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Commentary

On the Mechanistic Perceptions of Consciousness: From Quantum Mechanics to Consciousness and Free Will and from David Bohm to Benjamin Libet

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Biologists and biochemists have been reluctant to enter the realm of consciousness with real scientific methods. One approach by Nobel laureate Francis Crick in his book "Astonishing Hypothesis: The Scientific Search for the Soul" [1] was to look at scientific papers that, eventually, could give insight into consciousness. The problem, in my opinion, is that the author took data obtained from experiments in nonhuman animals. The question that immediately arises is whether studies using animal models can be of interest to what only humans can have, be aware of and verbalize: consciousness. He focused on the visual system; this is puzzling because blindness is not incompatible with consciousness. In fact, we know that subjective events are noted as consciousness in individuals whose cortical primary visual areas are not functional [2]. Francis Crick also focused on the brain and brain circuitry and, there is consensus that consciousness is based on phenomena that occur in the central nervous system. Benjamin Libet was an electrophysiologist who did research that came close to providing a mechanistic view of consciousness, or at least one aspect within consciousness, the temporal factor of being aware of an action. Most unfortunately, his book, "*Mind Time: The Temporal Factor in Consciousness*", is neither among the "*100 Best Consciousness Books of All Time*" selected by *BookAuthority* (https://bookauthority.org/books/best-consciousness-books; accessed on August 14, 2022) nor among "*The 115 Best Books about The Brain and Mind*" selected by Upjourney (https://upjourney.com/best-books-about-the-brain-and-mind; accessed on August 14, 2022). Libet approached the subject from the point of view of brain-mind interactions, thus assuming that both are independent variables (i.e., "dualism"). Whereas the brain is material and the mind is not, Libet wisely thought that interactions required, in his own words, a "cerebral mental field". He defined it as "*a system property produced by the appropriate activities of billions of neurons*" [3]. It is remarkable that he tried to measure something derived from this field; in other words, he tried to demonstrate its existence. He stated that the experiment to demonstrate how brain-mind interactions work requires humans and is possible. He did not have the ability to do it (doctors and surgeons are required) and, as far as I know, no one has tried it. I wonder why this possibility raised by Libet has not attracted enough attention to be carried out. He sensed that no one was willing to do the key experiment to test the brain-mind-field hypothesis, yet he wrote: "*but if it does indeed deliver a positive confirmation, this will create a Galilean type of revolution in neuroscience, and science in general!*" [3]. The cerebral mental field was, for Libet, equivalent to electromagnetism or gravity. Hence, the physicist's approaches to consciousness maybe similar to those used in electromagnetism or gravity, and they are.

Physicists have never been afraid to delve into the discussion of consciousness and have hinted at how the underlying processes may take place. Unsurprisingly, physicists rely primarily on the theory of quantum physics. A paper by Tuszynski [4] is an historical account of the potential for quantum mechanics to explain biological events and, also, to find the basis of consciousness. The paper also handles, in a very appropriate way, the issue of applying a theory that mainly works for both elemental particles and macroscopic elements or events. Of note is the Ricciardi-Umezawa model that in 1967 was proposed to "*satisfy the essential requirements of the observed functioning of the brain*" [5]. The model, which included variables to describe the states of an "isolated" brain, was considered similar to "quantum mechanics" [6]. The paper also deals with the Heisenberg uncertainty principle, for which quantum mechanics establish some limits but that would go against the laws of Chemistry as we know them today. There can be no uncertainty whether a biochemical reaction will take place in a living cell or not.

In his article, Tuszynski explores the potential of certain types of biological assays for advancing the understanding of consciousness [4]. One wonders whether nanotechnologies have real potential for approaching an explanation of consciousness or whether it is more a wish based on the potential they have in biomedical engineering. The hopes pinned on microfilaments are also intriguing because they are not a feature of neurons, per se, but are found in all types of eukaryotic cells. This problem goes back to the previously mentioned topic of consciousness in animals. Using animals to "measure" awareness is problematic because one cannot easily tell if an animal has been aware of a specific event. But there is an additional and relevant question, which is whether or not consciousness is a particular property of humans, or whether it can occur in other mammals, or perhaps in all eukaryotic cells. Does a yeast have a conscience?

Although the article by Tuszynski [4] is an excellent, informative, and worthwhile read, I think that the temporal factor demonstrated by Libet and collaborators should be considered in any paper on consciousness. The idea is that the stimulus reaches the brain "unconsciously" and it is made conscious by a decision of whether it happened or not. In temporal terms, actual awareness may take 0.5 seconds after the neural activity has been triggered although the stronger the stimuli, the shorter the delay for awareness [7].

The physicist David Bohm (1917–1992) deserves attention for providing useful insights into the potential of quantum mechanics and new physics theories in the understanding consciousness. It is not completely clear whether he refused to participate in the Manhattan project to develop the atomic bomb, or was not accepted due to both Jewish origins and "leftist" activities, but he did have to leave the United States in the era of McCarthyism. After a long journey of professional and personal enrichment in 1961 he became a professor at Birkbeck College, University of London.

Bohm together with David Pines showed that the electrons in a metal do not belong to any particular atom but "float" freely around all atoms; thus, they provided a solid foundation for understanding electrical conduction in metals [8–11]. For the demonstration made in the fifties, they used quantum mechanics approaches to investigate the interaction of electric charges in a high-electron-density gas [12]. The involvement of ion transport across membranes in neurotransmission was unknown at the time, and one wonders if the rapid transmission of electricity might have impacted Bohm's ideas about the mechanisms of consciousness. In 1951 he wrote a very informative book, "*Quantum Theory*", because he knew the difficulties of understanding a disciplinary subject that is based mainly on mathematical equations and complex algebra. Among other contributions to physics, he demonstrated the so-called Aharonov-Bohm effect that consist of magnetic-field influence on electron condition even when the field is no longer measurable. In the words of Aharonov and Bohm (1959): "*there exist effects of potentials on charged particles, even in the region where all the fields (and therefore the forces on the particles) vanish*" [13]. Bohm distanced himself from the "Copenhagen school", led by Niels Bohr, and stressed the impossibility of reconciling quantum and relativity theories. While waiting for a new unifying theory he thought that some *ad hoc* adjustments could be assayed. He exploited one of the fundamental differences between the two prevailing theories to propose a solution that would fit with what we observe in the universe. One theory focuses on the small, whereas the other is holistic. Hence, his view was that one must take into account the particularities observed individually or at the particle level together with the "whole" that is the substratum of the theory of relativity. Consequently, events in the universe are connected to each other, or in other words, the smallest circumstance in one part of the universe is immediately detected in a distant part of the universe.

In my opinion, consciousness cannot be separated from the concept of free will. Using classical approaches and current dogmas in biology, everything is predictable but we perceive that we, humans, have control over our actions. Life is sustained in chemical reactions that are governed by the laws of chemistry. The most relevant here is that any chemical reaction must satisfy a particular condition: that the difference in free energy (ΔG) between reactants and products must be <0. G comes from the last name of Josiah W. Gibbs (1839–1903), who defined the concept of "Gibbs free energy", and showed that no reaction can occur if ΔG is positive. Another wording for the same law is that a reaction is spontaneous if $\Delta G < 0$; therefore, a reaction whose $\Delta G > 0$ would not occur at all. A rigorous view determines that phenomena, including human decisions, are deterministic since, otherwise, Gibbs' law would not hold. A common way of conveying this hypothesis is to say that a supercomputer with all the parameters would be able to determine everything from the origin of the Milky Way to the next paragraph of this text. In short, it is conceptually different to be aware (conscious) of the actions for which we are responsible than to be conscious of the acts predetermined by the laws of the universe. In the latter case, the demonstration of Libet's cerebral mental field would be enough. In contrast, if we are really considering options, newer chemical rules are needed to overwhelm Gibb's law. I think of two not-necessarily-mutually-exclusive options for these new rules: (1) certain atomic/ionic/molecular phenomena in cells can only be explained in terms of quantum mechanisms; and (2) some phenomena in cells occur at nearly the speed of light. To close the cycle, anything new or novel to explain consciousness and beyond requires bridging the now unbridgeable gap between quantum and relativity theories.

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