Draft Essay

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(This is from an earlier essay that needs corrections and updating to better represent John's current views)

Quantum Physics and the Mind-Brain Relationship

John Wilcox

Abstract: Various physicists have thought that quantum mechanics tells us something about consciousness and its relationship to the physical world. Eminent physicists John von Neumann and Eugene Wigner once thought as such. And now, Bruce Rosenblum and Fred Kuttner are two of the most recent physicists in this tradition, as they argue that quantum physics supports mind-brain dualism, the view that the mind and the brain (including its activities) are two distinct phenomena. In this essay, I critically discuss this tradition using Rosenblum and Kuttner's argument as a case study, especially since it is one of the most recent and clear examples of the tradition. Regardless, my criticisms of their view will apply to similar views potentially held by others. In brief, I claim that Rosenblum and Kuttner's argument contains some insights. However, these insights are not necessarily that mind-brain dualism is plausible, but rather that the Copenhagen interpretation—or at least Rosenblum and Kuttner's version of it—plausibly entails consequences that some will find unintuitive. Mind-brain dualism is potentially one of these, but another one is that there is some non-physical entity which collapsed the wavefunction prior to the evolution of sentient beings. Not only is the existence of this entity questionable on metaphysical grounds, but its invocation is in tension with the motivation for claiming that the consciousness of humans also collapses the wavefunction. And while we cannot conclusively rule out the possibility of such consequences, they do give grounds to doubt the Copenhagen interpretation at the very least, especially when other alternatives are available, such as the Bohmian interpretation.

Introduction

What is the relationship between the mind and brain? One might think that this question is important and interesting for various reasons. One of these is that an answer to this question may tell us about the nature of what *we* as human beings *are*. We often identify ourselves at least in part with our minds, with some thinking that if their mind—including their memories, thoughts, desires and so forth—were placed in someone else's body, then there is a sense in which *they* simply would *be* in someone else's body. A popular view is that our minds simply *are* our brains or—put more accurately—that our minds are neural activity in our brains. But if it turns out that our minds simply are the activities of brains, then we might think that there is a sense in which we simply are our brains.

This question about the mind-brain relationship, however, is essentially a question about the relationship between our minds and the physical world, for brains clearly are physical objects. Naturally, then, another question arises: what, if anything, can the scientific study of the physical world can tell us about the mind-brain relationship?

Various physicists have thought that it can tell us a great deal. John von Neumann, an earlier and influential quantum physicist, argued that quantum physics entails a kind of dualism, according to which the mind is wholly distinct from the physical world. He writes that "the measurement or the related process of subjective perception is a new entity relative to the physical environment and is not reducible to the latter. Indeed, the subjective perceptions leads us into the intellectual inner life of the individual, which is extra-observational by its very nature…".[1] Nobel Prize winner Eugene Wigner also thought that consciousness had a special role in causing the transition of wave-like physical systems to definite particle-like physical systems, although he later changed his mind when he was compelled by the arguments of Heinz-Dieter Zeh, a pioneer of so-called *quantum decoherence*.[2] More recently, Berkeley physicist Henry Stapp has claimed that

[1] John von Neumann, *Mathematical Foundations of Quantum Mechanics* (Princeton University Press, Princeton,, 1955), 418.

[2] In 1984, Wigner writes, "This writer's earlier belief that the role of the physical apparatus can always be described by quantum mechanics implied that "the collapse of the wavefunction" takes place only when the observation is made by a living being—a being clearly out of the scope of our quantum mechanics. The argument which convinced me that quantum mechanics validity has narrower limitations, that it is not applicable to the description of the

contemporary "*physical theory allows, and its orthodox von Neumann form entails, an interactive dualism that is fully in accord with all the laws of physics*" (emphasis original).[3]

In this tradition, Bruce Rosenblum and Fred Kuttner are among the most recent and well-known physicists who have advocated a connection between physics and dualism. In *Quantum Enigma* (published by Oxford University Press), they argue that physics suggest that the mind is *not* the brain, nor is it any other physical system.[4] Call this *mind-brain dualism*, the view that the mind and the brain are two distinct entities.

This essay critiques Rosenblum and Kuttner's argument as case study in this tradition, proceeding in two parts. In part I, I set out Rosenblum and Kuttner's discussion of quantum physics and consciousness, particularly their argument that physics supports mind-brain dualism. In part II, I attempt to reconstruct and critically evaluate their argument.

At the paper's conclusion, I shall lastly summarize what I take to be the main implications of the debate, implications which apply to other potential arguments for mind-brain dualism that are motivated for similar reasons. In particular, these implications are that the Copenhagen interpretation—or at least Rosenblum and Kuttner's version of it—plausibly entails consequences that some will find unintuitive. Mind-brain dualism is potentially one of these, but another one is that there is some non-physical entity which collapsed the wavefunction prior to the evolution of sentient beings. Not only is the existence of this entity questionable on metaphysical grounds, but its invocation is in tension with the motivation for claiming that the consciousness of humans also collapses the wavefunction. And while we cannot conclusively rule out the possibility of such consequences, they do give grounds to doubt the Copenhagen interpretation at the very least, especially when other alternatives are available, such as the Bohmian interpretation.

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detailed behaviour of macroscopic bodies is due to D. Zeh." Eugene Wigner, "Review of the Quantum-Mechanical Measurement Problem," in *Science, Computers and the Information Onslaught*, edited by D.M. Kerr, 63–82 (New York: Academic Press, 1984).

[3] Henry Stapp, *Mindful Universe* (Berlin: Springer, 2007), 81.

[4] Bruce Rosenblum and Fred Kuttner, *Quantum Enigma: Physics Encounters Consciousness* (Oxford; New York: Oxford University Press, 2011).

Part I: Rosenblum and Kuttner's argument for Mind-Brain Dualism

Rosenblum and Kuttner's argument for mind-brain dualism can at times be difficult to interpret, in part because seemingly relevant aspects of their discussion are scattered throughout different parts of their book.[5] For that reason, I present what seem to me to be the relevant aspects of their discussion in this part, and I will then reconstruct, evaluate and tighten the structure of their reasoning in the next.

Experimental results

To understand the experimental results at the heart of Rosenblum and Kuttner's discussion, consider this experiment which they describe.

At the heart of this description is the concept of a wavefunction. This wavefunction is a mathematical representation of some entity or entities. Precisely what it represents is a subject of controversy; however, on the Copenhagen interpretation, it is typically taken to represent some entity which acts as a wave at some times and as a particle at others.

Following Rosenblum and Kuttner's experiment, suppose you have a wavefunction representing the wave that corresponds to an atom. You then send the wave through a semitransparent mirror. On the Copenhagen interpretation, the mirror then separates the corresponding wave into two "wave packets", to use Rosenblum and Kuttner's terms.[6] One wave packet goes through the mirror towards a box; the other wave packet is reflected in a different direction to a different mirror, and this mirror in turn directs the packet toward another box. The two wave packets are then separately trapped in the two boxes, also called the "box pair".

In this experimental set up, Rosenblum and Kuttner argue that a so-called "quantum enigma" arises from two sets of observations.

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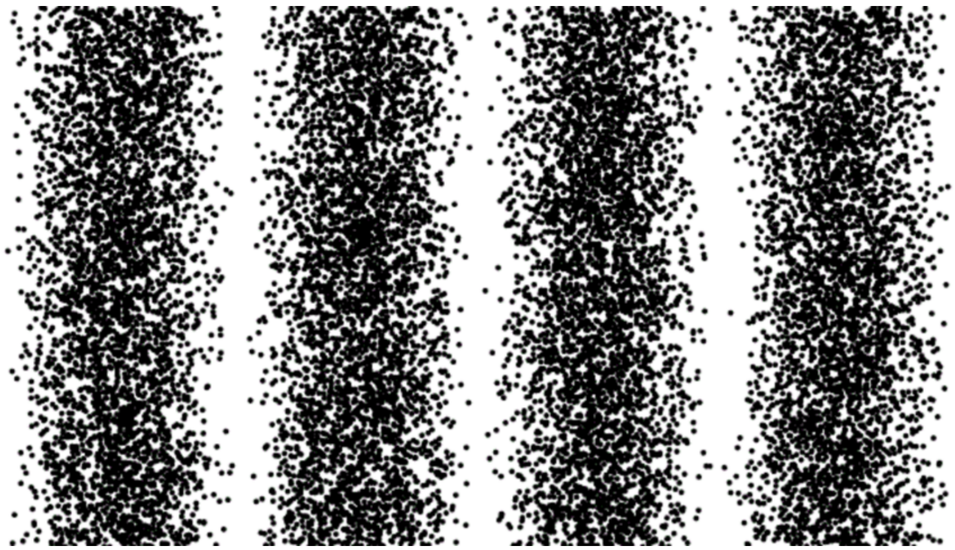
[5] For example, their discussion of von Neumann's chain (which I shall soon describe) occurs in a section which is separate to their explicit argument for mind-brain dualism, and while von Neumann's chain seems relevant to their argument (as I shall argue in Part III), its relevance is neither precisely stated nor clarified.

[6] In order to get a well-defined interference pattern for atoms, they should move with the same speed or, in physics parlance, have the same de Broglie wavelength.

They interpret the first set of observations to suggest that something of the one atom is in both boxes. These observations can be understood *independently of quantum theory,* or so they claim.[7] Suppose you were to repeatedly send single atoms into a box pair, as per the procedure just described. You then place a screen behind the box pair, produce a slit in each of the two boxes and measure only the location where the atoms land on the screen. If you repeatedly fire the atoms, you will find that they will land on some places of the detection screen but not others, thus generating an interference pattern like the following:



Furthermore, if you change the distance between the boxes, you will see a corresponding change in the patterns formed by the atoms, much like interference patterns with light.[8] Greater spacing between the boxes corresponds to smaller distances between the clusters where the atoms land. Rosenblum and Kuttner interpret these experimental results as such:

> Something of each atom had to come from each box because where atoms landed depended on the box-pair spacing. This interference experiment establishes that each atom had been a spread-out thing, in both boxes of its pair.[9]

[7] Rosenblum and Kuttner, *Quantum Enigma,* 97 and 99.

[8] This image is originally from https://www.researchgate.net/figure/Interference-pattern-from-single-particles_fig3_313835874.

[9] Rosenblum and Kuttner, *Quantum Enigma,* 93.

They claim that such an interpretation is shared by other physicists: "Finding no other reasonable explanation, physics universally accepts interference as establishing spread-out waviness."[10] So that is the first set of observations, observations which indicate that each atom was spread out in both boxes—according to Rosenblum and Kuttner.

In contrast, they interpret the second set of observations to suggest that each atom is either *wholly* in one box or *wholly* in the other. In the previous set of observations, one opened slits in the boxes to produce patterns on the screen which look like interference effects. In the second set of observations, no slits are in the boxes, and one then looks in one box or the other. If they do so, they will find that a given atom is in a particular box half the time, while it is in the other box the other half of the time.

The Quantum Enigma:

Rosenblum and Kuttner claim that these sets of experimental observations show that we are able to prove either of two "contradictory" outcomes.[11] With the first experimental setup—which they call an "interference" experiment—"you could choose to prove that each atom had *not* been wholly in a single box."[12] With the latter experimental set up—which they call a "which-box" experiment—you could choose to prove "that each atom had been *wholly* in a single box".[13] They claim it is impossible to run both kinds of experiment at once, since any attempt to detect the atom in either box will inhibit the production of an interference pattern.[14]

The ability to choose between the outcomes gives rise to what they call "the quantum enigma":

[10] Ibid., 95.

[11] Rosenblum and Kuttner, *Quantum Enigma*, 95.

[12] Emphasis original. Ibid., 94.

[13] Emphasis original. Ibid., 84.

[14] Ibid., 94.

> Did your free choice determine the external physical situation? Or did the external physical situation predetermine your choice? Either way, it doesn't make sense. It's the unresolved quantum enigma.[15]

They tie the problem inextricably to free will, or at least to one's beliefs about it:

> We experience an enigma because we believe that we *could have* done other than what we actually did…. The quantum enigma arises from our *conscious perception* of free will. The mystery connecting consciousness with the physical world displays physics' encounter with consciousness.[16]

So those are the experimental results which they claim give rise to the quantum enigma, but what is the standard interpretation of such results? On the standard Copenhagen interpretation, each atom is a wave prior to measurement. When such a wave is sent through the mirror, it splits into two waves which enter the two boxes. When the slits are closed, the atom is said to be in a *superposition* where it is in either of the two boxes. However, it is not until a measurement occurs that the atom transitions to a state where it occupies a definite point in space as a particle, at which time it will be in one of the two boxes. The transition from a wave to a particle is called the *collapse of the wavefunction.* According to Rosenblum and Kuttner, the orthodox interpretation of quantum mechanics has it that the "observations actually *produce* the measured result" in the sense that such observations cause the transition of the atom from a wave to a particle.[17]

This paves the way for their discussion of consciousness in relation to the box pair experiment. They introduce the topic with what is known as *von Neumann's chain*, a puzzle introduced by John von Neumann. Essentially, the puzzle arises from the idea that any instrument for measuring a quantum system is itself a quantum system, and one which would *entangle* with the measured quantum system. For example, so-called *Geiger counters* could be placed in the boxes to ascertain whether the atom is in one box or another. However, as soon as the wavefunction of the atom interacts with a counter, the objects entangle, yielding a composite quantum system that is

[15] Ibid., 95.

[16] Emphasis original. Rosenblum and Kuttner, *Quantum Enigma*, 95.

[17] Ibid., 82.

describable with one wavefunction. In this sense, the counters and the atom are in superposition states, with each counter being in a superposition where either the atom is in the box and the counter has fired, or the atom is not in the box and the counter has not fired. Rosenblum and Kuttner believe that Von Neumann "showed that *no* physical system obeying the laws of physics (i.e. quantum theory) could collapse a superposition state wavefunction to yield a particular result."[18] But if the standard interpretation of quantum mechanics is correct, then something must cause the collapse of the wavefunction. After all, we directly observe physical systems in definite states rather than superpositions of mutually exclusive states. There is a chain, then, extending from the initial quantum system—such as the atom—to the observer, and the puzzle arises as to where in the chain do physical systems occupy definite states rather than superpositions. Von Neumann, they claim, concluded that the chain ends at the "Ich", the Ego, or the conscious observer; it is the consciousness of the observer that causes the collapse.

While they introduce their discussion of consciousness and the experimental results with a discussion of von Neumann's chain, they present their argument for mind-brain dualism in a different section.

There, they ask you to imagine an experiment in which you have set of box pairs. You and a colleague can choose to open the boxes in a pair in two different ways. The first way is to open only one box at a given time. If you do so, suppose you always find that, for each pair, a marble will be wholly in one or other of the boxes. The second way is to open the boxes in a pair at the same time. Suppose that if you do this, you always find that there is half a marble in both of the boxes. Rosenblum and Kuttner further ask you to suppose that you and a team of experts establish beyond reasonable doubt that the physical process of opening the boxes does not affect the outcome. They state the implications of this experiment:

> Of course, this demonstration *cannot* be done. But *if* it could, you would have little alternative but to accept it as objective evidence that the *conscious choice* of opening technique can affect a physical situation. This would be *objective,* third-person evidence (though not proof) that consciousness exists as an entity beyond its neural correlates.[19]

[18] Ibid., 238.

[19] Emphasis original. Rosenblum and Kuttner, *Quantum Enigma*, 244.

They say that the archetypal quantum experiment—be it the canonical two slit experiment or their box pair experiment—“comes close” to a demonstration like this.[20] This is for three reasons: in their quantum box pair experiment, the choice of whether to look in the boxes or only at the screen influences the outcome of the experiment; no physical process can be found to account for such outcomes; and the outcome is “objective” insofar as the experiment could display to anyone that one’s choice of observations to make is influencing the experimental outcomes. The key difference between the quantum experiment and the marble experiment, they claim, is that rather than observing the atoms in both boxes *directly* like how one observes the marbles in both boxes, one instead *infers* from the interference pattern that the object was in both boxes.[21] As such, it provides “*objective* evidence of consciousness”, although the evidence has the weakness of requiring an inference from the interference patterns to the existence of waves in both boxes. Therefore, while the experimental results are not conclusive, Rosenblum and Kuttner claim that they are “the suspicious footprint at the crime scene *suggesting* a culprit.”[22]

[20] Ibid., 244-5.

[21] Rosenblum and Kuttner, *Quantum Enigma*, 244.

[22] Emphasis original. Ibid., 245.

Part II: Argument Reconstruction and Evaluation

In part II, I attempted to fairly present Rosenblum and Kuttner's discussion of consciousness and quantum physics. In this part, I hope to distil and critique their argumentation by faithfully reconstructing it in standard form. I will then argue that this argumentation is deficient, and I will attempt to provide a less faithful but more clear and compelling reconstruction of their argumentation before evaluating its content.

Argument Reconstruction: The Faithful Version

Rosenblum and Kuttner provide an argument for the quantum enigma in chapter 7:

P1. One can choose to run a box-pair interference experiment or to run a "which-box" experiment with some atoms
P2. If one chooses to run an interference experiment with some atoms, then one obtains an interference pattern
P3. If one obtains an interference pattern, then each atom was partly inside both of the boxes
P4. If one chooses to run the "which-box" experiment with some atoms, then each atom was inside only one of the boxes
C. Therefore, whether each atom is in one or both boxes is dependent on the choice of the experimenter

The conclusion of this argument is the "quantum enigma", and they claim that such an enigma follows directly from the experimental results without any contestable interpretation of quantum mechanics.[23]

On the basis of this "enigma", they then provide an argument for mind-brain dualism in chapter 17:

[23] Rosenblum and Kuttner, *Quantum Enigma*, 97 and 99.

P5. Whether each atom is in one or both boxes is dependent on the choice of the experimenter

P6. If whether each atom is in one or both boxes is dependent on the choice of the experimenter, then the experimenter's conscious choice is affecting the physical situation

P7. If the experimenter's conscious choice is affecting the physical situation, then we have evidence for mind-brain dualism—that consciousness exists as an entity beyond brain activity

C. Therefore, we have evidence for mind-brain dualism

Argument Evaluation

Let us now evaluate their argument, starting with premise 3: if one obtains an interference pattern, then each atom was partly inside both of the boxes. While the standard interpretation of quantum mechanics jibes with this premise, it is not uncontestable, for it is clearly denied on alternative interpretations of quantum mechanics.

To take an example, consider Bohmian mechanics. According to Bohmian mechanics, there are really two entities in the box pair interference experiment: an atom and a quantum potential. The atom always has definite properties—such as a specific spin—and it always takes a definite trajectory from the atom emitter to the box or detection screen. The quantum potential, however, is what explains the interference pattern. The quantum potential generates a force which guides the atom and provides potential paths for the atom to take. In the interference experiment, it is the force of the quantum potential which acts as a wave, going through the two boxes as it were, and producing an interference pattern of possible paths for the atom to take. What determines whether the atom takes one path or another is the initial position of the atom. However, according to Bohmian mechanics, the reason we are unable to predict which path it takes is because the trajectory of the atom is extremely sensitive to subtle features of its initial position, features which are difficult to detect and whose trajectorial import is difficult to ascertain. The Bohmian, then, would deny that any atom was in both boxes, contra Rosenblum and Kuttner's claim; rather, the force of the quantum potential was interacting with both boxes, and the conjunction of the force and of the atoms' initial conditions produced the experimental outcomes in accordance with the wavefunction of the system.

On this interpretation, the rest of Rosenblum and Kuttner's argument clearly falters: whether the atom is one or both boxes is *not* dependent on the choice of the experimenter, simply because the atom is *never* in both boxes. Instead, the choice of experiment to run is merely a choice affecting the force of the quantum potential and the possible trajectories, something that is hardly more remarkable than the choice of where one will shine the waves of a light emitter.

Bohmian mechanics accounts for all of the current experimental results of quantum mechanics, but, in saying that, it is also not without its objections.[24] Perhaps the most significant of these is that it forsakes a degree of simplicity, both in postulating an additional entity—the force of the quantum potential—and in requiring more complicated mathematics to derive the experimental results of quantum mechanics. Indeed, even David Bohm himself considered the quantum potential to be "rather strange and arbitrary".[25] However, such objections are not necessarily decisive, for the history of science is also a history of discovering new forces and formulating more complex mathematical equations to account for experimental outcomes, so it is not altogether impossible that additional forces and complexity are needed in describing reality.

Interestingly, Rosenblum and Kuttner mention Bohmian mechanics, but they do not give any explicit reason to prefer their interpretation over the Bohmian interpretation of the experimental results.[26]

In any case, premise 3 is at least not obviously true and—contra Rosenblum and Kuttner—it clearly presupposes some theory-laden interpretation of the experimental results.

However, Rosenblum and Kuttner's argument is also challengeable elsewhere. Recall premise 7: if the experimenter's conscious choice is affecting the physical situation, then we have evidence for mind-brain dualism—that consciousness exists as an entity beyond brain activity. This premise is not immediately obvious at all, especially since our choices often affect physical situations, but this is arguably compatible with such choices being some physical events—such as the firing of neurons—which then affect other physical events.

One might also challenge their argument with a hypothetical "delayed choice" experiment, but we shall discuss this challenge in the next section.

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[24] Sheldon Goldstein, "Bohmian Mechanics," *The Stanford Encyclopedia of Philosophy* (Summer 2017 Edition), Edward N. Zalta (ed.), https://plato.stanford.edu/archives/sum2017/entries/qm-bohm/.

[25]David Bohm, *Wholeness and the Implicate Order* (New York: Routledge, 1980), 80.

[26] Rosenblum and Kuttner, *The Quantum Enigma,* 213-215.

Argument Reconstruction: A More Compelling Version?

I have then identified at least two salient points of objection for Rosenblum and Kuttner's argument, at least as they present it. The first is the premise linking interference patterns with an atom being in both boxes; the other is the premise linking physically efficacious choices with mind-brain dualism.

However, I think there is another rendition of their argument. Although this rendition is not quite their argument as they present it, it does draw on some aspects of their discussion, and they would likely accept all of its premises. I believe that this rendition is at least a *more* clear and compelling argument in support of their conclusion, even if it is not definitive in and of itself.

As we saw, Rosenblum and Kuttner's argument appears to presuppose the Copenhegen interpretation of quantum mechanics, or something like it, where interference patterns are indicative of an atom being in both boxes in some sense.

I then propose a rendition of this argument where this supposition is explicit and where the collapse of the wavefunction is understood as the transition of a system from a wave-like entity to a configuration of some definite particle(s). The rendition then runs as follows:

P1. No physical system causes the collapse of a wavefunction

P2. Something causes the collapse of a wavefunction

SC1: Therefore, that thing which causes the collapse of a wavefunction is not itself a physical system (from premises 1 and 2)

P4: That thing which causes the collapse of a wavefunction is consciousness

SC2: Therefore, consciousness is not a physical system (from sub-conclusion 1 and premise 4)

P5: The brain is a physical system

C: Consciousness is not the brain (from sub-conclusion 2 and premise 5)

This is a significant departure from Rosenblum and Kuttner's argument as they present it, particularly since it does not revolve around the notions of "choice" or "free will" which permeate their discussion. Regardless, I think they would endorse the premises of this argument, and that these premises provide a case for their overall conclusion which is at least more compelling than their initial argument.

Now let us turn to evaluate the rendition.

It seems that premises 2 and 5 are plausible. Clearly the brain is a physical system, so premise 2 is true. And if the Copenhagen interpretation is correct, then premise 2 is obviously true: we never directly observe quantum systems in superpositions of mutually exclusive states, so something must cause the collapse of a wavefunction.[27]

If there are problems with the argument aside from the presupposition of the Copenhagen interpretation, then they presumably reside with premises 1 and 4.

Rosenblum and Kuttner do not explicitly cite premise 1 in their argument for mind-brain dualism, but they clearly endorse it when they say that von Neumman "showed that *no* physical system obeying the laws of physics (i.e. quantum theory) could collapse a superposition state wavefunction to yield a particular result."[28] And in support of premise 1, they cite and give a description of von Neumann's argument, offering no additional argument of their own. As discussed in part I of this essay, the argument essentially asserts that any physical system which would interact with another system in a superposition would then entangle with the system, thereby creating a complex superposition of the interacting systems.

However, Rosenblum and Kuttner's reading of von Neumann is not uncontestable. So far as I can tell, von Neumann nowhere explicitly claims something to the effect that "*no* physical system obeying the laws of physics (i.e. quantum theory) could collapse a superposition state wavefunction to yield a particular result." What *is* uncontestable, however, is that von Neumann believed that the phenomenon of measurement raised a puzzle as to where the boundary is to be

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[27] Some might think that this statement is false since we observe superpositions for various phenomena, such as C_{60} molecules. However, in such cases, what is actually observed is an *interference pattern*, and from this it is *inferred* that the phenomena were in a superposition. However, some physicists are so accustomed to thinking of interference patterns as demonstrating superpositions that they speak of observing the superpositions themselves. This presupposes a contestable interpretation of quantum mechanics when others (such as the Bohmian interpretation) are no less viable. See, for example, Markus Arndt, Olaf Nairz, Julian Vos-Andreae, Claudia Keller, Gerbrand Van der Zouw, and Anton Zeilinger, "Wave–particle duality of C_{60} molecules," *Nature* 401 (1999): 680-682.

[28] Rosenblum and Kuttner, *Quantum Enigma*, 238.

drawn between the observer and the observed system, and that "the measurement or related process of the subjective perception is a new entity relative to the physical environment and is not reducible to the later."[29] To some extent, then, von Neumann's view jibes with at least some of Rosenblum and Kuttner's argument, but precisely to what this extent is is nevertheless debatable.

Regardless of what von Neumann thought, the advocate of the Copenhagen interpretation might resist premise 1, claiming that some physical systems *can* collapse the wavefunction of other physical systems according to the theory of decoherence. The theory of decoherence is the study of particular interactions between a quantum system and its environment which eliminate interference effects.[30] For example, suppose we repeatedly run a two slit experiment where the measurement of an electron's position occurs only at the detection screen. Suppose further that, on the way to the detection screen, there are stray cosmic particles which bounce off the electrons, so to speak. Here, the interaction of a quantum system—the electron—with its environment—some stray particles—eliminates the interference effect: instead of seeing the stripe-like distributions of electrons which land on the screen, one will instead observe a uniform distribution. In such circumstances, the entanglement of the atoms with objects in their environment leads to the "decoherence" of the wavefunction, that is, the suppression of the interference effects. Here, the measured locations of the electrons at the detection screen and the disappearance of the wave-like interference effects look as though the electrons had collapsed from waves to particles *prior* to their measurement at the screen. It is as though the physical environment had made measurements on the physical quantum systems, thus providing a putative counter-example to the claim that no physical system can cause the collapse of any other physical system.

However, decoherence does not necessarily show that physical systems can cause the collapse of other physical systems prior to measurement by conscious beings. As Bacciagaluppi, Rosenblum and Kuttner put it, decoherence shows that interactions between a system and its environment change the probabilities of measurement outcomes *as if* the wave had already collapsed prior to the measurement.[31] Despite this, the mathematical terms representing the wave

[29] von Neumann, *Mathematical Foundations of Quantum Mechanics,* 418.

[30] Guido Bacciagaluppi, "The Role of Decoherence in Quantum Mechanics", *The Stanford Encyclopedia of Philosophy* (Fall 2016 Edition), Edward N. Zalta (ed.), https://plato.stanford.edu/archives/fall2016/entries/qm-decoherence/.

[31] Bacciagaluppi, "The Role of Decoherence," and Rosenblum and Kuttner, *Quantum Enigma,* 209-10.

properties of the quantum system—the so-called “phase relations”—do not disappear from the wavefunction of the larger system composed of the electrons and the stray particles. Instead, the phase relations have been merely distributed over the composite system, thereby yielding probabilities of measurement outcomes that are *as though* the system was conformable to classical physics, *as though* some phase relations were not in the calculations of the outcomes.[32] On the Copenhagen interpretation, however, this is completely consistent with the possibility that the electrons had not collapsed prior to measurement at the detection screen. Consequently, the Copenhagen advocate might claim that the electrons had merely entangled with the stray particles prior to measurement, thus giving rise to different superpositions which eliminate interference effects, which include interactions and which only collapse when a measurement has been made by an observer.

Hence, the adherent of the decoherence theory may try to ultilise it in resisting premise 1 while also committing to the Copenhagen interpretation, but, at the very least, it is controversial as to whether they would succeed. Indeed, some have suggested that decoherence may even *help* the von Neumannian view that collapse of the wavefunction happens only with the involvement of consciousness.[33]

So I am inclined to think that the Copenhagen advocate should be committed to premise 1, but in any case, we can critically discuss some aspects of Rosenblum and Kuttner’s argument without needing to settle whether von Neumann and the Copenhagen advocate are committed as such. It suffices to discuss Rosenblum and Kuttner’s argument and its implications *qua* their interpretation of quantum mechanics.

Of course, then, one point of criticism is that alternative interpretations are available—including the Bohmian interpretation—and it is doubtful that the experimental facts themselves, perhaps coupled with other uncontroversial principles of theory choice, commit us to their preferred interpretation of quantum mechanics.

Furthermore, premise 1 arguably entails an unintuitive consequence. Presumably there was a period in the universe’s history when there were no conscious beings. Sometime after the big bang, it is plausible that some physical interaction of molecules formed the early building blocks

[32] Bacciagaluppi, "The Role of Decoherence”.

[33] See, for example, Bacciagaluppi, "The Role of Decoherence”.

of life, and this began a process which eventually culminated in the evolution of conscious living beings. However, presumably such an interaction required *definite* particles that were not merely in a superposition of mutually exclusive states. In this case, such an interaction would have required the collapse of a physical system.

The question arises, then, what caused the collapse of the wavefunction prior to the emergence of conscious beings?

Rosenblum and Kuttner countenance the idea (which they call the "strong anthropic principle") that *our* looking back through the history of the universe gives rise to its physical existence. They state:

> A different version of the strong anthropic principle is implied in our quote [from Martin Rees]: *We* created the universe. Quantum theory has observation creating the properties of micropscopic objects, and we generally accept that quantum theory applies universally.[34]

While Rosenblum and Kuttner do not explicitly accept the principle, and they claim that it "is probably too much for anyone to believe, or comprehend", they do not offer any alternative treatment of the problem of what caused the collapse of the physical preconditions for the development of sentient beings.[35] One is left wondering whether this is then their preferred treatment of the problem. If so, many would probably find their treatment of the problem unsatisfying—even by their own lights—and we are then left with an unresolved problem of what we should think about the origins of the universe if their interpretation of quantum mechanics is correct.

In this sense, I think it is extremely implausible that *we* created the physical *pre*conditions for our own existence, almost on par with the claim that a married couple conceived themselves.

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[34] Emphasis original. Rosenblum and Kuttner, Quantum enigma, 267. The quote from Martin Rees comes at the beginning of their final chapter, and it reads as such: "In the beginning there were only probabilities. The universe could only come into existence if someone observed it. It does not matter that the observers turned up several billion years later. The universe exists because we are aware of it." Martin Rees, "The Anthropic Universe," *New Scientist*, August 6, 1987, 46.

[35] Rosenblum and Kuttner, Quantum enigma, 268.

But in this case, if premise 2 is true and if no physical system causes the collapse of a wavefunction, then a consequence of this is that there must have been some non-physical entity which caused the collapse of the system *prior* to the existence of conscious beings as we know them.[36]

Some people have embraced this consequence, with physicist Fred Alan Wolf being one of them. He states:

> For me, there can't even have been an origin of the universe unless there was some consciousness there to perceive it coming into being. This is a lesson that all physicists are eventually coming to, if not the majority by now, certainly a sizeable minority who believe that consciousness must enter into the field of physics in a direct way through something called the observer effect.[37]

To others, however, this consequence may be unpalatable, for it seems bizarre that quantum physics by itself should commit one to the existence of some entity beyond the physical realm and beyond the conscious living beings which we are familiar with.

Regardless, even supposing that there is such an entity, other problems arise, as we shall see when discussing premise 4.

At the very least, I take it that this unintuitive consequence itself provides reason to hesitate in accepting Rosenblum and Kuttner's interpretation of quantum mechanics, and that premise 1 is therefore questionable.

Of course, the intuitions against these consequences are not necessarily infallible indicators of the truth. Indeed, the experimental outcomes of entanglement have already contradicted the intuitions of many, since it is not obvious that, say, the properties of two previously interacting

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[36] Technically, there could have been some *entities* that were responsible for the collapse of the waves function rather than just one entity, but this point is unimportant for the critical remarks I shall make here.

[37] Fred Alan Wolf and Jeffrey Mishlove, "Fred Alan Wolf: The Spiritual Universe (excerpt) -- A Thinking Allowed DVD w/ Jeffrey Mishlove," *YouTube,* http://www.youtube.com/watch?v=GUVrvlaPuGE (accessed March 14, 2018). I was unable to discover the date of this interview, but it would have occurred sometime during or after the late 1980s since that is when the *Thinking Allowed* TV series began. Although the interview is somewhat dated, I have no reason to suspect that Fred Wolf's thinking has changed in this respect after having perused more recent work of his.

electrons will be correlated, even when they are isolated at great distances from each other. So it is not altogether impossible that other intuitions may be mistaken, in which case Rosenblum and Kuttner's interpretation might be vindicated despite its consequences.

So that is one source of trouble for the rendition of the argument, but one might also resist premise 1 on other grounds. Suppose that we run the two slit experiment multiple times, this time with a randomized set-up which drives the measuring system into one kind of experiment or the other, perhaps even after each electron has been emitted but prior to each electron going through the slits. (Such a procedure would be described as a randomized "delayed choice" set up.) Then, the choice of which experiment to run is delegated to a randomizing mechanism and is thereby divorced from conscious agency. Whether the quantum system collapses at the screen or at the slits is consequently in the hands of a physical system—a randomizing device. In such circumstances, the objection that we have a counter-example to the claim that no physical system collapses the wave function of another system.

Rosenblum and Kuttner have a response to a similar objection, one asserting that, in their words, "[w]e don't need a *conscious* observer to collapse a wavefunction, because a *not*-conscious robot can do the same thing."[38] They consider an analogous case in which the choice of whether to run a "which-box" or an "interference experiment" is up to a robot. Furthermore, the robot's choices are always connected with the "appropriate" experimental outcome: when the robot chooses a "which-box" experiment, it finds the atom wholly in one box or the other; when the robot chooses an interference experiment, it finds that the atom was distributed (in some sense) over the two boxes. Rosenblum and Kuttner then ask you to suppose that the robot uses a coin flip to decide what experiment to run. Their discussion of the objection at this point is best presented in their own words:

> The robot's appropriate choices arose from the coin's landing being connected with what was presumably actually in a box-pair set. You find this connection inexplicable, mysterious.
>
> Continuing your investigation, you replace the robot's coin flipping by the decision method you are *sure* is not correlated with what was actually in a particular box-pair set: *your own consciously made free choice.* You now push a button telling the robot which experiment to do

[38] Rosenblum and Kuttner, *Quantum Enigma*, 242.

> with each box-pair set. You find that by your free choice you can establish *either* that the objects were concentrated in a single box *or* that they were distributed over both boxes, *either* of two contradictory things. You are now faced with the quantum enigma, and consciousness is encountered. The robot argument denying the encounter with consciousness does not work.[39]

I present their response in their own words because, I must confess, I find it inexplicable, mysterious. I do not see how this adequately addresses the objection or any other serious objection in the vicinity of their discussion, and various questions arise: what is so mysterious and inexplicable about the connection between the flipping and the outcomes? Why would this connection lead one to replace the flipping method with their own conscious choice which it seems they would think that this choice is actually just as "correlated" to the experimental outcomes? In their story, why would the connection between the coin flip and the experimental outcomes *not* suffice to show that the robot indeed had collapsed the physical systems without any conscious observer? If there is a way to make sense of their particular defense, I cannot see it.

Regardless, I can see another line of defense which one could have taken but which they did not. Presumably with the randomizing set-up, there is a physical chain linking the randomizing device to the measurement apparatuses, to the outcomes and thereby to the quantum system. Consequently, the Copenhagen advocate may claim that the systems in the chain interact and entangle, thus giving rise to a composite system in a superposition. Here, the superposition features states where the randomizing device has different outcomes just as the quantum system being measured does. The advocate may claim that the composite system collapses only when the outcome of either the randomizing device or the measurement apparatuses has been observed by a conscious agent.[40] On this picture, if only the outcome of the randomizing device is observed, then it collapses from its superposition, in turn collapsing what measurement was performed and

[39] Emphasis original. Rosenblum and Kuttner, *Quantum Enigma*, 243.

[40] Technically, one might think that observing the outcome of the randomising device does not suffice to collapse the quantum system being measured, but it merely *constrains* the superpositions of the quantum system so that it is either a particle at one of the slits or alternatively a particle at the screen. In other words, once the randomizing device is observed, either you know that the system would collapse at the slits or alternatively you know that it would collapse at the screen. However, exactly which slit it is at, or which point of the screen it occupies, is not definite or determinable until the outcome of the selected measurement device has also been observed.

at what point the quantum system was in a particle form. In this sense, the randomizing device did not collapse the quantum system; the conscious observer did, but it was the randomizing device that dictated whether the system would collapse at the slits or the screen once an observation had been made.

Of course, this story does not prove that premise 1 is true, and it does not defend Rosenblum and Kuttner's claim that the *choice* of an observer would determine whether the system collapses at the slits or the screen; but it does shield premise 1—the premise they endorse—from the objection that it is ultimately a physical system which collapses the quantum system in the randomized set up.

In any case, the rendition of Rosenblum and Kuttner's argument faces some problems, but they do not end there, for premise 4 is also contestable—the premise that the thing which causes the collapse of a wavefunction is our consciousness. For one, it is logically possible that something else which we are unaware of could cause the collapse of the wavefunction, but this premise is especially questionable if one is already committed to the existence of some non-physical entity which caused the collapse of the wavefunction prior the emergence of living conscious brings. More specifically, there are two worries here. One is that there is *explanatory redundancy* in believing that conscious living beings cause the collapse of the wavefunction if one already believes that some other thing must have collapsed the wavefunction of other systems. The other is that there is *explanatory arbitrariness* if one assumes that this other thing collapses some wavefunctions whereas, for some unknown reason, it is only ordinary conscious beings which collapse particular other wavefunctions.

Rosenblum and Kuttner might have pushed back against these worries by claiming that our *conscious choice* is correlated with the collapse of the wave function (as per when one chooses to run a "which-box" or alternatively an interference experiment) and that this justifies thinking that our *consciousness* causes the collapse. While this response may somewhat help their cause, it does not entirely bury the worries. For even if the collapse of the wavefunction is correlated with consciousness, the question arises as to why one should not think that this other entity causes the collapse *and* that this entity's activity is also correlated with our conscious choice. In this case, our conscious choices might be physical entities, even if the collapse-causing entity is not. Rosenblum and Kuttner may claim that this scenario is too strange to countenance, but it is no less logically possible than the other strange ideas which they countenance, including the ideas that our conscious collapses the wavefunction and that it perhaps even created the preconditions for its own existence.

In any case, premise 4 might be true, but its potential redundancy and arbitrariness invites further doubts about Rosenblum and Kuttner’s interpretation of quantum mechanics and its implications.

Conclusion

So we have examined Rosenblum and Kuttner's argument that physics supports mind-brain dualism. In part II, I argued that their argument—as they present it—suffers serious shortcomings. I attempted to reconstruct a more clear and compelling version of the spirit of their argument, but found that this too faced some objections. In particular, the alternative argument plausibly entails that some non-physical entity caused the collapse of the wavefunction prior to the existence of living conscious beings. This is a strange consequence of the argument, but it is also in tension with the argument's other premise that ordinary conscious beings collapse the wavefunction, for such a premise is potentially redundant and implies a degree of arbitrariness. For these reasons, I am inclined to regard Rosenblum and Kuttner's argument as more of a reason to doubt their interpretation of quantum mechanics—and the Copenhagen interpretation in general—than as a reason to endorse mind-brain dualism. Ultimately, however, we are unable to deliver a decisive verdict in favour of either belief or disbelief of their viewpoint since, as far as I can tell, it is consistent with the observational evidence, even if it inconsistent with our potentially mistaken intuitions. In any case, perhaps the takeaway message is that, as philosophers occasionally remark, one man's modus ponens is another man's modus tollens—one person's proof of a conclusion is another person's refutation of its premises.

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