A Review of The Physics of Consciousness by Evan Harris Walker

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REVIEW OF: Evan Harris Walker (2000). The Physics of Consciousness: The Quantum Mind and the Meaning of Life. Cambridge, MA: Perseus. 368 pp. ISBN 0-7382-0436-6.

At least three books struggle to emerge from this volume. One book, at the level of popular science, leads us through the development of physics, from Newton's laws to Bell's inequalities, in order to argue for the relevance of consciousness to the understanding of quantum theory. This is followed by a sketch of an interpretation of quantum mechanics. Interwoven with both is a memoir of Walker's teenage girlfriend, who died of Hodgkin's disease nearly fifty years ago. The theme which holds the volume together is Walker's insistence on the importance of looking beyond materialism.

In this review, I intend mainly to criticize Walker's interpretation of quantum theory. It seems to me that popular science is very important, and that Walker's effort in this direction is, on the whole, interesting, well-written, and competent. Nevertheless, I feel that there is a problem, albeit one which is not uncommon, with attaching to popular science what amounts to no more than a collection of undeveloped proposals, requiring a very different audience for its evaluation.

Walker expresses materialism as the claim that, "We need only enumerate the basic pieces of matter, write down the forces acting on them, and turn the crank. Out will come the answer to every question about the nature of our reality" (p.68). Such a claim might be attacked not only by those philosophers who are unhappy with the idea of explaining *consciousness in entirely physical or functional terms, but also by some physicists who have doubts about whether we really do have such perfect theories that all we have left to do is to "turn the crank". The most interesting possibility is that new solutions to problems within physics might help resolve philosophical problems with materialism; perhaps, for example, by radically altering the physical terms at our disposal. Indeed, some of us do believe that quantum theory, our most powerful, wide-ranging, and accurate physical theory, has huge conceptual gaps, and that those gaps can be interpreted as indicating that "consciousness" may refer to more than just a way in which it is natural for some particularly-complex physical systems to talk about themselves. Walker does a good job of reviewing these issues; very much from the point of view of a modern physicist. The general reader who is more inclined to philosophy than physics might like to try, as an alternative, either Lockwood (1989) or Chalmers (1996). Albert (1992) introduces more mathematics but also provides better coverage of recent work in the foundations of quantum theory. All three of these authors pay more careful attention than does Walker to the many-worlds idea. Walker's rejection of this idea is based on a caricature which bears very little relation either to modern work on the subject, or to anything published by Everett himself.*

There is nothing new in the suggestion that there are difficulties with quantum mechanics and that those difficulties may have something to do with the idea of an "observer". It is not easy to go further. Walker starts with a discussion of Zen Buddhism. Like psychoanalysis, Zen is a system which can repudiate any comment, but Walker seems to invoke it merely to underline the primacy of the subjective over the objective. Even this is a dangerously radical move for a physicist, as it threatens to make the detailed technical triumphs of science irrelevant. Indeed, the major problem as I see it, for anyone who wants to look beyond conventional materialism is to explain the successes of neuroscience.

Walker attempts to tie together quantum theory and neuroscience by arguing that quantum tunnelling has a vital role in synaptic transmission. This depends upon very specific and technical assumptions about the mechanism involved, for which he refers to Walker (1977). In that paper, he claims that his theory "predicts specific results for future experimental work. Its utility will be measured by the validity of these predictions." It is disturbing, therefore, that his book gives no more recent references to work in this area, despite the fact that synaptic structure and function are among the most studied topics in neuroscience. A magnificent survey of the entire field which has just appeared (Cowan, Suedhof, & Stevens, 2001), certainly leaves no space for his hypotheses.

Walker claims that "only in the most exceptional circumstances [...] do we ever find quantum mechanical effects entering the macroscopic world" (p.194). By a "quantum mechanical effect", he seems to mean an effect which he cannot explain in classical terms. In view of this, he might seem required, if he is to demonstrate that quantum effects underpin consciousness, to argue that something like quantum tunnelling has a role to play in the brain. But, in fact, if the fundamental laws of physics are quantum mechanical, then every physical effect is quantum mechanical. Quantum mechanics infects every physical structure at every level. In particular, as I have argued in Donald

(1990), the unpredictability of the detailed functioning of a living human brain requires an explanation compatible with our understanding of quantum theory.

The firing of an individual neural synapse on any single occasion is certainly unpredictable (Regehr & Stevens, 2001). In classical terms, this unpredictability is caused by unknown thermal molecular motions. In quantum terms, on the other hand, even under the conventional hypothesis in which quantum tunnelling is not involved and vesicle release is an ordinary biochemical process triggered by an electrochemically-driven influx of calcium into the pre-synaptic neuron (Suedhof & Scheller, 2001), the unpredictability lies deeper, stemming from an entire history of uncertain scatterings and interactions at the molecular level and below. But a central task of an interpretation of quantum mechanics is to explain how and at what level quantum unpredictability is resolved. Walker only attempts a resolution at the level of synaptic function. Molecular interactions lie below this level, and therefore he could argue for the relevance of quantum theory to consciousness, even without invoking quantum tunnelling. In conventional quantum-mechanical terms, if it never "collapsed" at any other moment, the quantum state of the brain would have to "collapse" at a great number of synaptic firings in order to make each of those firings definitely happen at moments definite in biological terms.

Walker says, however, that this is only "talking about quantum noise randomly affecting things in the brain" (p.220). He wants to "integrate[ ] synaptic firings into a single quantum mechanical conscious existence" (p.228). To do this, he builds on the idea of quantum tunnelling at synapses to produce what seems to me to be an even more fantastic mechanism. This requires the electrons which according to him are involved in synaptic tunnelling, going on to jump from synapse to synapse using soluble RNA molecules as stepping stones. Not only does this mechanism strike me as biologically implausible, but also I cannot understand how it is supposed to act as an integrating process. Walker's argument seems to depend on an unexplained confusion between a classical picture of an electron as a hopping object and a quantum picture of its wavefunction. The electron wavefunction in the brain is an irreducibly many-body object. Neural electrons are indistinguishable not just in the sense that they are all identical, but also in the sense that, on biological timescales, they are inseparably entangled. Walker refers to "interlaced collections of quantum potentialities weaving together the possibilities" (p.237). What he does not explain is how the individual "possibilities" are characterized. Are they vesicle releases? Are they electron hops or trajectories? This is a version of the preferred basis problem; a problem which in one guise or another is utterly fundamental for most interpretations of quantum theory. An argument which simply assumes a solution to this problem can hardly be convincing. Nevertheless, a solution to the preferred basis problem is assumed, not only here, but also in Walker's subsequent invocation of a non-linear modification to the Schroedinger equation, based on Walker (1988).

According to Walker, his treatment of consciousness is dualist. The problem is that his theory seems to require mental abilities which go well beyond any sort of parallelism between mind and physical brain structures. Walker claims that quantum possibilities *allow us a non-illusory free will, stating that "for will to have any meaning, it must be possible for the mind to affect events -- for the mind to control the body" (p.259). This gives a picture in which mind decides among the elements of a quantum superposition. What is not made clear, however, is where the mind keeps the computational power required for this decision making. If it is in the brain, then the brain should be capable of detecting and analysing the structure of an uncollapsed superposition so as to match the willed choice to the collapsed outcome. Even if the structure is merely guessed at, the matching process would seem to require a new type of physical interaction; and anyway the choice seems to be made before that interaction comes into play. On the other hand, if the decision making is extra-physical, then Walker has merely invented a homunculus in a Cartesian theatre (Dennett 1991) and is denying all the vast range of evidence which indicates that our physical brains provide the mechanisms by which we think. The theory of consciousness proposed by Eccles (1986) also suggests an influence of mind on quantum uncertainties at synapses and is vunerable to similar criticism.*

In his final chapter, Walker elevates his homunculus to the status of a god. He invokes this mind, apparently without a brain, to explain how the structure of the universe arose from its initial quantum state. I suspect that, even in the framework of his own theory, he is making a mistake here in assuming that "collapse" must happen at the moment when our conventional picture of the universe would require it. If, as Walker supposes, it is "observers" who bring about "collapse", then our conventional picture of the universe may be radically incorrect. The universe could have continued as a vastly complicated superposition until such time as entirely physical processes allowed observers to evolve within some part of that superposition. Not until that time would it seem to be necessary for any "collapse" to occur.

Although I disagree with many of Walker's proposals, there are only a couple of points where I feel he has made mistakes which should never have been published. One is his assertion that the square of the absolute value of the complex number R+iS is R^2 - S^2 rather than R^2 + S^2. This could be ignored as a misprint were it not both discussed and repeated. Another repeated claim which might make one lose confidence in Walker's mastery of the wide range of subjects on which he depends is his estimate of 2.35 times 10^13 for the number of synapses in the human brain. I have no idea what the best estimate should be, but I am sure that to give three, or even two, significant figures is absurd, and that any such accuracy would be swamped by variation between individuals. By comparison, Churchland and Sejnowski (1992, p. 51), give the number of synapses as "about 10^15".

Walker raises many interesting and important questions. Even if incomplete, his answers, in general, are thoughtful, provocative, and original. I disagree with these answers, but then of course I do have my own alternative theory (Donald 1999), so I may be biased.

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