

# Quantum physics: A better model to understand consciousness-related brain functions

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**Abstract.** With the development of quantum mechanics, it is applied to different fields, including biology. As intricate as human brains, quantum physics is replacing classical physics in explaining consciousness-related brain functions. The bilayer phospholipid membrane enables neurons in the brain to store and protect quantum information, and the abundance of 1/2-spin phosphorous creates potential for quantum entanglement that allows information to transfer along long distances and process consciousness. Scientists have used Schrödinger's cat thought experiment to explain how the uncertain and superimposed states in quantum physics can be applied to our decision-making behavior with conditions of "Yes" or "No." Scientists also conducted experiments to witness the quantum entanglement of particles in the brain. The observation of the phenomenon broke the pre-assumption that quantum entanglement is too fragile to occur in the chaotic environment in human brains, and it allows the possibility of ongoing conscious processing there. To further understand the decision-making mechanism, physicists should also integrate the knowledge in neuroscience, psychology, sociology, and other interdisciplinary subjects.

**Keywords:** Quantum physics, brain, decision making

## 1. Introduction

With more knowledge about the human brain and quantum physics, scientists suggest quantum physics is a better model for explaining the human brain than classical physics. Quantum mechanics might explain why our brain is so powerful that it can defeat robots carefully designed and built with physics. According to Schwartz, "Classical physics is deterministic: [...] the state of the physical world at any time is completely determined by the state of any earlier time" [1]. With our previous understanding based on classical physics, the brain works as an automated machine in which every response is predetermined from the very beginning. In this case, our conscious thoughts and decision-making are nothing more than an illusion.

As the classical model falls short in explaining the complicated and mysterious behavior of the human brain, scientists begin to seek a connection between the brain and the equally intricate quantum field. In quantum physics, the connections between the environmental input and the brain's response are not passive, and "quantum theory is thus an information-based theory built upon the preparative actions of information-seeking agents" [1]. Instead of merely witnessing natural occurrences, quantum physics takes the interactions humans have with their surroundings as information input and stimulates a

response to them. In other words, quantum mechanics provides a more dynamic explanation for brain-behavior through its integration with real-life experiences.

The fundamental units of the brain, neurons, have a natural protection of quantum information due to their bilayer phospholipid membrane, which acts as a chiral insulator. [2] With the special membrane features, the “bionic” quantum devices help carry brain signals. In a recent study by Matthew Fisher, he proposes that the nuclear spin of  $^{31}\text{P}$  is uniquely suited as quantum information carriers in human brains since phosphate is one of the few elements that have a  $\frac{1}{2}$  spin and is substantial in the brain, making it suitable as memory qubits. [2]

Despite a new field of study, quantum biology has come into real-life applications. In a recent study on human's response to Earth's magnetic field, scientists discovered that humans had an enzyme that is similar to the magnetically sensitive proteins birds have. With quantum computing, scientists were able to model the effects of the enzymes and brought light to the theory that external situations, such as the change in magnet field, may affect our internal senses. [3]

## 2. Quantum Physics and Decision Making

Quantum physics makes it possible to explain consciousness-related brain behaviors, especially decision-making. Humans process information in the form of a superposition of the conscious and unconscious states. In quantum modeling, whether a specific quantum matter contributes to a decision-making behavior or not is not essential; instead, the brain is treated as a black box on a meta-level where uncertainty and probability are involved. The modeling is usually described with classical probability until the irrationality of the behavior requires a quantum explanation. [4]

In quantum theory, systems can be closed or open [5], characterized by a famous thought experiment: Schrödinger's cat could be both alive and dead at the same time under quantum explanation, whereas it was either alive or dead based on classical physics [6]. The experiment shows that quantum superposition can explain the “uncertain” aspects of the brain's functions, which contain “the sequence of conscious events that constitute the willful selection of action” [6]. Schrödinger's experiment resembles the brain function of generating a response between “Yes” and “No”, where the probability of either response follows the rules of quantum mechanics. [4]

According to Khrennikov, “any alive biosystem is an open system” that involves the interaction between the complex quantum system and its environment. Emotional coloring, or contextualization, makes consciousness cover up unconsciousness in the system. During the process of contextualization, decoherence scatters the information, a process that can be disturbing. Nevertheless, decoherence, a transition from quantum physics to classical physics through the loss of quantumness, is crucial in describing emotional colorings, such as decision-making. [4]

Scientists have come up with evidence to prove the fascinating connections between quantum physics and consciousness in human brains. An interesting finding that the Lithium-6 isotopes can increase complex brain activities while the Lithium-7 isotopes have the opposite effects has caught scientists' attention. The difference between the two isotopes is their electron spin: Lithium-6 has nuclear spin of 1, and Lithium-7 has nuclear spin of  $\frac{3}{2}$ . Likewise, Xenon isotopes with  $\frac{1}{2}$  spin are effective anesthetizers, while Xenon isotopes with spin 0 have little impact on brain activity. [7]

The discovery suggests that elements' nuclear spin plays a role in their function in the brain. Scientists proposed that in order for the brain to carry out quantum computation, it needs to utilize the  $\frac{1}{2}$  nuclear spin of phosphorous, an active participant in many biochemical reactions, to form quantum entanglement, which is required to bring out the full functions of quantum computation. However, quantum entanglement is very fragile, and scientists believe that it cannot happen in the damp, warm environment in human brains, where electrons are crowding against each other. To fight back the claim, Christian Matthias Kerschen and David López Pérez designed an experiment and successfully detected entanglement in the brain. [7]

By experimenting with the isotopes of Xe, the group of researchers led by Li N discovered that “atoms with nuclear spin of  $\frac{1}{2}$  are more capable of forming quantum entanglement than those with other types of nuclear spins” [8]. While the Xe isotopes with 0 spin are effective anesthetics, Xe-129 does

not have the anesthetic function. Due to its nuclear spin of  $\frac{1}{2}$ , Xe-129 is more likely to entangle with other particles than other Xe isotopes, and the entanglement allows it to send information at a distance. [8] Quantum entanglement may therefore become the key in conscious processing, and the entangling states of particles may explain the conflicting thoughts generated daily in our brain.

Although there is appealing evidence suggesting the relation between quantum physics and brain function, some scholars believe there is no bond between the two subjects. They claimed that even though quantum physics seemed a compelling model that could explain the most intricate mechanisms, its ability might have been overestimated. They argued that putting together the two things we barely understand would lead to futility.

### 3. Discussion

Neuroscientists were the first to understand the mechanisms of humans' decision-making behavior. They had amazing findings about how communication between the prefrontal cortex and hippocampus promotes the decision-making process in four steps: First, the sensory input stimulates hippocampal neurons. Second, reacting to secondary stimuli, the hippocampus generates initial information. Then, the prefrontal cortex processes the initial information and adds additional information needed. Last, the prefrontal cortex determines the proposed controlling process. The mutual communication between the prefrontal cortex and hippocampus creates a closed circuit to produce a decision. [9]

Besides the prefrontal cortex and hippocampus, other parts of the brain also affect the decision-making process, and we have yet to know their mechanism. With quantum physics, we might better understand the cooperation among different components in the brain by applying a quantum model to the complicated and somewhat unpredictable patterns of neural signals. With quantum computation, we can process more signals simultaneously, keeping up with the rapid rate at which our brain generates conscious and unconscious thoughts.

In addition, human decision-making behavior is subject to cognitive biases, emotional influences, social influences, risk tolerance, etc. [10], factors outside the realm of biology. Thus, in order to thoroughly understand how we make decisions, biophysicists need to integrate the knowledge of psychology and sociology into quantum biology. While the mechanism inside the human body is crucial to decision-making, the factors in the outside environment also play a role in generating the information input and affecting the internal mechanism.

### 4. Conclusion

In the paper, we discussed the difference between classical and quantum physics. The dynamic feature of quantum physics makes it a better model for explaining intricate brain behaviors. Scientists have proposed that our brain acts like a quantum computer. To prove the idea, researchers have identified quantum entanglement in the brain environment previously considered hostile to delicate entanglement activities. The nuclear spin of atoms turns out to be the key to conscious processing, and phosphorous, an abundant element in human brains with  $\frac{1}{2}$  spin, plays a vital role in entangling with other particles. The consciousness-related brain functions, such as decision-making, involve uncertainty and superposition, as quantum physics does. The Schrödinger's cat thought experiment can parallel our daily decision-making behavior. The two states of the cat being alive and dead correspond with our responses of "Yes" and "No". The study of quantum mechanics in human brains has led to a further understanding of our response to the change in Earth's magnetic field and the mechanisms of anesthetics. It is important to keep up with the study of the intricate relationship between quantum mechanics and brain activities, and the integration of subjects such as neuroscience, psychology, and sociology will further help our investigation of consciousness-related brain behaviors.

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