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Retrocausation in Quantum Mechanics and the Effects of Minds On the Creation of Physical Reality

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Abstract. The classical physical theories that prevailed in science from the time of Isaac Newton until the dawn of the twentieth century were empirically based on human experience and made predictions about our mental experiences, yet excluded from the dynamics all mental properties. But how can one rationally get mental things out if no mental elements are put in? The key step in the creation of quantum mechanics during 1925 by Heisenberg and his colleagues was to recognize and emphasize the essential dynamical role of mental properties in the creation of our mental empirical findings. This basic feature of quantum mechanics was cast into rigorous mathematical form by John von Neumann, and was made a central feature of contemporary relativistic quantum field theory by the work of Tomonaga and Schwinger. That theory is causally strictly forward in time. But it is explained here how it can nevertheless accommodate the seeming backward-in-time causal effects reported by D.J. Bem, and many others, by means of a slight biasing of the famous Born Rule. The purpose of this communication is to explain how those reported retrocausal findings can be explained by a strictly forward-in-time and nearly orthodox causal dynamics that, however, permits the Born Rule to be slightly biased under certain conditions. A feasible experiment is proposed that, if it gives the outcomes predicted by the proposed theory, will provide evidence in favor of this causally forward-in-time and nearly orthodox explanation of the reported retrocausal effects.

INTRODUCTION

In the science-based effort to understand the nature of the reality of which we are parts, a key step was the creation of quantum mechanics in 1925 by Heisenberg and colleagues [1]. This theory allowed physicists to explain a plethora of then-existing empirical data pertaining to the interaction of atoms with electro-magnetic fields and particles of light, and, moreover, to make valid detailed prediction about the observable macroscopic behavior of systems built out of combinations of these constituents. This new theory was built around the idea that the conscious thoughts of observing agents enter in an essential way into the behavior of the macroscopic aspects of their physically described brains and bodies. But in spite of the huge success of this quantum theoretical approach, most contemporary mainstream scientists and philosophers of science adhere to the *physicalist* doctrine, which claims that insofar as we are interested in the large-scale behavior of systems, including the bodies and brains of us human observers, we can assume that, just as in classical physics, our mental aspects are causally inert by-products of dynamically self-sufficient physically described activities, and can therefore be excluded from the effective dynamical description of the macroscopic aspects of the physically described world. In this paper a feasible experiment is described that can shed important light on this basic question of the role of mental realities in the unfolding of the observed physically described world.

This proposed experiment is a variation of the well-known “erotic picture” retrocausation experiment designed and executed by Daryl J. Bem [2]. In this experiment a human subject, often (and herein) called “Alice”, is seated in front of a screen showing two curtains, and is told that behind one of them lies an interesting picture, and behind the other lies a boring blank wall; and that she should choose (i.e., guess), on the basis of her “hunch” or “feeling”, the curtain behind which the interesting picture lies. After a delay, that chosen curtain will be removed, so that Alice can see what lies behind it. The other curtain is left in place. Soon *after* her choice of curtain is made and recorded, two well-tested 50-50 random number generators (RNGs) are activated. Their outcomes control mechanisms that, in each trial, place either an erotic picture or a non erotic picture, or an image of a blank wall behind each of the two curtains. Then later, at the end of the trial, Alice looks at what lies behind the curtain she has chosen. The set-up is such that

there is, by virtue of the known properties of the RNGs, a 50-50 chance that if she sees a picture, not a wall, she will see an erotic picture, not a non-erotic picture. But the reported empirical finding is that Alice tends to choose an erotic picture instead of a non-erotic picture roughly 53% of the time, in a long sequence of trials.

The simplest *classical* explanation (apart from faulty experimental design or execution) would seem to be that the RNGs are somehow producing a physical effect that acts backward-in-time and influences Alice's earlier choice of curtain—in order to tend to make that chosen curtain be the one behind which the erotic picture will later appear. Such a backward-in-time effect is appropriately called “retrocausation” in reference [2].

An alternative but non-retrocausal possible explanation of this unexpected correlation (of Alice's *earlier* choice of screen with, effectively, the later random choices of the RNGs) is that this correlation, like everything in the quantum universe, is due to features of the underlying quantum process of the creation of the unfolding of reality. I shall, in this connection, in agreement with Leibnitz, accept the “Principle of Sufficient Reason”, which asserts that nothing can happen without some reason for it to be what it turns out to be, rather than something else: i.e., a determination of something from nothing at all is, according to this principle, simply not possible! A sudden definiteness of something previously indefinite cannot simply pop out of nothing at all. A definiteness must be rooted in something sufficient to make it what it is, not something else!

According to orthodox quantum mechanics, certain choices of what an observer will experience are governed by a purely statistical rule called Born Rule. The principle of sufficient reason asserts that no such choice can be made strictly randomly on the basis of absolutely nothing at all –i.e., completely “out of the blue”! According to that principle, the “fact” that the workings of Nature result in the observed picture's being more often “erotic” than “non-erotic” must stem from some sufficient reason.

We human beings create during the course of our lives our own personal values, which influence, often unconsciously, our subsequent and otherwise “free” choices of how to behave. Quantum theory allows for this dependence of our own “free” choices of probing actions upon these essentially mental realities. In the quantum world our minds are enabled, by the asserted mind-brain connection, to affect our actions via our personal-value-influenced choices of our physical probing actions!

Orthodox quantum mechanics, as described by von Neumann [3], and extended by Tomonaga [4] and Schwinger [5] to Relativistic Quantum Field Theory [6], has, in addition to the “free choices” of probing questions by observers also associated “random” choices of responses made by Nature. Hence a key question arises: “What, in the end, determines Nature's individual ‘random’ quantum choices?” Does unexplainable-by-definition pure “randomness” give way in the end to some sufficient reason that would supply a rationale for the deviations of Nature's choice of response from the normal Born Rule?

The purpose of this communication is to describe a proposed feasible experiment, based on Bem's “erotic picture” experiments, here assumed empirically veridical, that could shed important light on this basic question by lending empirical support to the (nearly) orthodox quantum mechanical conception of Nature, which involves essential dynamical influences of mind upon macroscopic brain dynamics – in contrast to the contemporary mainstream physicalist approach that claims that a classical-physics-based theory that excludes macroscopic effects of mind upon brain is completely adequate.

The simplest classical explanation of the Bem “erotic picture” phenomena (apart from faulty experimental design or execution) seems to be that the RNGs produce an effect that acts backward in time and causes Alice to choose the place where the erotic picture will *later* be chosen to appear by these RNGs. That solution is retrocausal.

An alternative possible explanation is a strictly forward-in-time quantum mechanical one, and a manifestation of the principle of sufficient reason. According to orthodox quantum mechanics, the choice of what an observer will experience is determined in the end by a choice on the part of Nature that is governed by a statistical rule called Born Rule. But the principle of sufficient reason asserts that no such choice can be made strictly randomly on the basis of absolutely nothing at all – i.e., completely “out of the blue”! According to that principle, the fact that Nature, under the conditions imposed by the Bem experiment, chooses “erotic” more often than “non-erotic” must stem from some “sufficient reason”. Such a reason could be, for example, a dependence of Nature's response upon the character or potency of the mental state of the observer whose probing query instigates the collapse process that is the signature feature of orthodox quantum mechanics.

Such a biasing of Nature's choice by the character of the mental state of the observer *would be* an empirical finding of immense practical and theoretical importance. Or perhaps the biasing is a consequence of Nature's favoring worlds that, for example, promote the preservation of life. Further experimentation could explore such issues. The experiment proposed here speaks only to the central question of whether, as specified by orthodox quantum mechanics, the intervention of a human observer can produce a dynamical collapse of the state of the observed system that

is profoundly different from what is produced by the unitary (Schroedinger-equation-type) evolution of the full physically described system of observed system, measuring system, and environment? Does observation by a conscious human observer have a collapsing effect that an interaction with a purely mechanical system lacks? Do mental realities matter? Or are they merely physically inert by-products of the universally unitary dynamics?

ORTHODOX QUANTUM DESCRIPTION OF THE BEM EXPERIMENT

Niels Bohr [7] mentioned, at the 1927 Solvay conference at which the Copenhagen Interpretation of quantum mechanics was officially unveiled, that “An interesting discussion arose about how to speak of the appearance of phenomena about which only statistical predictions can be made. The question was whether, as to the occurrence of individual effects, we should adopt the terminology proposed by Dirac, that we were concerned with a choice on the part of ‘Nature’, or as suggested by Heisenberg, we should say that we have to do with a choice on the part of the ‘observer’ constructing the measuring instruments and reading their recordings.”

John Archibald Wheeler showed how these two views could be accommodated simultaneously by likening the process of observation to the parlor game of “twenty question”, in which the interlocutors (in the quantum case the conscious observers) poses yes/no questions to which ‘Nature’ responds ‘Yes’ or ‘No’. In this second phase, in the quantum case, the physical state of the universe “collapses” to a new state formed by eliminating the parts of the prior state that are incompatible with Nature’s just-chosen answer ‘Yes’ or ‘No’ to the observer’s probing question.

This two-phased process of first a probing question being posed by a conscious observer, followed by a responding physical action made by “Nature” was integrated into von Neumann’s “orthodox quantum mechanics” as his famous Process 1. The first phase of this process is an observer’s asking a yes/no probing question of the form “Will my forthcoming experience be ‘such-and-such’”, while the second phase is Nature’s (generally nonlocal) “Yes “or “No” psycho-physical response.

In the Bem experiment there are two 50-50 RNGs, and their combined action converts the state corresponding to what lies behind the curtain chosen by Alice to a mixture of four possibilities separated by the two conditions “picture vs blank wall”, and “erotic vs non-erotic”. Nature now chooses which of these alternative possible states to actualize and which to eliminate. The experimental set-up is such that the 50-50 weightings of the two outputs of the two RNGs entail, according to orthodox quantum mechanics, that the Born-Rule statistical weightings of the two alternative possibilities “erotic” and “non-erotic” are equal: it entails that these two possibilities are equally likely to be actualized by Nature’s response. But then the orthodox quantum theory entails that the Bem-reported effect would not be empirically realized. That null result is the normal prediction of orthodox QM for this experimental situation! But if, for some reason, Nature’s choice is biased in favor of Alice’s seeing erotic rather than non-erotic pictures then the Bem-reported results would be explained within the general framework of realistically interpreted *quasi*-orthodox quantum mechanics, where “*quasi*” signifies the slight relaxation of the Born Rule.

According to Tomonaga [4] and Schwinger [5] based relativistic quantum field theory (RQFT), the evolution of the physically described world, represented by the quantum mechanical state $\rho(t)$ of the universe, is strictly forward in time. Let “process time”, be represented by an integer “ n ” in the set $\{\dots -3,-2,-1,0, 1,2, 3 \dots\}$. It represents the actual “order of occurrence” of the ordered sequence of global collapse events. The *temporal* ordering of corresponding space-like surfaces $\sigma(n)$ along which the associated collapse occurs: at any 3D spatial point x in 4D space-time is such that the associated time of $\sigma(n + 1)$ is later than or equal to the time of the corresponding point of $\sigma(n)$. Thus we have an ordered sequence of space-time universes, each containing a 3D space-like surface “now”. Relative to this surface, along which a collapse occurs, there are two different “pasts”: the “actual past” that was there before the collapse, and the “effective past” that is defined as the backward-in-time continuation via a relevant Schrödinger equation, of the immediate future that exists just after the collapse. Thus the “effective past” keeps changing even though the causal dynamical process is strictly forward-in-time.

This is the orthodox temporal structure defined by the relativistic quantum field theory developed by Tomonaga and Schwinger. There is no actual backward-in-time action, but merely a sequence of piecewise increments to the expanding past. In the Bem experiment each collapse can be influenced by the state of mind of the associated observer, and by the current physical state of the universe, and by the reasons behind the choice made by Nature, but not by the yet-to-be-determined future.

THE ROLE OF CONSCIOUS MINDS IN THE DETERMINATION OF THE COURSE OF PHYSICAL EVENTS: A PROPOSED CRUCIAL EXPERIMENT

The most basic question in the general study of the nature of things is whether our conscious intentions, per se, are actually playing the active dynamical role in the determination of our physical actions that our normal everyday life experience tells us they are playing. (Thus, when I make a conscious effort to raise my arm, normally my arm subsequently rises. Our active lives are built around the resulting idea that our mental intentions can influence our bodily actions.) Yet, in spite of all that evidence, the physicalist/materialist philosophy that undergirds and guides most of mainstream neuroscience and biology essentially denies this notion that our mental aspects are actually playing the dynamical role in our lives that our every-day experiences tell us they are playing.

That physicalist philosophy is based, incredibly, on the known-to-be-false precepts of Newtonian/classical physics. Yet, in spite of its known-to-be-false classical basis, that philosophy has been able to survive in a science-based culture, and indeed to dominate almost all of science. That surprising survival is due in part to its relative simplicity, compared to quantum mechanics, and in part to the absence of really strong evidence showing that our thoughts are indeed causing our brain-body actions, rather than vice versa. In this section I shall describe a slight variation of the erotic-picture Bem experiment described above that may provide important evidence supporting the conclusion that our conscious thoughts do indeed, as claimed by orthodox quantum mechanics, influence our bodily actions.

The proposed experiment is a feasible variation of the Ben erotic picture experiment described above. The argument assumes the validity, and reliably reproducible character, of results similar to those reported by Bem.

The proposed variation of Bem's experiment consists of adding an extra observer, here called "Charlie", who is completely uninformed about the details of the experiment. He merely looks at *and perceives* the macroscopic physical outputs of the two RNGs, before they have activated any physical mechanisms, and thereby associated Charlie's immediate experiences with the yet to occur involvement with erotic and non-erotic pictures. Thus Charlie's current potential experiences involve no dependence upon the erotic vs non-erotic distinction, and they thus provide no basis for an associated biasing of Nature's choice of which possible Charlie-experience to actualize. Hence those potential experiences provide no basis for Nature to tend to choose, on the basis of the observer's alternative possible mental states, an erotic experience over a non-erotic experience. But then the 53% Bem effect should disappear if Charlie looks at and directly experiences the macroscopic physically described output of the 50-50 RNG that chooses between the erotic and non-erotic pictures.

If Charlie were to be replaced by, say, the IBM smart (but presumed mindless) computer "Watson" then, according to the orthodox theory, no quantum collapse would occur. Indeed, an experiment without conscious Charlie, but with a mindless Watson instead, is roughly equivalent to the normal Bem experiment itself. That is because the macroscopic action of the RNG and the associated recording devices is effectively already including a simple mechanical observer. So unless the high complexity of the "observer" is the essential cause of the collapse, instead of a mind per se as the orthodox theory asserts, then the usual Bem experiment is already sufficient to cover the case in which conscious Charlie is replaced by a mindless computer. According to the orthodox theory it is "mind" that matters: both the minds of conscious beings, and a capital MIND that can be gratuitously associated with Nature's choice of response, which is not deemed by orthodox theory to be determined by purely physical causes alone.

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REFERENCES

- [1] J. Mehra and H. Rechenberg, *The Historical Development of Quantum Theory*, Springer-Verlag, New York, Heidelberg, Berlin, Volume 2, pp. 150-322 (1982).
- [2] D.J. Bem, *Journal of Personality and Social Psychology*, **100**, 406 (2011).
- [3] John von Neumann, *Mathematical Foundations of Quantum Theory*, Princeton University Press 1955, translation of German Original, Springer-Verlag (1932).
- [4] S. Tomonaga, *Progress Theoretical Physics*. **1**, 26 (1946).
- [5] J. Schwinger, *Physical Review* **74**, 1439 (1948).
- [6] S. Weinberg, *The Quantum Theory of Fields*, Cambridge University Press, Cambridge (1995).
- [7] N. Bohr, *Atomic physics and Human Knowledge*, Dover Books. New York, p.51 (1958).

Appendix 1: Tomonaga-Schwinger-based forward-in-time Relativistic Quantum Field Theory versus True Retrocausation

I explain here how I deal with seeming backward-in-time actions! And in a recent communication to me from Stan Klein about my understanding of the nature of the quantum world I read that

“there is this Cartesian / Hindu / Whitehead’s Process version of Mind of Nature, ‘Mind’ for short. This cosmic Mind knows all about the past and doesn’t know the future. Given Henry’s all knowing Mind that is able to bias outcomes of actualities, to know something about a PRNG isn’t that big a deal. So if Bem is replicable I’m not bothered by a cosmic Mind that has deep knowledge about the past. The big mystery for me would still be how does sentience and Mind interact to collapse the wave function and also to produce qualia.”

(Stan informs me that the above passage was meant to pertain to a narrow context regarding the meaning of PRNG (Pseudo RNG). Nevertheless it compactly introduces the ideas that this appendix is about.)

I replied: . . . Cosmic MIND (i.e., Nature) does not *directly* influence Alice’s early choice of curtain: it directly influences which experience Alice will have at the *end* of the trial, by virtue of her viewing at that time the picture that appears behind the curtain that she had at the *beginning* of the trial chosen to eventually see behind. That choice (of picture) “On the part of Nature” *collapses*, 53% of the time, the then-existing mixture of the two co-existing branches of the state of the full system (that were created earlier, by the creation of the two alternative possible choices of the RNG) to the branch in which the erotic picture appears behind the curtain that she had at the outset of the trial chosen to eventually see behind. But this favored branch is, of course, precisely the branch in which she had at the outset of the trial, *effectively* picked by picking the curtain behind which she chose to eventually view. This collapsing action, *viewed in 4D space-time*, is an action into the backward light-cone: it extends backward from Nature’s final choice of what Alice will see, back to Alice’s earlier original choice of curtain. But such a backward-in-time action raises the question of whether, by multiple applications, a “grandfather” paradox could be produced.

Tomonaga and Schwinger devised a RQFT in which the unitary (Schroedinger-type) evolution of the state of the universe, and all of its component parts, evolve strictly forward-in-time: the causal effects of earlier events are integrated into an always forward-moving well-ordered sequence of space-like surfaces $\sigma(n)$, where the integer n labels the *ordering* of the associated collapse processes, and $\sigma(n)$ is the space-like surface along which the collapse process n occurs. The essential property of the surfaces $\sigma(n)$ is that $\sigma(n + 1)$ is never, at any 3D spatial point x , earlier in time than $\sigma(n)$. This property prevents any “grandfather” paradox. Each intervention ‘ n ’ of Nature (i.e., capital MIND) occurs in a local patch along the space-like surface $\sigma(n)$, and produces an instantaneous non-local collapse process that occurs along that space-like surface $\sigma(n)$! The backward-in-time change extending backward from Nature’s choice at the “final time” of Alice’s seeing the picture, *back* to her initial choice of curtain, is regarded not as actual (the “actual past” is “fixed and settled”) but as the “record of the past” that survives the collapse that occurred along the space-like surface $\sigma(n)$ that contains Nature’s choice of the picture that Alice ultimately sees. In

short, the apparent backward-in-time action is regarded not as a (deemed impossible) revision of the actual fixed and settled past, but rather as the “Effective Past” generated by the backward-in-time continuation of the reality existing immediately *after* the collapse. This is discussed at length in my book (On the Nature of Things) (attached) in the chapter on Actual Past versus Effective Past!

As regards the general idea of a cosmic MIND, see my Mind, Matter and Quantum Mechanics (2nd Ed., p.76) near the end of Ch.3 (The Copenhagen Interpretation), where Heisenberg writes to me positively about ideas existing outside our human minds (before human minds have existed). He refers to “the Philosophy of Plato.” And, as I have mentioned, Dirac refers to “choice of the part of nature”, which also suggests that “Nature” (natural law) has mind-like aspects.

Exactly what Nature knows is not made clear in the writings of the founders. Still, there certainly are in the writings of the founders, various hints that Nature is ontologically like a “Cosmic MIND”; like a Whiteheadian-type Mind that contains “potentia” for future experiences.

Thus Nature enters in a very limited way, specified by von Neumann’s famous “Process 1”, not as an “all knowing” Super Mind, of the kind suggested by Stan’s statement. It enters as a non-mechanistic responder to choices of probing questions/actions of observers. I stay in agreement with the words of the founders, filling herein a few missing needed details.

Appendix 2: Von Neumann’s Process 1

I have described in many places von Neumann’s Process 1, which is the observer-initiated process that produces the famous “quantum collapse”, or “reduction of the wave packet”. It is the following two-part action:

1. The mind of the observer poses the following Yes-or-No question: “Will my forthcoming experience be E”, where E is a description of a possible forthcoming experience.
2. Nature responds “Yes” or “No”. A “Yes” response causes the experience E to occur in the stream of consciousness of the observer. It also eliminates from the state (i.e., density matrix ρ) of the universe all parts that are incompatible with the occurrence of experience E. A “No” response causes all parts of the state of the universe that are incompatible with the non-occurrence of experience E to be eliminated.

A statistical condition called the Born rule governs the relative frequency of nature’s choice between “Yes” and “No”.

Readers interested seeing von Neumann’s account of this basic idea, of taking the key observables to be projection operators, are referred to Chapter IV, entitled “Deductive Development of the Theory”, where vN begins to describe the essence of quantum theory in terms of projection operators, which correspond to Yes/No questions, and to page 401 where he focuses explicitly on the asking of questions by observers, and the character of Nature’s response.

A projection operator P satisfies $PP=P$. Thus an eigenstate of P has eigenvalue either one or zero, which can represent “Yes” or “No”. Instead of dealing, for example, with unbounded operators like Energy, Momentum, or Position, one can deal with finite intervals in these variables by means of projection operators that “project” onto finite intervals in these variables, as for example the action of projection operator $P(3>x>2)$ on the density matrix ρ of the universe. This action, $P(3>x>2)\rho P(3>x>2)$, sets to zero the numbers in the rows and columns of ρ in which the linear variable x does not lie between 2 and 3, but leaves the others untouched. Here x might label the position of the pointer along the dial of a measuring device that is being observed by an observer.

An outcome concentrated at a single value of x , say 2.5, has zero probability to occur. So it is useful to formulate the theory of measurement in terms of properties defined by projection operators associated with Yes/No questions about observable properties. Quantum theory says, in general, that if one measures the value of a Hermitian operator one will get for the outcome one of its eigenvalues, and that the probability of getting a specified eigenvalue is given by the Born Rule. But in the case in which the eigenvalues form a continuum (like the location x of a pointer along a dial) the specified outcome “Yes” (plus 1) should be required to lie in a finite interval. That condition is neatly expressed by using projection operators that project onto such intervals, in the way just explained.

The Born rule, applied to this case, says that the probability, in an initial state ρ , that the measurement of a projection operator P will give the Yes (i.e., plus one) outcome is: $\text{Tr}(P\rho)/\text{Tr}(\rho)$, while the probability of No (i.e., eigenvalue zero) is: $\text{Tr}(P'\rho)/\text{Tr}(\rho)$, where $P'=(1-P)$.

So both the conceptual structure, in terms of the connection between mind and matter, and the basic dynamical and computational rules are neatly described in terms of the projection operator formalism.