QBism and the Limits of Scientific Realism

David Glick

david.glick@sydney.edu.au

Abstract

QBism is an agent-centered interpretation of quantum theory. It rejects the notion that quantum theory provides a God's eye description of reality and claims instead that it imposes constraints on agents' subjective degrees of belief. QBism's emphasis on subjective belief has led critics to dismiss it as antirealism or instrumentalism, or even, idealism or solipsism. The aim of this paper is to consider the relation of QBism to scientific realism. I argue that while QBism is an unhappy fit with a standard way of thinking about scientific realism, an alternative conception I call "perspectival normative realism" may allow for a reconciliation.

1 Introduction

QBism is an interpretation inspired by the central role played by information in contemporary applications of quantum theory. Accordingly, the emphasis of QBists is on the application of quantum theory by agents intervening on the world. The guiding idea of QBism—which originally stood for 'quantum Bayesianism'—is that the probabilities delivered by quantum theory are to be understood as degrees of belief along the lines of the subjective Bayesian approach to probability (Caves et al., 2002). Since its original proposal, the view has evolved and attracted new followers in the physics community, but has been less warmly received by philosophers. Many, it seems, share the view of Hagar (2003) that "Fuchs' 'thin' realism, and the entire 'fog from the north' which inspires it, are nothing but instrumentalism in disguise" (p.772).[1] However, this is at odds with the

[1] For other critiques of QBism, see Timpson (2008); Bacciagaluppi (2014); Norsen (2016); Brown (2017); Earman (2018).

avowed realism of QBists such as Fuchs (2017b) and Mermin (2014).

The aim of this paper is to clarify the status of QBism with respect to scientific realism. This issue is of importance not just for those with an interest in QBism and other "non-ontic" approaches to quantum theory (e.g, Healey (2012, 2017b); Friederich (2013)), but also serves to test the limits of scientific realism in the context of quantum theory. QBism proposes a non-standard understanding of the relation of a scientific theory to the world, and as such, casts the question of realism in a new light. At the very least, the following investigation should make clear that the question of realism about quantum theory is more complex than it may at first seem.[2]

This paper proceeds as follows. Section 2 briefly introduces QBism and some of its core motivations. Section 3 assesses QBism under a standard conception of scientific realism, which gives rise to several problems. Section 4 seeks to take seriously the agent-centered and prescriptive aspects of QBism to motivate an altogether different approach: perspectival normative realism. Finally, section 5 considers realism in the context of normative theories to make the case that perspectival normative realism—and hence, QBism itself—may legitimately claim to be a form of realism.

2 What is QBism?

The empirical support for quantum theory consists in the success of its probabilistic predictions. Every opportunity taken to test quantum theory has vindicated its predictions over those of potential rivals. In the standard formalism, these predictions follow from the quantum state ascribed to a system and the Born rule. QBism maintains that these probabilities are subjective degrees of belief of some agent concerning what she will experience, e.g., upon performing a measurement of some observable. Moreover, the sole function of

[2] Cf., Healey (2018), who attempts to broaden the understanding of scientific realism along pragmatist lines to accommodate his account of quantum theory.

the quantum state is to encode the agent's information (or subjective beliefs) associated with the system.[3] So why would one adopt a subjectivist interpretation of quantum theory?

There are several kinds of arguments put forth by QBists. One family of arguments notes the unifying power of taking the quantum state to be epistemic. The idea is that certain puzzling features of quantum theory follow naturally from the epistemic approach. A notable example here is Spekkens (2007), which seeks to show that a purely classical theory—Spekkens toy model—can reproduce a number of "quantum" effects if states are understood epistemically. For example, the no cloning theorem that prohibits perfect duplication of a quantum state is shown to hold in the toy model. Of course, Spekken's model is quite limited in its application and cannot recover the full content of quantum theory. Nevertheless, QBists maintain that it goes far enough to demonstrate the explanatory virtues of an epistemic view of quantum states; features such as no-cloning that appear unexplained or ad hoc on the ontic view are given a natural explanation on the epistemic view.

The other sort of argument maintains that various conceptual puzzles that dog the interpretation of quantum theory are dissolved by adopting the subjective epistemic viewpoint. According to advocates, the process of measurement and the presence of non-local phenomena are described simply and without paradox by QBism. Measurement involves simply updating one's subjective beliefs about future experiences on the basis of new information. Non-locality doesn't arise in an EPR experiment because each agent–Alice, Bob, an agent at the source—has their own quantum state which reflects their individual beliefs.

[3] The QBist should avoid saying that the quantum state encodes beliefs *about* the system because this suggests that the system has an underlying ontic state that is the target of the agent's beliefs. As discussed below, this "epistemic ontological" view (Spekkens, 2007) runs into difficulties, such as the no go theorem of (Pusey et al., 2012). So, strictly speaking, the quantum state encodes an agent's beliefs about their future experiences that are associated with the physical system—e.g., what they will experience when performing a measurement of it. That said, it will often be useful to speak of "measurement outcomes" and "the quantum state of a system," which should be taken to be eliptical for more careful expressions of the sort just mentioned.

A distant measurement has no effect on an agent's beliefs (until they become aware of it), so nothing in the vicinity of Bob changes when Alice performs her measurement.[4]

QBism also manages to avoid the various "no go" results surrounding epistemic approaches. For instance, the PBR theorem (Pusey et al., 2012) rules out a version of the epistemic approach in which the quantum state represents our uncertainty about the underlying ontic state of a physical system. QBism—and other non-ontic views, such as Healey's pragmatist approach—avoid the PBR theorem by rejecting this understanding of epistemic states. QBism rejects that there is an underlying ontic state about which we are unsure, rather, it contends that we have degrees of belief about our own future experiences only. This may lead to charges of idealism or solipsism, but the QBist need only deny that quantum states encode credences over unknown ontic states of the physical systems to which they are applied. The QBist is free to believe that objective reality exists and that quantum theory can tell us about it in some other, more indirect manner.[5]

In sum, QBism attempts to give a picture of quantum theory in which agents use quantum theory to guide their degrees of belief about potential future experiences. QBists reject the standard realist assumption that to interpret quantum theory is to say how it describes external reality. Indeed, QBists often forsake the external, "God's eye" perspective altogether in favor of a diversity of different agent-centered perspectives on the quantum world.

[4] This does not preclude the presence of some form of non-locality. For instance, one may argue that when Alice and Bob compare results, they will find non-local correlations in measurement outcomes. The QBist may wish to treat such a revelation as simply Alice performing another (local) measurement, but doing so relegates Bob's testimony to merely an aspect of Alice's experience, arguably moving us closer to solipsism (see, Norsen (2016); Earman (2018)).

[5] Alternatively, one may view QBism as not rejecting ontic states, but rather as conceiving of them more broadly. In other words, one could allow that there is *something* about which we are being epistemic, but deny that it's of the right character to function as PBR and Bell assume for their λs—there are no "local beables" over which our subjective probabilities range. Whichever strategy is adopted, the point is that some epistemic views may be ruled out by the no go theorems, and QBism is recommended by remaining viable in light of them. Thanks to [xxxx] for emphasizing this alternative.

3 Standard Scientific Realism

While there remains disagreement about the correct formulation of scientific realism, many follow Psillos (1999) in identifying three main components of the view, roughly:

Metaphysical realism: a recognition of the existence of a mind-independent reality.

Semantic realism: a commitment to interpret theories literally,

Epistemic claim: a commitment to the approximate truth of our best confirmed theories.

As noted above, QBism is occasionally dismissed as solipsism or idealism. After all, on this view quantum theory functions as a user's manual that guides agents' beliefs about their own future experiences. However, the QBist needn't deny that there is a reality external to the agent. Indeed, Fuchs offers the following support for metaphysical realism:

> We believe in a world external to ourselves precisely because we find ourselves getting unpredictable kicks (from the world) all the time. (Fuchs, 2017b)

What QBism denies is that models in quantum theory should be viewed as third-personal descriptions of external reality, but this doesn't bear on metaphysical realism, which they are free to adopt for other reasons.

Assessing the status of the other two aspects of standard scientific realism with respect to QBism is less straightforward. First, consider semantic realism. The commitment to take a theory literally fits most naturally with scientific theories presented in linguistic form (e.g., as a set of partially-interpreted sentences that function as its axioms). Semantic realism is intended to rule out views such as logical positivism that seek to reinterpret certain sentences so as to avoid making reference to putative unobservable entities. But, this view is not an easy fit with theories in contemporary physics which are more naturally associated with a family of mathematical models. Here it is unclear what would be meant by taking some piece of mathematics literally. Second, the concept of approximate truth that figures in the epistemic claim also requires explication. In the context of a linguistically-presented scientific theory, perhaps this can be made out in terms of the successful reference of central terms (Laudan, 1981), but on a model-based approach the notion is harder to pin down. One must locate some relation between models and the world capable of playing an analogous role to successful reference in the linguistic case.

As a starting point, consider a simple version of scientific realism about models that is clearly at odds with QBism. It maintains that models mirror the world, in the following sense:

Mirroring Account: The models associated with successful scientific theories mirror reality in that each element of a model corresponds to an element of reality.

While few would accept the Mirroring Account as stated, it plays an important role in several debates in the philosophy of science. For instance, van Fraassen (1980) uses a version of the Mirroring Account to characterize the realist alternative to his constructive empiricism. First, he presents his semantic view of theories:

> To present a theory is to specify a family of structures, its models; and secondly, to specify certain parts of those models (the empirical substructures) as candidates for the direct representation of observable phenomena. The structures which can be described in experimental and measurement reports we can call appearances: the theory is empirically adequate if it has some model such that all appearances are isomorphic to empirical substructures of that model. (van Fraassen, 1980, p.64)

He continues later:

> With this new picture of theories in mind, we can distinguish between two epistemic attitudes we can take up toward a theory. We can assert it to be true (i.e., to have a model which is *a faithful replica, in all detail*, of our world), and call for belief; or we can simply assert its empirical adequacy, calling for acceptance as such. (van Fraassen, 1980, pp.68–69, emphasis added)

Thus, for van Fraassen, constructive empiricism is distinguished from realism by denying that *all parts* of models correspond to aspects of our world. This paints a picture of realism very close to the Mirroring Account sketched above.

QBism is clearly at odds with the flat-footed realism of the Mirroring Account. Most—although not all—elements of the models used in quantum theory do not correspond to elements of reality. In particular, quantum states and their evolution are features of quantum models with no counterpart in mind-independent reality. Thus, if scientific realism is understood in this way, QBism is not a realist position, despite the claims of its proponents.

But is the Mirroring Account plausible? While it may have a certain intuitive appeal, there are several reasons to think it's overly naïve. First, the models used in contemporary physics typically contain *artifacts of the representation*. For instance, gauge quantities such as the field potentials in classical electromagnetism are generally regarded as artifacts.[6] More generally, it is implausible to suppose that each term that appears in an equation corresponds to an element of reality. What, for example, is the worldly counterpart of the gravitational constant G in Newton's law of universal gravitation?[7]

[6] Of course, the status of gauge quantities is controversial. Even the view that electromagnetic potentials are non-physical leads to difficulties in the context of the Aharanov-Bohm effect (Leeds, 1999; Nounou, 2003; Healey, 2007). But, regardless of one's view on this particular case, it remains plausible that many of the models deployed by contemporary physics contain some measure of "surplus stucture" (Redhead, 2003).

[7] One may try to view G as a property of the gravitational force between massive bodies—its "proportionality"—but, it's unclear whether such an abstract property is the right sort of thing to count as an element of reality in this context. It seems far more natural to regard the force as corresponding to $G\frac{m_1 m_2}{r^2}$ leaving G on its own as having no specific counterpart in reality.

Second, even taken as whole, models don't seem to stand in a one-to-one relation with reality as the Mirroring Account suggests. One place in which this issue arises is the hole argument in general relativity (Earman and Norton, 1987). In this case we have distinct models ($\mathcal{M}$ and $d^*\mathcal{M}$) related by a "hole diffeomorphism" that seem to describe different states of affairs. However, general relativity treats $\mathcal{M}$ and $d^*\mathcal{M}$ as physically equivalent. A popular resolution to this tension is to regard the $\mathcal{M}$ and $d^*\mathcal{M}$ as different representations of the *same* spacetime. This means that neither model can correspond to the world in the sense of the Mirroring Account. At a minimum, there must be some looseness of fit between models and the world.[8]

The implausibility of the Mirroring Account is unsurprising. In other terms, it means that one cannot read off metaphysics directly from the mathematical models deployed in physics, which is a point most working in the philosophy of physics would unreservedly endorse (indeed, it may be seen as the basis for much of the work in the area). That said, we should be careful to note what does not follow from rejecting the Mirroring Account. In particular, two points are worth emphasizing: First, "mirroring" may still be a useful way of viewing the relation of models to the world, so long as it's not understood in the naïve way expressed in the Mirroring Account. Second, while one cannot read off metaphysics from physical models, it may still be seen as a virtue of one's methodology to take them at face value to the extent that it's possible to do so.

[8] There is a vast literature on the hole argument and its implications (see Norton (2011); Pooley (2013)). It is not my aim here to enter into the debate, but rather to indicate a limitation of the Mirroring Account: it leaves one unable to endorse the view that distinct models represent the same state of affairs. Leibniz equivalence in the context of the hole argument is one well-known instance of this position, but it may be inappropriate there and/or more appropriate elsewhere. At the very least, ruling out the possibility of such representational redundancy seems problematic.

3.1 Sophisticated Scientific Realism

A sophisticated scientific realist maintains that our best theories can tell us about the world, but not in the simple manner of the Mirroring Account. In particular, the sophisticated scientific realist seeks to distinguish the elements in our models that are genuine reflections of reality from those that are merely artifacts of the representation. This task requires substantial interpretative work and its results are often controversial, but so long as one preserves the sense that models have latched onto the structure of the world, there is some legitimacy to its claim to being a genuine form of scientific realism.

There are many varieties of sophisticated realism. Structural realism, for instance, maintains that models capture only the structure of the world. Thus, individual elements of theoretical models needn't correspond to individual entities, but structural or relational features do have worldly counterparts. For example, Worrall (1989) claims that Fresnel's equations do not describe genuine physical properties of a luminiferous ether—as Fresnel supposed—but rather, reflect the structure underlying optical phenomena. Other versions of this approach of selective skepticism are possible as well. One might countenance only entities with certain causal features (Hacking, 1983), or those involved in novel predictive successes (Psillos, 1999). Any such view of differential ontological commitment counts as sophisticated scientific realism as understood here.[9]

Is QBism compatible with sophisticated scientific realism? Initially, one may think not. After all, QBists deny that core elements of quantum models—quantum states and their evolution—correspond to elements of reality. However, Fuchs urges that

> ...there is more to quantum mechanics than just three isolated terms (states, evolution, and measurement)—there's the full-blown theory that glues these

[9] One might add a further requirement that the extent of ontological commitment must reach some threshold, below which models are simply too remote from reality to qualify as realism. I discuss the implications of this for QBism below.

> notions together in a very particular way, and in a way that would have never been discovered without empirical science. (Fuchs, 2017b)

More specifically, recently QBists have placed increasing emphasis on the place of the Born rule as an objective feature of reality. The Born rule is typically formulated as a function that takes a quantum state to the probability of an observable taking a certain value or the occurrence of a certain measurement outcome. For example, one may write the Born rule for finding an eigenvalue k_i of an observable O for a system in a pure state ψ:

$$p(k_i|\psi) = \langle\psi|P_i|\psi\rangle = |\langle k_i|\psi\rangle|^2, \tag{1}$$

where P_i is the projection onto the eigenspace of O corresponding to k_i. However, given their focus on subjective probabilities, QBists have sought to eliminate reference to the misleading quantum state and formulate the Born rule entirely in terms of probabilities, understood as subjective degrees of belief about (experiences of) measurement outcomes. The resulting version of the Born rule is what QBists now call the "Essential Representation" (DeBrota et al., 2018).

The Essential Representation is cast in terms of hypothetical measurements called SICs (Fuchs, 2010; Fuchs and Schack, 2013). Before describing SICs, we should note that the Born rule can be stated in terms of more general measurements than those associated with a projection onto the eigenspace of some Hermitian operator as assumed in equation 1. A positive operator-valued measure (POVM) is a collection of positive semi-definite operators E_i on a Hilbert space H such that $\sum_i E_i = I$. In terms of POVMs, the Born rule takes the simple form:

$$p(i|\rho) = \text{tr}\rho E_i \tag{2}$$

for an outcome i and an arbitrary quantum state ρ. A SIC is a symmetric, informationally complete POVM. Formally, a SIC is a set of d^2 rank-one projection operators $\Pi_i = |\psi_i\rangle\langle\psi_i|$ on a finite d-dimensional Hilbert space such that $|\langle\psi_i|\psi_j\rangle|^2 = \frac{1}{d+1}$ whenever $i \neq j$. For now, whether SICs exist for all finite values of d is an open research question.[10] But, provided the relevant SICs exist, we find that an arbitrary quantum state ρ can be expressed in terms of a fiducial SIC measurement Π_i and the probability $p(i)$ of a subsequent measurement result:

$$\rho = \sum_{i=1}((d+1)p(i) - \frac{1}{d})\Pi_i. \quad (3)$$

Consider a standard von Neumann measurement with outcomes $D_j = |j\rangle\langle j|$. The probability $q(j)$ is given by the standard Born rule (equation 2). Now, suppose we perform a SIC measurement with outcomes H_i before the von Neumann measurement. In this case, we apply the law of total probability to arrive at the following:

$$s(j) = \sum_{i=1}^{d^2} p(i)r(j|i), \quad (4)$$

where $p(i)$ is the probability of an outcome i of the SIC measurement, $r(j|i)$ is the conditional probability of an outcome j of a subsequent von Neumann measurement conditional on i, and d is the Hilbert space dimension associated with the system. But, this probability $s(j)$ differs from the Born rule probability $q(j)$ that applies if the SIC is not performed. In particular,

$$q(j) = (d+1)s(j) - 1. \quad (5)$$

[10] So far SICs have been found for dimensions up to 151, with several sparse analytic proofs up to 323. See Fuchs et al. (2017) and the references therein.

Putting these expressions together, we arrive at the Essential Representation of the Born rule:

$$q(j) = (d+1)\sum_{i=1}^{d^2} p(i)r(j|i) - 1. \tag{6}$$

The QBist maintains that the Essential Representation (equation 6) provides a more perspicuous version of the Born rule. Whereas the standard version of the Born rule relates a quantum state to the probability of a measurement outcome, the Essential Representation expresses a relation between probabilities associated with different sequences of measurements. According to the QBist, such probabilities should be understood as subjective degrees of belief, and hence, the Essential Representation functions as a kind of coherence constraint analogous to the axioms of (classical) probability theory.[11] Moreover, this version of the Born rule allegedly "correlates with something that one might want to call 'real' " (Fuchs, 2017b, p.6), and hence, we may wish to regard QBism as at least committed to this minimal claim about external reality.[12] It is also worth noting that Fuchs claims the dimension d of the Hilbert space associated with a physical system—which appears in the Essential Representation—also indicates an objective feature of reality. In particular, it reflects a "previously unnoticed capacity inherent in all matter" (Fuchs, 2010, p.23).[13]

Sophisticated scientific realism allows for a range of positions with the Mirroring Account acting as a limit case. The present suggestion is that we locate QBism toward the opposite end of the spectrum—in which almost nothing in the model corresponds to an element of reality. One may wonder whether a view may be appropriately regarded as

[11] I will return to this point in section 4.1 below.

[12] What is intended by Fuchs here is far from clear. One might try to explicate this idea as a form of structural realism: the Born rule represents an aspect of the structure of our world. After all, structural realists frequently associate *structure* with what is encoded in the equations of physical theories. E.g.: "On the structural realist view what Newton really discovered are the relationships between phenomena expressed in the mathematical equations of his theory" (Worrall, 1989, p.122).

[13] See section 4.2.

consistent with scientific realism. For some, scientific realism is equated with a belief in the unobservable entities posited by our best scientific theories. We've seen that a natural way of implementing this idea in the context of contemporary physics—the Mirroring Account—is problematic. However, one may reasonably wonder whether a view that rejects so much of the apparent ontological commitments of quantum theory retains any significant portion of this motivating idea.

Another motivating idea for realists is the "no-miracles" argument, which contends that (approximate) truth is required to explain the empirical success of our scientific theories. Moving away from the linguistic notion of truth as successful reference, we may capture this idea as the intuition that a model must reflect something in the world for its successful application to be unsurprising. Again, we may wonder whether merely latching onto one (albeit fairly central) feature of the world—the Born rule—is sufficient to explain the astonishing empirical success of quantum theory. This may lead the sophisticated scientific realist to impose a threshold of ontological commitment, under which a position no longer qualifies as realist. On such a view, it's unlikely that QBism will meet this standard.

Even if we put this issue to one side, there are further worries with adopting this perspective on QBism. The main one is that the resulting view is deeply uninformative. On this understanding, QBism posits an external reality and claims that the Born rule is (somehow) true of it. If there is nothing more to say, this has the effect of leaving the metaphysics of our world largely unconstrained. This leads to a view in which reality is fundamentally "unspeakable"(Timpson, 2008) or "ineffable"(Brown, 2017). Thus, the metaphysician is free to speculate on what the world is like, which could lead to radically different ontological pictures. For example, one might arrive at Berkeleyian idealism (Brown, 2017), Cartwrightian dispositionalism (Timpson, 2008), Kantianism (Mohrhoff, 2014) or countless other views.

Thus, the standard picture of scientific realism is an unhappy fit with QBism. The naïve Mirroring Account flatly rules it out and even a more sophisticated variety of realism—one that allows for differential ontological commitment—is problematic in the context of QBism. If QBism is a genuine form a scientific realism, it cannot be in virtue of quantum models reflecting features of the world. The vague appeal to the real correlates of the Born rule (and Hilbert space dimension) is too thin a basis to support the realist's demands for explanation and understanding. One possible conclusion is that QBism simply isn't a realist view, despite the urging of its proponents. But, there is some reason to resist this implication and instead challenge the vision of scientific realism on offer. After all, QBism rejects the idea that an interpretation of quantum theory is exhausted by what it tells us about external reality. It is unsurprising, then, that it is vague and uninformative when cast in these terms. For the QBist, while it may be true that we can glean some modest claims about such a reality from quantum theory, these are downstream consequences of the interpretation rather than its essence. This explains why the ineffable world isn't a problem for the QBist; understanding what the theory is telling us is divorced from the project of giving a metaphysics.

4 Perspectival Normative Realism

The difficulties that beset the sophisticated scientific realist understanding of QBism suggest that we need a fundamentally different approach to capture what is distinctive about the view. QBists are not simply rejecting the representational status of much of the quantum formalism; if they were, critics would be correct in comparing the view to a version of instrumentalism. A more charitable interpretation seeks to take seriously two key aspects of the view that have been ignored thus far: (1) quantum theory is always applied *from a perspective* and (2) the Born rule functions as a *normative constraint* on one's beliefs.

Taking these features to heart suggests a view I call *perspectival normative realism*. The aim of this section is to sketch the position and assess its claim to scientific realism.

QBists emphasize the first-personal nature of quantum theory as one of the central tenets of QBism. In distinguishing his view from the Everettian interpretation of Wallace (2012), Fuchs notes that "...this is one of the most distinguished differences between Everett and QBism. 'QBism don't do third-person!' For QBism, all of quantum theory is first-person for the person who happens to be using it" (Fuchs, 2017a, p.22). A common feature of the standard and sophisticated varieties of scientific realism discussed above is that (some features of) models should correspond to the world in a perspective-independent sense. The Mirroring Account would have it that there is a mapping from each element of scientific model to an element of reality. This implies that quantum models provide something like a "God's eye" description of the world. Sophisticated scientific realism loosens the fit between models and world, but retains the idea—to switch metaphors—of a "view from nowhere." Does QBism's rejection of this framework for thinking about quantum theory make the view incompatible with scientific realism?

First, consider the perspectival aspect of QBism. The idea that quantum theory is always applied from the perspective of some agent seems to be in tension with its objective truth. Standard scientific realism requires (approximate) objective truth as part of its epistemic claim and model-based approaches require some appropriate mapping between models and the world. If quantum models apply only from a certain perspective, it's hard to see how any kind of scientific realism is appropriate. However, a number of philosophers have sought to develop realist views that incorporate ineliminable perspectivalism. Giere (2010), for example, argues that scientific observation and theorizing is always carried out from a perspective, but is nevertheless capable of providing partial accounts of objective reality. More recently, others such as Massimi (2018) and Teller (2018) have developed their own versions of perspectival realism. These views share the desire to allow for a plurality of models, applied from different perspectives, to faithfully represent the world. QBism also advocates a kind of pluralism: different agents will often assign different quantum states to the same system. While such pluralism invites certain challenges, it's far from clear that it undermines a position's claim to realism.

In the specific case of quantum theory, Rovelli's relational approach (Rovelli, 1996, 1997) provides another way of combining perspectivalism and realism. On Rovelli's view, there are no observer-independent properties, rather, all properties are possessed relative to some observer.[14] Despite its essential appeal to observer perspectives, Rovelli's relational interpretation still qualifies as a realist interpretation according to a familiar standard: it provides a description of the quantum world capable of explaining the success of quantum theory. Of course, there are important differences between perspectival scientific realism and Rovelli's relational approach, on the one hand, and QBism on the other. However, these cases show that the perspectival aspect of QBism needn't disqualify it as a realist position.

A second crucial feature of QBism is its emphasis on normativity. This is a point QBism shares with other non-ontic approaches, such as Healey's pragmatism, which emphasizes that the primary role of quantum theory is *prescriptive* rather than descriptive.[15] An important difference between the two views is in what they take the normative content, or prescriptions, of quantum theory to be. For Healey, an agent's quantum state ascriptions taken individually are subject to normative constraints; there is an objective fact

[14] Note that, for Rovelli, an "observer" is any physical system (microscopic or macroscopic) capable of carrying information about a quantum system.

[15] Of course, there is an sense in which *any* interpretation has the normative implication that one should expect to find what the quantum formalism predicts. However, on many interpretations, such normative claims follow from the truth of the description of reality the theory is taken to provide. By contrast, on QBism (and other non-ontic views), quantum normative claims do not follow from a description of reality in any straightforward sense. (See section 4.1.)

about which quantum state an agent should ascribe in a given physical context. QBists, however, only recognize a *relational* normative constraint in the Born rule (in the form of the Essential Representation). As Fuchs (2017a) says, "[n]othing is sacred except that [an agent] should strive to satisfy the Born Rule for all probabilities" (p.13). What both views share is that quantum theory imposes objective normative constraints on all agents (see Healey (2017a)).

What are the implications of this for scientific realism? Note that in other contexts some are happy to regard as "realism" a position that takes normative claims as objectively true even without any accompanying descriptive metaphysics. In ethics, for instance, Scanlon and Parfit defend versions of moral realism that explicitly reject the demand for moral metaphysics.

> ...the point of judgments of right and wrong is not to make claims about what the spatiotemporal world is like. The point of such judgments is, rather, a practical one: they make claims about what we have reason to do. Metaphysical questions about the subject matter of judgments of right and wrong are important only if answers to them are required in order to show how these judgments can have this practical significance. (Scanlon, 1998, p.2)

For Scanlon, moral metaphysics is only relevant to the extent that it is needed to account for the prescriptions of morality. For QBists, who view quantum theory normatively, the parallel point is that quantum metaphysics is only relevant to the extent that one needs it to account for the prescriptions of quantum theory—i.e., the constraints imposed by the Born rule. As long as one can provide such an account, there are some grounds for regarding the view as a form of scientific realism. After all, it maintains that the dictates of quantum theory are objective and is able to say why they are important.

4.1 Grounding Normativity

QBism maintains that the significance of the Born rule—formulated purely in terms of subjective probabilities—is to tell us what we have reason to do. If this role can be sustained without getting involved in metaphysical questions, then QBism can maintain some measure of objectivity without making any claims about external reality. However, there is an obvious problem with such a claim in the context of quantum theory (whether it is successful in ethics is another question): How, without providing a description of the world, can we say that we have reason to do what the Born rule prescribes? Without an answer to this question, the scientific realist will be unsatisfied as the central (normative) content of the theory is left unaccounted for.

One strategy for grounding the normative prescriptions issued by quantum theory is inductive in nature. It says that we should do as quantum theory recommends because (1) this is what it is to *accept* quantum theory and (2) we should accept quantum theory on the basis of its past success. This is the approach of Healey (2017b).

> To accept quantum theory is to commit oneself to setting credence in each significant canonical magnitude claim equal to the probability specified by a legitimate application of the Born rule based on the best available quantum model, in the absence of more direct access to the truth value of the claim. (Healey, 2017b, p.131)

He goes on to defend point (2):

> The strongest reason to accept quantum theory is provided by the success of its applications in predicting and explaining physical phenomena of a statistical nature. If we set credences in accordance with the Born rule we are led to

> expect and can come to understand the patterns displayed by these statistics. (Healey, 2017b, p.131)

However, it's not clear that this strategy is available to the QBist. First, measurement outcomes are not objective features of reality according to QBism, so there are no objective frequencies to appeal to. Each agent will have their own memories of measurement experiences, which are the result of their interactions with the world, but will differ between agents. Second, the Born rule alone doesn't make any predictions. One needs to supplement the Born rule with a quantum state ascription—or the probability of another measurement outcome in the Essential Representation—to arrive at a specific probability. This relational nature of the Born rule means that measurement statistics cannot bear on it directly. This isn't a problem for Healey, as he maintains that quantum state ascription is objective (though relational), but QBists demur. So, it seems QBism lacks the resources to offer an inductive grounding of the Born rule.

Instead, QBists adopt a strategy for grounding normativity that borrows from the subjectivist tradition in probability. Bruno de Finetti famously denied that there is anything in external reality corresponding to our judgments of probabilities, and hence, was compelled to offer an alternative account of the axioms of probability theory. This alternative was the Dutch book approach, which views the probability axioms as coherence constraints. In terms of betting behavior, if one doesn't adhere to the axioms, they will be vulnerable to a "Dutch book": a series of fair bets in which they are guaranteed to lose money regardless of which outcomes obtain (Ramsey, 1926; De Finetti, 1937). Of course, there needn't be any actual "Dutch bookies" lurking. The point is rather that the possibility of such sequences of bets reveals an internal inconsistency in one's degrees of belief.

Fuchs and Schack (2013) argue that the Essential Representation of the Born rule should be viewed in along the same lines:

> It expresses a kind of 'empirically extended coherence' not implied by Dutch-book coherence alone, but formally similar to the kind of relation one gets from Dutch-book coherence. (Fuchs and Schack, 2013, p.1702)

The proposal is to afford the Born rule a similar status to the axioms of probability theory taken subjectively; if we don't follow the Born rule in our subjective degrees of belief, we are being incoherent. In terms of betting behavior, violating the Born rule opens one up to the possibility of a Dutch book that guarantees a sure loss. There is a crucial difference between the cases, however: the quantum Dutch book, unlike the standard Dutch book, requires more than logic and mathematics. The quantum Dutch book applies only in a world relevantly similar to ours—one in which quantum theory provides a good guide for agents in it.

But what is it about our world that makes the Born rule the objectively correct coherence constraint? QBists have two sorts of replies to this question. First, they may leave this as a brute feature of reality. That the Born rule acts as a coherence constraint is the limit of what we can say about the world. As Fuchs says, it is "nature's whisper" (Fuchs, 2017b, p.6). Sometimes QBists express a desire to say more, but note that QBism is an active research project, and as such, doesn't have all of the answers at present. So, a second approach is to seek out the features of our world that necessitate the use of the Born rule. One way to do this would be to derive the Born rule from logic and mathematics supplemented with a minimal empirical claim. However, it's hard to see what resources the QBist has at their disposal for this task. For instance, consider the approach of a non-QBist, Pitowsky (2003), who argues that quantum probability (i.e., the Born rule) follows from rational betting on quantum gambles. The empirical premise in Pitowsky's derivation is the assumption that the algebra formed by the outcomes of incompatible quantum measurements has a non-Boolean structure.[16] But, such a claim is incompatible with QBism's subjective understanding of measurement outcomes. So, while such a derivation may eventually be possible, it's presently unclear what empirical premises would be involved. At present, then, QBism must rest content with the first approach: it is a brute fact that the Born rule acts as a coherence constraint.

This picture may be unsatisfying for traditional scientific realists, but recall that QBism's primary focus is not describing reality, so it's unsurprising that it's unsatisfying by this metric. It is the burden of a normative theory to ground its normative claims—to give an account of their reason-giving force—and the Dutch book approach does this. The Born rule gives us reasons to set our credences as it prescribes because it's an objective coherence constraint for agents in a world like ours.

In sum, QBism should be understood as a perspectival normative realism according to which quantum theory is prescriptive rather than descriptive, and perspectival rather than applied from the God's eye view. Whether such a position counts as realism depends on the existence of grounds for the normative claims involved in quantum theory, so understood. The inductive approach isn't available to the QBist, but the Dutch book approach provides another option. For now, QBism is unable to identify the specific features of our world that ground its use, but the Dutch book approach may nevertheless account for why we should set our credences in accordance with the Born rule.

[16] More specifically, a quantum gamble proceeds in four stages:

1. A *single* physical system is prepared by the bookie.
2. A *finite* set $\mathcal{M}$ of incompatible measurements is announced by the bookie, and the agent is asked to place bets on possible outcomes of each one of them.
3. One of the measurements in the set $\mathcal{M}$ is chosen by the bookie and the money placed on all other measurements is promptly returned to the agent.
4. The chosen measurement is performed and the agent gains or loses in accordance with his bet on that measurement.

The empirical assumption is that the quantum gambler is aware of the Boolean algebras corresponding to the outcomes of two incompatible measurements. When considered together, these outcomes form a non-Boolean algebra (Pitowsky, 2003, pp. 396–397).

4.2 The Participatory Universe

The discussion thus far has largely ignored another feature of QBism that may pertain to its viability as a form of realism. Inspired by John Wheeler, QBists have sought to emphasize the "participatory" aspect of quantum theory.

> When an experimentalist reaches out and touches a quantum system—the process usually called quantum 'measurement'—that process gives rise to a birth. It gives rise to a little act of creation. And it is how those births or acts of creation impact the agent's expectations for other such births that is the subject matter of quantum theory. (Fuchs, 2017b, p.9)

This talk of measurements as acts of creation suggests a metaphysical picture in which we construct the world via our interactions with it. This may be further supported by consideration of the role played by Hilbert space dimension, which figures in the Essential Representation and which Fuchs (2010) describes as a "universal capacity" of quantum systems. Indeed, Timpson (2008) suggests an ontology of primitive capacities on the basis of such considerations. Now, there is nothing obviously anti-realist about a metaphysics in which humans build the world bit by bit via their interactions with it—if quantum theory is telling us that this is how reality operates, then as realists we had better endorse it.

But, such a picture does raise a number of questions. If agents construct reality via their measurements, how do we make sense of *different* agents performing different measurements with different results? Indeed, the case of Wigner's friend—usually taken to support epistemic approaches like QBism—would seem to lead to a paradoxical situation in which the world is more than one way, or in which Wigner and his friend occupy different worlds. Fortunately, these puzzles are avoided when we recall the perspectival aspect of QBism discussed above.

According to QBism, the primary function of quantum theory is to guide agents in their beliefs, not to describe external reality. This means it is a mistake to elevate what it says about an individual agent's experiences to the level of a God's eye description of the world. Indeed, a central tenet of the view is that quantum theory can provide no such God's eye description. Thus, while it may be true *from the perspective of an individual agent* that she creates the world via her measurements, this should not be taken as a metaphysical proposal about external reality.

By way of analogy, consider the approach to time found in Ismael (2016). On Ismael's view, temporal experience (the passage or "flow" of time) is a genuine feature of situated agents, but that doesn't mean we need to add anything to our metaphysics—a "growing block" or "moving spotlight"—rather, we can understand passage as a result of a human agent with certain perceptual capacities being embedded in a world like ours. Crucially, this doesn't imply that temporal experience is illusory, but simply that it is perspectival.[17] Similarly, the QBist can say that for an agent situated in a quantum world measurements are little acts of creation and that quantum theory will provide objective advice for what to expect of the next act of creation. The core claim of QBism is that this situated perspective is the important one for thinking about quantum theory. It is here that quantum theory is intended to apply, not as a guide for philosophers constructing a metaphysics.[18] But granting the QBist all of this still leaves the metaphysics wide open. As noted in section 3.1, the constraints on external reality imposed by quantum theory are quite weak.

[17] "To think that accepting the Block Universe as an accurate representation of time as it appears [from a God's eye view] means rejecting passage, or flow, or openness, as illusory is like thinking that accepting a map as a non-perspectival representation of space means that you are under an illusion that anything is nearby."(Ismael, 2016, p.119)

[18] Again the analogy with temporal experience is apt. "I think that philosophers are overly inclined to think that everyone is a metaphysician. I think that many of the people I know best never asked the question "What is time?" in a form that demands a metaphysical answer."(Ismael, 2016, p.120, n.32) On the current proposal, QBism answers the question "What is quantum theory?" in a similarly ametaphysical manner.

Thus, the QBist can say both that (a) agents create their own worlds by performing measurements and (b) agents exist in a single reality. The former should be viewed as a claim from the situated perspective while the latter should be viewed as a claim about objective reality. Now, it may be thought that QBism's rejection of the God's eye perspective renders QBists unable to endorse claim (b), but this cannot be right. For as we have seen, QBists wish to claim that there is an external reality independent of our thoughts of it (this is what kicks back when we prod it) and that we can know certain things about it (i.e., that it supports our use of the Born rule). The denial of a God's eye description is a claim about the limits of quantum theory, not the impossibility of metaphysics.

5 Conclusion: Meeting Realist Demands

The aim of this paper has been to investigate the relation of QBism to scientific realism. The conclusion we have reached is partially negative: standard ways of thinking about scientific realism are an unhappy fit with QBism. It is flatly inconsistent with the naïve "mirroring" account, and cast in terms of a more plausible "sophisticated" form of realism, QBism tells us preciously little about the world. Moreover, these ways of thinking about realism are a poor fit with QBism's perspectival and normative aspects. Perspectival normative realism aims to preserve the realist's demand for objective truth while taking these features seriously.

Realist critics of QBism often complain that the position is explanatorily inadequate—that there are numerous phenomena that it's incapable of accounting for.

> ...QBism seems explanatorily inert. For scientific explanations typically explain phenomena in terms of underlying mechanisms. Here is a simple example. Why is the Sun able to produce so much energy over such a long period of time? (McQueen, 2017, p.7)

McQueen (2017) goes on to argue that QBism can provide no underlying physical mechanism responsible for the sun's energy production (presumably because the nuclear processes involve quantum models which fail to describe reality according to QBism). But, it's question-begging to demand of QBism that it provides causal-mechanistic explanations of quantum phenomena, given that one of its central features is a rejection of quantum theory's alleged descriptive role. Moreover, QBism can offer a certain kind of explanation of phenomena in the scope of quantum theory: the QBist can note that quantum theory tells agents that they should *expect* to find certain things. McQueen considers such an explanation of his case, but quickly rejects it for failing to account for *why* we should expect these phenomena to occur (*ibid.*).

In addressing this worry, we may again profitably compare the case of moral realism. In the passage quoted above, Scanlon goes on to distinguish two motivations for asking whether moral judgments are about something "real":

> One worry would be that there may be no right answer to questions of right and wrong... A second interpretation of the charge that judgments of right and wrong are not about anything 'real' would take it as the claim that they should not have this importance. This is a charge that any account of the reason-giving force of judgments of right and wrong needs to meet. (Scanlon, 1998, pp.2–3)

Applied to QBism, the first worry is that without offering an adequate description of the world, the QBist cannot maintain that there are objectively correct answers to questions about how to set our credences. The second worry is that only such a description can account for the reason-giving force of quantum theory and the Born rule. QBism meets the first challenge by regarding the Born rule as an objective coherence constraint. While there aren't correct answers to individual probability judgments, there are correct answers to relational or conditional probability judgments—namely, they must conform to the Born rule. The second challenge is met by the Dutch book approach. The prescriptions of the Born rule have importance because all rational agents are compelled to adhere to them, in the same manner as the axioms of subjective probability theory. According to QBism, quantum theory provides correct answers to questions about what we should do, answers which provide us with reasons to do as they prescribe. Thus, it would seem that QBism can meet the realist demands appropriate to a normative theory.

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