, mood disorders, as well as multiple sclerosis, and traumatic brain injury [79, 80]. The cardiac coherence training is known to intensify afferent vagal neuronal inputs to cortical and subcortical systems and to Neuronal Correlates of Consciousness (NCC) with long term capabilities to reset the reference set up points resulting in increased afferent nerve activity noninvasively and ultimately improves psychophysiological parameters and the consciousness experience. There is thus a need to explore novel ways of repairing lost consciousness. Vagus nerve stimulation (VNS) may also contribute to breaking advances in awakening the unconscious vegetative state patient as approved by improvement in behavioral responsiveness and enhanced brain connectivity patterns. The vagus nerve carries afferent connections to the deep nuclei of the brain via the nucleus solitaries (see **Figure 4**). These afferent connections have multiple consciousness related targets, which include the thalamus, amygdala, reticular formation, hippocampus, raphe nucleus, and the locus coeruleus. VNS will create improved global neurostimulation state leading to promoted spread of cortical signals and caused an increase of metabolic activity leading to behavioral improvement as measured with the Coma Recovery Scale-Revised (CRS-R) scale. [81] Theta waves dominance were shown in the right inferior parietal and the parieto-temporal-occipital border, a region known to be instrumental in conscious awareness. *Improvement in long white matter tracts namely the corticocortical and thalamocortical disconnected pathways by vagus nerve stimulation is a true revolutionary therapeutic option. Today it is conspicuous to the whole medical communities that* **vagal nerve is never vagal**.

5.4 Cardiac coherence: repatterning psychophysiological neural networks and consciousness experience

McCraty and colleagues introduced the term physiological coherence to describe the degree of order, harmony, and stability in the various rhythmic activities within living systems over any given time period [82]. This harmonious order signifies a coherent system that has an efficient or optimal physiological functioning which will be reflected in more resilient personality and higher consciousness. Physiological coherence (also referred to as cardiac coherence) can be measured by HRV analysis where more ordered sine like HRV pattern will be seen around frequency of 0.1 Hz (10 seconds) which will be seen as very narrow, high-amplitude peak in the low frequency (LF) region of the HRV power spectrum with no major peaks in the VLF or HF regions [83].

Ground breaking discovery emphasizing the ability of afferent cardiac signals to reprogram the cortical and subcortical neural networks is what we describe as the *repatterning process* in the neural architecture, where coherence becomes established as a new, stable baseline reference memory [84]. Coherence is adaptable to be the new set point or the default reference point, facilitating the ability to self-regulate

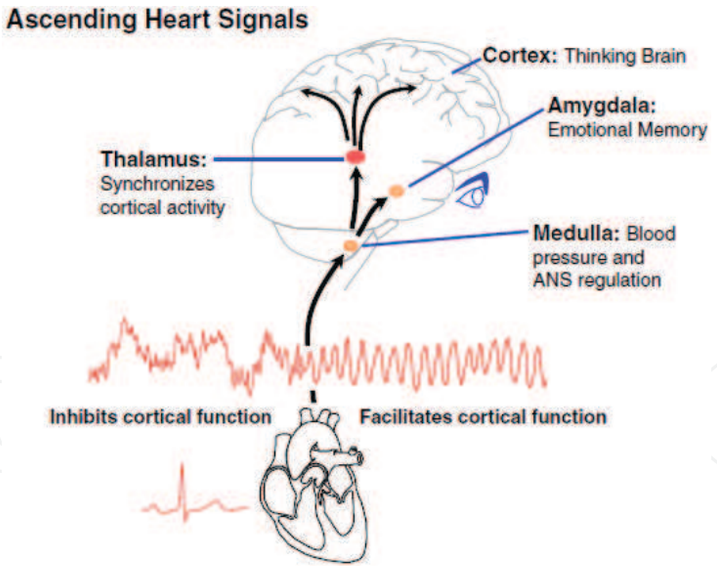

Figure 7.
Heart activity affects brain function. The ascending heart signals impact autonomic regulatory centers in the brain and cascade up to higher brain centers involved in emotional and cognitive processing, including the thalamus, amygdala, and cortex [83].

stress and emotions, a process that then becomes like a habit and eventually automatic [85–89]. Mental and emotional flexibility to remain in self-directed control is a well-known outcome with repeated coherence training. This will end up with more resilient personality and psychophysiological well being including capability to reduce systemic blood pressure without medications. [70] It also builds one's capacity to access intuitive state with higher consciousness to achieve intelligent life options easier through what we can call heart intelligence (**Figure 7**).

5.5 The heart signature on the brain interoception: heartbeat evoked potentials (HBEPs)

Heartbeat evoked potentials (HEPs) are segments of electroencephalogram (EEG) that are synchronized to the heartbeat. The ECG R-wave is used as a timing source for signal averaging, resulting in waveforms known as HEPs. Based on animal studies, Those cardiac afferents are transmitted to cortical areas including the insula, amygdala, somatosensory cortex and cingulate cortex, through subcortical relays such as the nucleus of the solitary tract, parabrachial nucleus, and thalamus Changes in these evoked potentials associated with the heart's afferent neurological input to the brain are detectable between 50 and 550 ms after each heartbeat [70].

Initiation of negative or positive emotion conditions by recalling past events reduced HRV and N250 amplitude. In contrast, resonance frequency breathing with HRV frequency around the 0.1 Hz peak increased HRV and HRV coherence above baseline and increased N250 amplitude [90]. We and others thought of HEPs as a neural marker of cardiac-related cortical processing in in consciousness and other diverse cognitive functions. Different afferent input mechanisms from the heart to the brain during different emotions and HRV can be identified using HEPs. Hyeong-Dong Park et al., found that neural responses to heartbeats can be recorded mainly in the insula (i.e., anterior, posterior) and operculum (i.e., frontal, central, posterior)., although it can be found in other regions distributed across the brain including the amygdala and fronto-temporal cortex [91]. It is known that insula is the primary cortical projection site of interoceptive signals. It is interesting to know

that the HBEP is significantly higher during interoceptive compared to exteroceptive attention, in a time window of 524–620 ms after the R-peak [92].

5.6 Consciousness patterns, heart and brain interconnectivity

Similarities of basic frequencies, harmonics, magnetic field intensities, voltages, band widths, and energetic solutions between the Schumann resonances in the space between earth and ionosphere and the activity within the human cerebral cortices suggest the capacity for direct interaction [93]. Every cell in our body is bathed in an internal and external environment of fluctuating invisible magnetic forces that can affect virtually every cell and circuit in biological systems [94]. Therefore, it should not be surprising that numerous physiological rhythms in humans heart and brain and global collective behaviors are not only synchronized with solar and geomagnetic activity, but disruptions in these fields can create adverse effects on human health and behavior. The most sensitive body systems to those fluctuating electromagnetic environments are the heart and brain. [95] The heart is the largest dynamic organ in the human body. No surprise that the heart magnetic field is the strongest rhythmic field produced by the human body. The second strongest magnetic generator is the brain. The primary source of the electromagnetic activity of the brain measured from the scalp and emerges from the cerebral cortices because of the parallel arrangement of the dendrite-soma-axo orientations perpendicular to the surface for most of the approximately 20 billion neurons. Superimposed upon the steady potential are fluctuating voltages that define the electroencephalogram (EEG). It is not surprising that the heart's electrical field is about 60 times greater in amplitude than the electrical activity generated by the brain. There is a direct mathematical relationship between the HRV *patterns* and the spectral information encoded in the magnetic field [96]. The coherence model predicts that different emotions are reflected in state-specific *patterns* in the heart's rhythms regardless of the heart rate. *Patterns* in the activity of cardiovascular afferent neuronal traffic can significantly influence cognitive performance, emotional experience and self regulatory capacity via inputs to the thalamus, amygdala and other subcortical structures. There is 75% accuracy rate in detection of discrete emotional states from the HRV signal using a neural network approach for pattern recognition. It was found that information reflecting one's emotional state is encoded in the *patterns* of the HRV waveform and in addition, is contained in the heart's electromagnetic field radiated into the environment [96, 97]. When an individual is in a heart coherent state, the heart's magnetic field also has a more coherent structure. Information also is encoded in the interbeat intervals of the pressure and electromagnetic waves produced by the heart. It was shown that when two people are in a loving relationship that their hearts rhythms can synchronize even at great distances apart (Presented in King of Organs Congress 2019,permission from author Peter Granger). As the heart secretes a number of different hormones with each contraction, there is a hormonal pulse pattern that correlates with heart rhythms. In addition to the encoding of information in the space between nerve impulses and in the intervals between hormonal pulses, it is likely that information also is encoded in the interbeat intervals of the pressure and electromagnetic waves produced by the heart. This supports Pribram's proposal that low frequency oscillations generated by the heart and body in the form of afferent neural hormonal and electrical *patterns* are the carriers of emotional information and the higher frequency oscillations found in the EEG reflect the consciousness. The correlation of those physiological patterns to the Neuronal Correlates of Consciousness (NCC) and the correlation of this possible link to consciousness is to be investigated in the future.

5.7 Solar and planetary geomagnetic activity, the delicate orchestration of neuronal cardiac afferents to cerebral cortex

Resonance refers to vibration of large amplitude in electrical or mechanical system caused by a relatively small periodic stimulus of the same or nearly the same period as the natural vibration period of the system. The concept of resonance and its implementations in physiological as well as astrophysical rhythms is of critical significance for life on earth and to human consciousness experience. All biological systems on the planet are exposed to an external and internal environment of fluctuating invisible wide range of magnetic fields frequencies. These fields can affect virtually every cell and circuit to a greater or lesser degree. Numerous physiological rhythms have been shown to be synchronized with solar and geomagnetic activity. Geomagnetic and solar influences affect a wide range of human rhythmic systems with the nervous and cardiovascular systems, with their significant contribution to consciousness, being the most clearly impacted [70]. Sharp variations of sudden and sharp nature of geomagnetic, solar activity and its resultant geomagnetic storms can act as stressors, which has the capacity to alter body regulatory processes and rhythmic systems such as melatonin/serotonin balance, blood pressure, breathing, reproductive, immune, neurological, and cardiac system processes [98–101]. In the clinical arena significant increases in hospital admissions for depression, mental disorders psychiatric admission, homicides, suicide attempts, and traffic accidents are associated with planetary geomagnetic disturbances [102–108]. Increase incidence of myocardial infarctions, vascular variability disorders, local and global communication between humans during geomagnetic disturbances are all denotes that brain and cardiovascular systems are clear targets for the planetary geomagnetic disturbances [109–114]. Exacerbation of present disease like development of cardiac arrhythmias and epilepsy is well known during disturbed geomagnetic activity. Low frequency magnetic oscillations, around 3 Hz, was observed to cause Altered EEG rhythms with sedative effect [115]. Applying the lowest Schumann Resonance (SR) frequency of 7.8 Hz with 90 nano Tesla for 1.5 hours was found to be cardioprotective from stress conditions with reduction of the amount of CK released to the buffer, during normal conditions, hypoxic conditions and oxidative stress induced by 80 μM H2O2 [116]. The longest record in human history of human heart rate variability (HRV) synchronized with Solar Wind indices, Shumann Resonances (SR) and Galactic Cosmic Rays (GCR) monitoring was achieved by our group [117]. Schumann resonance frequency is 7.83 hertz (Hz), with a (day/night) variation of around ±0.5 Hz. The higher frequencies are ~14, 20, 26, 33, 39 and 45 Hz, all of which closely overlay with alpha (8–12 Hz), beta (12–30 Hz) and gamma (30–100 Hz) brain waves. The delicate orchestration of this universal symphony and vibrations with the human autonomic nervous system (ANS) that interacts with cerebral cortex and control heart rhythm, respiration, digestive functions and other involuntary activities was investigated. We were able to confirm that changes in solar and geomagnetic activity during periods of normal undisturbed activity affect daily ANS activity. In an other publication, we were able to document significant correlations between the group's HRV and solar wind speed, Kp, Ap, solar radio flux, cosmic ray counts, Schumann resonance power, and the total variations in the magnetic field [110] This affect is initiated at different times after the changes in the various environmental factors and persist over varying time periods. Peaks of increased solar activity occurs every 10.5 to 11 years. During those peaks, the sun emits increased ultraviolet (UV) energy and solar radio flux, which is measured by the 2.8 GHz signal (F10.7) [110] We considered Solar wind intensity as biological stressor as increase in its intensity is well correlated to increase heart rate. Galactic Cosmic Rays (GCR) are highly energetic particles that originate outside the solar system and are likely formed by nuclear explosive events in supernova and other mega giant galaxies. These highly

energetic particles consist of fully ionized nuclei ranging from hydrogen, accounting for approximately 89% of the GCR spectrum, to trace amounts of uranium. The planetary magnetic field and the solar winds are protective for life on earth from this extremely ionized rays. We documented that human HRV with its modulatory effect on the consciousness pillars through ascending neuronal input to cortical and sub cortical structures increases with rise of the three major universal vibrations that we examined: Solar Winds, Shumann Resonances (SR), and the Galactic Cosmic Rays (GCR). This complex interaction between HRV and those environmental energetic fields may contribute to the human knowledge about the pathomechanistic effects on human psychphysiological homeostasis and the consciousness experience.

6. The realm of consciousness, from within the skull to the sky

6.1 Classical mechanics cannot explain consciousness

It is conspicuous from the previous sections that the neuronal firing of brain structures is not enough to explain subjective consciousness experience. Quantum physicists Larissa Brizhik and Emilio DelGiudice suggested that the most likely physical agent that can continuously provide an exchange of information between living systems within the larger ecosystem is the magnetic fields. According to the quantum field theory, potentials of the magnetic field, governs the dynamics of biological systems and the whole ecosystem. As a matter of fact, the planetary magnetic field is ubiquitous and involved in the deep behavior of biology. Animals can detect the Earth's magnetic field through magnetoreception-related photoreceptor cryptochromes [118] through which the planetary magnetic field guides the different species in their thousands of miles migration in land and oceans. The field causes the emergence of the coherent structures, which, in view of their coherence, openness and nonlinearity, are able to self-organize and form a chain of hierarchical levels of ecosystems [119] Coherence in the quantum language implies correlations, connectedness, consistency, efficient energy utilization, and the concept of global order, where the whole is greater than the sum of its individual parts. In medicine we refer to coherence to implies a harmonious relationship, correlations and connections between the various parts of a system. The Wight of evidence towards new evolutionary paradigm of the origin and effect of human consciousness with mutual effect to the environment is prevailing.

Evidence is accumulating supporting the hypothesis that our consciousness can even influences our physical world. Random number generators (RNGs) are one tool used to evaluate micro-psychokinesis or our ability to affect the physical world with our consciousness. Research conducted by the Global Consciousness Project (GCP) (which maintains a worldwide network of random number generators running constantly at about 60 locations around the world, sending streams of 200-bit trials generated each second to be archived as parallel random sequences), has found that human emotionality affects the randomness of these electronic devices in globally correlated manner. Roger Nelson who is the founder of GCP reported in a recent publication multiple examples of striking similarity between event-related brain potentials and event-related correlations in random data [119] (**Figure 8**).
If all living systems are indeed interconnected and communicate with each other via biological and electromagnetic fields, it stands to reason that humans can work together in a co-creative relationship to consciously increase global coherence and raise the global consciousness. It is conspicuous that classical mechanics cannot explain consciousness. Quantum consciousness is the science that incorporate conceptual discussion of phenomenon of quantum mechanics like entanglement and superposition to explore the deep science of human consciousness.

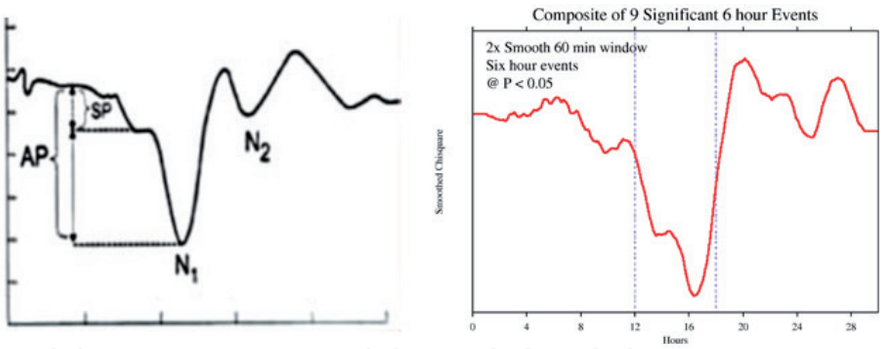

Figure 8.
Striking similarity between evoked potential (EP) from an auditory stimulus (the black) and composite of GCP data from nine 6 hour events (the red) [119].

6.2 The quantum consciousness

The idea that quantum mechanics has something to do with the workings of the mind was developed by Eugene Wigner, Hungarian-American theoretical physicist and Nobel Prize Laurete in Physics in 1963,who proposed that the wave function collapses due to its interaction with consciousness. Freeman Dyson argued that "mind, as manifested by the capacity to make choices, is to some extent inherent in every electron. David Bohm is theoretical physicists who contributed significantly to quantum theory, neuropsychology and the philosophy of mind. He stimulated new era of conceptual approach to consciousness with more fundamental level in the universe. He claimed both quantum theory and relativity pointed to this deeper theory, which he formulated as a quantum field theory. Bohm's proposed implicate order which applies both to matter and consciousness. He suggested that it could explain the relationship between them. Bohm's views mind and matter as projections into our explicate order from the underlying implicate order This more fundamental level was proposed to represent an undivided wholeness and an implicate order, from which arises the explicate order of the universe as we experience it. Holonomic brain theory is a branch of neuroscience investigating the idea that human consciousness is formed by quantum effects in or between brain cells. This specific theory of quantum consciousness was developed by neuroscientist Karl Pribram initially in collaboration with David Bohm. In addition to the neuroanatomical components of the human brain including the large fiber tracts in the brain, neurotransmissions also occurs in dendrites and other webs of fine fiber branche, that form webs. Due to the billions of action potentials and neural impulse formations, dynamic electrical fields will result around these dendritic trees. Those dendritic trees can affect other surrounding neurons without physical contact between them by entanglement. In this way, processing in the brain can occur in a non-localized manner. An energy-based concept of information was described by Dennis Gabor, who invented the hologram in 1947,which he described as quanta of information. Later on, he won Nobel prize in physics for this invention in 1971.Kal H.Pribram's holonomic model of brain processing was described in his 1991 *Brain and Perception* book which include his perspectives on human consciousness with David Bohm. It describes human cognition by modeling the brain as a holographic storage network. Pribram suggests these processes involve electric oscillations in the brain's dendritic networks, which are different from the more commonly known action potentials involving axons and synapses. These oscillations are waves and create wave interference patterns in which memory is encoded naturally. The waves are found to be analyzable by Fourier transform. Gabor, Pribram and others noted the similarities between these brain processes and the storage of information in

a hologram. Pribram's holonomic model contributes significantly to human consciousness understanding, specially to the fast associative memory and the non-locality of memory. In 1991 Orchestrated Objective Reduction (Orch-OR) theory was introduced by physicist Roger Penrose and anesthesiologists Stuart Hameroff. It is a biological philosophy of mind that postulates that at the quantum level consciousness originates inside neurons, rather than the traditional perspective that it is a product of connections between neurons. The interpreting mechanism is contributed to non computational quantum process performed by quantum bits (qubits) formed collectively on cellular microtubules- called objective reduction. The qubits are based on oscillating dipoles(either electric or magnetic) forming superposed resonance rings in helical pathways throughout lattices of microtubules. Orchestration refers to the hypothetical process by which microtubule-associated proteins (MAPs) and other connective proteins, orchestrate qubit state reduction through modification of space time-separation of their superimposed states. Penrose was faced with a wave of criticism which is in our view not justified as his opponents were too limited with their perspective for human consciousness within the today computational intelligence language. In addition, postulating intuitive thoughts in the context of acceptable scientific language is well known and accepted approach in the philosophy of science. Other important contributors in the field are Hiroomi Umezawa and collaborators who proposed a quantum field theory of memory storage which is fundamentally different from the Penrose-Hameroff theory. In 1967, Hiroomi Umezawa together with L.M. Ricciardi, proposed a quantum theory of the brain which posits a spatially distributed charge formation exhibiting spontaneous breakdowns at micro levels as the basis for processing at macro levels. According to this model, the information resides in the virtual field associated with the dynamics of the cellular matter. Hiroomi Umezawa was known by his extreme originality. His approach was built upon by Karl Pribram and many others and expanded by Giuseppe Vitiello to a dissipative quantum model of brain. An other pioneer in the field is Henry Pierce Stapp. He is American mathematical physicist, known for his work in quantum mechanics who favors the idea that quantum wave functions collapse only when they interact with consciousness. According to Stapp hypothesis alternative quantum possibilities when exposed to conscious mind will select one. His explanation hypothesis differs from that of Penrose and Hameroff. Stapp postulates a process of global collapse through an effect on the synapses by exploitation certain aspects of quantum Zeno effect. David Pearce, British philosopher has conjectured that unitary conscious minds are physical states of quantum coherence (neuronal superpositions). It is clear at this point that scientist from different disciplines over the last 8 decades were trying to come closer to the absolute fact of consciousness. Each theory discussed has its strength and weaknesses but all lack the comprehensive universal perspective incorporating the origin of consciousness with more homogenous incorporation of current theories in a stronger model capable of bringing us closer to consciousness realm closer than any time ever.

7. Conclusion

In this chapter we investigate the elusive issue of human consciousness. We introduce revolutionary paradigm in the time line of consciousness science, where we discuss a comprehensive perspective of the process of consciousness of neurobiological and astrophysical bases. Our new perspective is built on our work confirming the symphony interplay of human ANS represented by HRV on one hand and Shumann Resonances, Solar Wind Indices and Cosmic Rays on the other hand. In addition to up to date discussion on the neuroanatomical aspects of consciousness,

the delicate and powerful contribution of cardiac afferent input to brain consciousness related cortical and subcortical structures and pathways and heartbeat evoked potentials (HEP) is discussed. The role of the quantum principles and magnetic potentials in the universal information processing is emphasized. Our new perspective is complementary but never competitive to the quantum consciousness theories discussed especially the theories of Karl Primbram-David Bohem, Penrose and Stuart Hameroff, and Pierce Stapp. This new comprehensive understanding of human consciousness should bring many scientific disciplines closer to illustrate the necessity of the intelligent blend of science branches to solve historical human issues in medicine, science, philosophy, and religion.

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References

[1] Lewis CS. Studies in Words. Cambridge: Cambridge University Press; 1960.

[2] Bogen JE. On the neurophysiology of consciousness: An overview. Conscious Cogn 1995;4:52-62.

[3] Edelman GM. The remembered present: A biological theory of consciousness. New York:Basic Books; 1989.

[4] Newman J, Baars BJ. A neural attentional model of access to consciousness: A global workspace perspective. Cogn Neurosci 1993;4:255-90.

[5] Flohr H. An information processing theory of anaesthesia. Neuropsychologia 1995;33:1169-80.

[6] Sheinberg DL, Logothetis NK. The role of temporal cortical areas in perceptual organization.Proc Natl Acad Sci U S A 1997;94:3408-13.

[7] Crick F, Koch C. Are we aware of the neural activity in primary visual cortex. Nature 1995;375:121-3.

[8] Hirstein W. The contribution of prefrontal executive processes to creating a sense of self. Mens Sana Monogr 2011;9:150-8.

[9] Milner AD, Goodale MA. The Visual Brain in Action. Oxford: Oxford University Press; 1995.

[10] Aleksander I. How to build a Mind. In: Mapping the Mind Series. London: Weidenfeld and Nicolson; 2000.

[11] Moruzzi G, Magoun HW. Brain stem reticular formation and the activation of EEG. Electroencephalogr Clin Neurophysiol 1949;1:455-73.

[12] Tononi G, Koch C. The neural correlates of consciousness: An update. Ann N Y Acad Sci 2008;1124:239-61.

[13] Tononi G. Phi: A voyage from the brain to the soul. New York: Pantheon Books; 2012.

[14] Young GB, Pigott SE. Neurobiological basis of consciousness. Arch Neurol 1999;56:153-7.

[15] Maquet P. Functional neuroimaging of normal human sleep by positron emission tomography. J Sleep Res 2001;9:207-31.

[16] Alkire MT, Haier RJ, Fallon JH. Toward a unified theory of narcosis: Brain imaging evidence for a thalamocortical switch as the neurophysiologic basis of anesthetic induced unconsciousness. Conscious Cogn 2000;9:370-86.

[17] Clare Timbie and Helen Barbas. Pathways for Emotions: Specializations in the Amygdalar, Mediodorsal Thalamic, and Posterior Orbitofrontal Network. The Journal of Neuroscience, August 26, 2015 • 35(34):11976-11987

[18] Balleine BW, Killcross S. Parallel incentive processing: An integrated view of amygdala function. Trends Neurosci 2006;29:272-9.

[19] Kim SJ, Loucks RA, Palmer AL, Brown AC, Solomon KM, Marchante AN, et al. Structural and functional connections of the amygdala: From normal emotion to pathological anxiety. Brain Behav Res 2011;223:403-10.

[20] Schmahmann JD. Disorders of the cerebellum: Ataxia, dysmetria of thought, and the cerebellar cognitive affective syndrome. J Neuropsychiatry Clin Neurosci 2004;16:367-78.

[21] 193.Schmahmann JD, Weilburg JB, Sherman JC. The neuropsychiatry of the cerebellum insights form the clinic. Cerebellum 2007;6:254-67.

[22] Strata P, Scelfo B, Sacchetti B. Involvement of cerebellum in emotional behavior. Physiol Res 2011;60:S39 S48.

[23] Schmahmann JD. In: The cerebellum and cognition. San Diego CA: Academic Press; 1997. p. 613-34.

[24] Hal Blumenfeld. Neuroanatomical Basis of Consciousness chapter. Book:The Neurology of Conciousness. December 2016.DOI: 10.1016/ B978-0-12-800948-2.00001-7

[25] McCormick, D.A., 2002. Cortical and subcortical generators of normal and abnormal rhythmicity. Int. Rev. Neurobiol. 49, 99_114.

[26] Crick F, Koch C. Are we aware of the neural activity in primary visual cortex. Nature 1995;375:121-3.

[27] Rees G, Kreiman G, Koch C. Neural correlates of consciousness in humans. Nat Rev Neurosci 2002;3:261-70.

[28] De Sousa A. Towards An Integrative Theory Of Consciousness: Part 1 (Neurobiological And Cognitive Models). Mens Sana Monogr 2013;11:100-50.

[29] Michel M, Morales J. Minority reports: Consciousness and the Prefrontal cortex. Mind & Language. 2019;1-21. https://doi.org/10.1111/ mila.12264

[30] Andrea E. Cavanna1, and Michael R. Trimble. The precuneus: a review of its functional anatomy and behavioural correlates. Brain (2006), 129, 564-583.

[31] Steriade, M., 2004. Acetylcholine systems and rhythmic activities during the waking—sleep cycle. Prog. Brain Res. 145, 179_196.

[32] Shi YF, Yu YQ. *Zhejiang Da Xue Xue Bao Yi Xue Ban*. 2013;42(5):583-590.

[33] Rasmusson, D.D., Clow, K., Szerb, J.C., 1994. Modification of neocortical acetylcholine release and electroencephalogram desynchronization due to brainstem stimulation by drugs applied to the basal forebrain. Neuroscience. 60 (3), 665_677.

[34] Dringenberg, H.C., Olmstead, M.C., 2003. Integrated contributions of basal forebrain and thalamus to neocortical activation elicited by pedunculopontine tegmental stimulation in urethane anesthetized rats. Neuroscience. 119 (3), 839_853.

[35] Blanco-Centurion, C.A., Shiromani, A., Winston, E., Shiromani, P.J., 2006. Effects of hypocretin-1 in 192-IgG-saporin-lesioned rats. Eur. J. Neurosci. 24 (7), 2084_2088.

[36] Freund, T.F., Meskenaite, V., 1992. gamma-Aminobutyric acidcontaining basal forebrain neurons innervate inhibitory interneurons in the neocortex. Proc. Natl. Acad. Sci. USA. 89 (2), 738_742.

[37] Saper, C.B., Fuller, P.M., Pedersen, N.P., Lu, J., Scammell, T.E., 2010. Sleep state switching. Neuron. 68 (6), 1023_1042.

[38] Mesulam, M.M., Mufson, E.J., 1984. Neural inputs into the nucleus basalis of the substantia innominata (Ch4) in the rhesus monkey. Brain. 107 (Pt 1), 253_274.

[39] Parent, A., Steriade, M., 1984. Midbrain tegmental projections of nucleus reticularis thalami of cat and monkey: a retrograde transport and antidromic invasion study. J. Comp. Neurol. 229 (4), 548_558.

[40] Brown, E.N., Lydic, R., Schiff, N.D., 2010. General anesthesia, sleep, and coma. N. Engl. J. Med. 363 (27), 2638_2650.

[41] Foote, S.L., Bloom, F.E., Aston-Jones, G., 1983. Nucleus locus ceruleus:

new evidence of anatomical and physiological specificity. Physiol. Rev. 63 (3), 844_914.

[42] Jacobs, B.L., Azmitia, E.C., 1992. Structure and function of the brain serotonin system. Physiol. Rev. 72 (1), 165_229.

[43] Hannon, J., Hoyer, D., 2008. Molecular biology of 5-HT receptors. In: Monti, J.M., Pandi-Perumal, S.R., Jacobs, B.L., Nutt, D.J. (Eds.)

[44] Dugovic, C., Wauquier, A., Leysen, J.E., Marrannes, R., Janssen, P.A., 1989. Functional role of 5-HT2 receptors in the regulation of sleep and wakefulness in the rat. Psychopharmacology (Berl). 97 (4), 436_442.

[45] Sowers, L.P., Massey, C.A., Gehlbach, B.K., Granner, M.A., Richerson, G.B., 2013. Suden unexpected death in epilepsy: fatal post-ictal respiratory and arousal mechanisms. Respir. Physiol. Neurobiol. 189 (2), 315_323.

[46] Bandyopadhyay, S., Hablitz, J.J., 2007. Dopaminergic modulation of local network activity in rat prefrontal cortex. J. Neurophysiol. 97 (6), 4120_4128.

[47] Combarros, O., Infante, J., Berciano, J., 2000. Akinetic mutism from frontal lobe damage responding to levodopa. J. Neurol. 247 (7), 568_569.

[48] Brown, R.E., Stevens, D.R., Haas, H.L., 2001. The physiology of brain histamine. Prog. Neurobiol. 63 (6), 637_672.

[49] Dringenberg, H.C., Kuo, M.C., 2003. Histaminergic facilitation of electrocorticographic activation: role of basal forebrain, thalamus, and neocortex. Eur. J. Neurosci. 18 (8), 2285_2291.

[50] McCormick, D.A., Williamson, A., 1991. Modulation of neuronal firing mode in cat and guinea pig LGNd by histamine: possible cellular mechanisms of histaminergic control of arousal. J. Neurosci. 11 (10), 3188_3199.

[51] Sakurai T, Amemiya A, Ishii M, Matsuzaki I, Chemelli RM, Tanaka H, Williams SC, Richardson JA, Kozlowski GP, Wilson S, Arch JR, Buckingham RE, Haynes AC, Carr SA, Annan RS, McNulty DE, Liu WS, Terrett JA, Elshourbagy NA, Bergsma DJ, Yanagisawa M (February 1998). "Orexins and orexin receptors: a family of hypothalamic neuropeptides and G protein-coupled receptors that regulate feeding behavior". Cell. **92** (4): 573-85. doi:10.1016/S0092-8674(00)80949-6

[52] Lazarus M, Oishi Y, Bjorness TE and Greene RW (2019) Gating and the Need for Sleep: Dissociable Effects of Adenosine A_1 and A_{2A} Receptors. *Front. Neurosci*. 13:740. doi: 10.3389/fnins.2019.00740

[53] Nitsch R. 2012. Gehirn, Geist und Bedeutung: Zur Stellung der Neurowissenschaften in der Leib-Seele-Diskussion. Münster (Germany): Mentis. p. 17.

[54] Nitsch R. 2012. Gehirn, Geist und Bedeutung: Zur Stellung der Neurowissenschaften in der Leib-Seele-Diskussion. Münster (Germany): Mentis. p. 17.

[55] Abdullah Alabdulgader.The Ancient Wisdom at Intersection with Modern Cardiac Sciences.Special issue. submitterd to Heart and Mind Journal

[56] Penfield W. 1938. The cerebral cortex in man: I. The cerebral cortex and consciousness. Arch Neurol Psychiatry. 40(3): 417-442.

[57] Kolb B, Teskey GC. 2012. Age, experience, injury, and the changing brain. Dev Psychobiol. 54(3):311-325.

[58] R. Nitsch1,2 and F. W. Stahnisch3,4. Neuronal Mechanisms Recording the Stream of Consciousness–A Reappraisal of Wilder Penfield's (1891-1976) Concept of Experiential Phenomena Elicited by Electrical Stimulation of the Human Cortex. Cerebral Cortex, September 2018;28: 3347-3355. doi: 10.1093/cercor/bhy085

[59] Bjorn Merker. Consciousness without a cerebral cortex: a challenge for neuroscience and medicine. Review Behav Brain Sci 2007 Feb;30(1):63-81; discussion 81-134. doi: 10.1017/S0140525X07000891.

[60] Penfield W. & Jasper, H. (1954) *Epilepsy and the Functional Anatomy of the Human Brain*, Boston, MA: Little and Brown.

[61] James M. Sprague. Interaction of Cortex and Superior Colliculus in Mediation of Visually Guided Behavior in the Cat. *Science* 23 Sep 1966: Vol. 153, Issue 3743, pp. 1544-1547. DOI: 10.1126/science.153.3743.1544

[62] Bjorn Merker "Consciousness without a cerebral cortex: A challenge for neuroscience and medicine" *Behavioral and Brain Sciences* **30**:63-81 (2007).

[63] Lionel Feuillet, Henry Dufour, Jean Pelletier. Brain of a white-collar worker. Lancet 2007; 370: 262

[64] Witelson SF, Kigar DL, Harvey T. The exceptional brain of Albert EInstein. *Lancet* 1999; **3 5 3 :** 2 1 4 9-5 3 .

[65] *M Galaburda*. Albert Einstein's brain. THE LANCET • Vol 354 • November 20, 1999

[66] Lacey JI. Psychophysiological approaches to the evaluation of psychotherapeutic process and outcome. In: Rubinstein E, Parloff M, eds. *Research in Psychotherapy* Washington, DC: American Psychological Association, 1959:160-208.

[67] Lacey JI, Kagan J, Lacey BC, Moss HA. The visceral level: Situational determinants and behavioral correlates of autonomic response patterns. In: Knapp PH, ed. *Expression of the Emotions in Man*. New York: International Universities Press, 1963: 161-196.

[68] Wolk C, Velden M (1989) Revision of the baroreceptor hypothesis on the basis of the new cardiac cycle effect. In Psychobiology: issues and applications. Amsterdam: Elsevier Science Publishers B.V. 371-379.

[69] Lane RD, Reiman EM, Ahem GL, Thayer JF (2001) Activity in medial prefrontal cortex correlates with vagal component of heart rate variability during emotion. *Brain Cognit* 47: 97-100.

[70] Abdullah A Alabdulgader. The human heart rate variability; Neurobiology of psychophysiological well being and planetary resonance. Editorial. *Gen Int Med Clin Innov,* 2017.Volume 2(2): 2-4. doi: 10.15761/GIMCI.1000141

[71] McCraty R, Atkinson M, Tomasino D, Bradley RT (2009) The coherent heart: heartbrain interactions, psychophysiological coherence, and the emergence of system-wide order. Boulder Creek, CA: Institute of Heartmath.

[72] Lane RD, Reiman EM, Ahem GL, Thayer JF (2001) Activity in medial prefrontal cortex correlates with vagal component of heart rate variability during emotion. *Brain Cognit* 47: 97-100.

[73] Hyeong-Dong Park, Stéphanie Correia, Antoine Ducorps, Catherine Tallon-Baudry (2014) Spontaneous fluctuations in neural responses to

heartbeats predict visual detection. *Nature Neuroscience* 17: 612-618.

[74] McCraty, R., M. Atkinson, and R.T. Bradley, *Electrophysiological evidence of intuition: Part 2. A system-wide process?* Journal of Alternative and Complementary Medicine, 2004. **10**(2): p. 325-336. (Plenary lecture in King of Organs 2008 Conference)

[75] Cameron, O.G. (2002). *Visceral Sensory Neuroscience:Interception*. New York: Oxford University Press

[76] McCraty, R., Atkinson, M., Tomasino, D., and Bradley, R.T. (2009b). The coherentheart:heart-brain interactions, psychophysiological coherence, and the emergence of system wide order. *Integral. Rev.* 5, 10-115.

[77] Armour, J.A., and Kember, G.C. (2004). "Cardiacsensoryneurons," in *Basicand Clinical Neurocardiology*, eds J.A. Armourand J.L. Ardell (New York: Oxford UniversityPress), 79-117.

[78] Hassert, D.L., Miyashita, T., and Williams, C.L. (2004). The effects of peripheral vagal nerve stimulation at memory-modulating intensity on norepinephrine out put in the basolateralamygdala. *Behav.Neurosci*. 118, 79-88.doi: 10.1037/0735-7044.118.1.79

[79] Kosel, M., and Schlaepfer, T.E. (2003). Beyond the treatment of epilepsy: new applications of vagus nerve stimulation in psychiatry. *CNS Spectr.* 8, 515-521.

[80] Groves, D.A., and Brown, V.J. (2005). Vagal nerve stimulation: are view of its applications and potential mechanisms that mediate its clinical effects. *Neurosci. Biobehav.Rev.* 29, 493-500.doi:10.1016/j.neubiorev.2005.01.004

[81] Tiller WA1, McCraty R, Atkinson M (1996) Cardiac coherence: a new, noninvasive measure of autonomic nervous system order. *Altern Ther Health Med* 2: 52-65. [Crossref]

[82] Rollin McCraty, Fred Shaffer (2015) Heart Rate Variability: New Perspectives on Physiological Mechanisms, Assessment of Self-regulatory Capacity, and Health Risk. *Glob Adv Health Med* 4: 46-61. [Crossref]

[83] Bradley, R.T., McCraty, R., Atkinson, M., Tomasino., D., *Emotion Self-Regulation, Psychophysiological Coherence, and Test Anxiety: Results from an Experiment Using Electrophysiological Measures.* Applied Psychophysiology and Biofeedback, 2010. **35**(4): p. 261-283.

[84] McCraty, R., et al., *The coherent heart: Heart-brain interactions, psychophysiological coherence, and the emergence of system-wide order*. 2006, Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 06-022.

[85] McCraty, R. and D. Childre, *The grateful heart: The psychophysiology of appreciation*, in *The Psychology of Gratitude*, R.A. Emmons and M.E. McCullough, Editors. 2004, Oxford University Press: New York. p. 230-255.

[86] McCraty, R., M. Atkinson, and D. Tomasino, *Impact of a workplace stress reduction program on blood pressure and emotional health in hypertensive employees.* Journal of Alternative and Complementary Medicine, 2003. **9**(3): p. 355-369.

[87] Martina Corazzol1, Guillaume Lio1, Arthur Lefevre,et al. Restoring consciousness with vagus nerve stimulation. Correspondence. Current Biology *27*, R979–R1001, September 25, 2017

[88] Alabdulgader, A., *Coherence: A Novel Nonpharmacological Modality for Lowering Blood Pressure in Hypertensive Patients.* Global Advances in Health and Medicne, 2012. **1**(2): p. 54-62.

[89] Abdullah Alabdulgader (2016) Modulation of heart rate variability: A novel nonpharmacological modality

for lowering blood pressure in in hypertensive patients. *J Clin Exp Cardiolog*

[90] Starr MacKinnon, Richard Gevirtz, Rollin McCraty, Milton Brown (2013) Utilizing Heartbeat Evoked Potentials to Identify Cardiac Regulation of Vagal Afferents During Emotion and Resonant Breathing. Appl Psychophysiol Biofeedback 38: 241-255. [Crossref]

[91] Hyeong-Dong Park1, Fosco Bernasconi1, Roy Salomon2, Catherine Tallon,et al. Neural Sources and Underlying Mechanisms of Neural Responses to Heartbeats, and their Role in Bodily Self-consciousness: An Intracranial EEG Study. Cerebral Cortex, July 2018;28: 2351-2364. doi: 10.1093/cercor/bhx136

[92] Frederike H.Petzschner et al, Focus of attention modulates the heartbeat evoked potential. NeuroImage Volume 186, 1 February 2019, Pages 595-606

[93] Kevin S. Saroka, Michael A. Persinger. Quantitative Evidence for Direct Effects Between Earth-Ionosphere Schumann Resonances and Human Cerebral Cortical Activity. *International Letters of Chemistry, Physics and Astronomy Online: 2014-10-02 ISSN: 2299-3843, Vol. 39, pp 166-194.doi:10.18052/www.scipress.com/ILCPA.39.166.2014 SciPress Ltd, Switzerland*

[94] *Rollin McCraty. SCIENCE OF THE HEART Exploring the Role of the Heart in Human PerformanceVolume 2. Published by: HeartMath Institute.*

[95] Halberg, F., et al., Cross-spectrally coherent ~10.5- and 21-year biological and physical cycles, magnetic storms and myocardial infarctions. Neuroendocrinology, 2000. **21**: p. 233-258.

[96] *McCraty R, Atkinson M, Tomasino D, Bradley R. The coherent heart: heartbrain interactions, psychophysiological coherence, and the emergence of system-wide order. Integr Rev (2009) 5(2):10-115.*

[97] *McCraty R. The energetic heart: bioelectromagnetic communication within and between people. In: Rosch PJ, Markov MS, editors. Bioelectromagnetic Medicine. New York: Marcel Dekker (2004). p. 541-62.*

[98] *Cherry, N. Schumann Resonances, a plausible biophysical mechanism for the human health effects of Solar/ Geomagnetic Activity.Natural Hazards* **26***, 279-331 (2002).*

[99] Ghione, S., Mazzasalma, L., Del Seppia, C. & Papi, F. Do geomagnetic disturbances of solar origin affect arterial blood pressure?Journal of Human Hypertension **12**, 749-754 (1998).

[100] *Hamer, J. R. Biological entrainment of the human brain by low frequency radiation. Northrop Space Labs, 65-199 (1965).*

[101] *Chernouss, S., Vinogradov, A. & Vlassova, E. Geophysical Hazard for Human Health in the Circumpolar Auroral Belt: Evidence of a Relationship between Heart Rate Variation and Electromagnetic Disturbances. Natural hazards* **23***, 121-135 (2001).*

[102] *Gordon, C. & Berk, M. The effect of geomagnetic storms on suicide. South African Psychiat Rev* **6***, 24-27 (2003).*

[103] *Kay, R. W. Geomagnetic Storms: Association with Incidence of Depression as Measured by Hospital Admission. British Journal of Psychiatry* **164***, 403-409 (1994).*

[104] *Kay, R. W. Schizophrenia and season of birth: relationship to geomagnetic storms. Schiz Res* **66***, 7-20 (2004).*

[105] *Nikolaev, Y. S., Rudakov, Y. Y., Mansurov, S. M. and Mansurova, L. G. Interplanetary magnetic field sector structure and disturbances of the central*

nervous system activity. Reprint N 17a, Acad. Sci USSR, IZMIRAN, Moscow, 29 (1976).

[106] *Oraevskii, V. N. et al. Effect of geomagnetic activity on the functional status of the body. Biofizika* **43***, 819-826 (1998).*

[107] *Halberg, F., Cornelissen, G., Panksepp, J., Otsuka, K. & Johnson, D. Chronomics of autism and suicide. Biomed Pharmacother* **59***(1), S100-108 (2005).*

[108] *Berk, M., Dodd, S. & Henry, M. Do ambient electromagnetic fields affect behaviour? A demonstration of the relationship between geomagnetic storm activity and suicide. Bioelectromagnetics* **27***, 151-155 (2006).*

[109] *Timofejeva I, McCraty R, Atkinson M, Joffe R, Vainoras A, Alabdulgader AA, Ragulskis M. Identification of a Group's Physiological Synchronization with Earth's Magnetic Field. Int J Environ Res Public Health. 2017 Sep 1;14(9):998. doi: 10.3390/ijerph14090998. PMID: 28862697; PMCID: PMC5615535.*

[110] McCraty R, Atkinson M, Stolc V, Alabdulgader AA, Vainoras A, Ragulskis M. Synchronization of Human Autonomic Nervous System Rhythms with Geomagnetic Activity in Human Subjects. Int J Environ Res Public Health. 2017;14(7):770. Published 2017 Jul 13. doi:10.3390/ijerph14070770

[111] Abdullah Alabdulgade, Rollin McCraty, Mike Atkinson, Alfonsas Vainoras, Kristina Berškiene, et al. (2015) Human Heart Rhythm Sensitivity to Earth Local Magnetic Field Fluctuations. Journal of Vibroengineering:17.

[112] Franz Halberg, Germaine Cornélissen, Rollin McCraty, Jerzy Czaplicki, Abdullah A. Al-Abdulgader (2011) Time Structures (Chronomes) of the Blood Circulation, Populations' Health, Human Affairs and Space Weather. World Heart Journal 3.

[113] Abdullah A. Al-Abdulgader, Germaine Cornélissen Guillaume, Franz Halberg (2011) Vascular Variability Disorders in the Middle East:Case Reports. World Heart Journal 2.

[114] Inga Timofejeva , Rollin McCraty, Mike Atkinson, Roza Joffe, Abdullah A. Alabdulgader , Alfonsas Vainoras, Mantas Landauskas, , Minvydas RagulskisGlobal Study of Human Heart Rhythm Synchronization with the Earth's Time Varying Magnetic Field,Underr review in the BMC Bioinformatics journal.

[115] Belov, D. R., Kanunikov, I. E. & Kiselev, B. V. Dependence of human EEG synchronization on the geomagnetic activity on the day of experiment. Ross Fiziol. Zh Im I M Sechenova **84**, 761-774 (1998).

[116] Elhalel G, Price C, Fixler D, Shainberg A. Cardioprotection from stress conditions by weak magnetic fields in the Schumann resonance band. Nature Scientific Reports. 2019;**9**(1).

[117] Alabdulgader A, McCraty R, Atkinson M, Dobyns Y, Vainoras A, Ragulskis M, et al. Long-Term Study of Heart Rate Variability Responses to Changes in the Solar and Geomagnetic Environment [Internet]. Nature News. Nature Publishing Group. 2018. Available from: https://www.nature.com/articles/s. 41598-018-20932-x

[118] Siying Qin1, Hang Yin1, Celi Yang, Yunfeng Dou, et al .A magnetic protein biocompass. NATURE MATERIALS. 16 NOVEMBER 2015 | DOI: 10.1038/NMAT4484

[119] Roger D. Nelson. The Global Consciousness Project's Event-Related Responses Look Like Brain EEG Event-Related Potentials.Journal of Scientific Exploration, Vol. 34, No. 2 pp. 246-267, 2020