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Quantum Mechanics and the Human Brain. New Properties of Consciousness

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ABSTRACT

In this article the author describes methodologically consciousness based on the principles of quantum mechanics, illustrates different approaches in the field of organization of human consciousness. "Could this be more than just a coincidence? I cannot determine the real problem, so I suspect that there is no real problem, but I'm not sure that there is no real problem."- American physicist Richard Feynman said this about the mysterious paradoxes of quantum mechanics. Today, this theory of physics is used to describe the smallest objects in the universe. But in the same way, he could say about the confused problem of consciousness. Some scholars think that we already understand consciousness or that this is just an illusion. But to many others it seems that we generally did not even get close to the essence of consciousness.

Keywords: Neuronal Model; Quantum Mechanics; Consciousness; Wave Theory; Biocomputer

Introduction

A long-standing puzzle called "consciousness" even led some scientists to try to explain it using quantum physics. But their zeal was met with a fair amount of skepticism, and this is not surprising: it seems unreasonable to explain one riddle with the help of another [1,2]. But such ideas are never absurd and did not even come from the ceiling. On the one hand, to the great displeasure of physicists, the mind initially refuses to comprehend the early quantum theory. Moreover, quantum computers are predicted to be capable of such things as ordinary computers are not capable of. This reminds us that our brain is still capable of feats, inaccessible to artificial intelligence. "Quantum consciousness" is widely ridiculed as mystical nonsense, but no one was able to completely dispel it. Quantum mechanics is the best theory we have that can describe the world at the level of atoms and subatomic particles. Perhaps the most famous of its mysteries is the fact that the result of a quantum experiment may vary depending on whether we decide to measure the properties of the particles involved in it or not.

When the pioneers of quantum theory first discovered this "observer effect," they were seriously alarmed. He seemed to undermine the assumption that underlies all science: that somewhere there exists an objective world independent of us. If the world really behaves depending on how - or if - we look at it, what will "reality" really mean? Some scientists were forced to conclude that objectivity is an illusion, and that consciousness must play an active role in quantum theory. Others simply did not see any common sense in this. For example, Albert Einstein was annoyed: does the moon exist only when you look at it? Today, some physicists suspect that it is not that consciousness affects quantum mechanics ... but that it generally appeared thanks to it. They suggest that we may need a quantum theory to generally understand how the brain works. Could it be that both quantum objects can be in two places at the same time, and the quantum brain can simultaneously mean two mutually exclusive things? These ideas are controversial. It may turn out that quantum physics has nothing to do with the work of consciousness.

But at least they demonstrate that a strange quantum theory makes us think about strange things [3]. Best of all, quantum mechanics breaks into the human mind through an experiment with a double slit. Imagine a ray of light that hits a screen with two closely spaced parallel slots. Part of the light passes through the cracks and falls on another screen. You can imagine the light in the form of a wave. When the waves pass through two slits, as in the experiment, they collide - interfere - with each other. If their peaks coincide, they reinforce each other, which results in a series of black and white streaks of light on a second black screen [4]. This experiment was used to show the wave nature of light, more than 200 years, until quantum theory appeared. Then the experiment with a double gap was carried out with quantum particles - electrons. These are tiny charged particles, components of an atom. In an incomprehensible way, but these particles can behave like waves. That is, they undergo diffraction when the particle flow passes through two slits, producing an interference pattern.

Now suppose that quantum particles pass through the slits one after another and their arrival on the screen will also be observed step by step. Now there is nothing obvious that would cause the particle to interfere in its path. But the pattern of particle ingress will still show interference fringes [5,6]. Everything indicates that each particle simultaneously passes through both slits and interferes with itself. This combination of the two paths is known as a state of superposition. But here is the strange thing. If we place the detector in one of the slots or behind it, we could find out if particles pass through it or not. But in this case, the interference disappears. The simple fact of observing the particle path - even if this observation should not interfere with the motion of the particle - changes the result.

Pascual Jordan's Theory

The physicist Pascual Jordan, who worked with quantum guru Niels Bohr in Copenhagen in the 1920s, put it this way: "Observations not only violate what needs to be measured, they determine it ... We force a quantum particle to choose a specific position." In other words, Jordan says that "we ourselves produce the results of the measurements." If so, objective reality can simply be thrown out the window. But the oddities don't end there. If nature changes its behaviour depending on whether we look or not, we could try to circle it around the finger. To do this, we could measure which path the particle chose, passing through a double gap, but only after passing through it. By that time, it should already be "determined", go through one path or both. An American physicist John Wheeler suggested conducting such an experiment in the 1970s, and the experiment with a "deferred choice" was conducted in the next ten years. He uses smart methods for measuring the paths of quantum particles (usually light particles - photons) after they choose one path or a superposition of two. It turned out that, as Bohr predicted, there is no difference whether we delay measurements or not. As long as we measure the path of the photon before it hits and is recorded in the detector, there is no interference. It seems that nature "knows" not only when we peep, but also when we plan to peek.

Theory of Eugene Wigner

Whenever in these experiments we open the path of a quantum particle, its cloud of possible routes "shrinks" into a single clearly defined state. Moreover, a delayed experiment suggests that the act of observation itself, without any physical intervention caused by the measurement, can cause collapse. Does this mean that true collapse occurs only when the result of measurement reaches our consciousness? This possibility was offered in the 1930s by the Hungarian physicist Eugene Wigner. "It follows that the quantum description of objects is influenced by the impressions entering my mind," he wrote. "Solipsism can be logically consistent with quantum mechanics." Wheeler was even amused by the idea that the presence of living beings capable of "observing" transformed what had previously been a multitude of possible quantum pasts into one concrete story. In this sense, Wheeler says, we become participants in the evolution of the Universe from the very beginning. According to him, we live in an "accessory universe." Physicists still cannot choose the best interpretation of these quantum experiments, and to some extent the right to do so is granted to you. But, one way or another, the subtext is obvious: consciousness and quantum mechanics are somehow connected [7,8]. Starting in the 1980s, the English physicist Roger Penrose suggested that this relationship could work in a different direction. He said that regardless of whether consciousness affects quantum mechanics or not, it is possible that quantum mechanics is involved in consciousness.

Theory of Roger Penrose

And Penrose asked: what if molecular structures exist in our brain that can change their state in response to a single quantum event? Can these structures assume a superposition state, like particles in a double-gap experiment? Can these quantum superpositions then manifest in how neurons communicate through electrical signals? Perhaps, said Penrose, our ability to maintain seemingly incompatible mental states is not a quirk of perception, but a real quantum effect? In the end, the human brain seems to be able to handle cognitive processes that are still far superior in capabilities to digital computers. Perhaps we are even capable of performing computational tasks that cannot be performed on ordinary computers using classical digital logic [9,10]. Penrose first suggested that quantum effects are present in the human mind in a 1989 book, The Emperor's New Mind. His main idea was "orchestrated objective reduction." Objective reduction, according to Penrose, means that the collapse of quantum interference and superposition is a real physical process, like a bursting bubble.

Orchestrated objective reduction is based on Penrose's assumption that gravity, which affects everyday objects, chairs or planets, does not exhibit quantum effects. Penrose believes that quantum superposition becomes impossible for objects with more atoms, because their gravitational effect in this case would lead to the existence of two incompatible versions of space-time. Penrose further developed this idea with an American physician Stuart Hameroff. In his book Shadows of the Mind (1994), he suggested that the structures involved in this quantum cognition can be protein threads — microtubules. They are found in most of our cells, including brain neurons. Penrose and Hameroff argued that microtubule oscillations can take on a state of quantum superposition. But there is nothing in support of the fact that this is even possible. It was assumed that the idea of quantum superpositions in microtubules would be supported by experiments proposed in 2013, but in fact, these studies did not mention quantum effects. In addition, most researchers believe that the idea of orchestrated objective reductions was debunked by a study published in 2000. Physicist Max Tegmark calculated that quantum superpositions of molecules involved in neural signals cannot survive even the instant of time required for signal transmission [11].

Quantum effects, including superposition, are very fragile and are destroyed in the process of so-called decoherence. This process is due to the interactions of a quantum object with its environment, since its "quantumness" is leaking. Decoherence was believed to be extremely fast in warm and humid environments, such as living cells. Nerve signals are electrical impulses caused by the passage of electrically charged atoms through the walls of nerve cells. If one of these atoms was in superposition, and then collided with a neuron, Tegmark showed that the superposition should decay in less than one billionth of a billionth of a second. For a neuron to emit a signal, it needs ten thousand trillion times as much time. That is why ideas about quantum effects in the brain do not pass the test of skeptics. But Penrose inexorably insists on the Quantum hypothesis. And despite predicting Tehmark's ultrafast decoherence in cells, other scientists have found manifestations of quantum effects in living things. Some argue that quantum mechanics is used by migratory birds, which use magnetic navigation, and green plants, when they use sunlight to produce sugar during photosynthesis. With all this, the idea that the brain can use quantum tricks refuses to leave for good. Because they found another argument in her favor. Can phosphorus maintain a quantum state?

Theory of Matthew Fisher

In 2015, physicist Matthew Fisher of the University of California, Santa Barbara, argued that the brain may contain molecules that can withstand more powerful quantum superpositions. In particular, he believes that the nuclei of phosphorus atoms can have this ability. Phosphorus atoms are found in living cells everywhere. They often take the form of phosphate ions, in which one phosphorus atom combines with four oxygen atoms [12]. Such ions are the main unit of energy in cells. Most of the energy in the cell is stored in ATP molecules, which contain a sequence of three phosphate groups connected to an organic molecule. When one of the phosphates is cut off, the energy released by the cell is released. Cells have molecular machines for assembling phosphate ions into groups and for cleaving them. Fisher proposed a scheme in which two phosphate ions can be placed in superposition of a certain kind: in an entangled state. Phosphorus nuclei have a quantum property - spin - which makes them look like small magnets with poles pointing in certain directions.

In an entangled state, the spin of one phosphorus nucleus depends on another. In other words, entangled states are states of superposition involving more than one quantum particle. Fisher says the quantum-mechanical behavior of these nuclear spins can withstand decoherence. He agrees with Tegmark that the quantum vibrations that Penrose and Hameroff talked about would be highly dependent on their environment and "decode almost immediately." But the spins of the nuclei do not interact so much with their surroundings. Nevertheless, the quantum behavior of the spins of phosphorus nuclei must be "protected" from decoherence. Quantum particles can have different spin. This can happen, says Fisher, if phosphorus atoms are incorporated into larger objects called Posner molecules. They are clusters of six phosphate ions in combination with nine calcium ions. There are certain indications that such molecules can be in living cells, but so far they are not very convincing [13]. In Posner molecules, Fisher argues, phosphorus spins can withstand decoherence for a day or so, even in living cells. Consequently, they can affect the functioning of the brain. The idea is that Posner molecules can be absorbed by neurons.

Once inside, the molecules will activate a signal to another neuron, decaying and releasing calcium ions. Due to the entanglement in the Posner molecules, two such signals can turn out to be entangled in turn: in some way, this will be a quantum superposition of "thought". "If quantum processing with nuclear backs is actually present in the brain, it would be an extremely common occurring all the time," says Fisher. For the first time this idea came to his mind when he was thinking about a mental illness. "My introduction to brain biochemistry began when I decided three or four years ago to explore how and why lithium ion has such a radical effect in the treatment of mental disorders," says Fisher. Lithium preparations are widely used to treat bipolar disorder. They work, but no one really knows why. "I was not looking for a quantum explanation," says Fisher. But then he stumbled upon a work which described that lithium preparations had different effects on rat behavior depending on which form - or "isotope" - of lithium was used. At first, it puzzled scientists. From a chemical point of view, different isotopes behave almost the same, so if lithium worked like a regular drug, the isotopes should have the same effect.

Nerve cells are associated with synapses, but Fisher realized that the atomic nuclei of different lithium isotopes can have different spins. This quantum property can affect how lithium-based drugs work. For example, if lithium replaces calcium in Posner molecules, lithium spins can have an effect on phosphorus atoms and prevent their entanglement [14]. If this is true, then he can explain why lithium can treat bipolar disorder. At the moment, Fischer's assumption is nothing more than an intriguing idea. But there are several ways to check it. For example, that the phosphorus spins in Posner molecules can maintain quantum coherence for a long time. This is Fisher and plans to check further. Nevertheless, he fears being connected with earlier ideas about "quantum consciousness", which he considers speculative at best.

Conclusion

Physicists do not really like to be inside their own theories. Many of them hope that consciousness and the brain can be extracted from quantum theory, or maybe vice versa. But we don't know what consciousness is, not to mention the fact that we don't have a theory that describes it. Moreover, occasionally loud exclamations are made that quantum mechanics will allow us to master telepathy and telekinesis (and although somewhere deep in concepts this may be so, people understand everything too literally). Therefore, physicists are generally afraid to mention the words "quantum" and "consciousness" in one sentence. In 2016, Adrian Kent of Cambridge University in the UK, one of the most respected "quantum philosophers," suggested that consciousness can change the behavior of quantum systems in a subtle but completely detectable way. Kent is very careful in his statements. "There is no convincing reason to believe that quantum theory is a suitable theory from which the theory of consciousness can be derived, or that the problems of quantum theory must somehow overlap with the problem of consciousness," he admits.

But he adds that it is completely incomprehensible how one can derive a description of consciousness, based solely on pre-quantum physics, how to describe all its properties and features. One particularly exciting question is how our conscious mind can experience unique sensations like red or the smell of frying meat. Apart from people with visual impairments, we all know what red looks like, but we cannot convey this feeling, and in physics there is nothing that could tell us what it looks like. Feelings like these are called qualia. We perceive them as common properties of the external world, but in reality they are products of our consciousness - and this is difficult to explain. In 1995, the philosopher David Chalmers called this a "heavy problem" of consciousness. This prompted him to suggest that "we could make some progress in understanding the problem of the evolution of consciousness if we allowed (if only just allowed) that consciousness changes quantum probabilities." In other words, the brain can really influence the measurement results. From this point of view, he does not determine "what is real." But it can influence the likelihood that each of the possible realities imposed by quantum mechanics will be observed. Even quantum theory itself cannot predict this. And Kent believes that we could look for such manifestations experimentally. Even boldly evaluates the chances of finding them.

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