We remark on John Earman’s paper “Quantum Bayesianism Assessed” [The Monist 102 (2019), 403–423], illustrating with a number of examples that the quantum “interpretation” Earman critiques and the interpretation known as QBism have almost nothing to do with each other.

I. INTRODUCTION

“PROBABILITY DOES NOT EXIST”
— Bruno de Finetti, 1990 [1, p. x]

“Bruno de Finetti ... proclaimed ‘THERE ARE NO PROBABILITIES’ (de Finetti 1990, x)”
— John Earman [2]

Philosophers pride themselves on being careful readers and analyzers. In a recent article in The Monist, “Quantum Bayesianism Assessed” [2], John Earman analyzes a position he ascribes to a group of people he calls “QBians”—a term meant to suggest followers or contributors to the quantum interpretative project initially known as Quantum Bayesianism [3], but now after a significant number of modifications, simply called QBism [4–6].1 In another article [8], Earman even refers to “Quantum Bayesians (QBians as they style themselves).” As a point of fact, no QBist (the moniker that is used by followers of QBism2) has ever identified with this alternative term, and no previous commentator on QBism has ever employed it. QBians do not exist; it is a coinage of Earman alone.

In a way this is fortunate, as the portrayal Earman gives has so little to do with the actual language, goals, metaphysics, and mathematical technicalities of QBism as to be unrecognizable. Even the current Wikipedia article on QBism is truer to its subject [11]:

According to QBism, quantum theory is a tool which an agent may use to help manage his or her expectations, more like probability theory than a conventional physical theory. Quantum theory, QBism claims, is fundamentally a guide for decision making which has been shaped by some aspects of physical reality. Chief among the tenets of QBism are the following:

1. All probabilities, including those equal to zero or one, are valuations that an agent ascribes to his or her degrees of belief in possible [measurement] outcomes. [From later in the article: QBism considers a measurement to be any action that an agent takes to elicit a response from the world and the outcome of that measurement to be the experience the world’s response induces back on that agent.] As they define and update probabilities,
quantum states (density operators), channels (completely positive trace-preserving maps), and measurements (positive operator-valued measures) are also the personal judgements of an agent.

2. The Born rule is normative, not descriptive. It is a relation to which an agent should strive to adhere in his or her probability and quantum state assignments.

3. Quantum measurement outcomes are personal experiences for the agent gambling on them. Different agents may confer and agree upon the consequences of a measurement, but the outcome is the experience each of them individually has.

4. A measurement apparatus is conceptually an extension of the agent. It should be considered analogous to a sense organ or prosthetic limb—simultaneously a tool and a part of the individual.

But this also means that Earman’s paper is an opportunity lost, as it becomes essentially irrelevant to any meaningful discussion on the difficulties of QBism. (Any QBist would agree that QBism is an unfinished project in need of thoughtful input.)

To take some initial examples, consider the following quotes from Earman’s paper:

**Earmanism 1.** The elements of the projection lattice $\mathcal{P}(\mathcal{B}(\mathcal{H}))$ are referred to as quantum propositions (also yes-no questions, or quantum events). Quantum probability theory may be thought of as the study of quantum probability functions $\Pr$ on $\mathcal{P}(\mathcal{B}(\mathcal{H}))$.

**Earmanism 2.** For Bayesians, classical or quantum, probability is degree of belief, the objects of which are propositional entities. In contrast to the projection lattice $\mathcal{P}(\mathcal{B}(\mathcal{H}))$, the effect algebra does not have a natural propositional structure.

**Earmanism 3.** Suppose that a QBian agent learns that $F \in \mathcal{P}(\mathcal{B}(\mathcal{H}))$ is true.

None of this coincides with the way QBists think of probability’s usage within quantum theory. All one need do is look through any of the QBist and proto-QBist papers Earman cites in his article, Refs. [3–5, 10, 12–21], or even the critical assessment by Timpson [22] which he also cites. One will search in vain to find any use made of a non-Boolean “lattice of propositions” or any hint that QBists subscribe to a notion that upon measurement one “learns the truth value” of a proposition.

Indeed already as of 2002, one of us (CAF) was writing consistently [15] of an opposing conception of measurement:

It is a theory not about observables, not about beables, but about “dingables.” We tap a bell with our gentle touch and listen for its beautiful ring.

So what are the ways we can intervene on the world? What are the ways we can push it and wait for its unpredictable reaction? The usual textbook story is that those things that are measurable correspond to Hermitian operators. Or perhaps to say it in more modern language, to each observable there corresponds a set of orthogonal projection operators $\{\Pi_i\}$ over a complex Hilbert space $\mathcal{H}_D$ that form a complete resolution of the identity . . .

Nonetheless, one should ask: Does this theorem [Gleason’s theorem] really give the physicist a clearer vision of where the probability rule comes from? . . .
The place to start is to drop the fixation that the basic set of observables in quantum mechanics are complete sets of orthogonal projectors. In quantum information theory it has been found to be extremely convenient to expand the notion of measurement to also include general positive operator-valued measures (POVMs) . . .

And if one digs deeper into the literature, one will easily find discussions like this [23, 24]:

It is not that I reject a well-structured event space because it assumes its elements would correspond to intrinsic properties of quantum systems, but rather this is the result of a thoroughgoing subjective interpretation of probabilities within the quantum context. What cannot be forgotten is that quantum-measurement outcomes, by the usual rules, determine posterior quantum states. And those posterior quantum states in turn determine further probabilities.

[If] one takes the timid, partial move that [Pitowsky] and [Bub], say, advocate—i.e., simply substituting one or another non-Boolean algebra for the space of events, and leaving the rest of Bayesian probability theory seemingly intact—then one ultimately ends up re-objectifying what had been initially supposed to be subjective probabilities. That is: When I look at the click, and note that it is value \(i\), and value \(i\) is rigidly—or I should say, factually—associated with the projector \(\Pi_i\) in some non-Boolean algebra, then I have no choice (through Lüders rule) but to assign the posterior quantum state \(\Pi_i\) to the system. This means the new quantum state \(\Pi_i\) will be as factual as the click. And any new probabilities (for the outcomes of further measurements) determined from this new quantum state \(\Pi_i\) will also be factual.

So, the starting point of the reasoning is to assume that there is a category distinction between probabilities and facts (this is the subjectivist move of de Finetti and Ramsey). Adding the ingredient of the usual rules of quantum mechanics, one derives a dilemma: If there is a rigid, factual connection between the clicks \(i\) and elements \(\Pi_i\) of an algebraic structure, then probabilities are factual after all. Holding tight to my assumption of a category distinction between facts and probabilities, I end up rejecting the idea that there is a unique, factual mapping between \(i\) and \(\Pi_i\). . . .

Though [QBists] banish the algebraic structure of Hilbert space from having anything to do with a fundamental event space (and in this way their quantum Bayesianism differs from the cluster of ideas Pitowsky and Bub are playing with), they do not banish the algebraic structure from playing any role whatsoever in quantum mechanics. It is just that the algebraic structure rears its head at the conceptual level of coherence rather than in a fundamental event space. It is not that potential events are objectively tied together in an algebraic way, but that our gambling commitments (normatively) should be.

This, for instance, is a good bit of the reason that the technical side of the QBist program [10, 25–30] focusses on trying to recover the algebraic structure of quantum theory from a primitive (nonalgebraic) statement of the Born rule, rather than the other way around, as the Gleason approach does. Where Earman writes in his paper,

**Earmanism 4.** Some QBians struggle mightily over the status of the ‘Born rule.’ . . . But there is no mystery here . . . nor is extra normative guidance required. By Gleason’s theorem
a countably additive (respectively, completely additive) measure $\Pr$ on $\mathcal{P}(\mathcal{B}(\mathcal{H}))$ with $\mathcal{H}$ separable . . . whether or not it is given a personalist interpretation, corresponds to a normal state . . . .

it can only mean that he has not absorbed or internalized what the program is about.

Despite Earman’s assertions, QBists do not “struggle mightily” over the status of the Born rule: It is the centerpiece of their technical research program. QBists believe that, when expressed more primitively as a relation between probabilities (rather than as a hybrid of operators and probabilities), the Born rule exhibits the most incisive statement yet on how quantum probability departs from classical theory [31]. Thus it is the most promising place to look for the deepest lesson quantum theory is yet to reveal about physical reality. This outlook contrasts starkly with other interpretations of quantum mechanics, which typically want to take the Born rule as an afterthought to be derived or an embarrassment to be elided. How many times do the QBists have to say in print that QBism is seeking an inversion of what Gleason and Mackey were aiming for?

In summary, Earman’s QBian is a straw man—a creation of his own, not the literature he cites. Nothing says this more tellingly than,

**Earmanism 5.** QBians occasionally make use of this operational approach [i.e., the framework of POVMs], but it is unclear how it lends itself to something that deserves to be called quantum Bayesianism.

“Occasionally”? It was the foremost notion in nearly every paper Earman cited! “[I]t is unclear how it lends itself to something that deserves to be called quantum Bayesianism”? The only conclusion one can draw is that the author simply did not do his homework before declaring in print what he thinks QBism ought to be.

So it is that the term QBian is a fortunate choice to name this arbitrary creation. On the other hand, many a young philosopher will look up to the writings of the distinguished professors in their field as entry points for their own thinking. A philosopher is certainly more likely to first learn of QBism through another philosopher than to have stumbled across the original physics literature. Therein lies the danger of an article like Earman’s.3

What can be done about this? Does Earman’s paper deserve a careful rebuttal? We wouldn’t even know how to start, so disconnected the paper is from actual QBism. It does seem worthwhile, however, to make enough limited remarks on some of Earman’s passages to sow a seed of doubt and suggest that QBism is something else than he portrays it to be. The remainder of our paper is devoted to such an exercise.

**II. A HISTORICAL NOTE**

**Earmanism 6.** But in recent years the major push for a personalist reading of quantum probabilities has come not from philosophers but from physicists who march under the banner of quantum Bayesianism (or QBism for short). In the vanguard are Carleton Caves, Christopher Fuchs, Rüdiger Schack, and David Mermin.

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3 One of us (CAF) has witnessed this firsthand, in correspondence from PhD students at the University of Oxford and the London School of Economics, querying him about this or that “QBian” stance, not realizing the idiosyncracy of the term and how disconnected Earman’s commentary on QBism is from the actual view.
The view espoused by Caves, Fuchs and Schack [3] in the early 2000s, while it can be called a kind of “Quantum Bayesianism”, is not QBism [4]. The latter grew out of the former and rejects many statements made under the earlier banner [7]. Carlton Caves in fact does not consider himself a QBist [7] (and Carlton is not spelled with an E). To define QBism, Earman cites several papers from 2001 through 2014, not distinguishing the very different philosophies they represent. The cited papers do not form a coherent whole. The earlier ones say much that the later ones contradict, and the later publications explicitly disavow the earlier. This is a consequence of progress (the sort of thing physicists strive for). We, of course, believe that it is progress toward physical understanding, but we hope that even non-QBists can see it as advancing toward internal self-consistency.

Earman refers to a pair of completely different papers [4, 15] as “Versions of Fuchs’s QBian manifesto”. Of course, neither is “QBian”; moreover, the article from 2002 is still a significant phase transition away from QBism proper, not yet embracing the two levels of personalism [23, Introduction] that Fuchs and Schack had developed by 2010 in order to resolve the paradox of Wigner’s Friend [7, 32–34].

III. ON LATTICES AND LOGIC

The position that Earman invents resembles a probabilistic gloss on quantum logic. Indeed, it directly contradicts well-established features of QBism in multiple evident ways. For example, see Earmanisms 1–3 above. In QBism, performing a measurement is not a matter of learning that a proposition is true. Measurements do not reveal pre-existing properties of the measured object; nor do they merely instill properties within the object. Instead, a measurement outcome is an experience [35, 36], the agent’s side of a joint agent-object event.4

Because QBism does not treat measurement outcomes as propositions that are true-or false-valued, it has no fundamental role for a lattice of projections. Instead, a QBist assigns POVM elements (or “effects”) to potential future experiences, and then associates a consistent set of personal probabilities to those POVM elements. Both the probabilities and the choice of POVM elements are personal judgments, expressions from the agent’s own mesh of beliefs cashed out as gambling commitments. Quantum measurements are not restricted to the narrow notion of orthonormal bases, and even when POVM elements are rank-1 projection operators, they do not stand for “quantum propositions”. Consequently, Earman’s language is inapplicable, and his mathematical requirements are unmotivated. The effect algebra is a natural and physically meaningful entity, as decades of daily work in quantum information has proved; if it lacks a propositional structure, so much the worse for the notion of propositional structure.

In QBism, noncommuting operators and non-Boolean lattices are secondary or tertiary consequences of more fundamental physical principles [24]. Earman’s failure to recognize this has consequences. For example, he writes,

4 Predecessors to this view include Wheeler’s “elementary acts of observer-participancy” [37, 38]. We have also noticed a family resemblance to aspects of Whitehead’s process philosophy [39] and Barad’s “intra-actions” [40]. However, QBism aims to develop these kinds of imagery more exactly and quantitatively than has ever been done before.
**Earmanism 7.** But the failure of Gleason’s theorem [in dimension 2] should be a cause for alarm on the bottom-up personalist reading of probabilities.

The analogue of Gleason’s theorem holds in dimension 2 if the set of quantum measurements is the set of POVMs, rather than that of von Neumann measurements [41]. Without the antiquated quantum-logic drive to find the latter fundamental, there is no reason to regard the case of dimension 2 as exceptional or problematic. This observation, made independently by Busch and by Caves et al., predates QBism proper by several years [42].

Earman discusses the Lüders conditionalization rule [43, 44] at some length. A QBist agent is not constrained to use the Lüders rule. Instead, a QBist regards the Lüders rule as a sensible way that an agent *might expect to update her beliefs* under some conditions, not as a defining feature of rationality or anything like that [47, 48]. The standard formalism for representing quantum-state change is that of Kraus operators, which allow an agent to associate a different completely positive trace-preserving map to each outcome of a measurement [49]. To a QBist, the choice of assigning a particular POVM \{E_i\} to represent a measurement is a personal judgment, and so is the choice of Kraus decomposition

\[ E_i = \sum_j A_{ij}^\dagger A_{ij} \]  

for each POVM element. Consequently, all of the ingredients in the state-change rule

\[ \rho \rightarrow \rho' = \frac{1}{\text{tr}\rho E_i} \sum_j A_{ij}\rho A_{ij}^\dagger \]  

have the same conceptual status. Whether or not an agent chooses to have this reduce to the Lüders form

\[ \rho \rightarrow \rho' = \frac{\Pi_i\rho\Pi_i}{\text{tr}\rho\Pi_i} \]  

where \{\Pi_i\} is a set of projectors onto an orthonormal basis for \(\mathcal{H}\), depends on that agent’s personal mesh of beliefs. First, the agent would have to choose to associate a particular set of potential future experiences with the specific projectors \{\Pi_i\}, and then, the agent would have to decide that applying the Lüders rule is consistent with their belief mesh. Neither step is obligatory. For example, having chosen a POVM \{E_i\} as the mathematical model of her action, an agent may invoke a generalized version of the Lüders rule,

\[ \rho \rightarrow \rho' = \frac{1}{\text{tr}\rho E_i} \sqrt{E_i}\rho\sqrt{E_i}, \]  

or she may invoke an “entanglement-breaking” [50–52] update rule

\[ \rho \rightarrow \rho' = \frac{E_i}{\text{tr}E_i}. \]  

These will in general differ.

QBism subscribes to a school of personalist probability [45, 46] in which an agent need not always update by the Bayes conditioning rule, or even expect that she will [47]. Consequently, the question that Earman raises of when Lüders conditionalization can be made to resemble the Bayes rule is, on a basic conceptual level, doubly irrelevant.

Earman regards the subject of quantum-state preparation as vitally significant. He writes, for example,
Earmanism 8. From the objectivist perspective Prop. 3 can be viewed as a special case of Lewis’s PP [Principal Principle]: when an agent learns that $S_\varphi$ is true she learns that the objective chances are given by the state $\varphi$; updating by Lüders conditionalizing on this knowledge brings her credences into line with the objective chances assigned by $\varphi$.

Because there is no objective connection between raw experiences and POVM elements, there is no objective post-update state. The remainder of Earman’s treatment of this topic ignores this basic feature of QBism and is thus inconsequential.

IV. PERSONALIST PROBABILITY

Some of Earman’s statements about the conceptual basics of personalist probability theory are erroneous. For example, Earman asks how “QBians” can appeal to a Dutch-book construction

Earmanism 9. when $A$ and $B$ are noncommuting and there is no possibility of settling simultaneous bets on $A$, $B$, and $A + B$?

A cursory reading of the technical papers from the QBist research program would indicate that Dutch-book arguments are never made across multiple mutually exclusive experiments. Indeed, recognizing what must be added to Dutch-book arguments to bridge expectations between such alternatives is the central focus of that work [30, 53, 54].

Earmanism 10. In QBism where the quantum state is merely a device for representing the credence function of a Bayesian agent, the state changes only when the agent’s [sic] credence function changes. Changes in the credence function can happen because the agent updates her credence function on new information, or because of some sort of drift in beliefs uninformed by new information. QBians do not discuss the latter possibility, and for good reason since uninformed drift does not have a rational explanation. The upshot for QBians is that, as far as rational agents are concerned, there is no Schrödinger state evolution between updating events.

This is incorrect, because it is founded on a basic misconception about the treatment of time in personalist probability theory [55].

To illustrate, think of Alice the weather forecaster. On Monday, which we’ll call day 0, she makes a forecast for the coming week. She writes $P_0(\text{rain on day 1})$, $P_0(\text{rain on day 2})$ and so forth. The subscripts refer to the time at which she sets her probabilities — the time at which she makes her gambling commitments. The relation between $P_0(\text{rain on day 1})$ and $P_0(\text{rain on day 2})$ could be quite complicated, relying upon a representation of the atmosphere in terms of a stochastic process. This is not a change of probabilities, but rather a listing of probabilities for multiple related but distinct experiments: testing for rain on day 1, testing for rain on day 2, etc. Updating probabilities, whether by conditionalization or a more general probability kinematics, only enters the picture when day 1 rolls around and Alice must decide how to set her gambling commitments with a new subscript, like $P_1(\text{rain on day 2})$.

The situation in quantum mechanics is exactly analogous. A density matrix $\rho_0(t = 1)$ encodes Alice’s expectations, asserted at time 0, about the potential results of experiments
that she could conduct at time 1. Alice can use the Schrödinger equation to calculate $\rho_0(t = 2)$, by conjugating with a unitary:

$$\rho_0(t = 2) = U \rho_0(t = 1) U^\dagger.$$  \hfill (6)

This is not a change of probabilities, but rather a listing of probabilities for multiple related but distinct experiments. The fact that any density matrix is equivalent to a probability distribution over the outcomes of a reference measurement [30, 34, 56] underlines that in this respect, the quantum and classical stories are congruent. Moreover, fixing a reference measurement also gives a natural representation of unitaries as conditional probabilities, revealing that Schrödinger evolution is simply a deformed counterpart of classical stochastic evolution [4, 36]. This mathematical fact is one reason why QBism explicitly grants the same conceptual status to quantum states and to time-evolution operators, treating them even-handedly as doxastic quantities.

Because Earman has an incorrect view of how personalist probability includes time evolution, he erroneously infers that QBism must abandon the Schrödinger picture in favor of the Heisenberg:

**Earmanism 11.** In the conventional treatment of quantum evolution, Heisenberg and Schrödinger evolution are flip sides of the same coin since $\omega_0(A_t) = \omega_1(A_0)$. But in QBism Heisenberg evolution has primacy since the right hand side of this equality makes no sense for the QBian unless it is understood as a notational variant of the left hand side.

For the reasons explained above, this is inaccurate. A QBist can equally well use the Heisenberg or the Schrödinger picture.

**Earmanism 12.** What is disquieting about the QBian stance here is the dualism it implies: there is something like a realist/objectivist commitment to the structure of quantum observables and their temporal evolution but an instrumentalist/subjectivist attitude towards quantum states.

As explained above, QBism contains no such dualism. Fuchs rejected this dualism well before “Quantum Bayesianism” had matured into QBism, writing in 2002 that observables and time-evolution operators are “subjective information” just like quantum states [15, §7].

V. CONCLUSION: A DEFINITE OUTCOME

Earman’s final section before his concluding remarks is a discussion of whether QBism can be said to resolve conceptual problems in the interpretation of quantum mechanics. Regarding the question of why measurements have definite outcomes, he writes,

**Earmanism 13.** As long as a QBian agent is treated as an abstract, disembodied probability calculator that is fed information by an oracle, the issue can be avoided. But it resurfaces for physically embodied observers, such as ourselves, whose information acquisition has to be treated quantum mechanically in terms of an interaction with the (measurement apparatus + object system).

This is a fundamental misrepresentation of how QBists treat measurement in quantum theory: It ignores what even the Wikipedians know, “A measurement apparatus is conceptually an extension of the agent. It should be considered analogous to a sense organ or
prosthetic limb—simultaneously a tool and a part of the individual.” The trinary decomposition object + apparatus + agent simply does not exist in QBism. QBism is all about the agent and her external world—the decomposition is a binary one.

In some other interpretations, chiefly those of an Everettian bent, a measurement involves an observer becoming entangled with an apparatus that has become entangled with a system. The stories of how exactly this leads to everyday experience are elaborate and mutually contradictory [57]. However, at root, formulating an entangled state for the observer and the system, or the observer and the system and an apparatus, requires ascribing a quantum state to the observer. This contradicts the tenets of QBism, according to which an agent does not assign a quantum state to herself, and there is no God’s-eye super-observer who assigns a state to all agents [34]. QBism indeed regards agents as embodied; how could a disembodied entity take physical actions and experience consequences? The argument that because agents are embodied their interactions with the world must be treated as the generation of entangled states simply presumes its conclusion.

Perhaps we could say more, but this is enough for now. The scholarship in Ref. [2] is abysmal: QBians do not exist.

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