THE BRAIN MICROBIOTA AS IT RELATES TO THE ORCH OR THEORY OF CONSCIOUSNESS

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Abstract

It is proposed to incorporate the concepts of brain microbiota and microbial consciousness in the Orchestrated Objective Reduction (Orch OR) theory of human consciousness with the goal of increasing its explanatory and predictive powers. If consciousness arises from quantum computations in cytoskeletal structures inside human neurons, there is no theoretical impediment at hypothesizing that it might also occur in the cytoskeletal structures of the microbes resident in the human brains. If the concept of the brain microbiota is integrated in a general Orch OR theory, its explanatory and predictive powers would be vastly increased.

Introduction

A recent article by Hameroff describes Orchestrated Objective Reduction (Orch OR) as "the most complete, and most easily falsifiable theory of consciousness" (Hameroff, 2021). The Author proposes an experiment, based on exposure to anesthetic gases, that would confirm or reject the theory that consciousness is based on quantum computations occurring inside microtubules of brain neurons rather than in the plasticity of the web of connections established between cells of the central nervous system as proposed by the majority of theories of consciousness (Doerig et al., 2021).

The basic tenets of the Orch OR theory of consciousness

Orch OR is a revolutionary theory of consciousness published by Nobel Laureate Sir Roger Penrose and Professor Stuart Hameroff for the first time in the mid-nineties (Hameroff and Penrose, 1996), and further elaborated in successive publications (for updated review, see Hameroff 2021). A common denominator of the various evolutions and revisions of the theory is the concept that consciousness has its origin inside brain neurons, thanks to phenomena of quantum computing that occur in the context of subcellular structures, the microtubules, and involve the conformational arrangement of a protein, tubulin. This theory is fundamentally different from all other theories of consciousness that postulate the origin of consciousness in the web of synaptic connections between neurons. According to the Orch OR theory, consciousness is the result of a sequence of discrete phenomena, each being an instant of OR of a quantum state, where it is postulated that these quantum states are present as components of a biological quantum computing machinery operating inside the conformation of the protein molecular structure of neuronal microtubules. Actual consciousness is self-generated when these phenomena of OR are "orchestrated" in an adequate manner. Orchestration occurs thanks to inputs from other neurons through wireless transmission of resonant vibrations, quantum entanglement or classic synaptic transmission as well as to inputs arising inside the microtubules that constitute a sort of memory. Given the quantum nature of the computation events, these can be transmitted to a significant number of neurons across wide areas thus generating a quantum activity of large scale inside the brain. A point that differentiates the Orch OR

theory from all other theories of consciousness is that its implications are not limited to neuroscience or biochemistry, but extend to general relativity and quantum physics with ramifications in the fields of philosophy and spirituality. A most intriguing aspect of the theory consists in the implication that the processes of quantum computing due to Orch OR, as they occur in neuronal microtubules, are intimately connected with the processes operating at the level of the fine structure of the universe. Minute perturbations of the space-time fabric at the Planck/quantum level are deemed to be responsible for OR both in the brain and in the universe. In other words, the OR events that are responsible for computing and generation of consciousness when orchestrated, are the same that are at work at the level of the basic structure of the universe where minute perturbations of quantum coherence of the space-time fabric are considered responsible for the OR or the collapse to just one single state as originally postulated by Penrose (1989). In this interpretation, the Orch OR theory connects the working of the brain with that of the universe. In the decades after its inception, the theory has received many constructive criticisms that led to evolutions and revisions of the original theory, whose chore tenets, however, have never been proven false. Actually, as per the classical Falsification Principle by Popper, its falsifiability makes the theory stronger than many others up to the point that Hameroff entitled his latest article 'Orch OR' is the most complete, and most easily falsifiable theory of consciousness (Hameroff, 2021). In order to demonstrate the completeness and easy falsifiability of the theory, Hameroff proposes four paradigm cases:

1 Conscious vs non-conscious states; is the theory able to distinguish between the two states?
2 Small network criterion; how many neurons are necessary for consciousness to arise?
3 Reduced brain volume; there are people with significantly reduced brain volume, practically with no brain (Feuillet et al. 2007). How can consciousness arise if not through Orch OR?
4 Minimization of mysteries; the Occam's razor favors minimization of mysteries, thus favoring the hypothesis that Orch OR has explanatory value for a number of mysteries ranging from neuroscience to general relativity and quantum physics (Hameroff, 2021).

Here, it is introduced a fifth paradigm case that should be taken into consideration in designing experiments aimed at falsifying the Orch OR as well as any other theory of consciousness.

The fifth paradigm, the brain microbiota

Hameroff and all those concerned with theories of consciousness focus their attention on the human cells of the brain, neurons and glial cells, but do not take into account the presence of microbial cells that constitute the brain microbiota, whose influence on brain function is nothing less than "immense" (Branton et al., 2013). The first description of bacterial cells in the brains of healthy individuals was published in 2013 (Branton et al., 2013); the term "brain microbiota" in the context of neurological diseases was used for the first time in 2016 (Ruggiero, 2016). In 2018, ultrastructural studies demonstrated abundance of microbial cells in the areas associated with reward-seeking, learning, memory and consciousness, *i.e.* the *substantia nigra*, the hippocampus and the pre-frontal cortex (Roberts et al., 2018). The microbes in human brains are the same that are found in soil and water; it has been hypothesized that they reach the brain carried by cells of the immune system as well as travelling along the axons of peripheral nerves (Branton et al., 2013; Roberts et al., 2018). Whatever the case, just as it would be unrealistic today to discuss the function of the gut, or that of the immune system, without considering the essential role of the microbiota (Wu and Wu, 2012), it is proposed that also the discussion on the different theories of consciousness, and, in particular, Orch OR, should take into account the role of the brain microbiota.

Microbial consciousness

If consciousness arises from quantum computations occurring in cytoskeletal structures inside human neurons, there is no theoretical impediment at hypothesizing that cytoskeletal structures of microbes could give rise to forms of consciousness or awareness. Microbial consciousness arising from the cytoskeleton was described in 2017 (Reddy and Pereira, 2017) and this concept was further elaborated in an essay published in 2019 where the Authors postulate that subjective awareness emerged as an intrinsic

feature of the first unicellular forms of life through the working of oscillating cytoskeletal structures, and structurally flexible proteins, that is, in a manner closely reminiscent to the concepts at the basis of Orch OR (Baluska and Reber, 2019). If phenomena of quantum entanglement occur between the microtubules of adjacent neurons (Hameroff and Penrose, 2014a), they will also occur between the cytoskeletal structures of human neurons and those of the microbes of the brain microbiota as well as between the cytoskeletal structures of the different microbes. Wireless and quantum entanglement-based communication between microtubules of individual neurons has been theoretically conceived and experimentally demonstrated (Hameroff and Penrose, 2014b), thus supporting the hypothesis that the process of orchestration can take place on a large scale, in theory involving all neurons across the wholeness of the brain. According to what is proposed here, these phenomena of communication are not restricted to human neurons, but are extended to the brain microbiota. This is all the more conceivable when considering that wireless communication based on the resonance of vibrations inside microtubules does not require neurotransmitters or synapses (Sahu et al., 2013) and, therefore, can occur between neurons and microbial cells even though they are not anatomically connected by synapses. It is worth noticing that the interpretation of Orch OR described here is consistent with the concepts put forward by Barlow (2015) who described how the Orch OR theory can explain consciousness of plants.

Implications for the design of experiments

In designing an experiment to prove Orch OR, Hameroff proposes to expose the brain to anesthetic gases and observe whether dampening of quantum interference beats in tubulin and microtubules occurs (Hameroff, 2021). However, volatile anesthetics affect bacterial functions such as motility, biofilm formation and signal transduction (Chamberlain et al., 2017). Of particular significance are the effects on biofilm formation since this phenomenon is paradigmatic of the so-called microbial intelligence (Westerhoff et al., 2014). In short, in designing the experiment to prove or falsify Orch OR, the effects of volatile anesthetics on the brain microbiota should be considered in order to prevent potential misinterpretation of the results.

Conclusion

Orch OR might indeed be the most complete theory of consciousness even though it has to be considered special or relative to the human part of the brain; if the concept of the brain microbiota and the ensuing concept of the rhizome (Ruggiero, 2017) could be integrated in a more general Orch OR theory, its explanatory and predictive powers would be vastly increased. For example, the Orch OR theory postulates that consciousness may exist independently of biological substrates, namely human neurons (Hameroff and Penrose, 2014b). The cases of people with vastly reduced brains who lead normal lives appear to support this postulate (Feuillet et al., 2007). If the concept of the microbiota is incorporated in the Orch OR theory, the issue of permanence of consciousness independently of neurons would be further supported by the consideration that the microbiota survives the human body (Ruggiero, 2017); if the Orch OR phenomena occurring inside the microtubules of human neurons are entangled and shared with the microbiota, an organ that has 10 times more cells and 100 times more DNA-based information that its human counterparts in our bodies, then survival of consciousness becomes a microbiological rather than a philosophical issue.

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