IPP-QM-14: QBism

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MT24

The course

1. Basic quantum formalism
2. Density operators and entanglement
3. Decoherence
4. The measurement problem
5. Dynamical collapse theories
6. Bohmian mechanics
7. Everettian structure
8. Everettian probability
9. EPR and Bell's theorem
10. The Bell-CHSH inequalities and possible responses
11. Contextuality
12. The PBR theorem
13. Quantum logic
14. QBism
15. Pragmatism and relational quantum mechanics
16. Wavefunction realism

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- I'm now going to turn to approaches which are less obviously realist (but which in fact might qualify as realist—in their own way—on further reflection).
- The focus today will be on *QBism* (Fuchs, Caves, Schack); in the next lecture, I'll present *quantum pragmatism* (Healey, Menon) and *relational quantum mechanics* (Rovelli).

Today

QBism introduced

Four common objections to QBism

More serious objections to QBism

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QBism *dramatis personae*

Introducing QBism

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In any case, at the highest level, QBism is a combination of:

1. *Anti*-realism about much of the structure of quantum theory.
2. Realism about physics *in general*.

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4. Nevertheless, there is a real physical world ‘out there’.

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1. What exactly is at stake when one adopts this line?
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3. What would we have to be saying the world is like if QBism were the right way to understand it?

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(More on the connections between QBism and pragmatism in the next lecture.)

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So, the probability ascriptions arising from a particular state assignment are understood in a purely subjective, Bayesian manner, in the mould of de Finetti (1989, 1937).

Advantages of QBism's distinctive approach to the quantum state

1. Making out a non-mysterious and non-vacuous notion of objective probability is notoriously controversial (recall Lecture 8); by adopting a subjectivist view of probability, where probabilities are analysed simply as agents' degrees of belief rather than objective quantities fixed by the world, one supposedly avoids these perplexities.

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2. One thereby (supposedly) makes some headway with regard to certain knotty issues in the foundations of quantum mechanics—in particular, issues to do with the measurement problem and non-locality, as we've already seen. These problems are not so much resolved as dissolved in this setting; they do not arise in the first place.

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- We imagine Wigner's experimentalist friend in a lab, about to perform (say) a measurement in the z-direction on a spin-half system prepared in an eigenstate of spin in the x-direction.
- Wigner himself remains outside the lab. The experiment is performed. What state should the friend assign to the system and apparatus? What state should Wigner assign?

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But who is right?

Exercise: Think through what our three standard realist approaches to the measurement problem would say about this case.

QBism and the measurement problem, non-locality, etc.

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- Is Wigner or his friend correct, for the QBist?
- Answer: *neirther*, because the quantum state never represented anything physical to begin with!
- A similar putative resolution goes for puzzles about e.g. non-locality and the EPR experiment.

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Let's assess each of these in turn.

Objection 1: Solipsism?

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- *Solipsism* is the view that only my mind and my mental states exist, there is no external world and there are no other minds.
- QBism has often faced the charge that it is solipsistic.

The argument for solipsism in QBism

1. A quantum state is *my* sets of degrees of belief.
2. Everthing is made out of matter characterised quantum mechanically.
3. Therefore, everything reduces to my sets of degrees of belief.
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In other words, QBism does *not* reduce everything to the quantum state and so this argument doesn't get off the ground.

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  The non-realist view of the state is not the end point of the proposal, closing off further conceptual or philosophical enquiry about the nature of the world or the nature of quantum mechanics, rather it is the starting point. Thus it would be misguided to attack the approach as being instrumentalist in character. (Timpson 2008, p. 592)

Intermezzo: is QBism realism?

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QBism only uncontroversially holds onto metaphysical realism—possibly alongside some attenuated epistemic realism.

Objection 3: Worries about Wigner's friend

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2. These different states, however, correspond to different predictions for joint measurements on system and apparatus in the lab; and surely we can just test these predictions (at least in principle) to see who is right.
3. Given that, the QBist must be in error when they submit that Wigner and friend can disagree unproblematically: on the contrary, one is right and the other is wrong.

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> *With subjective Bayesian probabilities the facts do not determine or make right or wrong a probability assignment, so there is no measurement one could do which would show one assignment or the other to be wrong. This illustrates a general property of the quantum Bayesian position. No objection can be successful which takes the form: 'in such and such a situation, the quantum Bayesian position will give rise to, or will allow as a possibility, a state assignment which can be shown not to fit the facts,' simply because the position denies that the requisite kinds of relations between physical facts and probability assignments hold.* (Timpson 2008, p. 593)

Objection 4: QBism and PBR

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However, QBists maintain that there is no problem here, because on Ψ-epistemic approaches the quantum state ψ encodes ignorance of the ontic states λ, whereas QBists situate themselves entirely outside of the ontological models framework, and the quantum state encodes *only* subjective degrees of belief.

QBists on the PBR theorem

The PBR theorem does no damage to QBism. PBR say so themselves at the end of their paper. This is because what they demonstrate is the inconsistency of the idea of holding epistemic quantum states at the same time as holding that they are epistemic about *ontic states. In QBism, quantum states represent one's beliefs, not about some ontic variable, but about one's future* personal *experiences which come in consequence of taking an action on the external world. I.e., they are epistemic (or better, doxastic)* about *personal experiences.* (DeBrota & Stacey 2019)

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What to make of these?

Objection A: What's the ontology?

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Can we make out any kind of reasonable ontology for QBism? The worry here is that

> *the really crucial conception is that what (singular) event will occur when a system and a measuring device interact is* not determined by anything*, not even probabilistically.* (Timpson 2008, p. 595)

Fuchs' response to the worry

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> *For my own part, I imagine the world as a seething orgy of creation [...] There is no one way the world is because the world is still in creation, still being hammered out. It is still in birth and always will be [...]* (To Sudbery-Barnum 18.8.03)

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- It seems that the QBist *does* have things to say here, and they might even be interesting things.
- Nevertheless, can we not do better than a broadly (but not wholly) ineffable micro-ontology of this kind?

Objection B: QBism and explanation

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> *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)

The need for scientific explanations

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- It is hard to see how, if QBism were correct, we could have the kinds of explanation involving quantum mechanics that we certainly do seem to have.
- To put the point another way (in Einstein's terminology from 1919—see IPP SR), constructive (microphysical) explanations don't seem possible on QBism!

Timpson on the explanatory deficit

> *The point can be put in terms of an explanatory deficit: if we insist on the capacities-first picture, then the only explanation we have of why stable hydrogen atoms are possible is this: 'Protons and electrons are endowed with the capacity to form stable atoms under certain conditions'. This is laughably meagre explanatory fare (close to a 'dormitive virtue'-style explanation) when compared to the richness that follows when one begins with the thought that these systems are governed by the Schrödinger equation and proceeds to explore quantitatively as well as qualitatively exactly how and why stable conditions of various kinds arise.* (Timpson 2008, p. 601)

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Question: Even if we agree that *constructive* explanations are unavailable on QBism, does it follow that other scientific explanations are also unavailable on the account?

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- But these claims are question-begging against QBists, who take themselves to be in possession of a perfectly adequate account of probabilistic reasoning in quantum mechanics.

Objection C: Is subjective Bayesianism acceptable within quantum mechanics?

- Some (but not all! Recall Lecture 8) aver that there *must* be objective probabilities in quantum mechanics—for what are (say) decay rates of radioactive materials, if not objective?
- But these claims are question-begging against QBists, who take themselves to be in possession of a perfectly adequate account of probabilistic reasoning in quantum mechanics.
- But there nevertheless remain related worries in this vicinity which are worth exploring.

Moore's paradox

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> *Straight contradiction is avoided, runs the thought, because the first half of the sentence is used to state something about the world external to myself, while the second half is used to state something about me: the two halves are not quite talking about the same thing. Then what is wrong about these* Moore's paradox sentences*, what makes them uncomfortable and paradoxical, is not that they are nonsense or contradiction, but that they force one to* violate the rules for the speech act of sincere assertion. (Timpson 2008, p. 602)

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But then this generates the following Moore's paradox-like oddity for the QBist:

> *"I am certain that p (that the outcome will be spin-up in the z-direction) but it is not certain that p."*

Possible QBist response to quantum Moore's paradox

- In response to this problem, QBists might follow White (1972, 1975) in distinguishing between the *certainty of people* and the *certainty of things*.

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- Nevertheless, one might think that the problem speaks to a worry that in the QBist setting, something has gone wrong regarding the relation between the reasons one can have and one's beliefs; in how one's reasons could be good bases for action.

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Next time: quantum pragmatism and relational quantum mechanics.

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