

USING PSYCHIC PHENOMENA TO CONNECT MIND TO BRAIN AND TO REVISE QUANTUM MECHANICS

Stanley A. Klein

ABSTRACT: One of the deep mysteries facing science concerns how the subjective aspect of consciousness (qualia) comes to exist. There is a possibility that psychic phenomena (psi) can provide an answer since psi and qualia may have the same source. Although I'm a psi skeptic I would love to see reliable data supporting it, since that could then usher in an exciting new exploration into brain mechanisms and would force fundamental physics to change. This paper explores four different approaches for understanding qualia and psi: 1) Modify physics. Four quite different approaches will be discussed: a) a modified Born Rule, b) a modification to general relativity, c) a Bohmian update of hidden variables, and d) adding a panpsychic 'psychon' to QED. 2) Surprising emergence. This is the view whereby the neuroscience and psychology of the future will show how qualia and psi can come about by surprising brain mechanisms. 3) Panentheism and Cosmic Mind. In this view, consciousness is primary and possibly not amenable to scientific explanation. 4) Awesome illusion. Here, "qualia" is an ill-posed question and will therefore not be answered by science. For psi, being an illusion means that the past experiments are not replicable when steps are taken to satisfy friendly skeptics like me. Although I am a skeptic, I strongly hope that psi is replicable since that would usher in a revolution in physics and neuroscience. It could even lead to an understanding of qualia.

KEYWORDS: Psychic phenomena; Mind; Brain; Quantum mechanics

1. INTRODUCTION

1. Three Big Mysteries: Qualia, Psi and Quantum Mechanics. This paper will discuss the connections between three areas of science that are still deeply mysterious with no good answers in sight: the purely subjective aspects of consciousness (qualia), psychic phenomena (psi), and the collapse mechanism of quantum mechanics (QM). The FoM4 conference covered these three topics. A special treat for me was that it brought

together the leaders of the 1970's "Hippies Who Saved Physics" (see David Kaiser's 2011 book). These "hippies" were interested in all these three topics. They had a strong influence on me when I spent a week of 1976 at their summer-long conference at Esalen. I got my California DUALITY license plates shortly after that experience and those plates have been on my cars for more than 40 years. Duality considerations will be found throughout this article. The FoM4 conference (January 27, 2017) provided support for my hope that the wave particle duality of quantum mechanics, with possible help from psi may enable science deal with qualia and help to resolve the mind/matter duality. This Introduction will clarify the issues for these three domains and their interactions.

1.1 Quantum Mechanics.

There are two aspects to QM: the field theory and the measurement part.

The field theory part is often called relativistic quantum field theory (RQFT). RQFT is based on 17 particles: 6 leptons (including the electron), 6 quarks, four bosons (including the photon and gluon) plus the Higgs for providing mass to the others. For our purposes, the simpler quantum electrodynamics (QED) that deals with atoms, ignoring the complexity of the atomic nucleus, will be sufficient. That version just has electrons, photons and a pair of quarks to make point-like atomic nuclei. The rules of QED are simple but strange and are nicely discussed in Feynman's QED book. Not much needs to be said about RQFT/QED since there is general agreement on its rules.

The measurement part, on the other hand, is very contentious with about 20 different competing interpretations. Thirteen of the 20 interpretations are discussed in a separate article in this book (Cochran & Klein, 2017). That article contains a table that clarifies the interpretations using 9 criteria. The paper describes the many interpretations of QM and explains the differences between those interpretations. It classes the various interpretations according to their ontological assumptions such as dualism, monism, epistemic and ontic emphasis and so on.

The measurement problem is connected to both of the other two topics of this paper, psi and qualia. Some of the interpretations, like von Neumann, Copenhagen and Transaction, have a potential role for sentience. As will be discussed next, psi is especially interesting since it may be able to distinguish between the different interpretations. Furthermore qualia also has different explanations in the different interpretations.

1.2 Psychic phenomena (psi). There are four broad categories of psi: precognition, telepathy, clairvoyance and psychokinesis (PK). All four categories violate the presently

known fundamental laws of nature, specified by QM and gravity. Recall from the previous section that QM means RQFT plus measurement. With one exception psi is not possible given present physics. Precognition is ruled out because standard relativistic quantum field theory (RQFT) forbids *signals* going faster than light or backwards in time. Other types of psi are ruled out because the forces in present versions of RQFT are too weak to support psi by factors of many trillions. The one semi-serious exception to this claim is the possibility of aliens with futuristic technologies having come to Earth to do experiments on earthlings. The Wikipedia discussion of Newcomb's paradox https://en.wikipedia.org/wiki/Newcomb's_paradox is a silly, but useful, demonstration that present physics can be a platform for apparent psi.

If psi experiments can be validated (ignoring aliens for now), then either RQFT or the measurement process needs to be changed. One reason Nobel prizes in physics have not yet been awarded for psi findings is because simple data security precautions of the sort that will be discussed in Section 2, have never been implemented. Although at present I am a psi skeptic, I truly deeply hope that psi can be validated so that physics would be modified in ways that will enable the mental realm to be explored with new objective, replicable tools, as discussed next.

1.3 Qualia are the purely subjective aspects of experience. We use the word qualia rather than consciousness since the latter term has too many meanings. Stimulation of human brains plus measurements of brain activity show that qualia have neural correlates, called NCC. Sadly, the science of connecting qualia to specific NCC is in its infancy. However, that lack of connection hasn't stopped interested parties in speculating possible mechanism. Cochran & Klein (2017, this volume) point out that the various interpretations of QM have provided a fertile diversity of approaches for tackling qualia. If psi is someday be validated, it could provide a dramatic opportunity for learning about qualia. The rationale being that psi is clearly a mental phenomenon that requires great mental effort, just the sort of thing relevant to qualia. As discussed above, a future demonstration of the validity of psi will require changes to the present laws of physics and those changes are in the mental realm, precisely where qualia live. The modifications to physics that are needed to account for psi may be the modification needed to generate qualia.

There is a common misunderstanding that the study of qualia belongs to philosophy, not to science. However, many psychology experiments study a subject's response to their qualia. To give a flavor of that field let me describe an experiment that Dennis Levi and I did using ourselves as subjects (Klein & Levi, 1985). The task was to judge the location of a horizontal green line on a computer monitor relative to flanking lines. On each trial the line appeared in one of 5 equally spaced locations

between the parallel surrounding reference lines. We responded with numbers from -2 to +2 depending on whether the line appeared to be high or low. We practiced so that our qualia could be reported consistently. Our thresholds for that judgment were highly repeatable with Dennis' thresholds being slightly lower than mine. The thresholds were so low with closely spaced flanking lines that when one asks google "What is the Guinness record for acuity" the response is:

In April 1984, Dr Dennis M. Levi (USA) of the College of Optometry, University of Houston, Texas, USA, repeatedly identified the relative position of a thin bright green line within 0.85 seconds of arc. This is equivalent to a displacement of some 6 mm (0.25 in) at a distance of 1.6 km (1 mile).

The last 2/3 of Klein & Levi (1985) was devoted to developing NCC models that account for the data. We explored what are the aspects of neural processing that lead to the observer's responses. These studies inform us about what aspects of qualia are reportable and how those neural correlates are processed.

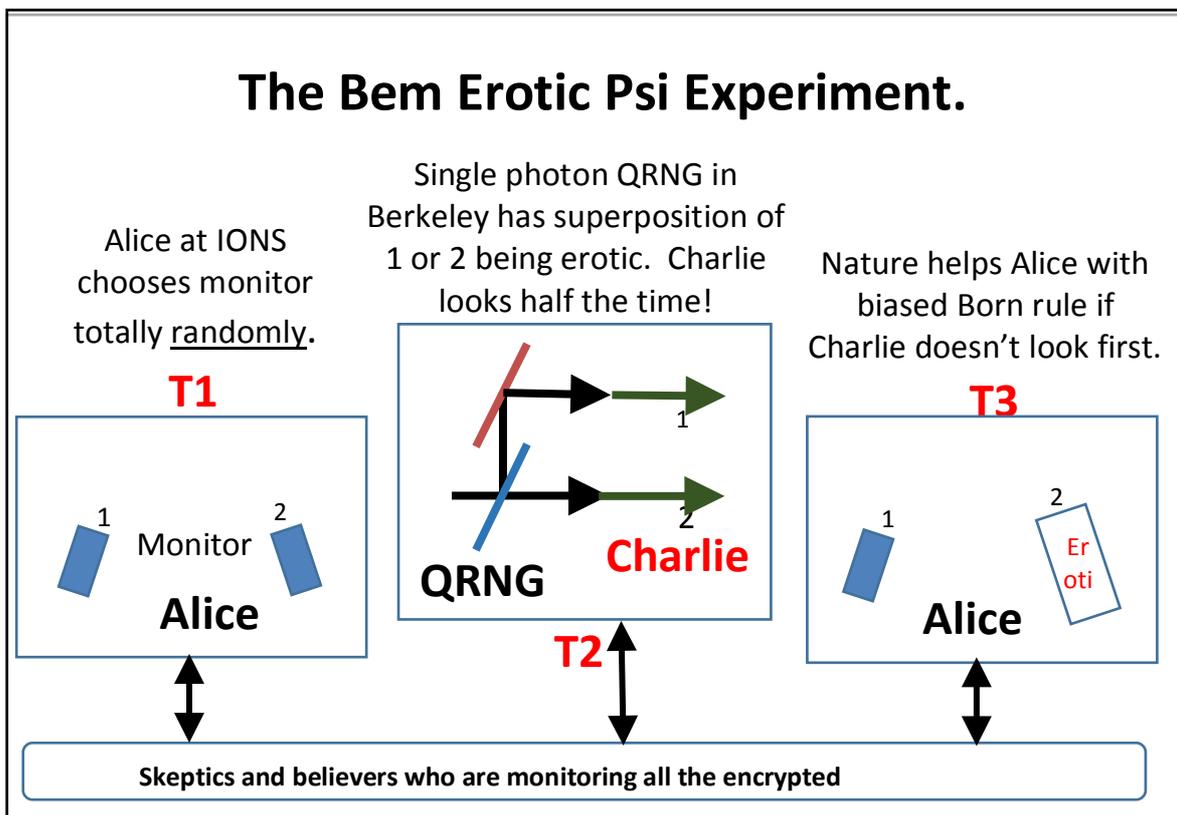
2. THE BEM EXPERIMENT

This section considers a modified Bem (2011) psi experiment. The modifications are twofold: a) improve psi methodology. By locating the random number generator in Berkeley, and the psi data acquisition at the psi friendly Institute of Noetic Sciences, we will introduce careful oversight missing in previous psi experiments. b) We will introduce Stapp's "Charlie" option that can actually discriminate between different versions of the measurement aspect of QM.

As a way of exploring psi, we investigate the well-known Bem (2011) "erotic psi" experiment. The experiment has three steps at times T_1 , T_2 and T_3 . At time T_1 Alice chooses which of two monitors to look at, hoping an exciting, erotic image to be presented on that monitor. At time T_2 a quantum random number generator (QRNG) makes its choice regarding which monitor will get the erotic image and then at time T_3 Alice sees the image if it is on her chosen monitor. Klein & Cochran (2017) also have a more detailed discussion of the experiment with an exploration for using a pseudo random number generator as well as the quantum random number generator. The present paper presents an aspect of the statistics of Bem's experiment that hasn't been discussed elsewhere.

When Bem did this experiment he found that his 100 subjects (named Alice) were correct 53.1% of the time. It is useful to note that Bem (2011) reported his statistics as: $t(99)=2.51$, $p=0.01$, $d=0.25$ where Cohen's d is the effect size given by $d=t/\sqrt{N_{\text{subj}}}$. It is useful to note that getting the standard deviation from the number of subjects ($N_{\text{subj}}=100$) is a conservative way to do the statistics since it

includes the extra variability due to individual differences. Based on the t value, the standard deviation formula of the 100 subjects would be $SDBem = t/(0.531 - 0.50) = 0.0124$. I would have calculated t based on binomial statistics where the standard deviation would be $\sqrt{p*(1-p)/N_erotic}$. N_erotic , the total number of erotic trials, is calculated from knowing that 40 subjects had 12 erotic images and 60 subjects had 18 erotic images for a total of 1560 erotic images. So for $p=0.531$, $SDKlein = \sqrt{0.531*0.469/1560} = 0.0126$. This is remarkably similar $SDBem = 0.0124$. So it is possible that Bem didn't use a more conservative method that included individual differences, and the degrees of freedom should have been 1559 rather than 99. In that case the effect size based on trials would have been $d=2.51/\sqrt{1560} = 0.064$, a very small value.



It should be noted that Bem did his experiment with the QRNG in a room next to Alice. This experiment has been replicated successfully many times in psi friendly environments and failed replication many times in psi skeptic environments. Our main suggested improvement for a future version of this experiment is to have the subject

doing the experiment in a psi friendly environment but with the QRNG in a skeptic's location, and with the two locations exchanging the critical information using encrypted communications between the computers to remove any mishandling of information. That is the sort of thing that skeptics would need to have in place to ensure that all the data is trustworthy.

A very useful addition to this experiment, suggested by Henry Stapp, is to include a lab assistant, Charlie, to the QRNG room. On half of the trials, chosen randomly, Charlie will look at the QRNG output before it is sent to Alice and he would then report his finding to the computers at the two locations. The purpose of the Charlie intervention is that according to several interpretations of QM, when a sentient creature (Charlie) observes the result of a quantum physics experiment, the superposition of states collapses to one of the possible outcomes at T₂. Thus Alice at T₃ no longer has the power to collapse the superposition and determine its outcome. Neither Charlie nor the QRNG are aware of Alice's choice at T₁. Therefore as will be discussed in Section 3.1 Charlie's intervention eliminates the possibility of Alice's interaction with Nature at T₃ that could have enabled the shift from the totally random 50% probability.

There are three outcomes of this experiment that have a substantial fan club: 1) The great majority of scientists would say that with or without Charlie's intervention, the Bem experiment would have null results if done with a skeptic's QRNG oversight. 2) A majority of non-scientists who believe in psi would probably say that the results would be positive and are independent of Charlie's intervention. 3) A number of us like the idea of sentience being needed for the quantum collapse and also those of us who pray that psi could be used for learning about qualia. This group hopes the Charlie intervention would shift the results from positive to null. Charlie's conscious intervention is a test about whether consciousness can produce measurable effects. That would provide a powerful tool for exploring consciousness. Although I'm a psi skeptic, I would love to see that positive outcome. It is rare for an experiment to distinguish between QM interpretations. It could play the role that Bell's theorem and associated experiments did 40 years ago.

Further discussion of implications of possible outcomes is provided by Klein & Cochran (2017) including implications of a variety of outcomes if a pseudo random number generator is used rather than the QRNG discuss here. However, Klein & Cochran (2017, present book) focus on just the biased Born rule for accounting for the data, whereas the present paper will explore a wide range of explanations.

3. THE MULTIPLE MECHANISMS FOR INFLUENCING PSI AND QUALIA.

This section has four parts corresponding to the four classes of mechanisms for psi and qualia. Section 3.1 will introduce four possible modifications to physics. Section 3.2 will be a speculation on emergence from present physics. Section 3.3 will involve cosmic mind outside of our physics. Section 3.4 will be the qualia as illusion route.

3.1 Modifications to physics.

The science of psi and qualia. The connection of psi and qualia to each other and to science is complex. We hope that psi can help us get a handle on qualia. But it is important to remember that present physics is incompatible with psi (ignoring the alien helper) but not incompatible with qualia.

We now present four examples of mechanisms by which present QM can be modified to allow for psi. For each of those mechanisms we will show how qualia could also be present. Even if those mechanisms may not produce psi, they may be mechanisms for producing qualia.

3.1a Biased Born Rule. The Born Rule specifies the outcome of a QM measurement. For several interpretations of QM (Cochran & Klein, 2017), the measurement occurs when a sentient creature makes an observation. This involves the Born Rule that has two parts. Part 1 is the transition from complex valued amplitudes to real valued probabilities. The Born Rule specifies that FAPP (for all practical purposes) the probability is the square of the RQFT or QED amplitude. Part 2 of the Born Rule is that the transition from probability to actuality is done totally randomly. The beauty of this option is that it only comes into play at the measurement step so it doesn't affect any of the calculations where RQFT/QED has been so successful. There are cases such as the energy levels of Hydrogen, where QED is in agreement with experiment to 12 decimal places. The successes of QM are quite astonishing and those successes are untouched by the biased Born Rule that involves sentient creatures.

Tests of the Born Rule have only been done with delicate instruments rather than sentient observers doing the measurement. Only psi experiments have "tested" the Born Rule using humans as observers. Thus it is easy to imagine that with human observers the Born Rule could be violated. Henry Stapp and I call it the "biased Born Rule". It would come into play at T₃ in the Bem experiment, when the signal from the Berkeley QRNG arrives at IONS, for the case when Charlie does not look at the QRNG output. Recall that Alice has been staring at one of the two monitors hoping for something exciting. We now make the big assumption that the quantum measurement involves a special relationship with what Stapp calls "Nature". Followers of Hinduism may call it Cosmic Mind, providing a link to what will be discussed in

3.1d. This extra force is assumed to be able to bias the probability correct, from the Born Rule actualization, to above 50% with higher values for gifted individuals. This easily understood mechanism, to our knowledge, has never been tested with simple controls whereby all communications in both directions use encryption that prevents leakage of information.

3.1b *Penrose & Hameroff use of general relativity and microtubules to account for qualia and psi.* The title of the Hameroff & Penrose (2014) paper is: “Consciousness in the Universe: A Review of the ‘OrchOR’ Theory”. The authors argue that objective reduction is related to qualia and that orchestrated objective reduction in microtubules gives rise to consciousness. From this view, Orch-OR is the carrier of qualia and Platonic values.

The very impressive thing about the Penrose hypothesis is that there are already plans for testing it. Pages 267 – 270 of Penrose’s recent book “Fashion, Faith and Fantasy: in the New Physics of the Universe” (Penrose, 2016) goes into detail of the experimental test being developed by Bouwmeester of Leiden and UC Santa Barbara (Marshall, et al. 2003). This is not a test of qualia or psi but rather it is a test of the whether gravity can be the mechanism for collapsing the quantum superposition. The Hameroff & Penrose (2014) paper goes into lots of detailed claims about the implications for their hypotheses that the microtubules found in neurons are related to consciousness. In that article it is also clear that values can be effective in determining outcomes of the measurement event. In case there is ambiguity on the role of mind in their approach it is useful to recall the title of Penrose (1994): “Shadows of the Mind: A Search for the Missing Science of Consciousness”. If the Penrose collapse mechanism is validated then all the other collapse mechanisms like von Neumann, Bohm, Transaction, and so on must be rejected. We are left with a panpsychism mechanism that is discussed next. Although the Penrose panpsychism gives no hint about how it would explain psi Hameroff and Penrose are clear that values such as exhibited in the Bem experiment are supported.

3.1c *Bohmian hidden variables, possibly with implicate order.* In our discussion above about QM we focused on collapse mechanisms such as found in von Neumann or Transaction interpretations. There are alternative interpretations of QM that work very differently. One dramatically different interpretation is the Bohmian hidden variables scheme. Rather than there being a superposition of states between measurements there are hidden variables that are constantly clarifying what state the system is in. For the Bem experiment according to Bohm, the photon going through the half silvered mirror makes a definite choice of going in one OR the other path, but not both and a complex wave guides the particle. An important advance has recently

been made by Sutherland (2015??) whereby instead of the hidden variable being a particle in 10^{80} dimensional space the new approach has a universe with 10^{80} hidden variable particles in our familiar 3-dimensional space. That modification has gotten me to greatly increase my aesthetic appreciation of Bohmian mechanics. The new hidden element that has been introduced could possibly be a carrier of qualia. At this point in its evolution I'm not familiar with whether the modified equations might be a platform for psi. I have heard that Jack Sarfatti has modified Sutherland's equations to possibly enable psi. His paper may be in this book.

3.1d *Add a 'psychon' to the Standard Model.* This is true panpsychism. The idea here is to make a major change to QFT. The properties of the psychon would be such as to enable both qualia and psi. At this point we have no idea how it would work. The nifty thing about this approach is that qualia is easily understood. Namely ALL of nature has qualia, including stones and air. More complex entities would have more qualia. Since the psychon has special properties relevant to sentience it might as well also have properties that enable psi. The major challenge to the introduction of a new particle is that it could easily mess up the super accurate calculations that have presently been made for things like the anomalous magnetic moment of the electron. However, if psychic phenomena are ever validated with the encrypted communications discussed above, we will have major research project devoted to using psi to study the psychon.

3.2 *Strong and Intermediate Emergence.* This category has the delicate placement of being between Category 3.1 with dramatic changes to present physics, and Category 3.3 that involves the possibly dualistic/monistic notion of Cosmic Mind that one finds in Abrahamic and Hindu religions. The word "dualistic/monistic" was used in the previous sentence to provide a provocative reminder that different cultures use dramatically different words to describe the same thing.

Philosophers of emergence tend to distinguish between "strong" and "weak" forms of emergence. Weak emergence refers to commonly understood phenomena such as the emergence of liquid properties from water molecules, or superconductivity. Strong emergence refers to emergence that is supposed to be ontological in nature, implying the emergence of something fundamentally different and new. The emergence of qualia from matter, for which the mechanisms have not yet been found, is an example of strong emergence (Chalmers, 2006, 2011). The only other example of strong emergence was the proton bootstrap that was a major effort in theoretical particle physics in the mid 1960's. I did my Brandeis PhD dissertation on the hot UC Berkeley proton bootstrap. It was known that the proton had excited states, similar to the Hydrogen atom. So, like Hydrogen it was thought to be a bound state of other

particles. The idea was that the proton, and other particles, were bound states of themselves with the particles doing the binding (like the photon in Hydrogen) being exchanges of the same particles. It was exciting and progress was being made until two separate teams at Caltech came up with the idea of quarks and acs. I bring up this example as an illustration that something entirely different from expectation might enable qualia and psi (other than the forbidden precognition) to strongly emerge.

A new option has recently appeared: the notion of intermediate emergence. Chalmers article (2006) “Strong and Weak Emergence” introduces the idea of intermediate emergence. Intermediate emergence is a form of weak emergence that has such an extremely rapid growth of complexity that calculations are not feasible to make predictions of outcomes. Another important link is Chalmers article on the “Explanatory Gap”. A possible example for intermediate emergence is Giulio Tononi’s proposal for an integrated information theory (IIT) approach that is specifically designed to account for qualia. One can think of qualia emerging from neural activity as being similar to superconductivity emerging from complex materials.

3.3 *Cosmic Mind*. The main competitor to item 3.1 (“Modification to Physics”) is that mind is fundamental to nature but with entirely different foundations than RQFT and accordingly physics cannot describe all of reality. We call this the Cosmic Mind hypothesis or position. This position can be philosophically complex. Chopra & Kafatos (2017, p. 213) quote Wolfgang Pauli, an important founder of quantum mechanics, who said, “It is my personal opinion that in the science of the future reality will neither be ‘psychic’ nor ‘physical’ but somehow both and somehow neither.” Consistent with the Chopra/Kafatos (2017) position, most theories of cosmic mind attempt to resolve the dualism of mind-matter into a unity or monism. Their Appendix 1 titled “Getting Comfortable With Qualia” has a Table titled: “Qualia Principles: The Foundations for a Science of Consciousness”. That Appendix lists 40 principles of qualia!

Of critical relevance to Cosmic Mind is the idea that Henry Stapp proposes in his writings. In his chapter in the present volume, Stapp (2017a) comments on how the biased Born Rule enables mind to affect outcomes, namely psychic phenomena:

“How can quantum mechanics account for this apparent influence of mind upon matter? I propose considering, as a modification of Orthodox Quantum Theory, that nature’s choices of responses to our queries are inclined to favor her values, which include allowing **us** to achieve what we value. In this **quasi-orthodox QM**, if a person asks a question whose affirmative answer is something he or she positively values, and nature’s responses tend to give us what we value, then we can, simply by asking the right questions, tend to make the physically described world behave as we desire.”

In the above piece and his recent book Stapp (2017b) implements the measurement aspect of QM by having the sentient creature (typically a human) having an interaction with Nature and Nature responding by biasing the Born Rule so that the actualization isn't done randomly. Followers of Abrahamic or Hindu religion may have that interaction taking place with a Cosmic Mind. The idea is that the outcome of events can include values held by the individual and by nature.

3.4 *Awesome Illusion*. This position states that psi and qualia are due to misunderstandings or are illusions. The situation for psi is easiest to deal with as it involves objective science. A psi skeptic can point out that given that psi violates the presently known laws of physics, the experimental methods need greater care than standard experiments. . Section 2 above presented a methodology using encrypted signals being sent between psi researchers and reasonable skeptics (like the present author). The use of encrypted communication is so easily done and so inexpensive it is shocking it has never occurred.

The topic of whether qualia is an illusion or a badly posed question is much trickier to deal with since qualia is a subjective matter. Luckily, three days before the deadline for submitting this article Thomas Nagel (2017) published the following book review on precisely this topic: *Is Consciousness an Illusion? NY Review of Books 3/9/2017. Review of Dennett's new book: "From Bacteria to Bach and Back: The Evolution of Minds."*

The following are two excerpts from his review. Nagel is referring to Dennett by the word 'he':

He says that the manifest image of each species is "a user-illusion brilliantly designed by evolution to fit the needs of its users." In spite of the word "illusion" he doesn't wish simply to deny the reality of the things that compose the manifest image; the things we see and hear and interact with are "not mere fictions but different versions of what actually exists: real patterns."

Dennett holds that consciousness is not part of reality in the way the brain is. Rather, it is a particularly salient and convincing user-illusion, an illusion that is indispensable in our dealings with one another and in monitoring and managing ourselves, but an illusion nonetheless.

Nagel's first sentence above with the reference to "each species", refers to Nagel's famous 1974 article "What it is like to be a bat". Many philosophers and other scholars have provided accounts of why the very way the notion "qualia" is proposed as a scientific problem simultaneously presupposes qualia is a domain outside scientific explanation, leading to logical paradox. So, the point being made here is that a substantial fraction of scientists and philosophers put qualia into an illusion category.

The special new approach of the present paper us the connecting of qualia and psi. If psychic phenomena are found to be valid, then present physics needs to be modified and the resulting changes for our understanding of qualia will be substantial. The new physics may give pointers to how qualia might be real. I am skeptical, but carefully done psi experiments could change my opinion.

ACKNOWLEDGEMENTS.

Christopher Cochran has given excellent feedback and suggestions on many aspects of this paper. I thank Ruth Kastner for noting there are ways of producing psi in a manner compatible with present laws of nature. That got me to think of the alien possibility.

sklein@berkeley.edu
UC Berkeley

BIBLIOGRAPHY

- Bem, D.J. Feeling the future. Experimental evidence for anomalous retroactive influences on cognition and affect. *Journal of Personality and Social Psychology*, **100**, 407-425, (2011).
- Bohm, D. A suggested interpretation of the quantum theory in terms of 'hidden' variables. I. *Phys. Rev.* **85**, 166–179 (1952).
- Bohm, D. A. & Hiley, B. J. *The Undivided Universe* Routledge, London (1993).
- Chalmers, D. J. Panpsychism and panprotopsyism. *Amherst Lect. Philos.* 1–32 (2011).
- Chalmers, D. J. Strong and Weak Emergence. In *The Re-Emergence of Emergence*, Clayton, P., Davies, P., Eds.; Oxford University Press: Oxford, UK, 2006.
<http://consc.net/papers/emergence.pdf>
- Chalmers, D. J. Phenomenal Concepts and Explanatory Gap, In Book *Phenomenal Concepts and Phenomenal Knowledge*. Eds. Torin Alter, Sven Walter.
<http://consc.net/papers/pceg.html>
- Chopra, D. & Kafatos, *You are the Universe: Discovering Your Cosmic Self and Why It Matters* Penguin Random House, New York (2017)
- Cochran, C. & Klein, S.A., Quantum Interpretations for Building Science/Religion Bridges, *Cosmos & History* 13(1), (2017).

- Hameroff, S. & Penrose, R., Consciousness in the universe: An updated review of the "Orch Or" theory. *Phys. Life Rev.* **11**, 39–78 (2014).
- Klein, S. A. & Levi, D. M. Hyperacuity thresholds of 1 sec: theoretical predictions and empirical validation. *J. Opt. Soc. Am. A.* **2**, 1170–1190 (1985).
- Klein, S.A. & Cochran, C., Physics and the Role of Mind, *AIP San Diego Conference Proceedings*, (2017).
- Koch, C. Consciousness Does Not Reside Here. *Sci. Am.* **23**, 11–12 (2012).
- Marshall, W., Simon, C., Penrose, R. & Bouwmeester, D. Towards Quantum Superpositions of a Mirror. *Phys. Rev. Lett.* **91**, 130401 (2003).
- Nagel, T. Review of Dennett's *Is Consciousness an Illusion?* *The New York Review of Books* (2017/3/09).
- Narasimhan, A., & Kafatos, M. C. Exploring Consciousness, 184–191 (2016).
- Penrose, R. *Fashion, Faith and Fantasy in the New Physics of the Universe* Princeton University Press, Princeton (2016)
- H.P. Stapp, *Mindful Universe: Quantum Mechanics and the Participating Observer* Springer-Verlag, Berlin, Heidelberg (2011).

