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Quantum Consciousness and Other Spooky Myths

Quantum mechanics is mysterious. Consciousness is mysterious. The thought that there may be a connection has led to a lot of quantum biological pseudoscience.

BY MARTIN BIER

ABOUT A HUNDRED YEARS HAVE PASSED since quantum mechanics was first developed. Quantum mechanics proved very successful in describing what is happening on the atomic level. The emission of light by objects when they are heated up (e.g., a light bulb), spectral lines, and later things like superconductivity, superfluidity, and the laser could be well understood and described with quantum mechanics.

Quantum mechanics is not an approximation or an *ad hoc* trick to make the equations agree with reality and with each other. It is a fundamental theory that is supposed to describe what is really happening at the subatomic level. A wave function is the basis of the theory and Schrödinger's equation, named after the German physicist Erwin Schrödinger, explains the evolution of that wave function over time. The equation is linear and for many specific cases there is an exact solution or, at least, a good way to approximate the solution. However, a problem arises when you want to leave the math for a moment to try to understand what is happening when an observation is made on a system on the atomic level.

In quantum mechanics a particle—for instance an electron—is represented by the aforementioned wave function. The electron is then no longer a point particle, but a wave, or something like a rippling of the water in a pond; a rippling that is simultaneously present at more than one spot. Suppose you have a device that takes the outcome of an atomic level event, amplifies it, and makes it visible on a macroscopic level, such as a Geiger counter. What is supposed to happen when the observation is made is that the wave function collapses onto one of its coordinate axes. Such coordinate axes are not to be thought of as tangible geometrical objects with real directions in three dimensional space. They are part of a mathematical model in which there may be infinitely many such axes. There is no equation that describes the collapse. The numerical outcome of the observation depends on which of the coordinate axes the wave function collapses on. It is only probabilities that are associated with the different coordinate axes that can be derived from Schrödinger's equation.

"Observation" is a somewhat vague notion and many physicists have a problem with its central role in quantum mechanics. Furthermore, the element of randomness in the collapse of the wave function is troublesome, and led to Einstein's famous remark that "God does not play dice." Richard Feynman, in his 1967 book, The Character of Physical Law, noted: "I think I can safely say that nobody understands quantum mechanics."[1] It is this spooky aspect of quantum mechanics that leads some to speculate wildly on possible connections to consciousness and other aspects of human psychology.

Our story begins with the Nobel Prize winning physicist Eugene Wigner, who stood somewhat alone in his conviction that consciousness is required to make the wave function collapse—that is, that human thought can act as an "observation" to trigger the collapse of the wave function in a quantum event. Wigner died in 1995. That was one year after the Queen of England knighted Roger Penrose, who basically inverted Wigner's idea. According to Penrose, consciousness is a consequence of the collapse of quantum mechanical wave functions.

Roger Penrose had built an impressive record in physics before he devoted himself at a later age to the quantum origins of life and consciousness. His 1997 book, The Large, the Small, and the Human Mind, contains a concise and very readable explanation of his quantum-biological theories.[2] Through many examples, Penrose argues that the human mind does not operate algorithmically. According to Penrose, the way in which we analyze a move in a chess game, for example, is more than just a sequence of procedures. There is something else going on, and that something else may be found, Penrose argues along with his colleague, the anesthesiologist Stuart Hameroff, in the cytoskeleton of neurons that, they believe, harbor the equivalent of a quantum computer. The operations carried out by this quantum computer are what lead to consciousness.

How? Every cell that is larger than a bacterium has a cytoskeleton—a kind of a network of support beams that gives the living cell structural reinforcement. A microtubule (Figure 1) is a very stiff polymer and it is the main constituent of the cytoskeleton. The monomers in a microtubule are proteins that consist of about 800 amino acids. Two conformational states are possible for each individual monomer. By associating these states with the 0 and the 1 of the digital code of a computer, Penrose and Hameroff believe they have found the basis for the brain acting as a computer. It is a quantum computer, they argue, because for each monomer the wave function is suspended between the two states. The two different conformational states have different electric dipoles. The dipoles of neighboring monomers can "feel" and affect each other and, in this way, the monomers interact. This would entangle the involved wave functions and lead the microtubule to operate like a working quantum computer.

The cytoskeleton differs from a customary network of support beams in that it is in continuous motion. Cells grow, shrink, and change shape all the time. For nerve cells the dimensions of the synapses can be changed through the growing or the shrinking of the microtubules. It is at these synapses that signals are being transferred from one cell to the next. According to Penrose and Hameroff, it is at these synapses that the nervous system is connected to the microtubule network, and it is there that they interact to produce consciousness.

How? Suppose an electron can exist in two states—"spin up" and "spin down." The wave function would then be suspended between these two states. According to Penrose, there is a gravitational attraction between these two states. His idea is that the wave function collapses onto one of these states when the energy that is associated with the gravitational attraction becomes too large. For the microtubule this is supposed to work as follows: every monomer consists of two clusters and the distance between these two clusters is different in the 0 and the 1 state. It is a small difference: only tenths of a nanometer. Gravity leads to an attractive force between these two clusters and that force is different in the 0 and 1 state. In the electrochemical reality of the cell, this gravity is completely overwhelmed by electrostatic interactions and the thermal motion of the molecules. But, according to Penrose, gravity is essential for the collapse of the wave function. Two states with a gravitational energy difference ΔE can coexist, according to Penrose, in a wave function for a time Δt as long as ΔE and Δt are within the limits that are set by Heisenberg's uncertainty relation, i.e. $\Delta E \times \Delta t \approx h/2\pi$. The symbol h represents Planck's constant, which is a very small number (6.6×10^{-34} J·s).

It is not hard to compute that the combined wave function of about a billion monomers lasts around one second in Penrose's scheme. For a heavier object such as a human being, the wave function collapses within 10^{-30} seconds according to the quantum gravitational model of Penrose. For

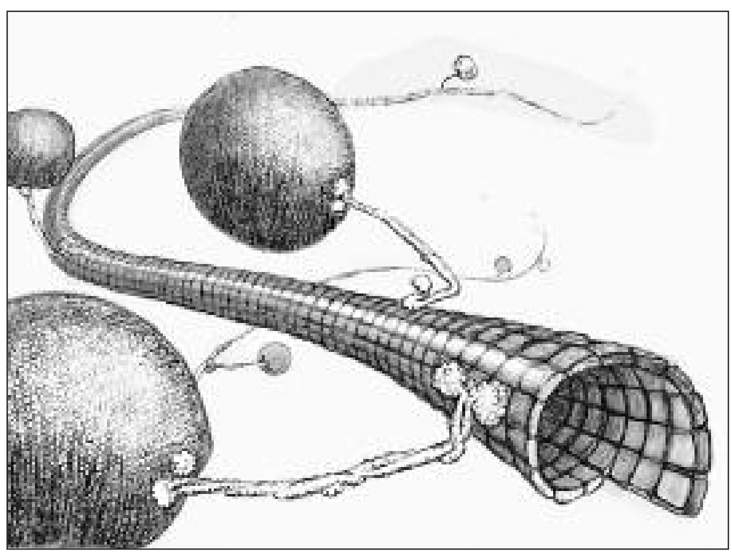

Figure 1—An artist's concept of a microtubule—a very stiff polymer that makes up the major part of the cytoskeleton of a neuron. This tube is the location of Penrose and Hameroff's hypothesized consciousness-generating "quantum computer."

Every little square on the microtubule is a monomer—an individual protein of about 800 amino acids. The polymer tube is a spiral made up of 13 monomers per winding with a diameter of 23 nanometers. Redrawn from an image by Graham Johnson published on the cover of the Journal of Cell Biology, Vol. 151 (2000).

lighter objects such as an electron or a proton, the wave function can persist for many millions of years. But for a polymer-like microtubule, the survival timescale of the wave function is one that could be relevant for the operation of the nervous system. The basic idea of Penrose and Hameroff is that the microtubule quantum computer starts calculating, but that after about a second the calculation is terminated by the quantum gravitational collapse of the wave function. The cytoskeleton would at that moment effectively transfer the state of the calculation to the nervous system. Because the precise moment of termination is not algorithmically determined, this hypercomputer transcends algorithmicity. It is in this way that, according to Penrose and Hameroff, we experience a "moment of consciousness" about every second.

With this idea, the anesthesiologist Hameroff feels that he is on to solving one of the greatest fundamental problems of anesthesiology. It is still not fully understood why certain chemicals lead to anesthesia and others do not. The key here, according to Hameroff, is not to be found in the interaction between the anesthetics and the nerve cells, but, instead, in the interaction between the anesthetics and the microtubule.

As ingenious as the theories of Penrose and Hameroff are, a great many very reasonable objections have been formulated against them. At the end of his book, The Large, the Small, and the Human Mind, there are three essays by prominent colleagues of Penrose critical of his theory. Penrose is somewhat alone in his idea that human thinking does not proceed algorithmically, and one essay examines this. The shortest essay is from none other than Stephen Hawking, who points out that invoking quantum gravitation as a criterion for the collapse of the wave function is questionable. There are other mechanisms that lead to a much quicker collapse.

In the original formulation of quantum mechanics it is "measurement" that causes the collapse of the wave function. Nowadays, however, there are not many physicists who believe that the consciousness of a measuring human being is the only way to trigger such a collapse. Any disturbance of the wave function, it is now thought, leads to collapse. Such a disturbance can be a measurement, but it can also be an interaction with another particle. In this way it is legitimate to put two proteins and their interaction in one wave function. But as soon as a molecule from the surrounding solvent comes even near one of the proteins, it is over and the wave function collapses.

In a 2000 article in Physical Review E, Max Tegmark worked out the numbers associated with this objection.[3] He demonstrated that the collisions between the microtubule and the water and ions from the surrounding solution make the microtubule-wave function collapse within 10^{-13} seconds. That is much faster than the one second yielded by quantum gravitation. The 10^{-13} seconds is also much faster than the timescale at which the nervous system operates. The reception, processing, and transfer of a signal through the nervous system takes about a millisecond. Wave functions that, during every millisecond, develop ten billion times and then collapse again can only act as background noise in the nervous system.

Tegmark's paper led to a lot of comments and debate. A short comment in Science made it appear as if Tegmark's article was the near-definitive refutation of the quantum brain.[4] But Hameroff and his colleagues claim that the microtubule is well insulated in a living cell and that the interactions that Tegmark evaluates simply don't occur.[5]

The collection and processing of information by living creatures has, for many decades, been part of the field of biology. The theory of Penrose and Hameroff looks like a giant leap straight from quantum physics to the solution of the central enigma of neurobiology—consciousness. However, it was by abandoning the vague notion of "consciousness" and focusing instead on the directly measurable transmission of signals through the nervous system that neurobiology has been successful in the last half century and has yielded applicable results.

Had it not been for the stature of Roger Penrose, quantum consciousness would have remained marginalized. But as it is, the idea has achieved a certain credibility even in the scientific world. At http://www.neuroquantology.com/ it appears that there is a new journal devoted to the subject. Quantum consciousness also featured prominently in a recent United Nations Symposium (http://www.mindbodysymposium.com/Beyond-the-Mind-Body-Problem/New-Paradigms-in-the-Science-of-Consciousness.html).

More disturbingly quantum consciousness has been commercially spun off into something called "quantum healing." For example, "quantum touch" therapy seems to have quite a following. With a quick visit at http://www.quantumtouch.com it can be ascertained that "quantum touch" is nothing but an old-fashioned laying on of hands, *sans* the Holy Ghost. An entirely new jargon has been manufactured. To wit: "When the practitioner holds a high vibrational field of life-force energy around an affected area, she or he facilitates healing through the process of resonance and entrainment." And: "We believe that what we're doing is affecting matter on that quantum, subatomic level and it works its way up through the atoms, the molecules, the cells, the tissue…and then we see bones move."

We are then informed that this is all bona fide and scientific, because quantum biologist Glen Rein "has found that healers were capable of affecting the very winding of DNA. In order to accomplish this, healing must first begin on a quantum or subatomic level and work its way though the rest of the body." Elsewhere (http://www.soundenergy.net/dnamod.htm) it appears that Glen Rein has also figured out that rock music cannot loosen the windings of DNA, but that Gregorian chants and religious incantations in general can. Glen Rein runs the Quantum Biology Research Lab in Northport, NY. He is a faculty advisor at the somewhat obscure Holos University. And he is also an editor with the Journal of Alternative and Complementary Medicine. If all this were not enough, Rein is also involved in the marketing of "Aulterra," "an organic, paramagnetic and diamagnetic material prepared with a unique blend of scientific and homeopathic processes." You can buy an "Aulterra Neutralizer" and attach it to your cell phone. This is purported to reduce the alleged harmful effects of electromagnetic radiation and to even reverse damage that has already been done.

Quantum consciousness is really nothing but New Age quantum flapdoodle and an excuse for quackery. S

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