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LOSING THE QUANTUM STATE OF MICROTUBULES TO SOUL: POSSIBILITIES AND CHALLENGES

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Abstract

Microtubules are the main component of a supportive structure within neurons. One group of scientists have argued that information in the microtubules constitutes the 'soul' or 'consciousnesses. 'Quantum consciousness' refers to the idea that the brain is similar to a quantum computer and that consciousness is related to the state of quantum information in the brains. When the body dies, the microtubules lose their quantum state but retain the quantum information which can never be lost. The soul remains and dissipates in the Universe as quantum information which can be restored into a microtubule when a dying patient is resuscitated. The second group of scientists suggested that quantum systems in the brain decohere quickly and cannot control brain function which contradicts the interpretations that the brain behaves like a quantum computer and that quantum coherence is associated with consciousness in a fundamental way. The purpose of the present paper is to open a more rigorous argument on the basis of the existing theories and information on quantum consciousness caused by transformation of microtubules to soul and to re-look whether the covered area can be more appropriately interpreted by taking help of classical physics or the quantum mechanics.

INTRODUCTION

During the last two decades there have been significant developments in our understanding of the physical world. Implementation of quantum mechanics may be considered as one of the very important scientific revolution to date in human history. The replacement of classical physics by quantum physics demands a thoroughgoing modification of our worldview. More specifically, from philosophical point of view, one might say that it needs a major modification of our fundamental metaphysics. It is claimed sometimes that quantum mechanics can be used to prove that the Universe is indeterministic and that there are a multitude of parallel Universes. Still others claim that quantum mechanics proves that there is no objective world outside of our perceptions. Microtubules are the main component of a supportive structure within neurons and have a well established position in conventional biology and neuroscience. In addition to a supportive structure, the known functions of microtubules include transport of molecules covering neurotransmitters bound for synapses and control of the development of the cell. They are mainly composed of tubulin protein dimmer subunits each have hydrophobic pockets that are 8 nm apart and may contain delocalized pi electrons. The purpose of the present paper is to open an argument on quantum consciousness caused by transformation of microtubules to soul and to re-look whether the covered area can be more appropriately interpreted by taking help of classical physics or the quantum mechanics.

Classical Physics *vis-a-vis* Quantum Mind

Classical physics is a catch-all phrase for a good number of theories developed between the time of Galileo Galilei and Maxwell. These theories are basically stood on two main aspects, *viz.* (i) the state of each object in the world which can be well specified by assigning values to quantitative properties like its position, velocity, mass, etc. and (ii) there are laws of nature e.g., the state of each object at any future time can be completely determined by the state of all objects at any previous time. The classical physics can also pursued a strategy of reductionism by determining a small number of basic quantities wherefrom the values of all other quantities could be obtained in principle. These basic quantities include things like position and velocity but exclude many other quantities like colour and temperature which belong centrally in our everyday lives. Physicists at the late nineteenth century found ways to use classical mechanics in cases where precise knowledge of the states of objects is highly lacking. Thus from an elementary idea of the states of objects, the (deterministic) dynamical laws of the theory can be implemented to yield partial knowledge about the future states of objects.

The hypothesis based on quantum mind or the so called 'quantum consciousness' proposes with a strong view that classical mechanics is unable to explain consciousness. On the contrary, the quantum mechanical phenomena, such as quantum entanglement and superposition, may play a very crucial role in the brain's function and as a matter of fact could form the basis of an explanation of consciousness.

Some theoretical physicists have strongly argued that classical physics is intrinsically incapable of explaining the holistic aspects of consciousness while the quantum theory has the ability to provide the missing aspects though at the same time many others have a different view. In fact, some physicists and philosophers boldly consider the role of quantum phenomena to be unconvincing[1]. Even, physicist Stenger[2] characterized quantum consciousness as a simple myth without any scientific basis. The main argument against the quantum mind proposition pointed out that those quantum states in the brain would decohere before they attained a spatial or temporal scale where they could be useful for neural processing. According to Tegmark the quantum systems in the brain decohere quickly and unable to control brain function[3, 4]. Philosopher David Chalmers also argued against quantum consciousness by speculating in a number of ways with a view to relate quantum mechanics to consciousness[5]. However, Chalmers was sceptical about the ability of any kind of new science for resolving the problem of consciousness[6, 7].

The Theory of Quantum Consciousness

On the recently emerging subject of quantum consciousness several quite distinct theories have been developed as outlined below.

Hameroff and Penrose first independently made their investigations and thereafter join forces to forward a new theory of quantum consciousness[8-11]. 'Quantum consciousness' refers to the idea that the brain is similar to a quantum computer and that our consciousness is related to the state of quantum information in our brains. Quantum theory has weird elements. It suggests that particles can be in a superposition of energies, rather than one fixed energy. It can have a 'spread out' position instead of one pinpoint location and that two systems separated from each another, might still be able to 'communicate' with one other, if they were linked to begin with. This idea is one of 'coherence'. If two systems are quantum mechanically linked or 'entangled', then by measuring one affects the other instantaneously, violating the intuitive concepts of Einstein's relativity. This can be further illustrated by saying that if a system A is entangled to system B then measurement of A will affect B, no matter how far B is situated from A. This instantaneous change of state has been hypothesized for making quantum computers wherein information is stored in energy levels and since there are more than two energy levels, the concept of two-bit limitation of a normal computer is not appropriate here. The much more stored information in a super computer can be handled to perturb a part of the system when immediately some other part of the system will be affected. However, for a machine to behave as a quantum computer the two systems mentioned as A and B must remain 'coherent'. If under any situation they disentangle, then they no longer form a quantum computer. In practice, there is a typical 'decoherence time', the time required for two entangled systems to disentangle.

Penrose and Hameroff[12] clearly pointed out that inside the neurons, there are tiny structures called microtubules. Microtubules are a major component of the cytoskeleton that helps cells to maintain their shapes. They are hollow cylinders of diameter D = 24 nm made up of 13 filaments that are strung together out of proteins called tubulin dimmers which can make transitions between two states marked as A and B, corresponding to different electric dipole moments along the axis of the tube. It has been strongly believed that microtubules may have additional functions to serve as a means of energy and information transfer. Information in these microtubules is what constitutes the 'soul' or 'consciousnesses. When the body dies, the microtubules lose their quantum state but retain the quantum information which can never be lost. Thus, the soul remains and is dissipated in the universe at large. Penrose and Hameroff dodge the cycle of births and further highlighted on near death experiences[8-11]. They suggested that the information can be restored into a microtubule when a dying patient is resuscitated.

Penrose[13] further argued that the brain had the ability to go beyond what could be achieved by axioms or formal systems. This meant that the brain had some additional function that was not based on algorithms whereas a computer is driven solely by algorithms. He asserted that the brain could perform highly complicated functions that no computer could perform and called this type of processing non-computable. He then went on to consider what it was in the human brain which was not driven by algorithms. Given the algorithm-based nature of most of physics, he assumed that the random choice of position etc. that happens when a quantum wave collapses into a particle was the only possibility for a non-computable process[14]. Penrose admitted that the randomness of the wave function collapse is not a basis for any useful form of human understanding.

Penrose[13] then proposed a second form of wave function collapse that could apply where quanta did not interact with the environment and suggested that each quantum superposition has its own piece of space-time curvature. When these become separated by more than the Planck length of 10^{-35} meters, they become unstable and collapse. This form of collapse was called by him '*objective reduction*'. According to him the objective reduction does not represent randomness nor the algorithm based processing but instead a non-computable influence embedded in the fundamental level of space-time geometry wherefrom mathematical understanding of the theory of consciousness derived. However, Penrose lacked a detailed explanation of how quantum processing could be implemented in the brain though Hameroff[15] suggested that microtubules could be suitable candidates for quantum processing, a hypothesis which remains intensely controversial.

Other Quantum Mind Approaches

David Bohm suggesting a more fundamental level in the physical Universe[8] proposed that quantum theory and relativity contradicted each other. From various considerations he claimed that both quantum theory and relativity can be suitably utilized to develop a deeper theory on quantum consciousness. He pointed out that this more fundamental level may represent an undivided wholeness and an implicate order wherefrom one may arrive at the explicate order of the universe. He suggested that the implicate order can be applied to both matter and consciousness to develop strong relationship between them. He also clarified that when we look at the matter in space, we can find nothing in these concepts which may help to understand consciousness.

In order to explain the nature of consciousness, Bohm[8] considered the experience of listening to music. He thought that the feeling of movement and change that make up our experience of music derives from both the immediate past and the present. Both of them act in the brain together, with the notes from the past seen as transformations rather than memories. The notes implicated in the immediate past are seen as becoming explicated in the present. He considered this as consciousness emerging from the implicate order. Bohm observed the movement and claimed to derive evidence for this from the work of Piaget[9] in studying infants. He stated that these investigations reveal that young children have to learn about time and space as they are part of the explicate order but have a "hard-wired" understanding of movement, as it is part of the implicate order. He compared this "hard-wiring" to the theory of Chomsky that grammar is "hard-wired" into young human brains[9]. However, Bohm was unable to propose any specific brain mechanism by which his implicate order could emerge in a way that was relevant to consciousness.

Another neuroscientist Georgiev[10], has provided a footnote to the Orch-OR theory accepting a major portion of Penrose's ideas, but criticising a good part of Hameroff's concept. Georgiev proposed that quantum coherence on the surface of the microtubules extends through presynaptic scaffold proteins to the synapses influences synaptic firing and is transmitted across the synaptic cleft to other neurons. The debate about Hameroff's proposals has critically analyzed by Reimers et al[11] and McKemmish et al.[16]. These papers claimed that microtubules could only support 'weak' 8 MHz coherence while the Orch-OR proposals required a higher rate of coherence. However, Hameroff claimed that 8 MHz coherence is sufficient for supporting the Orch-OR proposal. In an elaborate study McKemmish et al. made two claims (I) firstly that aromatic molecules cannot switch states as they are delocalized and (II) secondly changes in tubulin conformation driven by GTP conversion would result in a prohibitive energy requirement. In reply Hameroff claimed that he is referring to the behaviour of two or more electron clouds and all that is required is switching in electron cloud dipole states produced by London forces.

Main Argument against the Quantum Mind

The main argument against the quantum mind proposition was elaborated by Tegmark[3]. According to him quantum states in the brain would decohere before they reached a spatial or temporal scale where they could be useful for neural processing. Based on his calculations, Tegmark concluded that quantum systems in the brain decohere quickly and cannot control brain function which contradicts the suggestions that the brain behaves like a quantum computer and that quantum coherence is associated with consciousness in a fundamental way[3, 4]. Based on a calculation of neural decoherence rates, Tegmark argued that the degrees of freedom of the human brain related to cognitive processes should be thought of as a classical rather than quantum system. This means there is nothing fundamental wrong with the current classical approach to neural network simulations. He also suggested that decoherence time scales are typically much shorter than the relevant dynamical time scales both for regular neuron firing and for excitations in microtubules. For the purpose of classification of systems Tegmark explained that the dynamical time scale of a subsystem represents the characteristic of internal dynamics. The qualitative behaviour of a subsystem depends on the time scales for dynamics, dissipation, and decoherence, as illustrated in Figure 1. This classification is quite crude and so the boundaries should not be thought of as sharp.

Tegmark after critical mathematical considerations came to some definite conclusions and focused that always an observer can decompose the world into three subsystems[17], as illustrated in Figure 2. These are: (i) the degrees of freedom corresponding to subjective perceptions i.e. the subject, (ii) the degrees of freedom being studied i.e. the object and (iii) everything else i.e. the environment. He suggested that the subsystem Hamiltonians *Hs*, *Ho*, *He* and the interaction Hamiltonians *Hso*, *Hoe*, *Hse* can cause qualitatively very different effects and that is why it is useful to study them separately.

Neurons, as shown in Figure 3, are one of the key building blocks of the information processing system of brain. The figure shows a schematic illustration of a neuron (left), a section of the myelinated axon (centre) and a piece of its axon membrane (right). The axon is typically insulated with small bare patches every 0.5 mm or so where the voltage sensitive sodium and potassium gates are concentrated[18].

The complex network of neurons with their nonlinear synaptic couplings is, in practice, linked to subjective perceptions. Then if *Hs* or *Hso* puts the subject into a superposition of two distinct mental states, some neurons will be in a superposition of firing and not firing. Neurons have ATP driven pumps in their membranes which push sodium ions out of the cell into the surrounding fluids and potassium ions the other way. The former process being slightly more efficient, the neuron contains a slight excess of negative charge in it's ''resting'' state, corresponding to a potential difference across the axon membrane. When the potential becomes less negative by a substantial amount, then voltage-gated sodium channels in the axon membrane open up to allow Na ions to come gushing in. This makes the potential still less negative, resulting still more opening and continuing the chain reaction, ''firing''. The ATP driven pumps restore the Na and K concentrations very quickly to their initial values and thus making the neuron ready to fire again if triggered. For the investigation, a small patch of the membrane was assumed to be roughly flat with uniform thickness *h* as shown in Figure 3. If there is an excess surface density of charge near the inside/outside membrane surfaces, giving a voltage differential *U* across the membrane, then application of Gauss' law can be applied to get the electric field strength in the membrane. If we consider an axon of length *L* and diameter *d*, then the total active surface area becomes $A = \pi \, dL \, f$, where *f* is the fraction of the axon not insulated with myelin.

Soul Entering into the Universe

The theory developed by Hemeroff and Penrose holds that the essence of our soul is contained inside structures called microtubules within brain cells[12]. They argued that our experience of consciousness is the result of quantum gravity effects in these microtubules, a theory which they dubbed as Orchestrated Objective Reduction (Orch-OR). According to them a near-death experience occurs when quantum substances forming the soul leave the nervous system and enter the universe at large. This idea further extended to the point that consciousness is a program for a quantum computer in the brain which can persist in the Universe even after death. This explains the perceptions of those who have near-death experiences and suggests that our souls have more vital role than the interaction of neurons in the brain. They are assumed to be constructed from the very fabric of the Universe and may have existed from the beginning of time[19]. To some extent the concept is similar to the Buddhist and Hindu belief that consciousness is an integral part of the Universe and it is in a wider sense similar to Western philosophical idealism. Keeping all these backgrounds, Hameroff concluded that under the near-death experience the heart stops beating, the blood stops flowing and the microtubules lose their quantum state without destroying the information within them. Instead the soul merely leaves the body and returns to the cosmos. The quantum information within the microtubules cannot be destroyed but just distributes and dissipates to the Universe at large. If the patient is revived from the near death condition, this quantum information can go back into the microtubules again.

DISCUSSIONS

The Orchestrated Objective Reduction theory as proposed by the theoretical physicist Penrose and anesthesiologist Hameroff seems that there is something unique about consciousness. While the identity between genes and DNA is empirical, the identity between consciousness and a physical state will be a sort of primitive principle in one's theory of the world. This sort of primitive principle belongs to the fundamental laws of physics and, in fact, this sort of primitiveness i.e. the inability for deducing from more basic principles is the mark of a fundamental law of nature. The epistemically primitive connection between physical states and consciousness as a fundamental law when taken into account, it follows that consciousness is distinct from any physical property, since fundamental laws always connect distinct properties. Hence the usual standard will lead to one of the no reductive views and seek to explain this uniqueness by making use of the unique features of the concept of consciousness. The problems being manifold as the behaviour of microtubules have not yet been confirmed nor has the dissipation of quantum information demonstrated. Tegmark quoted the typical 'decoherence time' for the neurons as of the order of 10^{-13} s to 10^{-20} s, much smaller than what is required for a quantum computer (~ 10^{-3} s).

On the other hand, Hameroff proposed that the electrons inside the tubulin are close enough to become quantum entangled[20], forming a state known as a Bose-Einstein condensate[21, 22]. He further added[23] that electrons inside the tubulin subunits are part of a Frohlich condensate, a coherent oscillation of dipolar molecules. He concluded that condensates in one neuron could be extended to many others through the gap junctions between neurons to form a macroscopic quantum feature across the extended area of the brain. If the wave function of this extended condensate collapsed, this could give access to non-computational influences related to mathematical understanding and finally conscious experience that are embedded in the geometry of space-time. The activity of these condensates, according to him, is the source of gamma wave synchronization in the brain which has also been viewed as a possible factor to correlate consciousness in conventional neuroscience, and in turn to be linked to the functioning of gap junctions[23].

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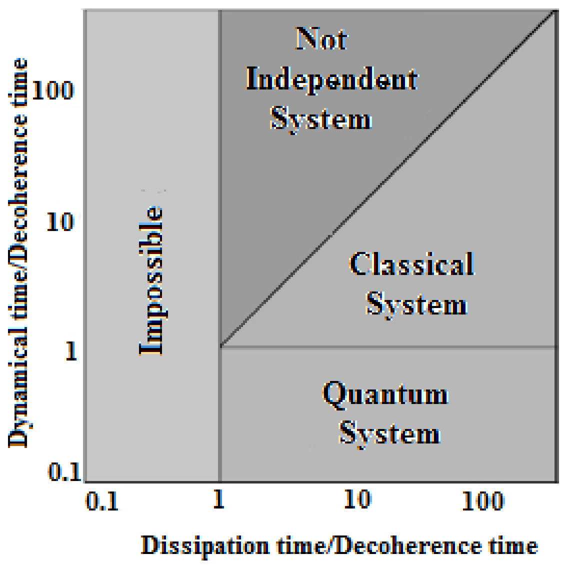

Figure 1 The qualitative behaviour of a subsystem

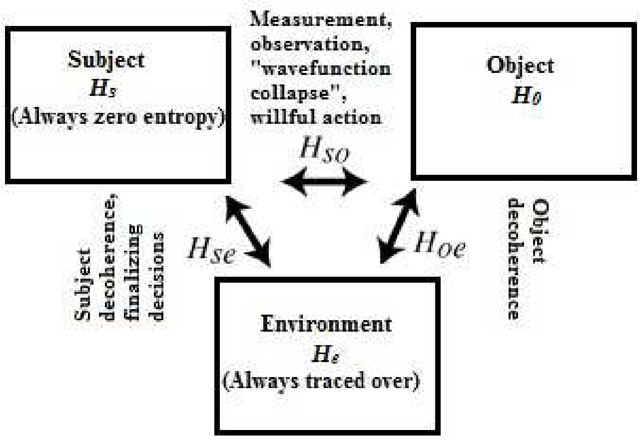

Figure 2 Three subsystems and their Hamiltonians

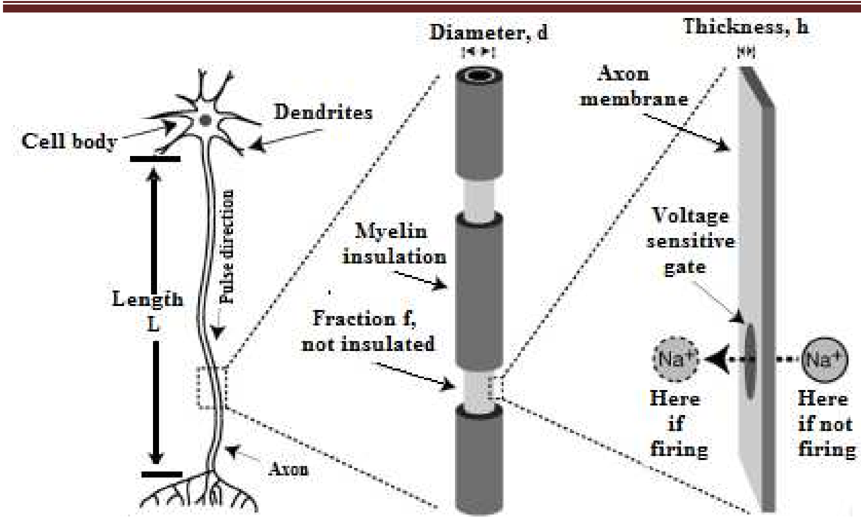

Figure 3 Schematic illustration of a neuron (left), a section of the myelinated axon (centre) and a piece of its axon membrane (right)

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