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Review Article

Toward A Quantum Pain Concept

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Abstract

Pain hasn't been objectively defined and evaluated until now. The generally accepted definition of pain bears so many missing parts which bring exceptions to the definition. Something which can not be scientifically well defined can not be measured precisely and treated correctly. The reason might be the classical mechanistic approach to try to discover a specific center in the brain or ascending pathway specific to pain. This approach has been failed and new concepts such as pain matrix or dynamic pain connectome have been proposed. We believe that quantum information theory together with complex and chaotic system analysis should be used to evaluate pain because its network is a multifractal and non-linear system to be analyzed with the methods of quantum mechanics. Thus, a new way of pain concept using quantum mechanics should be developed.

Introduction

Descartes' reflex theory, explaining the transmission of pain, through a single channel from the skin to the brain has directed both the study and treatment of pain for more than 300 years. It is still considered in physiology textbooks as fact rather than theory. The gate control theory proposed by Melzack and Wall, led to further investigation of spinal sensitization and central nervous system plasticity [1].

Since researchers have failed so far to identify specific cortical regions particular for the perception of pain, Ronald Melzack has developed the concept of Neuromatrix, as a widespread ensemble of neurons integrating different sources of nociceptive and non-nociceptive input. The function of the Neuromatrix has not been restricted just to the perception of pain, but also to many other possible perceptual subjects. The experience of pain is not just the result of the activity of a particular cortical area containing specific nociceptive neurons exclusively ''encoding'' pain. The neuromatrix, a network of neurons,turns the flowing information into a pattern as a sense of whole body. Both conventional macroscopic and microscopic neuroimaging approaches have repeatedly failed to isolate a''neural representation'' of pain in the brain. Neuroimaging and neurophysiological studies have shown that nociceptive stimuli provoke an extensive cortical network, so-called "pain matrix" including somatosensory, insular and cingulate, frontal and parietal areas [2,3].

Pain is a complex, multidimensional experience involving bilateral network of brain regions, activated depending on a number of factors such as context, stimulus, cognition, and emotion. To identify a so-called pain signature has resulted in the identification of regions, most essential to experiencing pain such as the descending pain modulatory system comprised of the periaqueductal gray (PAG) and rostral ventromedial medulla (RVM), as well as the reward-motivation network, including the perifrontal cortex (PFC), nucleus accumbens (NAC), and the ventral tegmental area (VTA) only as part of a larger system [4].

In search for a "neural signature", the discovery of a spontaneous brain-wide network communication being intrinsically dynamic on multiple time scales, led to the concept of a dynamic "pain connectome" in the brain [5].

Powerful ultrastructural tools have revealed anatomically well defined synaptic connections but the functional connectivity is actively shaped by neuromodulators that modify neuronal dynamics, excitability and synaptic function to reconfigure information processing by changing the composition and activity of functional circuits. Each ultrastructural connectivity map encodes multiple circuits either active or latent at any given time for alternative modes of information processing. These connections seem to be a set of alternatives, and not a set of invariant instructions. Defining the connectome is like sequencing the genome. Both for the genome and for the connectome, structure does not solve function. What the structure provides is a better overview, a glimpse of the limits of the problem, a set of hypotheses to be still tested by a framework with greater precision and power [6].

Multifractal analysis performed in space and in time proved that the connectome is multifractal. This result is of valuable importance since this particular multifractal analysis serves as a numerical measure of the spatial complexity of the neuron and correlates with the morpho-functional organization of such cells. The quantitative estimations indicate that neuron connections modify and modulate their multifractal regime constantly in time,and confirm that multifractal analysis enables distillation of the spatial complexity and morphofunctional organization under a dynamical time regime[7].

Complexity science is an attempt to understand the complex recursive and emergent properties of systems [8].

The biopsychosocial approach addresses the complexity of interactions between different domains of functioning and argues that it is the interaction of domains that illuminate important processes[9].

It is becoming clear that the pain experience is determined by a multitude of factors. Although pain research has traditionally focused on the sensory modalities and the neurological transmissions identified solely on a biological level, more attention is being placed on factors related to cognitive, affective, behavioral, and homeostatic factors and more recent theories integrating the body, mind, and society, have been developed. The most heuristic perspective is the biopsychosocial model, considering pain as a dynamic interaction among and within the biological, psychological, and social factors unique to each individual [10].

Biopsychosocial - Spiritual Model

Biopsychosocial researchers have studied the role of optimism and pessimism, hope, anxiety, fear, and depression, in pain perception and they have reported that a cyclical pattern of chronic pain leads to depression and depression causes an increase in chronic pain, creating a mutually reinforcing relationship and that anxiety and fear may exacerbate pain. They have presented a biopsychosocial-spiritual model, taking into account also the role of religious and spiritual belief systems in the appraisal process of pain, acknowledging the biological, psychological and social dimensions of the pain experience. Beliefs, words and images that evoke a source of love, support, and comfort reduce stress and exert a therapeutic effect. Fearful or pessimistic individuals worsen their pain. The development of hope, optimism, self-efficacy, and the ability to tolerate and accept pain, even words can affect the perception and tolerance of pain. They have a powerful effect on expectation, because their meaning may create fear or hope [10, 11].

Emotional states, intention, stress, and other psychosocial factors can significantly affect biological function and health outcomes. Emotional states generate corresponding metabolic biomagnetic fields that radiate in patterns reflecting these emotional states [12,13].

The informational content of subtle low energy light signaling may be more important than the physical energy of the input signal. The biophoton emission, also called ultraweak photon emission is the spontaneous emission of light emanating from all living organisms, including humans. Signaling by coherent biophotons explain many regulatory functions, including cellular orientation detection, biophoton regulation of neurotransmitter release, leukocyte respiratory activity, and enhanced seed germination [14-16].

Under specific conditions changes in photon emissions may reflect intercellular and interbrain communications with potential quantum-like properties. Quantum molecular computation, allows the interpretation of neuron modifications and ion channel function [17,18].

Inspired by the application of quantum theoretical methods to the study of the brain and other biological structures, scientists began to investigate brain functioning from the microscopic level of quantum physics. Recent experiments demonstrated that quantum information storage on the time scale of minutes or even hours is possible. Experimental and theoretical studies, evidence that the basic conceptual foundations of quantum mechanics can explain the basic functions of brain dynamics at perceptive and cognitive level. The most original peculiar feature of the brain is that it constantly attempts to realize predictions about the future and in such operations, the brain moves with intrinsic indetermination [19].

The necessity of using quantum mechanics as a fundamental theory applicable to some key functional aspects of biological system is especially relevant to three important parts of a neuron in the human brain, namely the cell membrane, microtubules and ion channels [20]. Human brain behaves like a non-linear mirror and does not create copies of the environmental reality and optical images are derived inverted in the brain. Via quantum entanglement, a quantum state can be moved from one point of the nervous system to the brain and vice versa. [21, 22].

Since the "quantum entanglement" term is applicable exclusively to the objects of microworld, particularly at submolecular level, it is more correct to use it "entanglement between neuron structures at submolecular level" instead of "quantum entanglement between nerve cells" [23]. The existence of non-trivial quantum effects is necessary for the functioning of living systems. It is demonstrated that classical mechanics cannot explain the stable work of the cell and any over-cell structure. Complex bio-systems process information by violating the laws of classical probability and information theory, as it is so called quantum-like paradigm. Therefore, the mathematical apparatus of quantum theory may be applied to describe behavior of bio-systems from cells to brains, ecosystems and social systems. To test the role of quantum mechanics in living systems, a detailed study of living systems on the level of individual atoms and molecules is required [24-26].

In the quantum model, structural and functional characteristics consistent with collective quantum coherent excitations possess a clocking mechanism on a sub-nano second scale in the aromatic groups of their tryptophan residues, and this phenomenon analogous in light-harvesting complexes in plants and bacteria, is induced by photons as evidence of quantum processes in biology [27, 28].

Conventional medicine follows conventional biology, conventional chemistry, and conventional physics in treating the material body- a complex, nonlinear system assembled from the same atoms and molecules that constitute nonliving objects. Conventional biochemistry refers to the readily measurable exchanges of energy within organisms, and between them and their environment, which occur by normal physical and chemical processes. This bioenergetic field as a holistic living force goes beyond reductionist physics and chemistry and can be considered as some special form of electromagnetism. Advocates claim that measurable electromagnetic waves are emitted by humans [29].

Biofield

Developments in biophysics, biology, functional genomics, metabolomics, neuroscience, psychology, and psychoneuroimmunology are interrelated from the level of basic biological processes to a dynamic systems or "biofield" level [30].

The term biofield can be defined as "an organizing principle for the dynamic information flow that regulates biological function and homeostasis". Molecular, cellular, and organismic function and regulation can be influenced by emotion, cognition, and psychosocial factors, within a "subtle" low-energy system of biofield interactions connecting these activities. Biofield interactions may modulate biological activity and informational content of biological processes operating via low-energy or "subtle" processes such as weak, nonthermal electromagnetic and quantum fields or processes related to consciousness and nonlocality. Biofield interactions can influence and be influenced by a variety of biological pathways, including biochemical, cellular, and neurological processes related to electromagnetism, and correlated quantum information flow across multiple scales of biology. Biofield interactions can organize spatiotemporal biological processes across hierarchical subtle and gross levels: from the subatomic, atomic, molecular, cellular, and organismic to the interpersonal levels [31-33].

In the so-called Biofield Hypothesis, there are extemely weak electromagnetic fields inside the organisms that are involved in growth, repair, and healing, which happens all the time within the body. Any intervention can be either structural, biochemical or regulatory. An example of a structural change is the use of surgical techniques for removing an obstruction or unwanted growth. Biochemical interventions are biomedical drugs and naturally occurring herbs. The regulatory ones are those related to genetic and weak electromagnetic information that control all aspects of cell dynamics. The biofield hypothesis is thought to be useful in understanding the scientific basis of energy medicine, which includes such diverse practices as homeopathy, acupuncture, and various healing methods. The biofield is defined as an endogenous dynamic electromagnetic field to an organism in its self-regulation and control. Each cell, tissue, and organ can be considered as generating and being influenced by this complex electromagnetic field. There are many models of healing based on quantum physics and quantum chemistry [34].

Quantum Physics and Chemistry

Quantum physics challenge the perceived "objectivity" of rationalist science. Despite the advances in medical science, there is still an intellectual gap to explain how the physics of matter became translated to the biology of life and application of quantum mechanics to human physiology, in particular to aspects of brain activity and pathology. Quantum biology is a new field between physics and biology promising new insights into the nature and origin of biological order [35-37].

A new field of quantum chemistry was developed with the extensions of quantum mechanics to chemical compounds and chemical reactions. In order to understand the creation of chemical bonds, especially covalent bonds in which electrons are shared between atoms of a molecule, a quantum mechanical wave function must be introduced into the formalism. All chemistry including biochemistry is based on the creation and destruction of bonds between atoms and hence on quantum interactions, so living systems, like non-living systems, depend on quantum states at the level of chemical bonds. The same can be said about biochemical reactions taking place in the brain such as ligands binding to receptors sending signals through neurons. However, quantum effects are washed out at scales larger than individual atoms or sub-atomic particles, at warm temperatures, and in aqueous media which provide a noisy environment for particle interactions. Collective quantum states of cells lead to entanglements between cells and coherence over organs and tissues, e.g., the entire brain or regions of the brain [26,38,39].

Functional neuroimaging reveals that certain brain regions are primed to decide whether a stimulus is painful. Bilateral anterior insula activation predicts whether a subsequent stimulation is painful or not [40].

Conclusion

The experience of pain is more than the movement of nociceptive impulses through hardwired pain pathways from the periphery to the brain. The crucial journey actually occurs inside the brain itself, through pain-relevant brain areas and top-down cortico-subcortical routes, as well as through the cortico-cortical highway, which gives meaning to pain in terms of intensity, quality and salience. Given its vast and varied role in pain modulation, the brain can not be totally devoid of skin with its abundant pain the receptors [41].

Pain is finally perceived and being given meaning in the brain eventhough we don't know yet the exact locations and mechanisms. What we understand, is that we should not follow to find a center and a specific pain pathway but rather we should try to analyze the pain network in its alterations. The analysis of such connectome should be done using quantum methods, such as multifractalanalysis, and take the pain connectome as a non-linear dynamic, chaotic and complex system. Consequently, we think that a new approach for pain assessment should be developed with quantum methods to be used in diagnosis and therapy of chronic pain.

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