A Historical View of the Relation Between Quantum Mechanics and the Brain: A NeuroQuantologic Perspective

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Review Article

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Abstract

Over the past decade, discussions of the roles that quantum mechanics might or might not play in the theory of consciousness/mind have become increasingly sharp. One side of this debate stand conventional neuroscientists who assert that brain science must look to the neuron for understanding, and on the other side are certain physicists, suggesting that the rules of quantum theory might influence the dynamics of consciousness/mind. However, consciousness and mind are not separate from matter. Submicroscopic world of the human brain give rise to consciousness and mind. We are never able to make a sharp separation between mind and matter. Thus, ultimately there is no "mind" that can be separated from "matter" and no "matter" that can be separated from "mind". The brain as a mixed physical system composed of the macroscopic neuron system and an additional microscopic system. The former consists of pathway conduction of neural impulses. The latter is assumed to be a quantum mechanical many-body system interacting with the macroscopic neuron system.

Key Words: mind, quantum biology, quantum mind, neuroquantology, consciousness, quantum physics, history

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Introduction

Developing technology and experimental techniques are pushing our specialized disciplines and theoretical viewpoints ever forward. With time, cognitive psychology has moved to join molecular neuroscience. Today, functional brain imaging enables us to carry out biological examination to a resolution of 1 mm. However, it seems that we need much more time to see the larger picture. We do not know what the glue is that binds neural activity to sub-cellular molecular mechanisms, and the mind as a whole to the brain, but at the same time, in physics we more or less know the nature of gluons, which hold matter together.

Modern physics is divided into two basic fields, and this division has to do with size. The first is classical physics – Newtonian mechanics or Newtonian physics. Newton set this physics out in his *Principia* in 1687, but at the same time, it was a product of René Descartes, Galileo and Johannes Kepler, who had gone before. This physics examines matter at the macroscopic level. Classical physics has ruled for 200 years, and still best explains the working of

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the universe; it has attained an almost sacred status. What secured this trust was its predictive ability. The second basic division of physics, quantum mechanics, is a relative newcomer. At the beginning of the 20th century, 200 years after Newton, it was found that classical physics was unable to explain certain phenomena, and so new research began, which finally gave birth to quantum mechanics.

Quantum mechanics stands at the very centre of theoretical particle physics. Although it is a perfect theory for describing and explaining atoms and molecules, many still feel that it is a theory that obscures probabilities, uncertainties and definite identification, and is not very explicit. Without quantum mechanics we could not have understood or explained the makeup and functioning of DNA, the colour of the stars, the stability of atoms, chemical bonds, the characteristics of superconducting fluids, or lasers (Cohen-Tannoudji, 2006). But quantum mechanics is not a theory in itself; rather, it is a framework which includes all the theories of classical physics.

Quantum mechanics often conflicts not only with some of the ideas of the old Newtonian mechanics but also with common sense and intuition. It clashes with our common sense, and sometimes seems nonsensical. Our reason for believing in quantum mechanics is its great predictive power (Feynman, 1988). For example, quantum mechanics predicts the momentum of the electron as 1.001159652(*46*), which differs only at the eleventh decimal place from the experimental result of 1.0011596521(*93*). The prediction of this theory is unbelievably close to reality (Gjertsen, 1989).

The birth of quantum mechanics commenced just over a hundred years ago in 1900 when Max Planck began to find a solution to a problem that physicists had been working on for years. When a piece of matter is heated, it begins to glow. With increasing temperature, it becomes red-hot, then white-hot. At high temperatures, such black bodies begin to produce radiation. This is so-called "black body radiation". Planck proposed that this radiation was transmitted in packets of a definite size. This idea that energy was transmitted in separate packets was new, and Planck was unaware that this explanation would shake the concepts by which we describe nature to the roots. The amount of energy in such a packet, or quantum, was directly related to the frequency of the radiation, expressed by this equation: $E=h\nu$. Planck indicated the constant which he found necessary with the letter h. Later, this was named the Planck constant, and took its place among the fundamental physical constant in nature such as the speed of light and pi. In this way the curtain was lifted on the quantum world (Mehra, 1982).

A Historical View of the Relation Between Quantum Mechanics and the Brain

Today, the brain is described in terms of classical Newtonian physics. However, Newtonian physics has limits: in terms of Descartes' division of the universe into *res cogitans*, or the mind, and *res extensa*, or matter, Newtonian physics deals only with the second. Thus, neurobiologists treat the brain and its parts as classical objects, and when they progress to smaller scales, give no importance to quantum mechanical effects. In this way, classical physics remains without mind or consciousness.

With the rise of quantum mechanics in the 1900s, the search in physics for a place for "something else" alongside matter began, and unfortunately, the searchers were physicists and not neuroscientists. Consciousness, which at first entered into the philosophical interpretations of quantum mechanics, was eventually incorporated into the equations. Classical physics contradicts the idea of free will, and connections were sought with quantum mechanics, which made random choices.

The first true pioneer who idea that quantum mechanics was operating in the brain was Alfred Lotka (1880-1949). Lotka's main work was on population dynamics, and he put forward his ideas on the place of quantum mechanics in the brain in his book *Elements of Physical Biology* in 1924. According to Lotka, the mind controlled the brain by quantum jumps arising completely randomly (Lotka, 1925) (**Table 1**).

Table 1. Interdisciplinary theories about quantum mechanics and the nervous system, people and theories.

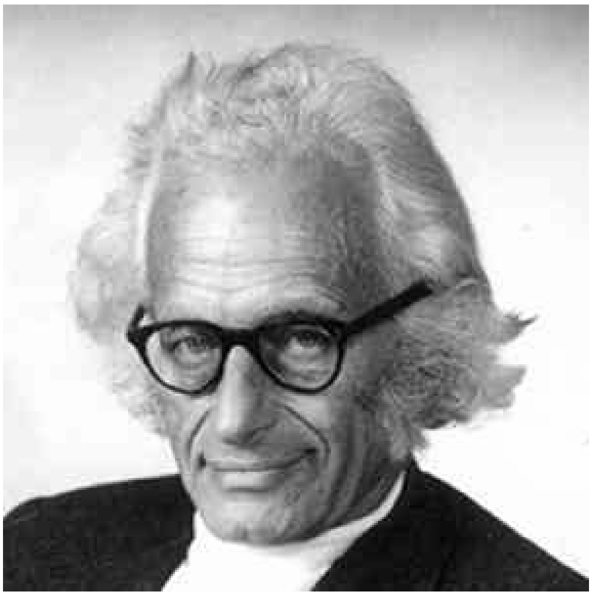
1924	Alfred Lotka	Quantum leap in mind-brain relations
1928	Arthur Eddington	Quantum mechanics-determinism in the brain
1930	Fritz London and Edmond Bauer	Consciousness creates reality
1932	John Von Neumann	First theory of the relationship between QM and consciousness
1934	J.B.S. Haldane	Quantum wave characteristics can explain life and the mind
1934	Niels Bohr	The mind and QM are connected
1934	Norbert Weiner	Quantum Mechanics, Haldane, and Leibniz
1951	David Bohm	Copenhagen interpretation, the holistic brain
1955	John Von Neumann	The effect of consciousness on quantum measurement
1965	Karl Pribram	The holographic brain (memory) model – non-locality
1966	John Eccles	Persuading the Pope to call a conference on consciousness
1967	L.M. Riccicardi and H. Umezawa	Quantum Neurophysics: corticons
1971	Karl Pribram	Dendritic nets – the holographic brain model
1973	David Bohm	Holomovement
1974	Ewan H. Walker	Electron tunnelling in synapses (1977)
1978	Stuart, Takahashi and Umezawa	Water in nerve cells – the quantum field theory
1986	Herbert Frölich	The Bose-Einstein condensate in biology
1986	John Eccles	Quantum tunnelling, psychons
1986	Roger Penrose	Subjective reduction in consciousness
1987	Ross Adey and Karl Pribram	Microtubular quantum coherence and electromagnetic fields
1989	Ian Marshall	Bose-Einstein condensate in the brain
1989	Michael Lockwood	Perception of brain states
1992	Friedrich Beck and John Eccles	Synaptic tunnelling
1992	Stuart Hameroff and Roger Penrose	Objective reduction in microtubules
1992	Teruaki Nakagomi	The brain and quantum monadology
1994	Henry Stapp	Calcium ions and the collapse of wave functions
1995	Mari Jibu and Kunio Yasue	Ordered water – superradiance
1995	Stuart Hameroff and Roger Penrose	Microtubules – quantum computation
1995	Gordon Globus	Quantum cognition and sensory input
1995	Henry Stapp	Experiences and the free will model
1998	Stuart Hameroff	Tunnelling in the close connections between cells
1998	Scott Hagan	Microtubules – biophoton emission
2000	Giuseppe Vitiello	The dissipative brain
2000	Henry Stapp	The quantum Zeno effect and the mind
2002	Huping Hu and Maoxin Wu	Spin-mediated consciousness theory

Alfred James Lotka (1880 –1949)

A year after Lotka's ideas, in 1925, the Bose-Einstein condensate was proposed theoretically (Einstein, 1925), and in 1995 was achieved experimentally. In a Bose-Einstein condensate, units particles in a system can under certain conditions act in coordination and in the same way. A laser is in fact a Bose-Einstein condensate, and it is photons in a coordinated. Atoms, which are bigger than photons, can, under certain conditions of very low temperature, act cooperatively. They all show the same behaviour, like the members of a dance group all moving to the same rhythm, and losing their individuality. The fact that this physical system resembled the coordinated working of the brain started discussion as to whether the brain could also be such as system.

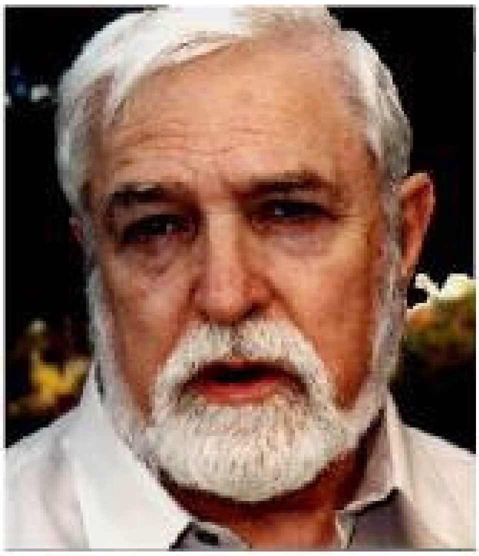
In 1963 computer scientist James Culbertson, in line with a long tradition of "*panpsychism*", proposed that consciousness is an aspect of space-time, and all objects are to some extent conscious. According to relativity, our lives are in a region of space-time. Our brains show us a film of matter changing in time. All space-time events are consciousness and are in the consciousness of other space-time events. A space-time experience is static, a frozen moment of space-time events. All subjective experiences take place in "psycho-space". An observer exists from the subjective evidence of the space-time region. Specialized areas of our brains create the feeling of passing time. The memory of an event is the re-experiencing of a space-time event. According to Culbertson, conscious memory lies not in the brain but in space-time. In the same way, the internal life of a system, that is its individuality, is its space-time history. Culbertson gives an interesting example: a robot is made and learns German. Then another identical robot is made. Even though the second robot is identical to the first robot, it cannot speak German. This is because their space-time histories are different (Culbertson, 1950).

In 1968, the physicist Herbert Fröhlich stated that Bose-Einstein condensates might exist in biological systems, both animal and plant, and that might be some sort of coordinated behaviour at the root of biological oscillators (Fröhlich, 1968).



Herbert Fröhlich (1905-1991)

Coming to 1970, Evan Harris Walker presented a model of synaptic tunneling between nerve cells (Walker, 1970). According to this model, electrons tunnel in a quantum physical sense across the synaptic gaps where nerve cells communicate. It took about four years for views on this topic to be accepted for publication by physics journals. The world of science resists any new or different idea, and that is what happened in Walker's case. The article was sent to the journal in 1970, but it was not until 1976 that it was re-considered and finally accepted, and ultimately published in the *International Journal of Quantum Chemistry* in 1977 (Walker, 1977).



Evan Harris Walker (1936-2006)

At the end of the 1970s, brain surgeon and researcher Karl Pribram (Pribram, 1971) and physicist David Bohm proposed that the brain worked like a hologram. Holograms are physical objects which harbour the three-dimensional image of another object. Each part of the recorded image contains all the characteristics of the whole. Bohm calls the world that we perceive the "shop window". All our consciousness, our knowledge of the past and our perceptions of the present join together in a shop window. But under the pieces and the makeup of the ego, there is a universal memory without time or space. We are born in the hologram and later our own brain forms a hologram. It is suggested that the memory is distributed through the whole brain and that this distribution is on holographic principles. According to this idea, memory is not recorded in the nerve cells, but rather as a wave interference pattern in the brain as a whole. According to Pribram, a sensory perception is spread through the brain as a brain wave, like an electromagnetic activation. Different waves spreading through the brain influence each other. Wave interactions are a result of quantum interactions. This approach accords with Karl Lashley's experiments in the 1920s. Lashley found that even when animal brains were severely damaged, memories were not lost, but to a large extent retained. Thus, the memory was not in one place in the brain, but everywhere in it. Lashley called this "mass action." This approach also answered the question of how the brain's memory capacity could be limitless. According to Pribram, consciousness arose from dendritic-dendritic information processing, and unconscious-automatic movement could be a result of axonal firing.

The Holonomic Brain Theory describes a type of process that occurs in fine fibered neural webs. The process is composed of patches of local field potentials described mathematically as windowed Fourier transforms or wavelets. The Fourier approach to sensory perception is the basis for the holonomic theory of brain function. Holonomy, as its name implies, is related to the unconstrained Fourier co-ordinate system described by holography. The Fourier transformation changes a space-time coordinate system into a spectral coordinate system within which the properties of our ordinary images are spread throughout the system. Fourier transformations are routinely performed on electrical recordings from the brain such as EEG and local field potentials. The term "holonomy" to describe a constrained, windowed, Fourier process, was borrowed from Hertz who used it to express in more generally applicable co-ordinates a specific co-ordinate system (Globus, 2004).

Karl H. Pribram

In 1977, the neuroscientist John C. Eccles suggested that the regions between the nerve cells of the cortex might operate in a quantum mechanical fashion (Popper and Eccles, 1977). According to Eccles, a convinced dualist, a non-material mind (or in his words psychons) excites nerves by quantum jumps (tunneling) and bring about movements of the body [14]. Eccles went outside classical physics, and with the help of the physicist Friedrich Beck, tried to explain mind-brain interaction (Beck and Eccles, 1992; Beck, 2008). In his theory, he joined the fine basic structure of the cortex with quantum physics. According to Eccles, the basic unit of the cortex is the dendron. Dendrons represent the material brain, while their equivalents representing the mind are the psychons. Psychons act on dendrons by intention and thought of voluntary actions, and increase the probability that the selected neurons will fire. In this way, when we have the intention of raising an arm, the nerve cells in the arm region of the brain fire, a signal is sent to the arm muscles, and we raise our arm. The interaction between psychons unites the internal world of our minds and our perceptions. According to Eccles, the interaction between mind and brain "is not by energy, but as if in a flow of information." If the mind can change the threshold of neural events, it will very likely be effective at quantum and sub-quantum levels. According to the first law of thermodynamics, the total energy of a closed system, that is one, which does not exchange energy or matter with the environment, is constant. In the materialist theory, the whole physical world is a closed system, and the amount of matter-energy is definitely unchanging. However, Eccles draws on quantum mechanics. According to the orthodox view of quantum mechanics, energy can be borrowed for a fraction of a second from the "quantum vacuum" (Beck, 2008).

According to Eccles, a new theory is needed to explain how mind events bring about neuro-electrical events. As a result of mind events, increased blood flow and consumption of sugar take place in parts of the brain actively related to the event. All these results are basically a response to the emptying of neurotransmitters from the synaptic vesicles. When the nerve signal reaches the pre-synaptic area, it excites the axon terminal and causes calcium ions to enter, and the vesicle contents to empty. This emptying can show up as increased blood flow in the relevant areas of the brain. But one link is missing. How can thoughts (the primary cause) make the activity, working and blood flow of relevant areas of the brain increase (the result)? How is this possible?

John Carew Eccles

In 1989, the physicist Ian Marshall showed that there were similarities between the overall properties of Bose-Einstein condensates and information (Marshall, 1989). Information, like the Bose-Einstein condensate, can arise from a stimulus. Marshall's theory, like Fröhlich's, contained condensates, and as they were stimulated with an electric field, conscious experience was created. According to the theory, the brain was in a constant dynamic relationship with the quantum entanglement underlying it.

In 1989, Roger Penrose proposed a connection between the mind and quantum mechanics in his work *The Emperor's New Mind* (Penrose, 1989). In this book, he claims that consciousness is created by quantum mechanical operations carried out in the brain cells by means of *objective reduction*. According to Penrose, the place in the brain where quantum mechanical operations take place is the microtubules found in concentration in the brain cells. Interestingly, while no reference was made to Penrose's claims in the main neuroscience journals and they attracted no attention there, they attracted the attention of Stuart Hameroff. Hameroff devoted a large part of the next ten years to understanding how the microtubules could act like a computer network inside the brain cells (2001). Hameroff had previously seen each brain cell as a key, with the microtubules in the cell performing the function of key. As with Penrose's work, Hameroff's ideas attracted little attention from neuroscientists. Although Hameroff had a theory of consciousness that involved microtubules, he did not know which quantum mechanical events were at the base of it (Hameroff and Penrose, 2003). Penrose also had a quantum mechanical theory of consciousness, but he had no suitable biological basis for it. In 1992, Hameroff arranged a meeting with Penrose. After talking for two hours, they produced an opinion on how consciousness could arise by quantum mechanics from the microtubules in the brain cells. This Penrose-Hameroff theory became one of the main foundations of the quantum mechanical theory of consciousness. Penrose says of these theories "*I am 90% sure that these claims are basically correct … at a good guess maybe 80% are correct*."

Penrose's objective reduction (OR) requires a coherent superpositioned state to work on. In his first book, Penrose had lacked any detailed proposals for how OR could occur in the brain. However, collaboration with Stuart Hameroff supplied this side of the theory during the early 1990s. Microtubules were central to Hameroff's proposals. These are the core element of the cytoskeleton, which provides a supportive structure and performs various functions in organic cells, including neurons. In additions to these functions, it was now proposed that the microtubules could support macroscopic quantum features known as Bose-Einstein condensates. It was also suggested that these condensates could link with other neurons via gap junctions. This is hypothesised to permit quantum coherence to extend over a large area of the brain. It is further suggested that when one of these areas of quantum coherence collapses, there is an instance of consciousness, and the brain has access to a non-computational process embedded in the fundamental level of space time geometry. At the same time, it was postulated that conventional synaptic activity influences and is influenced by quantum state activity in the microtubules. This part of the process is referred to as 'orchestration' hence the theory is called Orchestrated Objective Reduction.

Roger Penrose

In 1993, the physicist Henry Stapp proposed that classical physics could not explain how the whole could be more than the total of the parts, and that it was insufficient to explain consciousness; he suggested that quantum mechanics could do this (Stapp, 2001). In quantum mechanics, the descriptions of the relation between the parts and the whole created by the parts are quite different from each other. Stapp developed the quantum theory of consciousness on the basis of Heisenberg's interpretation of quantum mechanics (Schwartz and Stapp, 2004). Stapp's quantum model of consciousness has three bases. 1. The Schrödinger process, which is mechanical and deterministic, and predicts the state of the system; 2. Heisenberg's process, which is a choice made consciously. According to the theory of quantum mechanics, we know a thing when we ask a question of nature. We affect the universe with the question. 3. The Dirac process is that an answer must be given to the question which we asked. The answer is totally random (Stapp, 1995).

The idea that Quantum Field Theory might operate in the working of the brain was proposed in three articles by Hiroomi Umezawa between 1967 and 1979, and has since been expanded in various ways (Riccicardi and Umezawa, 1967). Between 1960 and 1970, many neuroscientists supported the traditional nerve cell doctrine, according to which the basic unit of brain function is the nerve cell. Umezawa's view was very different from this, and added an interdisciplinary dimension to brain studies. According to Umezawa, there are two important operations relating to quantum field theory in the brain: memory and consciousness. He wrote two articles with Luigi Ricciardi in 1967. A third (Stuart, 1978) and fourth (1979) article were published with Iain Stuart and Yasushi Takahashi. Stuart dealt mainly with the relationship between consciousness and the problems of measurement in quantum theory. Later, there were contributions from Mari Jibu and Kunio Yasue in 1995, and Karl Pribram in 1996, who realized that there might be a connection with the holographic brain model. More recently, in 2000, Giuseppe Vitiello added the concept of the dissipative brain to the theory (Vitiello, 2001).

In 1995, the physicist Kunio Yasue and the anesthesiologist Mari Jibu argued that the brain could be viewed in quantum field terms (Jibu and Yasue, 1995). Yasue had developed the idea of quantum field theory or quantum neurophysics along with the lines of Umezawa and coworkers earlier work in the 1960s. The quanta of the brain's quantum fields were called '*corticons*'. According to Jibu and Yasue, the classical system of neural networks interacts with a quantum field theoretical system. The brain is indeed a macroscopic quantum system, subject to Feynman's quantum electrodynamics of the water dipole field within the microtubules. The microtubules are the innermost portion of a continuous filamentous web that passes via proteins in neuronal and neuroglial membranes to extracellular regions. Fröhlich waves and solitons propagating rapidly throughout the nanolevel web integrate local neural systems. Looking at microtubules, Yasue tried to prove that quantum mechanical effects had a function in recording memory, and that consciousness arose from an electromagnetic field interacting with the electric dipole field of water and protein molecules.

The quantum field theory of the brain was built on the ideas that memory is not affected by time and that it is not localized in one particular place in the brain. However, a number of questions remain unanswered. One is the problem of memory capacity or 'overwriting'. According to quantum field theory, a particular memory is coded by a particular arrangement in the vacuum. Thus, new information coming from outside will be recorded by influencing the vacuum. That is, it will be recorded on the same vacuum by changing the previous arrangement of the vacuum. This is similar to one sound being recorded on a tape cassette over the top of the recoRding of another sound. Here, the previously recorded information is broken up and deleted. Vitiello presented a solution in 1995 by adding the concept of the dissipative brain to quantum field theory. The brain's memory capacity becomes ideally infinite in Vitiello's model but subject to quantum tunneling that is the mechanism for forgetting (Vitiello, 1995; 2001).

The spin-mediated quantum consciousness theory was developed by Huping Hu and Maoxin Wu (Hu and Wu, 2001). Hu is a physicist who had been working for years on nuclear spin. He had particularly worked on unpaired free electrons and nitrous oxide. Following this work, he started to work on the mystery of consciousness. Unpaired nuclear spins and/or electron spins in high-voltage cell membranes could be the basic location of consciousness. Thus in 2002 the spin-mediated consciousness theory was born. As if many other new theories it met opposition and it was not published even in journals devoted to consciousness until 2004, when details of the theory were published. This theory meant that the well-defined workings of the nerve cells was brought down to the sub-atomic level (Hu and wu, 2002; 2004). In this way everything that could be said on this topic was open to speculation.

Yes, the Physical Brain does Operate Quantum Mechanics

From the point of view of classical physics, we are entirely mechanical automatons. Our every physical action can be predicted totally by the mechanical interactions between the mindless bases on which we are formed. Quantum mechanics however turns man from an automaton into a personality with a mind that has an active role to play in wave function collapse. However, not all quantum physicists do this. Most are unaware of falling into particles, of the whole. The consciousness (and the observer), which for classical physics are passive, cease to be relegated to metaphysics and enter the scientific field of quantum mechanics. Man takes on the role of active participant and becomes a part of nature. Each expected or intended action causes an empirical response or feedback.

The billiard balls whose movements could be predicted for Newton have become at the same time a wave equation, and their movements can only be predicted with probability. And in modern physics, the observation of atomic phenomena has been put in the spotlight. Of course, trying to explain everything with physics and claiming that even moral and political errors come from not knowing the laws of physics is a bit much and seems nonsense. But at least one thing is certain: the equality of energy and mass expressed by the equation $E=mc^2$ shows that there is a relation between the brain and physics!

Most neuroscientists feel that classical physics will be enough to explain the relationship, which the brain has with consciousness. This point of view might have been valid before the establishment of quantum mechanics, but today it is questionable (**Table 2**). Quantum mechanics must be brought into the working of the brain and human behaviour because they are related to ionic nerve transmitters and atomic operations. For example, when neural electrical stimuli reach a junction between nerve cells, calcium ions enter the cell and cause the release of neurotransmitters. Ions and ion channels have very small dimensions. The opening of the channels and the movement of ions, as with other movements of ionic atoms, is a quantum mechanical event. Thus, the ions that enter may or may not cause the release of neurotransmitters from the vesicles in the nerve cells. The released neurotransmitters may or may not affect the sensors. This behaviour can only be described in terms of quantum probabilities. Such a quantum effect at a single nerve ending may not be important, but when this happens in a brain with 10^{15} synapses between nerve cells, classical physics is incapable of explaining it. It seems impossible that a being that does not contain within itself such a particular physical process should have a consciousness, and the search for it goes ever deeper.

Table 2. Why is quantum mechanics necessary in the brain?

1. The brain is not localized, it is holistic. Quantum mechanics is not localized either.
2. People have used the physics knowledge of their day to try to understand the brain. In the past, this was done when Newtonian physics held sway. Why should it not be done in the age of quantum mechanics?
3. The wave-particle duality in quantum mechanics recalls those of soul and body, and mind and brain.
4. The thought that it is a step towards the theory of everything, and might be a link between physics and neuroscience, and the internal world of man and the outside world of space, makes quantum mechanics necessary.
5. Consciousness cannot be explained and quantum mechanics cannot be explained; so then there might be a relationship between the two inexplicable phenomena!
6. There is a reduction: medicine→ biology→ organism→ tissue→ biochemistry→ physics→ classical + quantum mechanics, and the basic elements of this reduction can certainly be reached.
7. It is possible to explain how neurotransmitters enable communication between nerve cells by the laws of classical physics, but this explanation isn't the whole story. It is necessary to go into more detail, and the details are contained in quantum mechanics.
8. As our knowledge has advanced, we have separated science into many different disciplines. We have separated neuropsychiatry into neurology and psychiatry. There are two illnesses, which are caused by imbalances in the same neurotransmitters in different areas. One is Parkinson's disease and the other is schizophrenia. Parkinson's disease falls under neurology, schizophrenia under psychiatry. This reflects the fact that Parkinson's is a motor disturbance, and schizophrenia behavioural. Is this distinction justified? Science ought to move in the direction of integration. understanding of the nervous system might well be integrated by quantum mechanics.
9. No satisfactory explanation has been found for the problems of mind-brain and consciousness, and this motivates applying quantum theory.
10. The brain is equivalent to the sum of its basic particles. Since quantum mechanics is valid for the basic particles that make up the stars, why should it not apply to the matter inside the human head? In that case, that same quantum physics must apply to the brain also.
11. From the view of classical mechanics, from $E \equiv mc^2$, the brain has a mass and that mass is equivalent to a certain amount of energy.
12. Moreover, we know that the classical value of $E \equiv mc^2$ can be converted into $E \equiv mc^2$ and $E=h\nu$ (Planck constant x frequency) in quantum mechanics. Thus, there must be some connection with quantum mechanics here too.
13. Mind and consciousness are not part of metaphysics or mysticism. They must be brought within the laws of science.

Similarities

According to David Bohm there is a close similarity between quantum mechanics and our internal experiences and thought processes. For this reason, quantum mechanics may play an important role in the working of our mind. Among these similarities, as language and thought are made up of words, so the world described by classical physics is made up of fields and particles. The basic construction of thought and language can be analyzed, but at the same time, language is holistic. We cannot take concepts or words individually, and the same is true for thoughts. In quantum mechanics, the whole universe, like thoughts, is one indivisible whole. The particles under each material have their individual characteristics. Words also have their own individual characteristics.

There is a similarity between thought processes and quantum theory and classical limits. At the quantum level, actions are discrete, in classical theory they are continuous. Like the thoughts that we experience every day, the world of quantum theory is indivisible. The unpredictable behaviour of individual quanta is like the actions of an insurance company. Within a large group of people, the average life expectancy can be calculated, but it is impossible to determine the length of the life of any one individual.

There are similarities between logical thought processes and the logic of classical physics. No logical process can be analyzed by separating it into parts. Separating it into parts changes or spoils the meaning. This is true for logical thoughts also. Without logical thought, it would not be possible to reach conclusions from our thoughts, and we would not be able to keep a hold on reality. However, some basic thought processes cannot be defined logically (Penrose, 1994). Thus, that thing called inspiration comes in an instant. It generally comes following long and unsuccessful searching, and normal logical processes are not used. This shows a resemblance to a quantum jump. According to David Bohm, the emergence of new ideas is by a quantum-like general thought, an indivisible logical step. General thoughts use general logical thought stages. Basic or easy thought uses well-defined conceptual terms.

Seen from a general viewpoint, there are two levels in the physical activities of the brain, classical and quantum. These resemble our thought processes. There is the level of classical physics which can be defined by logical statements and neurophysiological terms (ion flow, action potential, neurotransmitter generation, oscillation), and the quantum mechanics level, which creates our elemental perceptual experiences (such as experience, pain, pleasure and taste) and thought processes. A typical state of mind includes both levels at the same time. Different states of mind may concern these two levels with different degrees of emphasis. We can in no way make a certain distinction between mind and matter. Thus, there is no mind, which can be separated from matter, nor is there matter, which can be separated from mind.

The similarity between quantum mechanics and thought processes can enable us to understand quantum theory. This deduction is the physicist's viewpoint and need, but is unimportant to the neuroscientist. What is necessary to neuroscientists is that the similarity should allow us to understand the brain that produces these thought processes. Another reason for the relation between quantum mechanics and the nervous system is that in the age of understanding the mind and the brain there must be a quantum renaissance. Quantum mechanics can help us to understand the characteristics of the mind, which we have not given importance to. In our quest to understand the brain and the mind, adding quantum mechanics to the approach of classical physics will take us one-step further forward (Pylkkanen, 2004). Because quantum mechanics is based on statistical mechanics, it does not apply to dissipative systems.

Everywhere we can check the correctness of the laws of physics and chemistry; we see that these laws must be valid for living things too. If we accept that living organisms are physical and chemical systems, we can expect that they will behave in accordance with these laws. Such important physicists as Niels Bohr, Erwin Schrödinger, Walter Heitler and Max Delbrück proposed that biological processes could only be described according to the quantum theory model. However, this view did not win any supporters in the field of biology (Matsuno, 2000). Whatever laws of physics and chemistry the atoms in the stars obeyed, the same laws would apply to the atoms in our brains. Our bodies and nervous systems are derived from stardust, and are not subject to different laws. Minerals, plants and animals are all made of the same material and obey the same rules. Biologists try to relate everything they know about life to chemistry, the theories behind chemistry, quantum theory and electrodynamics. Quantum theory, since it can explain all of chemistry and the various characteristics of objects, is accepted as very successful (Feynman, 1988).

In the running of the universe, why should the laws of quantum mechanics, which began at creation, not be valid in the material brain, which exists within it? But living organisms and their nervous systems are so dauntingly complex that the question can be raised as to whether that nervous system is capable of being described in terms of physics and chemistry. As Bohr stated, it may never be possible for a physicist to completely describe a living organism. However, as we progress up from the internal structure of matter, we enter the realms of physics, chemistry, and finally biology. Going the other way we reach the constituent particles of the atom (Heisenberg, 2007).

If we are to regard the brain as a physico-chemical mechanism, we need to look deeper than its whole. When discussing classical physics, although we are behaving as if we are talking about something completely separate from ourselves, in a system which involves quantum mechanics, when discussing human beings we are discussing a system which is not separate from us but within us. Thus, although in fact man and his brain are one and the same, when we consider classical and quantum mechanical approaches, we are moving between different viewpoints.

Physics was established by means of experiments and hypotheses in an altogether reliable fashion. If the objects of traditional physics present an appearance of being of many kinds, mixed and disorganized, they do not show the complexity of chaotic systems, but present a somewhat simpler situation. For today, rather than hoping to find new molecules and brain structures to explain the working of the brain and consciousness, we need new ideas on the interaction of molecules that will help us more. In this sense, the quantum mechanical approach may open up new avenues.

If we think that the atoms in our brains are in fact no different from those in the stars, or that they are the remnants of stardust, we must accept that whatever laws apply in nature, the same laws must also apply in the brain. Communication in the nervous system is effected by movement of chemical neurotransmitters in the connection points between cells, the synapses. These synaptic structures are macroscopic, and 95% of chemical transmitters are macroscopic in their peptide structure. Mini proteins are made up of around 100 amino acids and have an atomic weight of ten thousand at most. The dimensions of most are around 10nm. Thinking along the lines of *Heisenberg's Uncertainty Principle*, the number of receptors that will affect a peptide is numerous (at least more than one). For this reason, the quantum uncertainty principle can be invoked when considering whether a neurotransmitter will affect receptors. Nevertheless, the peptides may be subject to quantum superposition. In addition, because neurotransmitters may have an effect on our behaviour and our indecisiveness, it is possible that quantum uncertainty or probability principles come into play.

When a calcium ion enters the presynaptic area from a channel across the nerve cell membrane, its momentum is $\hbar/x$, and its speed is $(\hbar/x)/m$ according to Heisenberg's uncertainty principle. Its spatial diffusion time is t=200 microseconds (the period between the opening of the channel and the neurotransmitter cycle) and taking the diffusion distance as x=1nm, the wave function is found to be 0.04 cm. Given that the calcium ion measures a hundred billionth of a centimeter (1/100.000.000 cm), this is a very large value. This value means that the calcium ion can affect an area a hundred million times bigger than itself. That is, one calcium ion is showing a potential effect on channels outside the area which it itself affects. This may not be important in the case of a single calcium ion, but when trillions of calcium ions are involved it may cause an integrated and closely coordinated brain function. It can be seen that the involvement of quantum mechanics in brain function cannot be denied.

Many medicines taken into our bodies compete with peptides and neurotransmitters and affect the sensors that they affect. Most drugs, although they are very small, can show very large quantum mechanical spatial uncertainty. For example, endorphins are morphine-like pain-relievers produced in the body and are peptide structures. Naloxone is a blocker, acting on the same places as endorphins. Endorphins relieve pain; naloxone brings it back (Fries, 2002). There may be competition between them for quantum superposition resulting in such subjective experiences as pain or pleasure.

If we can define the oscillation of neurotransmitters in the synapses as being quantum mechanical, the sum total of synaptic activity in the brain may give an integrated brain wave function. At any moment in time, the potential state of observed events may be subject to superposition. That is, in the brain all alternative choices exist together at any one time, which Gordon Globus called a "*plenum of possibilia*." (Globus, 2009). At a suitable stimulus, one of these alternatives is chosen. A pattern of integrated neural quantum activity may be formed in the brain. It is possible that conscious perception may feel this. This kind of model can easily explain the concept of free will and free choice.

No, the Physical Brain does not Operate Quantum Mechanics

Since the 1970s, many writers have suggested that Eastern mystic philosophies such as Zen have a close relationship with the concepts of quantum mechanics. However, most of these ideas are pure fantasy and have no scientific basis. Quantum mechanics and the word "quantum" have been added to many money-making enterprises. Such nonsense as Quantum Neuro-linguistic programming (NLP), Quantum thought techniques, Quantum management, Quantum Tantra-sex, Quantum skin care, Quantum medicine, or Quantum reform. Almost anything new has an attractive quantum smell about it. This is because the word quantum has an air of mystery to it, and no one knows exactly what it means. If you look at a physics textbook that explains the basics of quantum mechanics, you will be confronted with terms such as observer, consciousness, or observation, which seem to be more appropriate to neuroscience. On the other hand, if you look at an academic book on neuroscience, you will not see any of the basic principles discussed in quantum mechanics. An example? Let us look at the headings in some popular works on physics. Roger Penrose's *The Emperor's New Mind*: What is the brain really like?, Split brain experiments, The blind spot, Does quantum mechanics have a role in brain activities?, Where does the brain's physics take place? In another book, *God and the New Physics* by the well-known physicist Paul Davies, we see free will and determinism, mind and soul, and individualism. In addition to all of this, many books have been written in the last ten years about the brain and quantum mechanics by experts in the field of physics.

Quantum mechanics is the best theory for describing matter at the most basic level. However, some people believe it does more than that. They set quantum mechanics as the basis of consciousness. Quantum mechanics is necessary to understand the atoms of the brain, it is needed to understand the atoms of a stone in just the same way, but there is no need to make inferences using quantum mechanics about a stone's consciousness. Thus, quantum physics is not the right way to start understanding the nature of consciousness (Hut *et al.,* 2006).

Some writers say that a stage has been reached where the invisible mystery of quantum mechanics has been the reason for a great many contradictions, and excessive meaningless claims have been made which a sane physicist would not know where to begin to answer. Some people claim that life on Earth started with a quantum leap, or that free will and consciousness developed from quantum mechanics. The idea underlying these statements is that 'inexplicable' events are somehow connected to 'inexplicable' quantum mechanics. But quantum mechanics is by no means inexplicable; it's just very surprising.

Another opposes the idea that quantum theory plays a significant role in the relationship between the brain and consciousness (Scott, 1996). According to him, non-linear classical physics is sufficient to explain the physical basis of consciousness and is more important. According to Scott, "liquid water is basically no different from gaseous hydrogen and oxygen". This difference belongs to quantum field theory. Quantum field theory generally consists of non-linear field equations, and for permanently known statistical values, there are linear wave function equations. Non-linearity does not obstruct the linearity of wave function equations.

Trying to explain the human brain and consciousness by means of quantum mechanics has been called "a new fairy-tale and a game of modern thought". This game places quantum mechanics at the centre of the human mind. It is not surprising that much has been written about this. But unlike the writers of traditional fairy-tales, those who associate quantum mechanics with mind and consciousness are experts in their own scientific fields. In this regard, an attempt is being made to change the reductionist materialist viewpoint that started in the 17th century with Newtonian physics. Today, materialism has been replaced by psychology, and reductionism by a holistic view. In a holistic universe, everything is related to everything else. Thus, quantum mechanics works without involving consciousness; it fits in with all observations and all the principles of physics (Song, 2008). However, this is unfortunately ignored in the popular press, because it does not support their preference for mystical nonsense (Stenger, 1993; 1996; Schaff, 2010).

One of those who opposed the idea that quantum physics or quantum measurement in the brain would have a place in human consciousness is Victor Stenger (1993). According to Stenger, quantum consciousness theory is as interesting and influential as the once-held theory of 'ether', but now quanta have taken the place of this medium that was once believed to carry light. In fact, the roots of this belief go back to ancient times: to the ancient Greeks ether was what the gods of Olympus breathed, and to Aristotle it was the material of the heavens. Newton proposed that the invisible ether was the means through which the force of gravity was propagated. Later, the propagation of electricity, magnetism, light, and heat were associated with ether. Today, concepts without scientific foundation such as *ch'i*, *ki*, *prana* and psychic energy have taken the place of ether. When mathematical concepts were developed in the 19th century, the characteristics of matter, light and gravity were defined. Michelson and Morley searched for experimental proof of the ether, but disappointingly could not find it. A short time later in 1905, Einstein developed his theory of relativity, and the ether was found to be at variance with Maxwell's equations for electromagnetism. In this way, the ether has been consigned to the realms of fantasy. According to Stenger, the current idea of an association between quantum mechanics and the brain, and consciousness and the mind will go the same way.

The trio Einstein, Podolski and Rosen, who did not like quantum theory from the start, proposed in 1935 a thought experiment, from which they claimed that since nothing could travel faster than light yet there was instantaneous action at large distances, then quantum mechanics was incomplete. However, this issue remained of interest up to the experimental work of John Bell in 1964. According to Bell, only imaginary mathematical equations or creations and quantum wave functions can move faster than light. Other than this, no signal can travel or carry information faster than light (Bell, 1964). In this way, the clash between quantum mechanics and relativity disappears. According to quantum mechanics, with a holistic approach, everything in the universe, mind and the universe, are in contact with each other irrespective of distance. The concept of relativity supports the exact opposite: particles can enter directly into contact by any interaction. If a universal cosmic field such as the ether creates the universal connection of quantum mechanics, then this clashes with relativity theory, and relativity has since 1905 passed every kind of experimental test.

Stenger states that universal relationships were suggested because of a wrong inference in the language used by Bohr, Heisenberg, Von Neumann (1955) and others. In order to describe the interaction between the observer (the subject, brain, or consciousness) and the observed (the object), language is required. Thus, human consciousness and an observer have inevitably entered the picture. When Bohr and Heisenberg talk of measurements made by non-living instruments, this does not necessitate placing a conscious observer between the quantum and the mind. According to Stenger (and contra Stapp and the Copenhagenists), nothing in quantum mechanics requires human intervention. Even if human beings were one day to disappear, quantum mechanics would still operate its own laws. Therefore, Stenger thinks quantum consciousness fairy-tales should be classed under works of fantasy (Stenger, 1996).

Stenger criticises the argument that the roles of the brain are related to chemical operations and so conform to the rules of quantum mechanics. By this logic, he says, we could not apply Newtonian mechanics to a stone thrown into space because a stone is made up of chemical elements. In particular, he criticizes the theories of quantum tunneling consciousness based on the synaptic connections between nerve cells, saying that quantum uncertainty is insignificant here. In particular, he points out that nerve cells and their components are macroscopic objects, and that temperatures are too high for quantum operations to take place. For this reason, more random particle movements occur in cooled macroscopic experimental quantum systems (superconductors). Therefore, quantum mechanical superposition does not happen in the brain.

The brain's cells, organelles and receptors are neither small enough nor cold enough for quantum superposition to take place. The brain is wet and warm. Maybe the brains of those living in the cold of Siberia are cold enough for quantum mechanical events! Quantum events according to the Schrödinger equation are linear. The nervous system however shows non-linear events at all levels. It is impossible to describe non-linear behaviour with linear equations. The same mistake can be seen when the brain is taken as a closed system. The brain is not a closed system containing energy and information, it is an open system relating to meaning and thought. For this reason, all our interpretations will be different (our subjectiveness, the contents of our minds, qualia).

Looked at another way, the mathematical symbols of quantum mechanics cannot be accepted as a reflection of the physical world (Mohrhoff, 2001). The mathematical equations of quantum mechanics give us the measure of probability, and compute probable results by means of probable measurements. That is all they do. According to Stenger, the rest is metaphysics. Mathematical symbols are known as state vectors or wave functions, and are unimportant as metaphysics. But the measurement of probability is presented as a problem of measurement and is false, because it is not impossible to guess changes from one physical state to another.

Another approach is false questions. False questions and false problems are often encountered in science, and the invocation of consciousness is one of these. The quantum consciousness theory arises from physicists not being able to explain the problem of measurement. There are also other reasons. *1*. Physicists working on quantum mechanics often talk about an 'observer' when discussing measurement. Thus, the things measured are 'observed'. Consciousness theorists immediately latch on to this 'conscious observer'. *2*. Quantum mechanics puts forward the idea of probability. In the deterministic world of classical mechanics possibilities are always subjective. However, quantum mechanical possibilities may be both subjective and objective. The fact that they are subjective opens the way for the consciousness theorists.

Bringing consciousness in to solve the so-called the measurement problem is giving the wrong answer to the wrong question (Green, 2000). On the one hand we must put measurements which have been made and their results, and on the other measurements which have not been made and their possible results. Measurements which have been made are known. The difference between measurements which have been made and those which have not is not whether the result is known to a conscious observer. What differentiates a measurement that has not been made is simply that it has not been made! The bottom line is that consciousness has been inserted into quantum mechanics, and this is an unnecessary complication. But it doesn't end there. Afterwards, the place of consciousness becomes assured by creating answers to the wrong questions, whereas in fact quantum mechanics has nothing to say about the relationship between consciousness and matter.

Another defense of quantum mechanics operating in the brain is as follows: even if consciousness does not help us to understand quantum mechanics, maybe quantum mechanics can help us to understand consciousness. This is known as the law of reducing the mystery. Consciousness is mysterious and quantum mechanics is mysterious, so maybe the two mysteries have the same origin. In fact, the real problem is not this at all. The basic problem is this: what is the relationship between consciousness and the material world? (Pylkkanen, 2004).

According to Stenger, there is an ideological- religious dimension to the ideas of those who say they are trying to insert quantum mechanics into the question of consciousness and the brain. He maintains that holistic philosophy is an obsession with New Age gurus, who are trying to solve the world's problems with love. In fact, classical reductionist physics (materialists and atheists) does not make people selfish; they were selfish long before that. The new quantum holism feeds our obsessions and tells us we are a part of the non-living cosmic mind. In this way, traditional religions are being modernized. A mystical physics is basically a wrong understanding of Hindu and Buddhist philosophy. Another reason for this approach is that it brings Man back to the centre of the universe. Four hundred years ago, Copernicus provided strong proof that we were not at the centre of the universe, and as time has passed, we have had even stronger proof. This feeling of being nothing special has created a great feeling of disillusionment. Therefore, being able to contribute human consciousness to the solution of the problem of measurement in quantum mechanics is part of the effort to return man to his privileged place at the centre of the universe (Chalmers, 1995).

The main argument against the quantum mind proposition is that quantum states would decohere too quickly to be relevant to neural processing. Possibly the scientist most often-quoted in relation to this criticism is Max Tegmark. Based on his calculations, Tegmark concluded that quantum systems in the brain decohere quickly and cannot control brain function (Tegmark, 2000). Proponents of the various quantum consciousness theories have sought to defend them against Tegmark's criticism.

Result

The descriptions of what constitutes reality are so complex that one might begin to wonder about reality itself. You feel like pinching yourself and saying "I'm real!" However, quantum mechanics is real. There is not doubt about its being based on firm foundations. One day, surely, its place will be taken by a better view, but one still consistent with the principles of today's quantum mechanics. This will be less disputable and will reach firmer conclusions. However, it will not contradict what we already know about the physical world. The change will be like that from Newton's mechanics to Einstein's relativity. Einstein did not reject Newtonian mechanics; he confined its reach to slow velocities, making Newtonian mechanics a limiting case (Vaas, 1999).

We may believe we can find a solution, however a very small but important point that we could not imagine or see beforehand can affect our ideas and force us to start again from the beginning. New philosophical concepts are born and new questions arise as a result. But the thought that a well-presented question is the key is a good way to start.

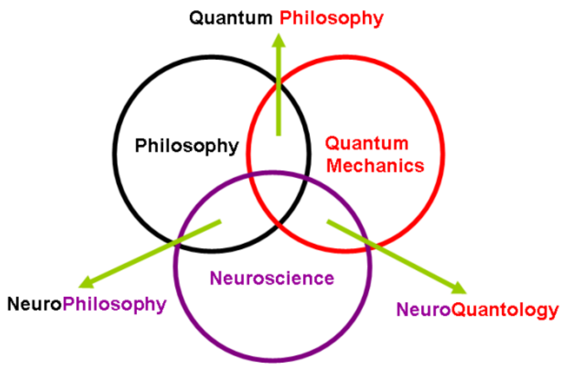


Figure. The great quantum revolution in physics was initially extended to the theory of brain functioning in the lasted sixties of the 20th century. First systematic proposals in the field of quantum neurophysics were made by Ricciardi and Umezawa and by Fröhlich. Since that beginning a robust literature has developed, academic meetings are held under the banner of "Quantum Mind", and a journal devoted to quantum neurophysics, called *NeuroQuantology*, has appeared (2002). (Globus, 2009).

NeuroQuantology is first and foremost a new scientific discipline. Since 2003, neuroscience and quantum physics have been growing together by examining two main topics. One of these is the problem of measurement in quantum mechanics. The measurement problem has brought many other still unanswered questions in its train. The other main topic of NeuroQuantology is quantum neurobiology: that is, the brain operates not only at a classical, macroscopic level, but also at a quantum, microscopic level. It covers the question of where this level begins and whether it has a bearing on our consciousness, mind, memory and decision-making. NeuroQuantology provides the motivation to break down this resistance and open a new door to quantum neurobiology (Tarlaci, 2010).

Quantum mechanics is not the final stage in the science of physics. At worst, quantum mechanics may have nothing to do with the workings of the brain. Even then, using the characteristics of quantum mechanics as a metaphor for consciousness and other brain functions can at least provide us with new viewpoints and new ways of thinking. If nothing else, it gives us the chance for a bit of mental gymnastics without doing any harm to our brains. Any new information that we have gained about consciousness and the brain will open up even bigger questions. If there is one thing we have learned from the course of science up until today, it is that in understanding completely our brain and consciousness, we cannot jump over our own shadows.

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