REVIEW ARTICLE
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Review of: Stapp, Henry, *Quantum Theory and Free Will: How Mental Intent Translates into Bodily Action* (Springer, 2017) and (passim) Freeman, Walter and R. Quian Quiroga, *Imaging Brain Function With EEG: Advanced Temporal and Spatial Analysis of Electroencephalographic Signals* (Springer, 2013)

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INTRODUCTION

The first book is about many things, of which Free will is indeed the most important, and we will start with a quick account of who Henry Stapp is. It is fair to say he is one of the last of the golden age of physics, when the adulation received by physicists – often not wholly inappropriately! – resembled that given to rock stars. His CV is remarkable – Segre, Pauli, Heisenberg, and Wheeler were all colleagues - and his focus on transmuting von Neumann's (VN) insights about mind and matter into a 21st century meme has been relentless. Appendix E in the book describes the onset of this trope.

There are several lacunae that should be pointed out immediately; not surprising given the author's advanced years. P.2 continues a quotation where a paragraph break should have begun so it looks like Newton knew about QM. The reference section is incomplete and there is no index. However, Stapp writes very well and passionately.

What must be emphasized at this point is how technically sharp, and appropriately sure of his own skills, he remains. The reader is invited to study Appendices A and B for his refutation/extension of JS Bell. This review will focus on free will, the explicit theme of the book, before venturing into the more troublesome philosophical waters. For the record, the Libet work cited in the book has been superceded by work cited in

Maoz et al (2017) and will be ignored; in a classic piece of political and scientific tragedy, Libet lost Feinstein, his neurosurgeon, to cancer before this work and SF gained a mayor, later Senator Feinstein, to replace the murdered Moscone.

There is a consensus about the cognitive impenetrability of Quantum mechanics (QM) with a few dissidents like Penrose. Underlying all this, to my mind at least, Max Born's distinction between the "ontological" interpretation, whereby the square of the modulus of the amplitude can refer to where a particle ACTUALLY IS , and the "epistemological' interpretation, a skeptical rejoinder that the most we can say is that IT IS FOUND there (sorry for shouting!).

Then come some antinomies. EPR (Einstein Podolsky Rosen's 1935 attempted reductio ad absurdum paper contra QM, underlying much of the argument in this book) rules out the idea that we can both have explanation based on local causality and an objectivist interpretation of QM. Yet another layer emerges with Bell's pointing to the cosine of the angle between the two axes of observation as being critical, as "QM" proposes, and the wealth of experimental data supporting this.

At this point, the tension is between QM and EPR; we have forgotten the "ontological"/"epistemological' dichotomy. Roger Penrose among other moderns would like to revive it, and indeed find in favour of the former. In that vein, Bohm's "pilot wave" can indeed rescue Penrose's championed cause, but does so at the cost of an omniscient pilot wave; Einstein's comment was that Bohm bought his results too cheaply.

It is highly unlikely that we can return to a notion of reality at this level which fits our physical intuitions, and yet QM abounds with great scientists shouting "The horror! The horror!", Speaking of which, this review is not meant to be the final word on this subject. It is a rather impressionistic cross-section of the fields to which this book relates, and an attempt to indicate where we should focus our energies. That does not mean that the current state of play in consciousness studies is in any way acceptable.

FREE WILL

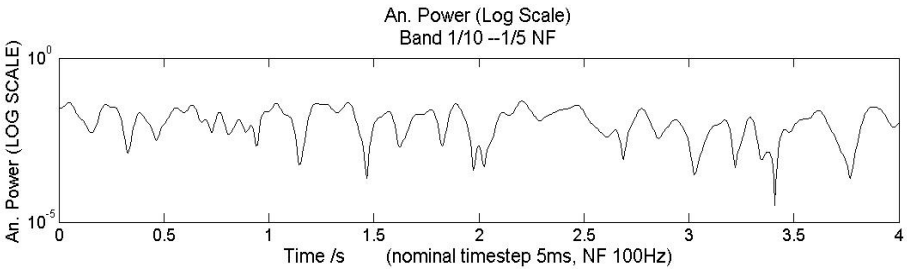
We do NOT want all our actions to be free – civilization has famously been described by Whitehead as the making automatic of processes that heretofore demanded voluntary effort. In fact, "ultra paranoid computing" researchers like Patrick Lincoln exploit the fact of automatism to provide secure access to computers. Essentially, in Lincoln's paradigm, users are encouraged to repeat a physical action (like learning a "guitar hero" solo) until a clear signature of that user emerges at a speed faster than the sampling rate of consciousness – in short, behaviour "tells" of which the person is

unaware.

It is also noticeable that we project "intent". "memory" and so on of individuals who may not be conscious of the processes that give rise to such projection; they perhaps have become embedded in their CNS (Central Nervous system). Consider this situation – you are driving, with your "focal awareness"/attention directed to that act. There is music on the car system. "Subsidiary awareness" is devoted to the music, and to the positions of your limbs, the desultory car conversation many people (like Dublin taxi drivers!) are very skilled at, etc.

Famously, any attempt to do another complicated task (like texting) at the same time is dangerous as our attentional system is serial, not parallel. We can think of this as a sampling issue, with perhaps 3 of the 7 conscious samples a second being given to driving, 4 to everything else. If it falls below 3 in this schema, as in texting, danger emerges.

We can think of these samples as the "null spikes" in this visualization of ECOG (electrocorticogram neural data, with sensors on the cortex as freeman describes) with fast neural gamma oscillations, a signature of consciousness, superimposed on the white noise of random neural firing;



In this schema, conscious apprehension of the external world - like that which produces a real number in QM observation – is a rarity. In general, the effects of our awareness are changes to our nervous system, If every decision was totally free, without reference to our experience as classically encoded in our CNS, we would not be able to function. Indeed, it is arguable that the cognitive role of self is precisely "remembering" for each domain experienced in the past, which aspect was best treated as subject and which as object. The pathologies associated with breakdown of this system are schizophrenia, epilepsy, and so on.

There may be one exception, where gap junctions (electrical as distinct from chemical synapses) are recruited in times of emergency to do tasks at a speed much greater that chemical synapses can. In that case, the subject often cannot remember what she has done as the actions/thoughts perhaps occurs faster than the sampling rate

of consciousness. We explore this below.

In general, then, we have limited attention, will and consciousness – pretty much the conclusion from the $4M + "free will" project. When attention enters conscious experience, the will becomes prominent. Arguably, most of our education involves training of attention. We cannot stay conscious of any process for more than a few seconds – those who can do so often have no control of attention and are labeled "autistic". Interestingly, people like Dirac, while "The strangest man", seemed to have access to a math realm not permitted to most of us and, conversely, did little work outside the regularity of Oxbridge.

Maoz et al (2017) distinguish between human action oriented to a specific deliberately-chosen goal and "Libet" pointless action, arguing they have different neural signatures. To return to Moscone; the "Twinkie" defence used to get his murderer a reduced sentence ironically helped the rise of Feinstein's widow as the spectre of moral breakdown loomed.

MEASUREMENT IN QM OR EUREKA - ARCHIMEDES LEARNS QM!

Please note that, while there is some evidence that this universal genius had intuited the elements of calculus, what follows is an entirely fictitious take on what is already a legend. Archimedes, disconsolate at not finding a way to measure the volume of filigree, takes a bath, Initially, it is fun – he pushes the water with his nether regions, and a wave propagates around the tub. During this phase he identifies himself with an "apparatus" that coincides physically with his body. We cannot say what the level is because there is a smudge/smear from all the impulses from Archimedes ensuring that the level is different all around the tub and it is changing too quickly for our instruments. Let's call this Process 2 (Von Neumann/Stapp – VNS) or U (Penrose) i.e. "unitary" evolution..

Depression sets in as he remembers his task from King Hiero. He decides to commit suicide and dunks his entire body and head under the water. The level settles and will remain that way while the body stays under water. Then Archimedes realizes – Eureka! – that the volume taken up by his body must equal the volume of water displaced. Roughly speaking, they are Hermitian matrices, and this is Process 1 (Von Neumann/Stapp) or R (Penrose) ie "non-unitary" evolution.

In fact, Archimedes can simply choose to identify himself with his non-material soul and observe the pointer/eigenstate like that – as VN/S would put it, pushing the cut all the way up to pure consciousness on one side and QM on the other. At this point, of course, the "apparatus" that is Archimedes' body reinstates itself and removes itself from the "system" of the bathtub and runs, jubilant and naked, down the street.

We know (inter alia) these three things about Quantum mechanics (henceforth, QM);

1. Contrary to the received wisdom pre 2010, it is now accepted that quantum coherence exists in biological systems;
2. QM is extraordinarily accurate;
3. It has something to do with mind in science. Just what is the topic of Stapp's book and thousands of others.

Why does this apparatus work? From time to time a math formalism turns out to have reference in the real world. The classic example is probably Einstein's use of non-Euclidean geometry in GR (general relativity).

This does not mean that the world(s) conform(s) to math as Tegmark would have us believe. It is useful to consider formalisms like the Lagrangian and Hamiltonian as "non-denotational semantics" with an occasional denotational application (or, perhaps better as "arbitrary" reference, including none, versus the "fixed reference" of ordinary math equations). In similar vein, the Quantum gravity group wants us to believe that an implementation of Sophius Lie's work is the royal road to reality.

DO NOT READ THIS BOOK: FREEMAN'S ENVOI

While not a Satanist adept of any sort, this writer has a dim memory that at least one of the initiation protocols is so extreme that would-be initiates are told as they begin it not to do it. In that spirit, but careful to assert that Freeman's motives are entirely benign, prospective readers are advised merely to dip into this book. It is in fact densely and very accurately cross-referenced and needs to be put into a hypertext format. The problem is that one follows the "links" (section names, not page numbers) in the hardcopy and stumbles on a passage at least as difficult as the one just left. It would make sense to include further links to Khan academy, EDX, or anywhere the often sketchily-explained physics is expanded.

The sentences themselves are often so long and deeply embedded that one is well out of shouting distance of the initial capital letter. Put together into massive paragraphs (eg 115-116, section 6.9 on criticality) the result is almost impenetrable. When listening to Walter, I found it helpful to write down what he had to say even when I didn't understand it as I wrote. When I read it back, it cohered. See our 2014 lecture for an example.

Kozma (2016) affords an easy entrée as does my 2008 paper. Kozma correctly points out that Walter realized even in his linear phase that perception functioned by

modulating carrier waves – like AM and FM. It should be noted that, in midlife, Walter changed from essentially linear into non-linear models of brain function. He first used models from chaoplexity theory before moving into formalisms like random graphs and quantum field theory. In particular, there is emphasis on "shutter" models according to which cognition (and with it) consciousness is discontinuous. As he put it in our 2016 book, probability distributions are created and destroyed in the whole cortex several times a second.

In a 2014 review of his friend and teacher Karl Pribram's intellectual autobiography, "The Form Within", Walter Freeman (2014) argued that adherence to the "neuron doctrine" (i.e. single neuron firing carrying all the information) will likely wreck the US and Asian Brain projects as it did the Markram/EC one. For neuroscience to prosper, it must instead embrace field effects. Yet the approaches by Pribram and Freeman focus on different levels of brain process; Pribram's holonomic approach arises from consideration of the "microscopic" level, in particular individual neurons, while Freeman was interested in mass action at the "mesoscopic" level. I was fortunate enough to work with both these greats; like Stapp, proud members of the "Greatest generation", all born in the 1920's.

The lesser known William Hoffman, an American contemporary of these two greats, had an occasionally intense rivalry with Pribram. Nor was he an experimentalist of anything like their calibre; instead, he championed a "geometry of systems" approach that could encompass Mathematical fiber bundles and category theory. While his work is necessarily more speculative, it can be argued that the three may have trailblazed for much of 21st century neuroscience. Pat Suppes, by contrast, another great from that period and my dear friend and mentor, brought his organizational brilliance into the field and used - along with conventional oscillators – speculations like "negative probability" to add axiomatizing clarity to the field.

Suppes ended his heroic life disillusioned with science. By contrast, it may well be the case that the Hoffman model (in which co-ordinate free neural flows approximate math functions) may turn out to be correct. How do we know that the brain is capable of thinking in fiber bundles? Because we do so, at least if suitably trained.

The wealth of empirical findings from Freeman et al and indeed Pribram and Suppes may be re-interpreted in the new paradigm to come. For Freeman, it was particularly helpful to think of EEG as the "roar of the crowd" (Kozma, 2016) at a baseball game; it is attending to that roar, instead of listening to the chatter of individual spectators, that best informs of what is going on in the match. Neural pulses are transformed to waves at the synapses and reconverted to pulses at the "target zones" before being disseminated through the axons. These waves are then

presumably summed at the ECOG sensor. Likewise, Pribram's near obsession with the Gabor and Fourier transforms for perception, as with the role of dendrites, may turn out prescient.

STAPP'S BOOK: MAIN THESES

Stapp's book, in contrast to Freeman's , is lucidly written. It divides into 13 (often very short) chapters followed by 7 rather longer appendices. While he is at pains to excoriate thinkers like Harris for being determinists in a quantum era, as befits his own book's title, his agenda is rather larger. No man's courage is perfect and Appendix D is essentially an unsubmitted paper arguing essentially that, since our voluntary action intends a benign future, nature will conform to this and thus psi is a trivial extension of QM. Appendices A and B, by contrast, are altogether more detailed arguments that information can be transmitted faster than the speed of light, an old controversy.

Henry argues, probably correctly, that QM allows a world in which one's intentions have consequences, a world that affirms human dignity. QM also allows predictions that have error terms, as he states, equivalent in ratio to the thickness of a human hair to the distance to the moon. The difficulties, in this writer's opinion, begin when this remote achievement of human thought in the austere context of a physics lab is assumed to extend to a cat looking at the moon (37) or the whole of human thought.

Stapp and Freeman, who were friends and can be seen in dialogue in my 2016 book, never cited each other and may have believed their languages incompatible. The review will below explore why this may have been the case.

ONTOLOGY AND EPISTEMOLOGY MEET PHYSICS

Henry keeps stating his is a "strong ontological form". The problem is that the interpretation of QM he uses is the Copenhagen, epistemological one. So while VN's process 1 may indeed provide an explanation for why this superposition is elided, HS is mixing a concern for ontology with Bohr's non-ontological position.

To continue on what I see as a flaw in HS's system; Ockham's razor cautions against unnecessarily multiplying explanatory entities. What Henry is doing IMO involves a la carte from the epistemological and VN interpretations of QM to force a rigorous neo-Cartesian dualism in which all "classical" thoughts are insulated from the brain, to be described in terms of QM, before finally settling for the "mental monism" pioneered by Schrodinger.

The ontological interpretation says that the square of the probability can tell us a particle is at x; the epistemological interpretation, a skeptical one, tells us a particle is – to repeat - FOUND at x. So this, the epistemological/ Copenhagen interpretation,

perhaps not coincidentally, acts analogously to the weasel words prefacing Copernicus' tome; the heliocentric system was to be viewed only as a measurement device, not relating to reality. In that era, of course, what was at stake was torture for heresy.

Now that we have no such fears, it is apposite to say that Henry's extension of epistemological/ Copenhagen, while motivated for all the right reasons of assertion of human dignity and free will, is both wrong and unnecessary. It is simply a fact that much human cognition can be described using classical computer models; quantum neuroscience is a limit case, perhaps specific neurally to gap junctions and psychologically to attentional processes. (In my 1997 collection, Taylor astutely combines these).

Henry adds VN's brilliant point that the cut could be put anywhere to create a thoroughgoing dualism with consciousness on one side and QM on the other, rather like Archimedes is the still bath looking on his body, hitherto subject, as an object. However, schemas like spontaneous localization allow one to dispense with the observer (see below for Zurek's "decoherence" alternative). Again, Henry has in my 2016 book successfully defended free will against decoherence theorists.

The problem arise when he attempts to put ALL mental life (including that of lower animals) on the same plane as a scientist doing a controlled observation; asserting an equivalence between a mouse looking at the moon (no, I'm not going to quote the passage) and a scientist, in a lab which is the culmination of nearly 3 millennia of western science, looking at a pointer.

Secondly, we should be able to say more than a particle is at x; we should be able to say that a state vector has been reduced to one of its Eigenstates (after perhaps billions of years in superposition) through an act of human observation. One such reduction can happen in the confines of a scientific experiment. Perhaps human cognition works in this way also outside the confines of a lab. It is very unlikely that we will discover ALL our cognition – let alone that of animals – has this result. In any case, determinism is defeated, but we are determined not to overplay our hand in victory.

Another problem underlying all this is that we have independent accounts of mind from psychology (particularly Piagetian genetic epistemology) that really need to be respected. So if we say a la Henry:

> "The latter is Heisenberg's considered view, QM is about our knowledge.."

we are forced into an explanatory cycle that will equate knowledge gained from sensorimotor interaction with the kind of application of math we see in QM. There is no way that Hilbert space can he handled in genetic epistemology and there was a very serious row in Berkeley math department when George Lakoff decided to educate the

mathematicians about the origins of their discipline in metaphor. He later decided to explain to an audience including the Nobel physics laureate Saul Perelman that he was not being scientific unless he accepted the conclusion about reality emerging from Lakoff's neural theory. I was there for the latter event at the Brouwer center in late 2015; Saul simply upped and left.

It is much better to consider QM observations as a very refined, austere act of the human mind. We do not know how we do it, and possibly never will. What we do know is that human cognition shows quantum signatures – see my 2013 paper below.

I tend toward an ontological interpretation, a notion that Henry is simply wrong in the remorselessness of his dualism (and later monism), and a belief that attention will prove to be the key unlocking the link between mind and matter. I believe that, once we retain a salutary skepticism about whether reality is cognitively – as distinct from mathematically – penetrable at (sub) microscopic levels, we can accept an ontological interpretation of the real number arising from state-vector reduction.

Now to the matter at hand. To recap, we have a choice; it can be either (ontological interpretation) where a particle IS or an expression of our knowledge (epistemological interpretation). That latter is exactly how they tried to rescue Geocentrism in the original edition of Copernicus.

> "The examination of the quantum mechanical process of observation/measurement leads, as noted above, to the conclusion that the ontological character of quantum reality is more mind-like than matter-like: the original explicit dualism devolves, naturally and rationally, to a mental monism."

Let's see how HS gets to that conclusion.

As he puts it;

> "These conditions are a natural carry-over from the Copenhagen pragmatic position that we are "users" of quantum theory."

So which is it? Reality is cognitively penetrable, or we are mere "users" of a black box a la Copenhagen?

In QM, the measurement problem must be resolved; specifically, the fact that the final state of the global system is both macroscopic and a linear superposition. Yet we don't see anything like that in real life, Here is the issue;

Zurek astutely pointed out environmental interference with a coherent quantum state and called it "decoherence". His view has been widely accepted. He grants that von Neumann anticipated him in 1932, but insists that "process 1" in fact produces a mixture identical to that due to decoherence.

Zurek (2003) invoked Von Neumann rather differently than Henry and describes this "non-unitary" diagonalization as occurring in addition to the unitary evolution;

> "process 1 would take the pure correlated state into an appropriate mixture. This process makes the outcomes independent of each other by taking the pure-state density matrix….and cancelling the off-diagonal terms."

This is not Henry Stapp's view. Stapp (2016) disagrees;

> "Within the diagonalized density matrix there still are huge uncertainties that need to be resolved in order to effect concordance with human experience. The two VN choices and their consequences are what resolve the remaining uncertainties."

Ironically, it is the apostle of decoherence who argues that decoherence may not take place when there are observer effects while Henry (personal communication) replies as follows;

> "The first thing that happens in the temporal sequence is the interaction of the primary system with the environment via the Schroedinger equation (vN Process 2), and this tends to damp out the off-diagonal elements of the primary system density matrix in the coordinate-space representation. It is easy to call this process Process 1 since it comes first, but VN calls it Process 2! I think Zurek agrees that this first-occurring diagonalization is via the Schroedinger equation, which causes different locations of the primary system to become correlated to different states of the environment. That VN calls this first-occurring process in this situation by the name Process 2 causes the confusion."

Stapp (personal communication) adds;

> "One can destroy environmental coherence in the coordinate space of the primary (pointer) variable by either an application of a "Process 1" measurement of the primary coordinate-space positions, or by an effect of process 2. I choose the latter, and I believe that this is, and has been, the standard way ever since the work of Erich Joos: primary objects located at different positions affect their environments differently, via process 2, and hence the trace over environmental variables needed to create the primary coordinate position variable density matrix produces a dampening effect on the off-diagonal locations of these primary objects! I am surprised to learn that Zurek does not follow this normal procedure!"

There is very deep and consequential disagreement here.

QUANTUM NEUROSCIENCE?

Unlike Walter, Henry is optimistic. For example;

> "But the advance of neuroscience, coupled with the difficulty of accounting in purely mechanical terms for complex behaviors of living organisms, has ignited

> renewed interest in the possibility that our minds may not be the useless and causally ineffectual appendages that the classical-physicalist dogma has proclaimed them to be."

It would be wonderful if neuroscience indeed ventured on this path. There is no evidence whatsoever, in an era in which both Europe and the US has committed several $ billions, that they are doing anything other than reductionism.

Henry makes very strong claims here: (32);

> "Macroscopic brain dynamics are quantum brain dynamics"

He wishes us to explore (36) "the connection between perceived scenes and their neural correlates." Indeed, he (37)"falsifies the belief that the connection between mind and brain can be understood within…relativistic classical mechanics."

In fact, there are other arguments (ibid) in addition to this one from faster than light transfer of information, which Henry argues is possible after all for nature's "process 3" response, as distinct from the individuals' probing. Of course classical physics cannot include conscious states (nor biology!); the uncertainty principle imbues a "pixilation" into nature as a result of the action of mind; finally, QM includes "potential", not billiard balls.

He wishes to emphasize the VN cut between a consciousness whose terms are those of classical physics and the Quantum neuroscience realm;

> "the associated classical description points to our perceptions not the related brain dynamics."

In fact, a very deep argument is that the "quantum zeno" effect allows the organism to gain control of its CNS incrementally, by almost infinite trial-and-error runs.

In my 2016 collection, and while arguing that Stapp is essentially correct, Montemayor makes some telling points. This almost infinite trial-and-error does not correspond to anything we can identify as consciousness. It must rather be related to attention. Secondly, the minimum human "now" is of the order of a tenth of a second (see graph above); Process 3 requires that the quantum wave function of the universe change much more quickly than this.

In my 1997 collection, John Taylor made an eloquent and well-argued case for the nuclei reticularis thalami (nrt), which "gate" matter entering consciousness, being an electrical "gap" junction rather than a chemical synapse. If so, and as of 2017 that seems to be the case, they are indeed capable of action at the kind required, particularly with the aid of the "quantum zeno" effect. Somewhere buried in the neuroscience and math there is a very deep insight awaiting our attention

Like Michelangelo, Beethoven, Lloyd Wright – and indeed Suppes – Freeman (et al 2016) experienced a revolution in his thought in his twilight years and thought of

Quantum field theory as the correct formalism for his intuitions about the brain. Essentially, the dynamic brain could be thought of as a fluid, with transitions from gas to liquid. Indeed, it is effectively a Bose-Einstein condensate in this process; exactly what the quantum consciousness people require it to be.

It is by no means impossible that somewhere here is a formalism that can implement the processes that Stapp describes in abstract math. At that point, QM will indeed finally have met neurodynamics.

CONCLUSION

Spoiler alert; I do not think we are even close to a full model of how "mind" affects "matter", and must countenance the possibility that both terms will be superseded. The Stapp system agrees with neo-Bohmians like Sarfatti that every decision affects the global state of the universe, be that expressed as a quantum wave function (Stapp) obeying Dirac's "process 3" dictate that it change state, or a global pilot wave experiencing qualia as it is "written" on by information from a local pilot wave. In both cases, human action is voluntary and disturbs the universe.

As someone whose initial research field was genetic epistemology (see my 2003 book), I marvel at the fact that my colleagues and I were so far from veridical models of mind and world. It seems to be the case that the further one veers from Piaget's common-sense insight that studying how knowledge develops in all its contingent details will reveal much of knowledge's necessary nature the closer we get to effective math. On the contrary, it seems rather to be the case that disincarnate ideas like Hilbert space, the Lagrangian and so on give us ever more precise models of reality as we eschew anything related to genetic epistemology.

A consensus is emerging that the extremely austere acts of mind that QM describes not only disturb the universe, but allow change to the past. Henry elides this by a la Milne (Kragh 1996) arguing for two types of time. This is consistent with the backward referral in time Libet found while he had Feinstein to hand. On the evidence of these two books, seem to be entering a new era of mind science and indeed a new Zeitgeist with no signposts.

We may indeed make discoveries that make ineffectual the RSA algorithm. For the moment, it is important to realize that the core neuroscience that might constrain speculations about mind by physicists is being ignored. This review attempts a finger in the dam.

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