# Physics and the role of mind

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**Abstract.** This paper explores the role of the mind in the physical world. We begin with a brief introduction to distinct types of *retrocausal* phenomena connected with parapsychology and physics. We provide an introduction to laws of quantum mechanics (QM) that lead some to surmise connections between QM and psychic phenomena (psi). Next, we present our argument that verification of psi will require changes to QM. As a possible placeholder for these changes we introduce "Mind", from Cartesian dualism. This area of research points the way to connections between two fundamental issues in science: the mind-matter hard problem and the measurement problem of QM. Positive outcomes of carefully executed experiments could demonstrate a close relationship between these two problems, including the possibility that sentience plays an important role in the fundamental laws of physics. We focus on a version of Daryl Bem's *seeing the future* experiments, which should allow for discrimination between various interpretations of QM. Finally, although the authors are psi skeptics, we suggest methodologies that may enable psi phenomena to be acceptable to mainstream science.

## INTRODUCTION

### Definitions and Distinctions

Here we define terms and lay groundwork for our discussion.

**a)** *Retrocausation in physics vs. parapsychology:* Retrocausation has different meanings in physics and parapsychology. In parapsychology (psi), retrocausation is equivalent to "precognition," and involves sending signals backwards in time. In physics, retrocausation refers to attributes of particular interpretations of quantum mechanics (QM) that involve sending *influences* backwards in time as a means to avoid nonlocality in the quantum measurement process.

**b)** *Signal vs. influence:* A *signal* involves sending data, for instance, whether the stock market went up or down, and requires the transfer of energy. In contradistinction, an *influence*, which involves a pair of entangled particles, does not imply an energy transfer . Particles are entangled when measurement of a property of one particle (e.g. spin) influences the possible values of the same property the other particle once it is measured. A financial tip: one can get rich from a signal but not from an influence.

**c)** *Three steps in quantum measurement:* Many foundational arguments in quantum mechanics concern the placement of the measurement cut. The *measurement cut* refers to the conceptual distinction between a measuring agency (above the cut) and the system that agency will measure (below the cut). In his *Mathematical Foundations of Quantum Mechanics*, von Neumann gave a proof that the cut is movable. He showed it is possible to have a late (high) placement, involving a sentient observer. For this to be possible it is useful to divide QM into three repeating steps: i) the mathematics for calculating amplitudes; ii) probability (mixture), the square of the amplitude erases phase information; and iii) actualization. The last two phases are the measurement process and are often (incorrectly) treated as a single event.

**d)** *Two aspects of the Born rule:* The Born rule governs the two transitions between the three steps. Transition 1: Going from step (i) to (ii) the probability as the square of the amplitude. Transition 2: Going from the probability of step (ii) to the actuality of step (iii) is a totally random event. Rather than the latter transition being totally random, psi anomalies can be explained by a biased Born rule. Our proposed experiment will test whether the transition to an actuality requires a sentient observer who has an emotional interest in the outcome. In his book *Mindful Universe* Henry Stapp [1] proposed a view of mind that enables a different approach to a biased Born rule that includes the ability to send faster than light signals. Our version of the biased Born rule avoids faster than light signaling. The last

section of this paper suggests a mechanism for getting the biased Born rule results without simply biasing the Born rule.

**e)** *Precognition vs. alternative explanations of Bem's data:* Given that precognition (sending signals backward in time) violates rules of quantum electrodynamics (QED), the amplitude aspect of QM, this paper will focus on alternative approaches, using a biased Born rule at the actualization step. The Born rule is an easy target because it has not been carefully tested. We agree with the Whiteheadian *process* approach that the Mind of Nature has many tricks up her sleeve, but seeing into the future is not one of them.

**f)** *Personal perspectives:* The authors of this paper consider themselves to be open-minded skeptics. We believe it highly likely that our proposed experiments will not show any evidence for psi. However, if any of the Bem-type experiments can be confirmed, their impact on physics would be profound. We believe careful experiments should be executed by a collaboration of psi skeptics working closely with psi believers.

## Two Definitions of Retrocausation

The 2016 AAAS conference on retrocausation brought together physicists and parapsychologists to discuss phenomena that appear to exhibit backward-in-time characteristics. It became clear that physics and parapsychology use the term *retrocausation* for two very different phenomena. The standard physics definition of *causality* prohibits a signal (like a stock market price or a roulette wheel landing) from being sent backward in time. That is, standard quantum mechanics forbids Nature from seeing into the future. In the physics domain the term retrocausation is compatible with causality and belongs to the interpretations of QM like the Time Symmetric Interpretation [2,3] and Transactional Interpretation [4,5] that do not allow signals to be sent to the past. To be clear concerning signals and influences (see item (b) above), only the former transfers energy, only the latter is able to propagate backwards in time or faster than light (FTL).

This paper focuses on the definition of retrocausality native to parapsychology. The experiments of Daryl Bem [6] involve a subject, Alice, who anticipates the output of a random number generator (RNG). There are three types of mind-associated psi mechanisms that, in principle, might account for Bem's findings of above-chance performance: precognition, psychokinesis or clairvoyance. A common explanation for Alice's successful anticipation is precognition, *seeing or feeling the future*. However, we will argue that forward-in-time psychokinesis (*mind controlling matter*), or clairvoyance (*mind detecting hidden information*) have greater explanatory potential, given that causality is a fundamental aspect of QM, thereby excluding precognition and literal retrocausation. We will also show how a previously untested modification to the Born rule will enable Bem's findings to be possible with only minor changes to traditional QM. Given the difficulties associated with modifying QM, our present approach is to say that if the Bem or other psi data are validated, then it would be useful to introduce *mind* as an explanation for psi. This amounts to an acceptance of some form of Cartesian dualism that leaves untouched most all of the predictions of QM. Thus we consider experimental validation of psi to be an important endeavor.

## Bem Experiment: Introduction

One of Bem's famous experiments works as follows [6]. A subject ("Alice") is presented with a computer screen that contains a picture of two curtains. The subject is instructed to guess which of the two curtains covers an image. Alice chooses a curtain. After Alice has made her choice, a random number generator (RNG) determines which curtain to place the picture behind. Bem found statistically significant results when working with emotionally charged (erotic) pictures with a confidence interval of $53.1\% \pm 2.5\%$, but not for neutral pictures (about 50% correct). (See Methods for details of calculation.) Although the effect size is relatively small, the significance of these results is robust, especially when compounded with other confirmation experiments. However, as noted in the preceeding section, these results violate present physics, which is why some skepticism is in order.

Bem used two types of *random number generators* (RNG), specifically: a *pseudo*-RNG (PRNG) and a *quantum*-RNG (QRNG). The QRNG will enable us to test aspects of QM and Mind, and will be the main topic of this paper. Here we introduce the Bem experiment using a PRNG, since the associated psi mechanism, clairvoyance, is much simpler to discuss. A PRNG is what standard computers use for generating random numbers. It produces deterministic random numbers from algorithms that are seeded by such things as the exact moment the computer was turned on. To ensure the random numbers are totally deterministic, the PRNG is seeded by a randomly-chosen 20-digit integer that is viewed by "Charlie" to actualize the number and thereby make all successive random numbers deterministic, not in a quantum superposition. For Alice to get above chance correct guesses with the PRNG, the Mind of Nature ("Mind" for short) must have clairvoyance and be able to know the future outcome of each pseudo-random number to bias

Alice into choosing the erotic image. How does Mind get its information into Alice's brain to influence her choice? For now this is a mystery, ontologically distinct from Alice's brain or other physical processes. While a person's ability to sense hidden information is typically called *clairvoyance*, we suggest that the ontological Cartesian dualism we are using has the clairvoyance in cosmic Mind, not in Alice's mind. (To our knowledge, the human brain does not have the machinery for such a capability.) One is not surprised the Mind of Nature both knows the past and also is able to transfer that knowledge into Alice's brain, so that she might choose the proper curtain. As will be discussed, we propose the introduction of a bias to the QM Born rule as a mechanism for influencing Alice's brain. We will refrain from worrying any more about that mystery until Bem's psi results are replicated under the relatively simple conditions to be discussed shortly. In sum, we tentatively explain the PRNG-based Bem data by invoking clairvoyance. No causality-violating precognition is needed because Alice's decision was based on information available before she made her choice. For more insight, we recommend Bem's original article, where he compares precognition, clairvoyance and psychokinesis ([6], pp. 11-14).

In most of the remainder of this article, when discussing the Bem experiment we will focus on using a QRNG, which enables us to discriminate between different interpretations of QM. Our introduction of a bias to the Born rule will be common to both the PRNG and QRNG. The role of Mind in this process will be linked with sentience for achieving the Bem results. To prepare for the discussion of the QRNG we will need to first review key aspects of QM and the two stages of the measurement process.

## Overview of Quantum Mechanical Measurement

Building on earlier discussion in the Introduction, quantum mechanic of measurement has three steps: Step 1: Quantum electrodynamics (QED) calculates amplitudes; Step 2: Measurement is performed and the amplitude is converted to a "probability" for the beginning of the measurement process; and Step 3: The resultant "actuality" ends the measurement process and the process begins again at Step 1. It is common to lump Steps 2 and 3 together, but this glosses over critical issues and distinctions. The temporal extent of Step 2 is relevant to the movability of the measurement cut, which was the focus of the last chapter of von Neumann's book *Mathematical Foundations of Quantum Mechanics*, entitled "The Measuring Process." The ambiguity of the cut's placement emphasized by von Neumann is relevant to the distinctions that are made among a number of different interpretations of QM. We now clarify these three steps.

(*Step 1: QED*) Quantum electrodynamics (QED) is a theory that describes fundamental electromagnetic interactions and is the foundation for other emergent sciences. It explains how protons, electrons and photons interact to produce atoms, molecules and, in principle, even more complex systems like computers and life. The rules of QED enable one to calculate the state of a system as represented by a probability *amplitude*. (The amplitude will later be used to calculate probabilities of experimental observations.) The amplitude is specified using the following notation:

$$\text{Amplitude} = A_1|a_1> \quad \text{AND} \quad A_2|a_2> \quad \text{AND} \ \ldots \ A_n|a_n>, \tag{1}$$

where $A_i$ are complex numbers. The *ket*, $|a_i>$, is a possible state of the system (orthonormality assumed). The usual way of writing (1) is with the plus sign (+) rather than the AND. Here we intentionally use AND to distinguish it from the OR that occurs for probabilities (below in Step 2). Arguably, the AND represents the strangest and most distinctive aspect of QM. In the two-slit experiment, for example, considered by many to be the archetypal quantum exercise, an incoming single electron (buckyball, photon or cat) encounters a wall with two separated slits. Equation 1 indicates the single electron (or cat) passes through *both* slits – i.e., through slit(1) AND slit(2) – rather than through just one or the other. Quantum entanglement is another case in which the AND operation plays a critical role.

(*Step 2: Probability (Mixture)*) Either as the first part of the measurement process or via entanglement with the environment, the state of the system collapses to a mixture (Stapp, *Mindful Universe* [1]):

$$\text{Mixture} = P_1 |a_1\} \ \text{FAPP\_OR} \ P_2 |a_2\} \ \text{FAPP\_OR} \ldots P_n |a_n\} \tag{2}$$

here the probability $P_i$ is the square of the amplitude ($P_i = A_i A_i^*$). It is the probability for state $|a_i\}$ to become actualized. As expected, one has $0 \leq P_i \leq 1$, with the unitary constraint (conservation of probability): $\Sigma P_i = 1$. We introduce the non-standard nomenclature $|a_i\}$ to indicate the mixture of probabilities.

The primary difference between Equations 1 and 2 is that the AND relationship between possible outcomes in (1) becomes an OR relationship *For All Practical Purposes* (FAPP) in Equation 2, in the spirit of J.S. Bell [7]. Here the need for FAPP is to account for substantial entanglement with the environment, allowing decoherence to be a FAPP-legitimate collapse mechanism [7]. We pointed out that before the sentient collapse by Alice on trial #1, it is possible that the PRNG is not in a pure actualized state. Rather, we hold it was FAPP-actualized. Then, after Mind

connects with Alice on trial #1, Alice's sentience collapses the superposition of probabilities such that the PRNG becomes a classical PRNG.

In our interpretation of the QRNG version of the Bem experiment, the state does not become actualized until a sentient observer, like Alice, views the outcome of the QRNG. Thus, the end of the mixture state is the crucial moment in our understanding of the experiment. The standard Born rule would govern the transition from Step 1 to Step 2. However, since psi involves the action of a sentient mind, it will be in the transition from Step 2 to Step 3 where we posit the Born rule bias may take place.

*(Step 3: Born Rule Bias and Actuality)* The final step of the process is the conversion of the mixture probabilities into an actuality, as when a flipped coin with a 50% probability of heads or tails is actualized as one or the other faces. In the standard application of the Born rule the transition from the spectrum of probabilities to a single actuality occurs randomly, in accord with the probabilities indicated in (2). The Born rule has been experimentally validated to about 1% accuracy [8] for cases not involving sentience. If QM is to be modified to accommodate psi, we speculate, following suggestions by Henry Stapp, that it is the Born rule that should be modified because this doesn't interfere with Step 1, which has been validated to an extraordinary accuracy, to about one part in $10^{13}$. (Note added in proof: Recently, Stapp prefers a QED mechanism rather than a Born rule violation to account for the Bem data.) We speculate that the Born rule bias is only activated in connection with sentient quantum observers and are most easily detected using psi. To our knowledge no laboratory experiments have been conducted to test this hypothesis of Born rule violation at the actualization step. To be clear, we hypothesize that sentient quantum observers can introduce bias into the standard Born rule, indicating Mind can modify the outcome of probabilistic quantum event.

Previous tests of the Born rule [8,9], have not explicitly involved a human observer in their experiments, whereas a sentient creature was involved in passing from Step 2 to Step 3, as is the case in the Bem experiments. Stapp's and our speculation is that a Born rule bias enables a place for Mind in the nature of things, a concept compatible with von Neumann's QM interpretation featuring a role for consciousness.

## MODIFIED BEM PSI EXPERIMENT

Working from the above hypothesis, the following is an overview of our proposed experiment, which is a modified version of one from Bem's suite [6].

## Methods

We plan to conduct most of our experiments at the Institute of Noetic Sciences (IONS) in collaboration with D. Radin. IONS was chosen because the best psi results have come from psi-friendly environments. A new element will be a close partnership between psi believers with psi skeptics (e.g., the authors of this paper) to ensure a robust and secure experimental design. Each trial will consist of three steps, each temporally separated by a few seconds, as follows:

**t1**: Alice is instructed to choose one of two displays, with the expectation that it will be the one with an erotic image. At time t3 one screen will be chosen to display a blank screen (with random probability, 0.50), while the other will display with random probability (0.50) either an emotionally charged (erotic) image or an emotionally neutral (natural scene) one. The purpose of copying Bem in interleaving non-erotic images is to render the erotic ones more surprising.

**t2**: A QRNG 'decides' which display posts the image and whether it is natural or erotic. The output of the QRNG will be an integer from 1 to 4. An example of such a QRNG would be a system starting with a low intensity 300 nm ultraviolet beam whose photons are down-converted to pairs of 600 nm photons. One member of a pair is detected to inform the system that there is a single photon in the other beam. That single photon is then sent though three half silvered mirrors. In the end, the single photon is converted to a superposition of four beams with 25% probability for each.

**t3**: The superposition of beam information is sent to Alice's computer, which then displays the image. We will use a distribution of images similar to that used by Bem.

A statistical analysis of Bem's original data is based on the following information. All 100 subjects were shown 36 images. 60 subjects were shown 18 erotic images and 40 subjects were shown 12 erotic images for a total of N = (60)(18) + (40)(12) = 1560 erotic images. Bem found that subjects chose the erotic images p=53.1% of the time. The standard deviation of the probability is given by Poisson statistics to be $\sigma = \sqrt{\frac{p(1-p)}{N}} = 0.0126$. To be statistically significant the percentage correct would need to be greater than 50% + (1.26%)(1.645) = 52.1%, for one-tail significance for N=1560 erotic images. Note that we are using a one-tail criterion factor (1.645) similar to Bem

because, as discussed by Bem [6], prior studies showed positive results so the tail is known. Thus, the Bem result of 53.1% correct is deemed statistically significant. This is an ideal observer significance level because it assumes that there are no individual differences or fluctuations in psychic powers. Surprisingly, Bem found the same statistical significance with N = 99 that would have allowed for indiviual differences. To reduce the confidence interval in our experiments we will test 110 subjects with 50 trials per subject, of which half would have an erotic or a neutral image on the left or right side of the monitor. With these modifications we would have N = (110)(50)/2 = 2750 erotic images, such that the significant probabilities would be reduced to 51.6% for a one-tail criteria in the ideal situation.

*The Charlie Intervention:* An important new feature of the proposed experiment is Henry Stapp's suggestion [9] of introducing Charlie, a generic lab assistant, who will be in the room with the QRNG. Half the time, chosen randomly, Charlie, unaware of Alice's choice at t1, will look at the QRNG output at t2 and press a button from 1-4 indicating the side and erotic charge of the image. As Stapp argues (see his article in this volume), Charlie, naïve regarding Alice's prior choice, would actualize the QRNG outcome at t2, before Alice has a chance to collapse the superposition at t3. Each subject (all named Alice) would do 100 trials, 50 without Charlie looking (as in the original Bem experiment), for a total of 11,000 trials in the full experiment. The data with and without Charlie looking would be analyzed separately, so the above statistical analysis remains valid.

In principle, the difference of outcome due to Charlie's intervention will allow distinguishing among different interpretations of quantum mechanics.

## Possible Outcomes

As derived above, a probability of guessing the correct screen in more than 51.6% of the trials is deemed statistically significant above chance. For our purposes, there are three outcomes of particular interest.

**a)**: The most interesting outcome would be to find a significant Bem effect for Alice only if Charlie does not look at the QRNG. This outcome has three immediate implications: 1) precognition is ruled out since Alice would become aware of the emotion directly from the QRNG output that should be independent of Charlie's presence; 2) the wave function collapse depends on a sentient observer since Charlie's intervention plays a critical role; and 3) emotional qualia plays a role. That is what distinguishes Alice's from Charlie's role. Because Charlie has no knowledge of Alice's choice for the erotic image, and because he is the first sentient creature to observe the outcome of the QRNG, Charlie's observation should make the outcome random.

Outcome (**a**), that a sentient mind is needed for the actualization, would indicate there is a role for a Mind of Nature, as discussed earlier in connection with the PRNG and clairvoyance. For the present QRNG experiment, we introduce the idea of *Mind-based psychokinesis* (MBPK). That is, the Mind of Nature is aware of the output of the QRNG, and this Mind somehow is able to affect the Born rule at t3, biasing the outcome in Alice's brain at the actualization step. The Mind of Nature operates only on sentient minds, not on computers. We call this psychokinesis since it is Mind affecting an event that is not explainable by standard QM.

There is an interesting possible connection between what psi researchers call "the Experimenter Effect", and the potential "Charlie Effect". The *Experimenter Effect* is the finding that when psi experiments are conducted by psi believers positive results often occur, while when conducted by psi skeptics the results are often negative. Charlie's intervention might be viewed as a controlled test of the experimenter effect, interfering with Mind's desire to satisfy Alice. We admit, of course, that the overall experiment is likely subject to an overarching experimenter effect. Insofar as any experiment must have a final overarching sentient observer who designs, executes and evaluates it, it may be impossible to escape all traces of this effect. Nonetheless, we believe this is a warranted and necessary first attempt to isolate and quantify it.

**b)**: This is the outcome probably predicted by most psi researchers, specifically, that a significant Bem effect will be found, but it will be independent of whether or not Charlie observes the QRNG. This result they would likely attribute to psi precognition or psychokinesis on the part of Alice.

**c)**: The Bem experiment outcome predicted by most mainstream scientists is that there should be no Bem effect, regardless of whether Charlie observes or not. The latest meta-analysis indicates 90 positive replications from 33 diverse psi-friendly laboratories; of course, there are also a large number of non-replications in the labs of skeptics. The issue remains unresolved in the collective Scientific Mind.

In summary, if Charlie "collapses" the QRNG wavefunction before Alice has a chance (outcome **a**), then Alice's positive results would not come about. In that case, this would support the hypothesis that human sentience has a direct role in wavefunction collapse, similarly as that originally advocated by von Neumann, Bohr, and other founders of QM. If, on the other hand, Charlie's intervention has no effect on Alice's above-chance average (outcome **b**), then

the Born rule bias is not attributable to consciousness as the collapse mechanism. This would be the prediction from many of the more recent interpretations of QM. Importantly, then, the Charlie intervention modification to Bem's experiment appears able to distinguish between different interpretations of quantum mechanics, which in itself should be a significant achievement.

## Collaborative Controls

An important difference between our proposed experiments and previously experiments is the effort taken to create a close collaboration between psi skeptics and psi believers. We will recruit trusted psi skeptics to participate at all levels of planning and executing the experiments, working with psi experimenters such as Dean Radin at IONS, who will conduct most of the experiments. Care will be taken with security. We will introduce encrypted communications among the computers to ensure that all the data are secure. The four critical computers are: 1) Alice's computer at psi-friendly IONS, which controls the display; 2) the QRNG located in Berkeley, with direct connection to IONS; and 3) computers at IONS and Berkeley that track and store data. For each trial there will be five encrypted signals sent from the experiment computers to the data storage computers; using the t1, t2, t3 notation above, they are:

t1:   Alice's choice   (encrypted);
t2a:  QRNG choice   (encrypted);
t2b:  Charlie checks QRNG choice 50% of the time, pressing the QRNG value once observed (encrypted);
t2c:  RNG transmits information to Alice's computer (no encryption needed);
t3a:  Alice's computer receives signal and presents stimulus (encrypt); and
t3b: Alice verifies she has observed image and presses same button she as in step t1 (encrypt).

The encryption guarantees that all participants are assured that the data are valid and cannot be improperly handled by either side during the experiments.

## DISCUSSION

### Why Psi is not Compatible with Present QM

It is often thought that traditional QM should be able to accommodate psi; however, this is not the case. Precognition, for instance, violates causality. A bit of background concerning causality and the Born rule might help. One of us (SK) did his doctoral research on an aspect of the *proton bootstrap*. The challenge was to determine what the proton was made of – this, before quarks were thought of. Geoff Chew's Berkeley bootstrap idea was that the proton is a bound state of the proton and mesons, mesons are bound states of protons and antiprotons, and the forces binding them together are due to exchanges of protons and mesons. This process got is name "bootstrap" by analogy to flying by pulling up on one's bootstraps. Calculations were made, summing Feynman-like diagrams, using two sacred principles: 1) unitarity: (probabilities sum to 1); and 2) causality: all calculations guarantee that no signals travel faster-than-light (FTL) and or backwards in time (a special relativity consequence of no-FTL). This principle was powerful because the exact calculations always preserved causality and unitarity. However, for many calculations, approximations were needed that often led to violations of causality and unitarity, a strong indication that the approximation was flawed. Precognition, as an explanation for the Bem data, violates causality and it is, therefore, in contradiction with a central tenet of QED. But QED has been validated to 13 decimal places for the magnetic moment of the electron. Changing the QED rules have never proved fruitful.

But a major caveat is needed to this straightforward argument against precognition. Although QED forbids FTL signals, maybe Mind-based mechanisms can be compatible with FTL and backwards-in-time signals. A standard argument against this possibility is the *grandfather paradox*. (York Dobyns [13] called it the *bilking paradox* in his 2011 AAAS retrocauation symposium article.) The idea is that a proper signal going backwards in time could possibly be used to kill one's grandfather before he gives birth to any children. Dobyns [13] frequently cites the 1991 article by Echeverria, Klinkhammer and Thorne [14]. We prefer to cite Thorne's more recent book "Interstellar" [15]. His book provided the science background for what became the movie version of "Interstellar". Thorne devoted many years of research on the topic of whether wormholes in general relativity can be used for sending signals backwards in time. The premise of the movie is that the movie's hero uses a wormhole to send future knowledge backwards in time to his daughter who became a leading scientist and enabled migrations of earthlings to settle on other planets.

Thus, precognition may be compatible with QM, as long as the backwards-in-time signals are needed for the future to evolve properly. In this case, there appears to be no paradox. For precognition experiments, wormholes

would be replaced by the special powers of Mind. It will be up to future scientists to work out mechanisms by which Mind can perform wormhole-like tricks. (We suspect that it will be easier to work out how Mind can do clairvoyance and psychokinesis.)

Clairvoyance and PK do not violate QED so one might think that they can be explained using standard QM. A central problem with these, however, is that presently understood QED interactions are far too weak to enable this sort of psi. The neurons in the brain are shielded from the sorts of electromagnetic signals that would be produced by physically-mediated clairvoyance and PK. To stimulate neurons one needs significant voltages, such as those found in transcranial magnetic stimulation, which are thousands of times stronger than those in psi signals. Our approach is to invoke "Mind" that has properties not yet understood by current science.

We argue that, if the Bem effect is real, it is better explained by a modified Born rule, a process that would not require alterations of standard QED. Clever efforts to modify QED interfere with its impressive successes. Different QM interpretations may cope with the possibility of a Born rule bias in different ways. A crucial point is that, should psi be verified, it would have strong implications for how modified QM would be interpreted. Current QM is subject to multiple interpretations, each varying on a number of technical and philosophical points including questions of ontology and epistemology, probability theory, determinism, consciousness, retrocausation (of the non-psi type) and so on. Verification of psi would amount to an objectification of *mind* insofar as it would be measured as a phenomenon distinct from *matter*. It is no surprise that some adherents of the orthodox von Neumann interpretation have been open to the possibility of psi, since that interpretation already presumes Mind as a distinct, ontological actor in the universe [1]. Many of the founders of QM (e.g., Heisenberg, von Neumann, Dirac, Bohr) held views that involved sentience in the quantum collapse process, but in recent times this stance has become a minority opinion. A notable exception is Henry Stapp, who maintains the importance of Mind in QM.

Interestingly, if psi were accepted, it may be possible to distinguish between two kinds of Born rule-modified QM interpretations. If the Bem effect were found to exist, whether or not Charlie intervenes, this would imply that a powerful "Mind" affects Alice and violates the Born rule, and not sentience as such since Charlie's sentience had no effect. However, a dampening of the effect by Charlie would support the Stapp/von Neumann interpretation that involves Mind-based interaction with sentience (MBPK or MBClairvoyance).

## Born Bias and Interpretations of QM

It is crucial to identify the step at which Mind-based PK and clairvoyance operates. The Born rule bias involves the step of going from a probability to an actuality. Equation 2 is where we dealt with probabilities in the FAPP sense. For the case of PRNG clairvoyance, the action takes place before the PRNG action, but after Mind knows the deterministic state of the PRNG.

For most of the interpretations of QM the Born rule is merely an assumption. However, for some interpretations such as the Transactional Interpretation [4,5,12], the probability of the actuality can be derived and is precisely the square of the amplitude. For example Ruth Kastner [12] claims:

> ... if the Born Rule were violated, this could result in detectable deviations from the energy conservation law applying to the field and its sources (Poynting's Theorem). The result suggests that the Born Rule is just as fundamental a law of Nature as are the conservation laws.

Most interpretations of QM, such as orthodox von Neumann, have no strictly logical problem with a Born rule modification made by introducing a bias at the last stage of actualization. (It is our understanding that energy and momentum are conserved at the earlier entanglement step as well as Maxwell's equations.) The Many Worlds interpretations also appear natural homes for the biased Born rule, whereby Born bias could affect which of those many worlds you and I will follow. In fact, we suspect that most the interpretations of QM could allow a bias at the stage of actualization.

The various interpretations of QM have arisen largely to pursue plausible mechanisms for the measurement process, not for the QED aspects. Von Neumann articulated the measurement problem in his explanation of the collapse mechanism associated with the Born rule. The collapse mechanism is thought to be instantaneous. But instantaneous in whose frame? We will wildly speculate that it is the "Double Dark" frame of dark energy and dark matter. This is roughly the frame of our local cluster of galaxies. We like this device because of its simplicity, but there are other candidates, such as the time symmetric [2,3] and transactional [4,5,12] interpretations that give identical predictions for measurable events.

## Different Outcomes of Bem Experiment

Earlier, we described the PRNG- and QRNG-Bem experiments. Here we summarize the implications of the possible outcomes. The notation probQRNG_C and probQRNG_NC will be used for the probability of *with* and *not with* Charlie, respectively.

(probQRNG_NC = probQRNG_C = probPRNG = 50%) In these cases (no psi), the notation "=" indicates that the outcomes are not significantly different from each other in terms of scientific outcomes. Note that for the PRNG case we are not considering the Charlie intervention since whether or not Charlie looks at the PRNG is irrelevant because the PRNG is deterministic.

(probQRNG_NC = probQRNG_C = probPRNG >> 50%) Here, the notation >> indicates a biased Born rule. This case of psi is independent of the RNG and independent of Charlie. It could be precognition (with its associated paradoxes). The finding of near equality of the PRNG and QRNG was the reason that Bem [6] gave for precognition. However, for this outcome it is likely that all three cases are not precisely equal; rather, it is possible there are subtle differences that experiments with greater statistical power might reveal (e.g., ones with more trials and more subjects).

(probPRNG >> 50%) For the following cases we will consider a significant PRNG effect and will explore other alternatives for QRNG. Our focus is on the effect of Charlie on the QRNG.

(probQRNG_NC = probQRNG_C = 50%) This case would indicate that the Mind can be aware of what has happened in the past (PRNG>>0) and can influence human behavior. The fact that the QRNG doesn't is because Alice has already made her decision and this outcome implies that Mind only can influence minds, not QRNGs. Alternatively, maybe the quantum collapse of the QRNG takes place before the superposition interacts with a human. This outcome would imply that the collapse does not require sentient intervention.

(probQRNG_NC >>50%); probQRNG_C = 50%;) This outcome, preferred by Henry Stapp, would demonstrate that sentience is needed for the collapse and, as discussed earlier, it would imply that Mind only intervenes when emotions are at play.

(probQRNG_NC >> probQRNG_C >> 50%;) This outcome would take a large number of trials and would indicate that Charlie intervention would weaken but not eliminate the psi effect. This possibility is a graded influence by Charlie.

Further distinctions are possible, but the above should suffice for demonstrating that small alterations in the experimental design can make differences in outcomes, thus giving clues about underlying physical mechanisms. Although we think the first of these outcomes (no psi) is most likely, even a small likelihood in the others strongly justifies the experiments both from the perspective of discriminating between various quantum mechanical interpretations, and also as a means for studying how the mind (and brain) interacts with the physical world.

## Collaboration vs. Conflict: How to Convince Mainstream Science to Address Psi

For more a century there has been a poorly-articulated but tangible antipathy between mainstream science and parapsychology. We propose a simple solution: get psi researchers and psi skeptics to work closely together in designing and carrying out experiments. In principle, this should be relatively easy: allow psi skeptics to be centrally involved in the experimental design, data collection and analysis. The encrypted communications at each step of the present protocol is an example of what we have in mind. This type of partnership has occasionally been attempted, e.g., Schlitz, Wiseman, Watt and Radin [16], but results thus far are mixed.

Currently, mainstream scientists are prone to reject the possibility of psi because it purportedly violates QM. However, as we have pointed out, a fairly straightforward modification to QM (a modified Born rule) might explain psi effects without negative implications for standard QM. There may be other ways to account for psi phenomena without Born rule violations as well. Currently, Stapp is working on a model to account for psi that does not violate the Born rule but instead uses a form of psychokinesis that is consistent with QM. Such a model requires specific ontological presumptions applied in this paper concerning a dualism between Mind and physics/biology. By Mind with a capital M, we mean a realm that Stapp calls "Nature" and others call "Cosmic Mind." To avoid interfering with the physics, we assume Mind only interacts with the neural correlates of consciousness (NCC) of sentient creatures, so it is not able to use psychokinesis to affect the QRNG. In our previous descussion, we had Mind operating at the final acualization step by biasing the Born rule. The new suggestion is that it may operate before the actualization, influencing the QED-NCC mechanisms in Alice's brain that science does not yet understand. An advantage to the hypothesis of Mind or modified Born rule operating in sentient creatures, however it be worked out, is that it is testable. Given the low cost and high benefit, we hope mainstream science will become involved with high-quality psi research.

Another important step is to develop definitions that have the same meaning across disciplines. As we found, a good example of miscommunication is the word *retrocausation*. It is common to call the Bem experiment an example of apparent "retrocausation". As the language of psi researchers becomes more compatible with the language of mainstream physics (or vice versa), the quality of communications will surely advance.

We also believe that it would be advantageous for psi proponents and skeptics to find agreement on what the implications for physics and science would be if psi were to be verified. We hope our discussion of a Born rule bias is a step in that direction.

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