Quantum Consciousness is Cybernetic

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ABSTRACT: Classical mechanics cannot naturally accommodate consciousness, whereas quantum mechanics can, but the Heisenberg/Stapp (H/S) approach, in which consciousness randomly collapses the neural wave function, leaves the conscious function unrestricted by known physical principles. The Umezawa/Yasue (U/Y) approach, in which consciousness offers superposed possibilities to the match with sensory input, is based in the first physical principles of quantum field theory. Stapp thinks of the brain as a measuring device, like a Geiger counter, and overlooks that the brain upholds second-order quantum fields that are symmetry-conserving with respect to reality. Consciousness is *cybernetic* rather than having a random function.

1. Introduction

1.1 The current upsurge of intense interest in quantum brain theory and consciousness (e.g., Hameroff, 1994; Jibu and Yasue, in press; Penrose, 1994; Stapp, 1993) is fueled in large part by what Stapp calls "the fundamentally holistic character of the quantum mechanical description [of] nature [which is] perhaps its most basic and pervasive feature" (3.12). Since consciousness, too, in some difficult to define sense is holistic in character, the hope has arisen that consciousness can finally be explained in quantum terms. Classical mechanics, on the other hand, does not naturally accommodate consciousness, as Stapp nicely shows. His theory of consciousness is problematically founded, however, which vitiates the impact of his article.

2. The Brain as Measuring Device

2.1 Lets consider Stapp's view that the brain is, at a certain level selected in evolution, a quantum measuring device where Heisenberg actual events are conscious events.

The brain is, in effect, treated as a Heisenberg-type quantum measuring device.
The mental life of each human being is representable as a sub-sequence of the full sequence of Heisenberg events." (Stapp, 1993, p. 201)
The neural wave function enfolds superposed possibilities, and then consciousness chooses one classical branch and annihilates the others. The choice is "unruly," Stapp (1993, p.32) says, "not individually controlled by any known law of physics." So the heart of consciousness is random on Stapp's view. He hopes that some future physics will find a law (1993, p.216), but it certainly looks like barring an enormous revolution in quantum physics, Stapp has installed chance deep in his theoretical framework, where the quantum choices associated with conscious events take place:
The question arises: What determines *which* of the alternative possible brain activities is actualized by an actual event? According to contemporary quantum theory, two factors contribute to that quantum choice. The first is the local deterministic evolution of tendencies governed by the Heisenberg equation of motion...Then an actual event occurs. This event actualizes one of the distinct top-level patterns of brain activity, and hence selects one of these distinct possible course of action. This selection is, according to contemporary quantum theory, made by the second factor: #pure chance#. (Stapp, 1993, p.168-9, emphasis added).
2.2 This unhappy result motivates a reconsideration of the assumption that the brain is a quantum measuring device. Lets consider a different model, which I call U/Y, since it is based in Umezawa's (1993) formulation of quantum field theory and Yasue's extension of quantum field theory to quantum neurophysics (e.g., Yasue et al, 1988; Yasue, Jibu and Pribram, 1991; Jibu et al, 1994; Jibu and Yasue, in press). Since Stapp is tightly linked to Heisenberg, I will call that model, which implies a random function to consciousness, H/S. I think that the brain is not properly considered a measuring device in U/Y, and in the reformulation, as we shall see, the troublesome random effects of consciousness are replaced by a more congenial cybernetic consciousness which is surprisingly consonant with the traditional notion of self as agent.

3. Yasue's Quantum Brain Dynamics

3.1 The brain is remarkable in that it provides a variety of substrates for quantum fields. Different brain substrates for quantum fields have different functions. The sensory quantum field, for example, supervenes on oscillating biomolecules of high dipole moment in the neuronal membrane. When the pumping rate reaches a critical value, Froehlich condensation occurs with macroscopic coherence of quanta (Froehlich, 1968).

3.2 Another quantum field-supporting biosubstrate is a dense nanolevel web of protein molecules which penetrates neuronal and neuroglial membrane boundaries. I call this filamentous web the "nanolevel neuropil." Inside the neuron the nanolevel neuropil consists not only of microtubules but also neurofibrils and other structures which connect via protein strands to proteins floating in the cell membrane. Outside the neuron in the synaptic cleft is the extracellular matrix of collagen and glyco-conjugates, which are also

connected to membrane proteins, so that a pervasive web is formed.

3.3 There are quasi-crystalline water molecules within the microtubules and associated with hydrophylic regions on the web of protein fila- ments. This ordered water is yet another brain biosubstrate for a quantum field which supports super-radiance and self-induced trans- parency within the microtubules (Jibu et al, 1994).

3.4 Jibu and Yasue (1992, 1993) have proposed, following some earlier suggestions by Umezawa (e.g. Ricciardi & Umezawa, 1967), that vacuum states of this water rotational field record memory. I have suggested that the function of the nanolevel neuropil is cognitive (Globus, 1995).

3.5 There is a fourth quantum field substrate where an interaction takes place between the sensory quantum field and the cognition/memory quantum field. This is a plasma of charged particles interacting with the electromagnetic field. The structure of this bio-plasma is peculiar: it is divided into two very thin layers separated by a permeable membrane. Membrane channels open and close, and ions rush back and forth between the two layers down electrical and chemical gradients. It is in this perimembranous bioplasma, whose state is given by the ionic density distribution, that sensory and cognition/memory quantum fields interact. In this interaction of quantum fields, classical orders may be formed (as when the multiplication of complex conjugates gives a real number).

4. U/Y v. H/S

4.1 The conception of the brain is far richer in U/Y than H/S; for U/Y, the brain generates second order quantum fields. A Geiger counter or Schroedinger's cat box has a quantum field description (as a Bogoliubov transformation of the quantized field) but such ordinary measurement devices do not sustain quantum fields like the brain does. So reality is described by wave functions, both microscopic and macroscopic, and among those macroscopic realities are well- developed human brains which themselves sustain quantum fields and their interactions.

4.2 We should not think of these second order quantum fields as making measurements but as offering possibilities to the match. Both sensory input and cognition/memory participate in the evolution of the state variable by offering possibilities to the match, but the latter is far richer than the former. I have previously called this rich quantum plenum of superposed possibilities the "holoworld" (Globus, 1987) and suggested that the probabilities of the various possibilities are tuned (Globus, 1995). The more limited possibilities of sensory input continually interact with the tuned holoworld, and a classical order continually unfolds in the perimembranous bioplasma.

4.3 So instead of a measurement collapsing the wave function of a quantum field to a classical order, we have a match between quantum cognition/memory and quantum reality, a match in which classical order is unfolded.

5. Quantum Cybernetics

5.1 In the U/Y model, there is no consciousness with a random core. Instead *consciousness is cybernetic*. We need more background in Yasue's quantum brain dynamics to see how this works. (See especially Yasue et al (1988) and Yasue, Jibu & Pribram (1991)).

5.2 The ionic density distribution of the perimembranous bioplasma is the state variable. The phase waves of the sensory and cognition/memory quantum fields are control variables. The cybernetic system is accordingly described by a wave function equal to the phase waves multiplied by the square root of the ionic density distribution. The equation for the evolution of this wave function is Schroedinger-like. The wave function of the cognition/memory quantum field steers the evolution of the perimembranous bioplasma toward certain possibilities, some of which are actualized in the complex match with the possibilities of the sensory input flux.

5.3 What rids U/Y of the randomness at the heart of H/S is that funda- mental physical conservation laws come into play, so that the quantum field interactions in the perimembranous bioplasma are symmetry- conserving with respect to sensory input. Cognition/memory is tied to reality in virtue of the match, and the result of the match conserves real invariance. Furthermore, there is a fundamental optimization principle, identical to Hamilton's principle of least action (in which the kinetic energy minus the potential energy is minimized along the trajectory of a moving particle), as applied to a particular system's dynamics. So evolution of the neural wave function is not random but optimized under Yasue's principle of least neural action.

5.4 Instead of consciousness collapsing a quantum superposition in a succession of quantum jumps, we have consciousness offering a quantum plenum of superposed possibilities to the match with the more restricted possibilities of sensory input. Instead of a saltatory world line in the Heisenberg succession of objective tendencies and actual events, there is a continuous unfolding of worlds from a holoworld.

5.5 The quantum cybernetics here are nonlocal in one of Stapp's senses (D.4c). Now one of the self's defining properties is that it has no location. (Thus Descartes distinguishes *res cogitans* from *res extensa*.) Furthermore, the self, as agent, controls. It is tempting to identify the unlocalizable self with nonlocality and its control with quantum cybernetics. Succinctly put: *I am nonlocal control.* So instead of the randomness at the core of consciousness found in H/S, there is nonlocal control construed as self-agency.

6. Conclusion

6.1 Classical mechanics cannot naturally accommodate consciousness, whereas quantum mechanics can, but the Heisenberg/Stapp approach, in which consciousness collapses the neural wave function, leaves the conscious function unrestricted by known physical

principles, which is suspiciously Cartesian. Thus despite its quantum basis, Stapp leaves quantum brain theory and quantum consciousness mired in metaphysics.

6.2 For the Umezawa/Yasue approach, in contrast, consciousness (qua cognition/memory) participates in an interaction. Consciousness is a quantum eruption offering possibilities to the match with sensory input and thus with reality. Mental states are not randomly chosen in mental acts but conserve real symmetry and evolve under optimal control (i.e., minimization of the neural action). Cybernetic conscious- ness here is fully consistent with the first physical principles of quantum field theory.

6.3 The key moves in shifting from H/S to U/Y are (1) recognizing that brain substrates uphold second-order quantum fields, and so should not be treated as ordinary physical measuring devices, and (2) replacing the random collapse of the neural wave function by a complex match which conserves input symmetry in the unfolding of classical orders.

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