Quantum Mechanical Approaches to Cognition/Consciousness (Excerpt)

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The currently prevalent view of cognition/consciousness is that cognitive processes are supported by the brain's neural computations and that consciousness is an emergent property of such neural computations that have reached a certain level of complexity. Despite its popularity, however, there are questions concerning cognition/consciousness that are yet to be answered in this stance. Some seek alternative approaches to find answers to those questions. One such alternative approach is to apply quantum mechanics to cognition/consciousness. Although this may seem somewhat too far-stretched, it is theoretically interesting just how (and how well) such approaches explain cognitive processes. In this paper I will review three quantum mechanical approaches to cognition/consciousness and then to pose some questions regarding these approaches.

The Penrose-Hameroff "Orch OR" model of consciousness

As the name suggests, this is a model of consciousness and has been developed to account particularly for subjective experience or "qualia". The model assumes that microtubules (hollow tube-like structures in neurons) consisting of protein molecules called tubulins are capable of sustaining their own quantum states and thus of functioning as qubits. They spontaneously go into quantum states due to the quantum level forces called London forces. However, their quantum states self-collapse, without being measured, after a certain period due to quantum gravity (a quantum mechanical phenomenon called "objective reduction" or OR). These forces create synchronous oscillation of tubulins between quantum and classical states (orchestrated objective reduction or Orch OR) at a certain interval.

The idea is that this synchronous quantum-classical state oscillation creates qualia. While tubulins are in the quantum states, the brain has no access to what they might encode as qubits. When they self-collapse to the classical state, the brain can "see" what is encoded and thus suddenly becomes conscious of what is sensed or perceived. Since the OR process is non-computable, it is virtually impossible for another OR to result in exactly the same classical state as the previous one. In other words, our perception cannot go backward in time, and thus the Orch OR process creates the flow of time. Hameroff also suggests that the same Orch OR process can account for cognitive processes such as face recognition and decision making.

Quantum Mechanical Approach to Representation and Natural Language Processing

A method for applying quantum mechanical computation to representation has been proposed by Joseph Chen. It was motivated by the poor performance by classical AI systems in certain cognitive tasks (such as logical inference). Although he admits that this is not a model for mental representation, Chen emphasizes the analogy between physical objects in quantum states and human mental states.

The basic idea is to treat mental representation (what he calls "a state of affairs" defined by logical statements) as a superposition of eigenstates (all the possible observables or outcomes) and logical inference as "an undisturbed evolution of the quantum system". He claims that an AI system using this method exhibits a representation of a state of affairs that fits human intuition in logical inference tasks, such as non-monotonic reasoning and counterfactual conditionals, which are considered difficult tasks to carry out on classical AI systems.

Chen and Kudlek applied this method also to natural language processing, more specifically, the German-English translation task. Again, the idea is to mental lexicon as a superposition of symbols (in this case, words) and thereby to avoid one-to-one mapping between German and English words. They reported a near perfect accuracy rate.

Active Agents Model of Intelligence

The basic assumption of the model is that intelligence is "a result of the workings of numerous active cognitive agents" and that its power lies in its ability to adapt to the environment. Kak proposes that, in order to achieve such intelligence, the brain processing has a hierarchical organization with associative at the bottom, self-organizational in the middle, and quantum at the top and that "each cognitive agent is an abstract quantum system. The linkages amongst the agents are regulated by an appropriate quantum field".

Questions

1. What are the relations between quantum and neural computation in the brain?
2. How does the brain set up quantum computation (e.g., how to set initial states of qubits)?
3. What structure(s) in the brain can function as quantum gates?
4. Can quantum accounts provide more insights into cognition/consciousness than

neural ones?