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Quantum Theories of Consciousness

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The assumption is often made in conventional cognitive science that consciousness is a computational process resulting from macroscopic neural activity as described by classical physics. That assumption has been questioned both because it has been unsuccessful in explaining consciousness and because it is based on outdated ideas about the nature of matter. More contemporary quantum theories may be more successful for understanding cognition. For example, Mari Jibu, Kunio Yasue, and Yasushi Takahashi have proposed a theory of memory as a spinor field underlying cortical dipoles in which quantum mechanical tunnelling instantiates memory decay and in which the creation of Goldstone bosons is the process of memory recall. Or, more radically, as proposed by Eugene Wigner, consciousness itself could be a causal agent that collapses the state vector describing physical reality. For Evan Harris Walker, such an effect occurs at synapses in the brain thereby regulating its electrochemical activity. According to Henry Stapp, Jeffrey Schwartz, and Mario Beauregard it is the attention density of our ongoing experiential stream that modulates neural activity through the quantum Zeno effect with demonstrated implications for the treatment of Obsessive-Compulsive Disorder. Such ideas address the possibility of the existence of a pre-physical substrate, akin to David Bohm's implicate order, which could also be the referent of the transcendent consciousness experienced by John Wren-Lewis and Franklin Wolff. The notion of a deep consciousness as a pre-physical substrate from which physical reality is precipitated is one way in which some of the ideas of the theorists presented here could be integrated. It would be worth pursuing this line of investigation to determine eventually the goodness of fit of the resultant theories with observational data.³

Keywords: Consciousness, quantum theories, cognition.

Motivation for Quantum Theories

Why should we consider quantum theories of consciousness? There are a couple of reasons. The first is the failure of classical computationalism to adequately explain cognition and, in particular, consciousness. By "classical computationalism" I am referring to standard computer analogue and connectionist models of cognition (e.g., Pylyshyn, 1986). These models have some value as metaphors, just as the psychodynamic conceptualization of the psyche as a hydraulic system or the behaviourist telephone switchboard have their usefulness. But intractable problems arise when these metaphors are taken seriously as actual explanations of reality. These problems have always existed (e.g., Barwise, 1986), but have become more obvious with time. As Jerry Fodor (2000) has said: "I would have thought that the last forty or fifty years have demonstrated pretty clearly that there are aspects of higher mental processes into

³ *Author's note. Correspondence concerning this article should be addressed to Imants Barušs, e-mail: baruss@uwo.ca*

which the current armamentarium of computational models, theories, and experimental techniques offers vanishingly little insight” (p. 2). In my case, over the course of more than a decade of carefully analysing them, I have found computational theories of consciousness to be so riddled with lacunae (e.g., Barušs, 1990a; 1990b; 1992; 1995; 1998) that I do not see any hope for them in the near future and have stopped paying attention to them. The point is that we need a good alternative to computationalism.

The second reason why we should consider quantum theories of consciousness has to do with grounding our understanding of the psyche in the best theories of physical reality. We need to understand the biological substrate of cognition, as, indeed, we try to do in neuroscience. But as Patricia Churchland (1980) has said: “For purists, the real bottom will of course belong not to neuroscience but to physics” (p. 207). Well, I am certainly a purist and welcome the role of physics in explanations of consciousness. However, “until recently, virtually all attempts to understand the functional activity of the brain have been based, at least implicitly, on some principles of classical physics that have been known to be fundamentally false for three-quarters of a century” (Schwartz, Stapp, & Beauregard, 2005, p. 1310). Neuroscientific theories based solely on classical physics are bound to fail because they do not take into account the occurrence of quantum phenomena. For this we need quantum theory. As Jibu and Yasue (2004) have pointed out: “It seems of much importance now to let the neuro- and cognitive scientists know the truth: it is necessary to rely on quantum theory . . .” (p. 287) and “incorporation of quantum theory into the investigation of brain functioning is an inevitable turning point of the consciousness research” (p. 288). Thus, it is necessary to consider quantum processes in any theory of cognition.

Relinquishing traditional computational theories and embracing quantum theories of cognition leads to a shift in the level of physical reality at which mental events can be thought of as taking place. Rather than emerging as a byproduct of cellular activity, mentation can be viewed as occurring within the molecules constituting biological organisms. In particular, consciousness, as an experiential stream, could be a phenomenon associated with subatomic events. Furthermore, consciousness could be inextricably interwoven into the fabric of physical reality in essential ways.

Condensation Theories

One way of thinking about mentation as a quantum process is to associate it with Fröhlich’s Bose-Einstein-like condensation. When a boson gas, such as a dilute gas of rubidium atoms, is cooled sufficiently, it undergoes a phase transition whereby the condensed bosons collectively fall into their lowest possible energy states. The resulting condensate is an ordered state in which the condensed particles behave in a coordinated manner (cf. Annett, 2004; Daintith, 2005). Something similar occurs in a biological system. According to Herbert Fröhlich, if energy is supplied to oscillating electrical dipoles, such as “protein molecules or parts of cell walls,” (Marshall, 1989, p. 80) some of that energy will go into the “lowest collective frequency mode” (p. 79) of the oscillators. Because of the properties of matter at the subatomic scale, the effect that this would have would be that of creating greater coherence between the separate parts of that biological system.

Mari Jibu, Yasushi Takahashi, and Kunio Yasue used these types of ideas to try to account for memory. For Jibu et al., proteins surrounded by water in the brain constitute a system of “corticons” which can go into an ordered state known as a “spinor field.” Incoming energy, gated through interactions with classical constituents of a cell, is a source of data for the corticons which then encode that information through a phase transition until such time as it decays through quantum mechanical tunnelling. Memory retrieval occurs when a signal similar to the encoded information prompts recall through the creation of Goldstone bosons (Jibu & Yasue, 2004; Takahashi & Jibu, 2004). Quantum mechanical tunnelling is a process whereby subatomic particles can escape energy barriers that would not be possible to transcend through classical means (cf. Goswami, 1997/2003), whereas Goldstone bosons are massless particles created in conditions such as those considered by Jibu et al. (Daintith, 2005; Sudbery, 1986). Although some of the details of this theory need clarification, it does suggest a way in which memory could be encoded in the quantum states of electrical dipoles in the brain rather than being a function of cellular biochemistry.

Collapse Theories

Before it is observed, there is no single state in which physical reality exists. Rather, there is a superposition of possible physical realities whose description is called the “state vector.” At the time of observation, one of the possibilities becomes the physical reality that is actually experienced. All of the other possibilities either disappear or continue on their own trajectories as alternate physical realities, depending upon one’s point of view. Or, as some physicists have posited, environmental effects introduce “decoherence” that erases some of the possibilities, although it does not appear as though all of them can be thus made to vanish (Adler, 2003). If the alternate realities are believed to disappear entirely in addition to any decoherence effects, then the state vector is said to have “collapsed.” The problem, known as the “measurement problem,” becomes that of determining the cause of the collapse.

One solution to the measurement problem has been to say that consciousness, acting as a non-physical source of intervention, causes the collapse of the state vector. This was the position taken, for example, by Eugene Wigner (1972): “. . . the ‘reduction of the wave packet’ . . . takes place whenever the result of an observation enters the consciousness of the observer or, to be even more painfully precise, my own consciousness, since I am the only observer, all other people being only subjects of my observations” (p. 137). However, if we are going to go down this road, then it makes sense to separate out two aspects of measurement, namely one which notes the effects of the collapse of the state vector and the other which triggers the collapse. And so consciousness can be thought of as having both an observational capacity and a volitional agency (Barušs, 1986). Evan Harris Walker (2000) has also, in effect, made this distinction, noting that it is the will which causes the collapse of the state vector.

Walker (1970; 1977; 2000) has said that the exercise of the will to collapse the state vector occurs, in particular, at synapses between nerve cells, resulting in modulation of electrochemical communication processes taking place in the brain. An electrochemical impulse arriving at a synapse creates an electrical potential across the synaptic cleft

leading to quantum mechanical tunnelling of electrons from postsynaptic to presynaptic structures. According to Walker, the tunnelling electrons induce conformational changes to presynaptic macromolecules thereby triggering the release of neurotransmitter. Walker has postulated that these effects are propagated throughout the brain by “hopping conduction” along ribonucleic acid molecules (Walker, 2000, p. 229). Because all of the electrons involved in this process are indistinguishable, the tunnelling and propagation of these electrons can be regarded as the activity of a single electron, thereby producing the kind of coordinated activity necessary to account for the nature of consciousness. For Walker, “consciousness is the collection of potentialities that develop as these electrons and these structures of the brain interact” (p. 237). Will, by causing the state vector to collapse in a particular manner, initiates this electron cascade, thereby selecting which synapses will fire and, hence, determining our experience and behaviour.

Henry Stapp, together with some colleagues, has developed a similar idea. For Stapp, when we talk about consciousness collapsing the state vector, we are talking about the influence of our ongoing subjective stream of consciousness. The example that Stapp has used is that of raising one’s arm. I think I would like to raise my arm and then my arm goes up. In this manner we have mental causation. The evidence to substantiate such a causal notion of volition comes from Jeffrey Schwartz’s brain-imaging studies of “self-directed neuroplasticity,” whereby changes to the right caudate nucleus were found after ten weeks of cognitive-behavioural therapy for Obsessive-Compulsive Disorder. Furthermore, he found that “dispassionate self-observation” appeared to be a critical aspect of the cognitive treatment for it to be effective (Schwartz, 2005; Schwartz & Begley, 2002). Of course, one’s experience of volition could be after the fact since the brain’s cybernetics operating through more conventionally conceptualized physiological processes could be the causal agents also in cases of neuroplasticity.

Stapp et al. call on a quantum phenomenon known as the “quantum Zeno effect” to suggest a mechanism for wilful action. Closely spaced repeated observational acts can hold a quantum system in a constant state even if there is pressure through classical mechanisms for it to change. They suggest that what happens is that, as we increase the amount of mental effort, we increase the rapidity with which the selection of alternatives occurs. For Stapp et al., “oscillating states of macroscopic subsystems of the brain” (Schwartz, Stapp, & Beauregard, 2005, p. 1320; emphases removed) acting in a widespread coherent manner instantiate the intended actions, thereby modulating the electrochemical neural activity of the brain. In practical terms, then, effort can hold in place a “template for action” (p. 1324; emphases removed) by increasing the density of attention so that an intended action has a higher probability of occurrence than it otherwise would. It should be noted that the quantum Zeno effect, which has been observed experimentally outside the context of mind-body interaction, is considered by some physicists to be, not an effect of consciousness during an observational process, but a decoherence effect (e.g., Polkinghorne, 2002).

The Notion of a Pre-Physical Substrate

With these collapse theories of consciousness, what we have essentially, is the notion of a pre-physical substrate from which causal effects on physical reality can emerge.

But there has been a more radical notion in quantum theory outside the context of consciousness studies, namely, that physical reality as such emerges from a pre-physical substrate. And this applies not just to physical bodies, but to physical space itself, within which physical bodies are situated. For example: "... space is no longer the all-embracing theatre of reality, but a structure that has emerged together with the macroscopic material entities that have emerged from the microworld" (Aerts & Aerts, 2005, p. 153).

David Bohm has used the notion of an "implicate order" to conceptualize a pre-physical substrate (Bohm, 1980/1983; Bohm & Hiley, 1993; Factor, 1985). His ideas can be illustrated with the following analogy. One of the physical phenomena that is predicted by quantum mechanics but whose existence is not possible within classical physics, is that of entanglement. In some cases, subatomic processes remain connected in non-local ways. For example, under some conditions, a photon moving away from another in the opposite direction from it can nonetheless behave in such a manner as to "take into account" the activity of the distant photon. Bohm has used the example of fish in a tank to discuss such quantum entanglement: Imagine two images taken with two separate cameras, from two different angles, of a single fish, projected onto two separate television screens. How is it that the fish on the second screen can so perfectly copy what the fish on the first screen does? Well, it is not at all unusual since they are both images of the same fish. In the same way "... we may regard each of the 'particles' constituting a system as a projection of a 'higher-dimensional' reality" (Bohm, 1980/1983, p. 188). According to Bohm, what we experience, our consciousness as well as the physical world, is an explication of an implicate order.

The notion of a pre-physical substrate is also found in some cases of alterations of consciousness. For example, following an opiate-induced coma, John Wren-Lewis (1994) felt that "some kind of brain-cataract [had been] removed, making unobscured perception possible for the first time" (p. 109). Upon examination of his experience, he found a "dazzling darkness" (p. 109) underlying his ordinary consciousness that was so palpable that it seemed as though the back of his head were exposed to the infinite reaches of space. This underlying darkness gave rise to the physical world so that: "... what I perceive with my eyes and other senses is a whole world that seems to be coming fresh-minted into existence *moment by moment* ..." (Wren-Lewis, 1988, p. 116). Similarly, following his experience of enlightenment, Franklin Wolff has maintained that our subject-object experience of reality arises from a generative underlying substrate. In fact, for Wolff, "... consciousness is itself the substantial substrate ..." (Merrell-Wolff, 1995, p. 195).

I agree with Wolff, in that I think that the pre-physical substrate has the quality of consciousness. Not consciousness in the sense of an ongoing experiential stream, but "deep consciousness" as a normally inaccessible aspect of our psyches of which our ordinary consciousness is a byproduct. This is consistent with Amit Goswami's (1993) contention that "... our consciousness is the consciousness of the Being that is beyond the subject-object split" (p. 187; emphases removed). Thus it is possible that such "... non-local consciousness... collapses the brain-mind from outside space-time..." (Goswami, 1993, p. 186). In such a quantum theory of consciousness, it is not that quantum theory explains consciousness, but rather that quantum theory allows for the understanding of a possible relationship of consciousness to physical matter.

I think that consciousness, in the sense of deep consciousness as a pre-physical substrate, analogous to the implicate order, could be giving rise to space-time with its constituent corporeality. Intentions within one's experiential stream, as aspects of the deeper consciousness, perhaps actualized as a coherent subatomic system through Fröhlich's Bose-Einstein-like condensation, could affect physical reality by directing the collapse of the state vector at synapses, thereby modulating the electrochemical activity of neurons. In this way, some of the ideas of the theorists presented here could be integrated. It would be worth pursuing this line of investigation to determine eventually the goodness of fit of the resultant theories with observational data.

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