Against “experience”

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Abstract:

Just as Bell proposed that we excise the word “measurement” from physics, so I propose that we should excise the word “experience”: “experience” and its cognates should not appear in the formulation of any physical theory, including quantum mechanics and its various interpretations. The reasons are more or less the same as Bell gives for “measurement”: “experience” is a vague term, and experiencing systems are made out of atoms obeying quantum mechanics. Bell’s exhortation concerning “measurement” has largely been taken on board in the foundations of quantum mechanics. But appeals to “experience” remain—in part, I will argue, because of a bad argument that can be traced back to von Neumann, and in part because of mistaken impressions about the fundamentality of experience.

1. Against “measurement”

Thirty years ago, J. S. Bell gave a talk called “Against “measurement”” (Bell 1990).[1] In it, he laments a particular kind of imprecision in the standard formulation of quantum mechanics. He locates the source of this imprecision in the use of certain “bad words” in textbook discussions: “system, apparatus, environment, microscopic, macroscopic, reversible, irreversible, observable, information, measurement” (1990, 34). He singles out the word “measurement” as *particularly* bad: “the word has had such a damaging effect on the discussion, that I think it should now be banned altogether in quantum mechanics” (1990, 34). I argue here that Bell’s list of bad words

[1] The conference was *62 Years of Uncertainty*, Erice, Sicily, 5–14 August 1989.

needs to be extended to include *experience* and its cognates like *awareness*, *perception*, *observation* and *consciousness*. The word “experience”, too, should be banned altogether in quantum mechanics.

Of course, Bell’s suggestion is hyperbolic: you couldn’t, and shouldn’t, excise the word “measurement” from physics altogether. His point is rather about the *role* the word should play: it’s fine for the word “measurement” to appear in an *application* of a physical theory, but it’s not OK for it to appear in the *formulation* of the theory. Similarly, my suggestion is hyperbolic: there is no need to completely excise the word “experience” from physics—although in this case, it seems like you *could*. It’s fine to discuss how the experiences of human observers arise in various *applications* of quantum mechanics—and indeed, as we shall see, such discussions play an important role in the philosophical literature concerning the interpretation of quantum mechanics. But it’s not OK for the word “experience” to appear as a primitive in the theory itself.

The basic reasons for the elimination of “experience” are parallel to those Bell gives for “measurement”. One of Bell’s concerns is that there is no clear answer to the question “What exactly qualifies some physical systems to play the role of “measurer”?” (1990, 34). Many kinds of physical systems can constitute measuring devices, and there is at best a vague line between those physical interactions that count as measurements and those that do not. Vague terms have no place in the foundations of a precise physical theory. Another of his concerns is that any measuring device “can be seen as being made out of atoms” (1990, 36). In that case, since atoms are subject to the laws of quantum mechanics, an appeal to measurement in the foundations of quantum mechanics becomes viciously circular, “like a snake trying to swallow itself by the tail” (1990, 36).

The same can be said of experience. What exactly qualifies some physical systems to play the role of "experiencer"? Many kinds of physical systems can constitute experiencers, including vertebrates with centralized nervous systems and cephalopods with more distributed ones (Godfrey-Smith 2016). The limits of experience are vague within a species (Brown, Lydic and Schiff 2010) and across species (Schwitzgebel 2018). And experiencing systems are, of course, made of atoms, so an appeal to experience in the foundations of quantum mechanics would be viciously circular.

So one might take my thesis here to be a simple extension of Bell's. Indeed, some of Bell's arguments seem to be directly *about* experiencing systems rather than measuring instruments: "Was the wavefunction of the world waiting to jump for thousands of millions of years until a single-celled living creature appeared? Or did it have to wait a little longer, for some better qualified system … with a PhD?" (1990, 34). But in fact, the character of our arguments is somewhat different.

Bell is primarily taking to task the standard theory of quantum mechanics and the textbook writers who present that theory. He gives substantial evidence that talk of "measurement" is pervasive and problematic in such textbooks. And his message has largely been taken on board, at least by the foundations of physics community. Bell can be taken as giving a particularly forceful expression of the *measurement problem*, and the main business of work in the foundations of quantum mechanics in recent years has been to solve, dissolve, or explain away the measurement problem. One can no longer blithely appeal to measurement in the formulation of a version of quantum mechanics; any such appeal would at least require a *lot* of footnotes.

Quantum mechanics textbooks do not typically appeal to "experience". They do appeal to "observation", but this can typically be taken as a synonym for "measurement" rather than as a synonym for "experience". So my complaint is not against textbook formulations. Rather, it largely concerns *responses* to the measurement problem—attempts to formulate quantum mechanics without appealing to measurement as a primitive term. A few of these directly appeal to experience as a primitive term—e.g. Wigner (1961). But more often, "experience" and its cognates show up in the surrounding discussion.

It is trickier, I think, to say what's wrong with these appeals to "experience" than with appeals to "measurement". In part, this is because it is rather obvious, when it is pointed out, that measurements don't constitute a primitive, unanalyzable kind. This is not so obvious when it comes to *experience*—it seems to some people that experience or consciousness *is* primitive or unanalyzable, and this makes it harder to say what's wrong with *treating* it as such. A second difficulty with saying what's wrong with appeals to "experience" is that there are legitimate and important discussions of experience in the literature on responses to the measurement problem, so this can't be a *blanket* condemnation. The best way to proceed, I think, is to by way of some illustrative examples—good, bad, and ugly.

2. The good

If, as Bell insists, you can't use "measurement" in the formulation of quantum mechanics, the theory needs to be reformulated to avoid any such use. There are, of course, various ways of doing this. One way is to replace the textbook "collapse on measurement" with a *spontaneous* collapse process, as in the GRW theory (Ghirardi, Rimini and Weber 1986). The spontaneous collapse approach raises various interpretational questions, and these questions can't be answered without talking about measurement, and about experience. These uses of "measurement" and "experience" are perfectly good.

The interpretational questions arise because of the way the GRW theory works. For a single particle, or a small collection of particles, the probability of a spontaneous collapse to a well-localized position during a reasonable period of time is very small. But for a macroscopic collection of particles, the probability of such a collapse is high, even during a small fraction of a second. So as long as all measuring devices record their outputs using the position of some macroscopic object, the GRW collapse process ensures that measurements have determinate outcomes.

This raises a legitimate question about the nature of measurement: Is it safe to assume that measuring devices always display their outputs using the position of a macroscopic object? Albert and Vaidman (1989) consider this question and answer it in the negative. In particular, they note that a cathode-ray TV screen can be used to display the output of a quantum measurement, and the production of a visible dot on such a screen involves too few particles to reliably produce a GRW collapse.

Note that nothing in Albert and Vaidman's critique of the spontaneous collapse program treats "measurement" as an unanalyzed primitive; indeed, the whole point is to *analyze* our actual measuring devices to see if they fulfill the assumptions required for the GRW approach to deliver determinate measurement outcomes. Hence their use of "measurement" does not fall foul of Bell's prohibition.

Albert and Vaidman go on to ask a similar question about *experience*. If, as they argue, a TV screen measuring device won't precipitate a GRW collapse, will the observation of such a device by a human being precipitate a collapse? The question is whether the human brain represents distinct visual experiences in terms of distinct positions of a macroscopic number of particles. This question is answered affirmatively by Aicardo et al. (1991): even if we use a measuring device that doesn't reliably precipitate a GRW collapse, because of the way human brains work, such a collapse will be reliably produced in the brain of a human observer.

Again, nothing in this investigation treats "experience" as an unanalyzed primitive; the whole point is to *analyze* the way visual experiences are actually grounded in human neurophysiology to see if they fulfill the assumptions required for the GRW approach to deliver determinate visual experiences. This use of "experience" is entirely appropriate.[2]

There are further questions that arise in this context. For example, even if actual human brains reliably precipitate GRW collapses, is it the case that *any possible* brain would do so? Albert (1992, 107) uses thought-experiments involving people with brain implants to argue that the answer to this question is "no". In particular, he envisions a person for whom an experience is grounded in the position of a single particle. For such a person, a measurement using a cathode-ray TV screen probably won't precipitate a GRW collapse even in the person's brain, and so probably won't produce a determinate experience. This thought-experiment raises tricky issues; I return to it in section 5.

3. The bad

Let us now turn to a case where I think that the word "experience" is used badly. The case concerns Bohm's (1952) hidden variable theory, another way of reformulating quantum mechanics to avoid "collapse on measurement". Rather than reconceiving collapse as a

[2] See Gao (2017, 134) for a similar "good" example: Gao considers the details of neurophysiology to argue that an observer will have determinate experiences under his preferred collapse model.

spontaneous process, Bohm's theory stipulates that the quantum state never undergoes a collapse at all. Instead, Bohm's theory supplements the quantum state with a set of particles with determinate positions, which move such that the probability distribution for the particle locations is always given by the Born rule.

Measurement has a natural interpretation in Bohm's theory: the quantum state gives us a probability distribution over all the *possible* particle locations, and measurement reveals where the particles *actually* are. But there is a potential issue here that needs attention: after a measurement, we *know* where the particles are, and yet because there is no collapse, the quantum state hasn't changed. This threatens the Born rule, which says that the probability distribution for any observable quantity, including particle locations, is *always* given by $|\psi|^2$ (the squared amplitude of the quantum state, written in the relevant basis).

Dürr, Goldstein and Zanghì (1992) address this issue, seeking to show that the Born rule can be given a consistent interpretation within Bohm's theory. They ask whether it is possible to learn more about the locations of the Bohmian particles than is given by $|\psi|^2$. They derive a result they call "absolute uncertainty" which answers this question in the negative: "no devices whatsoever, based on any present or future technology, will provide us with the corresponding knowledge. *In a Bohmian universe such knowledge is absolutely unattainable!*" (1992, 884).

This result secures the consistency of the Born rule, but at an apparently devastating cost: since the particle locations in Bohm's theory are supposed to tell us the actual outcome of our measurement, if we can't find out the locations of the Bohmian particles with greater precision than given by $|\psi|^2$, and there is no collapse, then we can't find out the outcome of our measurement! That is, "absolute uncertainty" might be taken to entail that Bohm's theory doesn't solve the measurement problem after all (Stone 1994).

But this conclusion is based on a misreading of Dürr et al.'s result: the $|\psi|^2$ appearing in "absolute uncertainty" is the *effective* state, not the full quantum state of the system (Maudlin 1995). If the state is written in an appropriate basis, it can typically be written as a sum of terms, only one of which is relevant (for practical purposes) to the future motion of the Bohmian particles; this term is the effective state. When the position of a particle is measured, the effective state depends on the accuracy of the measurement. That is, if your position measurement has an accuracy of 1mm, the post-measurement effective state has a width of 1mm, and you learn the actual position of the particle to within 1mm. After the measurement, you don't know the position of the particle with greater accuracy than is given by (post-measurement) $|\psi|^2$, but you *do* know the position of the particle with greater accuracy than is given by *pre*-measurement $|\psi|^2$. Hence the particle positions do, after all, tell you the actual outcome of the measurement.

The possibility of misreading "absolute uncertainty" is not my concern here.[3] My concern is with an *exception* to "absolute uncertainty" suggested by Dürr, Goldstein and Zanghì: "There is one situation where we may, in fact, know more about configurations than what is conveyed by the quantum equilibrium hypothesis $\rho = |\psi|^2$: when we ourselves are part of the system!" (1992, 903). This exception is where things go bad.

Why should there be such an exception? Stone (1994), because he (mistakenly) thinks that "absolute uncertainty" precludes us from learning *anything* about the locations of the particles, suggests that Dürr et al. postulate the exception in a vain attempt to secure determinate outcomes to our measurements. That is, Stone suggests that their idea is that direct awareness of the locations of certain particles in your brains tells you the outcome of your measurement. But

[3] See Lewis (forthcoming) for further discussion of this misreading, and of the related question of whether knowledge of measurement outcomes would allow superluminal signaling.

this attempt is in vain, Stone argues, because Dürr et al.'s "absolute uncertainty" means that the locations of these particles in your brain must be inaccessible to the *rest* of your brain, and hence you couldn't, after all, be aware of them.

As discussed above, there is no need for an exception for this purpose: you *can* learn about the locations of Bohmian particles in your measuring device, and by the same token, the locations of the Bohmian particles in one part of your brain are accessible by the rest of your brain without any exception to "absolute uncertainty".[4] So again: why the exception?

I suspect the reason goes deeper than Stone suspects: it is not that Dürr et al. postulate the exception as an ad hoc fix to a problem in their account, but rather that they think that *any* physical theory must contain some such exception. It is not hard to construct a tempting argument for this claim. Consider a spin measurement on a particle whose state is a symmetric superposition of spin-up and spin-down eigenstates. If the particle is passed through an inhomogeneous magnetic field, the result is a superposition of two wave packets, one deflected upwards and the other deflected downwards. The Bohmian particle follows one component or the other depending on its initial position. But how do we know which wave packet contains the particle?

Well, to find out, we can run the particle into a fluorescent screen, resulting in a superposition of two terms, one describing a flash at the top of the screen and one describing a flash at the bottom. Again, the Bohmian particles are associated with one term or the other. But

[4] Gao (2017, 100–103) argues that Bohm's theory is problematic under *any* assumption about how experience supervenes on the ontology of the theory. In particular, he argues that the *instantaneous* Bohmian particle configuration cannot ground determinate experience. However, I think this overlooks the possibility that the evolution of the particle configuration over time grounds experience. Indeed, Gao later notes the dynamical nature of neurochemical explanations of experience (2017, 134).

how do we know which term contains the particles? Well, to find out, we can consider the interaction of the flash with the human eye. We get a superposition of two terms describing the retina, where the Bohmian particles are associated with one of them. But how do we know which term contains the particles? We can proceed into the human brain: we get a superposition of two terms describing the state of the visual cortex, where the Bohmian particles are associated with one of them. But how do we know which one? We could consider the interaction of the visual cortex with some other region of the brain, but this is going nowhere. Rather, we just have to assume that at some stage we are *directly aware* where the particles are—we are directly aware of the configuration of Bohmian particles in parts of our brains. Otherwise, we could never know which wave packet contains the particles.[5]

There is a construal of this argument according to which it is unobjectionable: unless *awareness* arises at some stage in the above process, we couldn't have *knowledge* of the outcome of the measurement. But the argument is surely fallacious if it is taken to imply that something needs to be *posited* to accomplish this awareness, something in addition to the process otherwise described. You need something beyond a flash on a screen in order for there to be awareness of the flash: what you need is a correlated brain state. But you don't need to posit something in addition to the brain state in question in order for there to be awareness *of the flash*. Maybe you need something outside that particular brain state in order for there to be experience or knowledge of *that brain state* as an object of scientific inquiry, but that's a separate issue.

[5] There is nothing distinctly Bohmian about this argument: we could replace the Bohmian particles with the underlying ontology of any other physical theory, and the question of how we know the state of that ontology can be asked at any stage of the measurement process. I consider the historical roots of this kind of "tempting argument" in section 5.

Insistence on experience as *exceptional* in this way gives critics of Bohm's theory some extra ammunition. For example, Brown and Wallace suggest that in order to defend Bohm's theory, Dürr et al. (1992) and Maudlin (1995) have to assume that "our conscious perceptions supervene directly *and exclusively* on the configuration of (some subset) of the corpuscles associated with our brain" (2005, 534). But this assumption, they suggest, rests on the further assumption "that consciousness is some sort of bare physical property (like, say, charge) whose connection with physical matter can simply be posited rather as we posit other basic physical laws," which in turn "makes consciousness completely divorced from any assumptions rooted in the study of the brain" (2005, 536). You can't just *posit* a connection between experience and the physical brain; you have to *discover* the connection via neuroscientific study.

My claim here is that the assumptions about experience that Brown and Wallace object to are both entirely unnecessary and counter-productive for the Bohmian. There is no need for Bohmians to say anything special about experience: a measurement correlates some property of the measured system with the configuration of Bohmian particles in the measuring device, and eventually with the configuration of Bohmian particles in the brain of the human observer. As Maudlin (1995) rightly observes, that's all that needs to be said by the interpreter of quantum mechanics. Dürr et al.'s "absolute uncertainty" result, which is exceptionless, ensures that measurements are always governed by the Born rule. There is no need for a further postulate about the connection between Bohmian particles and experience.

Furthermore, a postulate that says that we are directly aware of the positions of the Bohmian particles in our brains is counter-productive, serving only as a lightning-rod for criticism. By itself, such a postulate doesn't work: direct "awareness" of the position of an isolated particle would not have the functional connections to other cognitive powers to truly constitute *awareness*. And once you add the functional connections, it is unclear what the *direct* awareness was adding in the first place. Maybe we don't know the full story about how the physical state of a human brain produces experience, but this is not a matter for interpreters of quantum mechanics to worry about. Whatever the full story is, it can surely be expressed in terms of the configuration of Bohmian particles.[6]

4. The ugly

So far, I have presented two examples of the discussion of experience in the literature on the foundations of quantum mechanics, one I take to be clearly good and the other I take to be clearly bad. But sometimes it is not so easy to tell whether a discussion of quantum mechanics is good or bad. I consider two such cases here, both of which concern the spontaneous collapse approach again.[7]

One of the earliest philosophical discussions of the spontaneous collapse approach is Bell (1987). Bell worries that the GRW theory represents the world using a wave function alone; this is a potential problem because the wave function is defined over a configuration space, with 3*N* dimensions for an *N*-particle system, not over ordinary three-dimensional space. Here is Bell's proposed solution:

> However, the GRW jumps (which are part of the wavefunction, not something else) are well localized in ordinary space. Indeed, each is centered on a particular spacetime point (**x**, *t*). So we can propose these events as the basis of the 'local beables' of the theory.

[6] It is plausible that whatever the full story about experience is, it can also be expressed in terms of the wave function configuration. This is part of Brown and Wallace's (2005) argument for the redundancy of the Bohmian particles, which I return to in section 5.
[7] There is, of course, nothing intrinsically ugly about these cases; they are only "ugly" insofar as they make life difficult for me in distinguishing good from bad uses of "experience".

> These are the mathematical counterparts in the theory to real events at definite places and times in the real world… A piece of matter then is a galaxy of such events. As a schematic psychophysical parallelism we can suppose that our personal experience is more or less directly of events in particular pieces of matter, our brains, which events are in turn correlated with events in our bodies as a whole, and they in turn with events in the outer world. (1987, 45)

What is Bell up to here? It looks like he is postulating a direct connection between the physical world and experience as part of his exposition of the GRW theory. Isn't that *bad*?

Something similar can be found in the work of Hameroff and Penrose (1996). They adopt a spontaneous collapse theory incorporating general relativity, according to which superpositions of distinct arrangements of matter produce superpositions of distinct space-time geometries. The latter superpositions are hypothesized to be unstable, collapsing to one matter arrangement or the other. They combine this spontaneous collapse theory with a particular account of conscious experience, according to which a conscious event is associated with a spontaneous collapse occurring in a specific neuronal structure (a coherent superposition involving a number of tubulin molecules). Again, Hameroff and Penrose seem to be postulating a direct connection between physics and experience as part of the exposition of their preferred quantum theory.

In the previous section I characterized postulating a connection between physics and experience as *bad*. But in each of the cases just described there are mitigating factors. In Bell's case, I think he's not really postulating such a connection at all; rather, his concern is to show that we can find our ordinary three-dimensional ontology in the $3N$-dimensional wave function of the GRW theory. If we can't, then a peculiar form of empirical inadequacy threatens: the theory says nothing about the three-dimensional world, and hence fails to predict experimental outcomes expressed in three-dimensional terms. But if we *can* associate three-dimensional objects with sets of GRW collapse events, then we *also* find brains and their contents in the GRW ontology, since brains are three-dimensional objects. The "psychophysical parallelism" Bell outlines isn't really an additional postulate, but simply an expression of the nature of physical stuff according to GRW, consistent with more or less *any* neurological theory of experience.[8]

Hameroff and Penrose cannot be defended in this way: they make it clear that they are postulating a *particular* connection between quantum collapse events and conscious experience. Rather, their approach here can be taken as exemplifying an *objection* to my claim that postulating a connection between physics and experience is a bad thing in discussions of the foundations of quantum mechanics. We don't know the details of how the brain gives rise to conscious experience. Hameroff and Penrose are offering a *hypothesis* concerning some of those details, a hypothesis that is open to empirical test. Thus a prohibition on postulating a connection between quantum physics and experience looks like an unwarranted restriction on scientific exploration.

I think I have to grant this point. One can object to Hameroff and Penrose's hypothesis on scientific grounds (e.g. Grush and Churchland 1995), but surely not on general methodological grounds. The unification of apparently disparate phenomena is a feature of several notable

[8] This is not to say that the GRW theory as Bell envisions it will *automatically* succeed in accounting for determinate measurement results or determinate experiences. Parallel concerns to those of Albert and Vaidman (1989) can be posed using Bell's event-based GRW: perhaps there will be no collapse events associated with a particular measurement outcome, or with a particular mental state, because they involve too few particles. These concerns about experience are of the "good" kind explored in section 2.

episodes of scientific progress. Hameroff and Penrose may or may not succeed at their chosen unification, but you can't fault them for trying.

Note, though, that their proposal about conscious experience is quite cleanly separable from their proposal for solving the measurement problem in quantum mechanics. Penrose (1996) formulates the latter without postulating any particular connection to consciousness—and indeed, the spontaneous collapse theory he develops seems consistent with more or less any such connection.[9] Maybe he always had his eye on a connection to consciousness (Penrose 1994), but the interpretation of quantum mechanics *itself* does not appeal to any such connection. So Hameroff and Penrose (1996) does not constitute an objection to my thesis, construed as the claim that postulates about experience have no place *within* the interpretation of quantum mechanics.

5. The extent of the problem

The examples considered in the previous sections show that "experience" and its cognates appear regularly in discussions of the foundations of quantum mechanics, and that such discussions are not always bad. It's fine (and sometimes necessary) to consider whether some interpretation of quantum mechanics can account for the determinacy of experience. What's not OK is to incorporate a posit about experience within the interpretation itself.

But is this really a significant problem? The example of section 3 could, for all I have said, be an isolated case—an offhand comment that doesn't reflect anyone's considered opinion about how to approach the foundations of quantum mechanics. However, a look at the history of appeals to experience suggests otherwise.

[9] Again, subject to caveats of the kind raised by Albert and Vaidman (1989).

Consider, for example, the classic discussion of “psycho-physical parallelism” in von Neumann (1955). Von Neumann describes a simple temperature measurement, and notes that we can choose whether or not to include the thermometer in the physical analysis, and similarly for the eye and the brain of the human observer:

> But in any case, no matter how far we calculate—to the mercury vessel, to the scale of the thermometer, to the retina, or into the brain, at some time we must say: and this is perceived by the observer. That is, we must always divide the world into two parts, the one being the observed system, the other the observer. In the former, we can follow up all physical processes (in principle at least) arbitrarily precisely. In the latter, this is meaningless (1955, 419).

There is something very like the “tempting argument” of section 3 in this passage; indeed, I take von Neumann to be the canonical source of such arguments. However, one might read von Neumann as talking about *measurement* rather than *experience* here: the discussion occurs at the beginning of a chapter called “The Measuring Process” in which he elaborates his proposal that measurements obey a different dynamical law from non-measurements. The folly of this approach to quantum mechanics is precisely Bell’s point in “Against “measurement””.

But this would not be the best reading of this passage, I think. Von Neumann’s goal in this chapter isn’t just to *describe* his collapse-on-measurement proposal; the discussion above occurs in the context of an attempt to *justify* it:

> Indeed experience only makes statements of this type: an observer has made a certain (subjective) observation; and never any like this: a physical quantity has a certain value. Now quantum mechanics describes the events which occur in the observed world, so long as they do not intersect with the observing portion, with the aid of the process 2 [unitary

> dynamics], but as soon as such an interaction occurs, i.e., a measurement, it requires the application of process 1 [collapse dynamics]. The dual form is therefore justified (1955, 420).[10]

That is, the duality in the dynamical laws is justified because it reflects a fundamental duality in nature. The distinction between measurements and non-measurements is clearly not fundamental, as Bell forcefully points out: measurements are just a rather loosely-defined set of ordinary physical processes. But the distinction between experience and that which is experienced—between subjective and objective—looks at first glance like a reasonable candidate for such a fundamental distinction. Plausibly, it is that distinction that von Neumann is appealing to here.

However, the subjective-objective distinction as von Neumann understands it is unable to deliver the justification he needs for the duality in the laws. Von Neumann thinks that where we place the boundary between the experiencing subject and the experienced object "is arbitrary to a very large extent" (1955, 420). But the point at which the collapse dynamics takes over from the unitary dynamics is *not* a matter of arbitrary stipulation; it is empirically decidable, at least in principle (Albert 1992, 84).

What von Neumann needs is a precise boundary between those entities that precipitate collapse and those that do not. Such a sharp line can be had, at a cost: Wigner (1961), for example, proposes that there are fundamental facts about which systems are *conscious*, and that consciousness acts on physical systems to precipitate collapse. Note that these fundamental facts have to float free of the physical facts about a system if Wigner's proposal is to avoid the problem that experiencing systems are just systems of atoms (see section 1). That is, Wigner postulates a strong form of interactive dualism in order to justify a duality in the physical laws.

[10] Von Neumann cites Bohr (1929) as the source of this line of justification.

Few will want to follow Wigner down this path: non-physical minds, especially causally active ones, are mysterious at best. But the point is that unless you are willing to go to such extremes, von Neumann's appeal to a fundamental subjective-objective distinction is idle: it doesn't do the work he requires of it. Furthermore, by assuming that the physicist can simply *posit* a connection between the physical world and experience at her convenience, von Neumann opens himself to the objection that he is treating consciousness as "some sort of bare physical property", rather than paying serious attention to the results of neuroscientific research (Brown and Wallace 2005, 536).

There are, of course, perennial (but controversial) arguments for the irreducibility of the mental to the physical, for example based on *qualia* (Chalmers 1996). But the existence of a "hard problem" of consciousness is distinct from the methodological question at issue here: whether or not qualia are irreducible, you can't posit whatever psychophysical connection you like. Neuroscience constrains the connections between brain structures and experience, irrespective of whether what it tells us constitutes a reduction of qualia.

Nevertheless, von Neumann's approach is tempting. It is tempting, I think, because coming up with a consistent interpretation of quantum mechanics is hard, and the freedom to simply *posit* a psychophysical connection appears to give you an additional free variable to play with in constructing an adequate theory. But this appearance is deceptive: the additional variable is only *free* because it is disconnected from anything that might do any genuine explanatory work, and because we are ignoring any *constraints* on the psychophysical connection coming from scientific research on the brain.

Dürr et al.'s exception to "absolute uncertainty" provides one example of succumbing to this temptation. But it is not hard to find others; I only need to look as far as my own CV. In

“How Bohm’s theory solves the measurement problem” (Lewis 2007), I attempt to resist Brown and Wallace’s (2005) redundancy argument against Bohm’s theory. Brown and Wallace argue that since experiences could supervene on the wave function configuration just as easily as on the Bohmian particle configuration, the Bohmian particles are redundant, and Bohm’s theory reduces to the many-worlds theory. I respond, in part, that the Bohmian can *posit* that we are directly aware of particle configurations in our brains. I now think this is a mistake: such a posit does no work, and ignores neuroscience. This is not to say that the redundancy argument necessarily succeeds: the argument can be resisted (see e.g. Ney 2013 and Callender 2015), but notably *not* by postulating a special connection between particles and experience.

Even Albert’s (1992, 107) thought experiment concerning determinate experience in the GRW theory, which I earlier characterized as “good”, raises some concerns. There is an assumption in Albert’s argument, namely that an “enhanced human” could, in principle, have an experience that is grounded in the position of a single particle. Is this a (bad) example of simply *positing* a psychophysical connection? Or is it just a conjecture for the sake of argument, one that might be overruled by research on the kinds of physical states that could possibly underlie experience? It is not easy to tell.

This is why my polemic against “experience” is not as straightforward as Bell’s polemic against “measurement”. It is relatively easy to tell whether a use of “measurement” in a discussion of quantum mechanics is good or bad, and a case for the *badness* of the bad uses can be made in relatively uncontroversial terms. But it is not so easy to tell whether a use of “experience” is good or bad, and even making the case that *some* uses are bad gets us into the contested territory of the nature of the mental.

Nevertheless, I hope to have shown that it is worth trying to disentangle the good from the bad, because there *are* bad uses of "experience", and they have the capacity to sow confusion in the foundations of quantum mechanics just as much as bad uses of "measurement". Whatever the philosophical status of experience, the mental-physical connection is not something that philosophers or physicists can posit at their convenience.

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