BEING BAYESIAN IN A QUANTUM WORLD

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Abstract

To be Bayesian about probability theory is to accept that probabilities represent subjective degrees of belief and nothing more. This is in distinction to the idea that probabilities represent long-term frequencies or objective propensities. But, how can a subjective account of probabilities coexist with the existence of quantum mechanics? To accept quantum mechanics is to accept the calculational apparatus of quantum states and the Born rule for determining probabilities in a quantum measurement. If there were ever a place for probabilities to be objective, one might think it precisely here! (And many do.) This raises the question of whether Bayesianism and quantum mechanics are compatible at all. For the Bayesian, it only suggests that we should rethink what quantum mechanics is actually about. Is it "law of nature" or really more "law of thought," though "law of thought" conditioned by the particularities of our world?

From transistors to lasers, the evidence abounds that we live in a quantum world. However, one should not confuse the quantum WORLD with quantum THEORY. In particular, one should not jump to the conclusion that wave functions are as successful as calculational tools as they are because they mirror some kind of elements of reality. A more Bayesian-like perspective is that if wave functions generate probabilities, then they too must be Bayesian degrees of belief, with all that such a radical idea entails. In particular, quantum probabilities have no firmer hold on reality than the word "belief" in the phrase "degrees of belief" already indicates. From this perspective, the only sense in which the quantum formalism mirrors nature is through the normative constraints it places on gambling agents who wish to better navigate through this (quantum) world in which they are immersed. It might be thought that this is rather thin information about nature itself—and thus that the whole view collapses into a kind operationalism or positivism—but the information is not insubstantial! To the extent that an agent should use quantum mechanics for his uncertainty accounting rather than some other theory tells us something about the world itself—i.e., the world independent of the agent and his particular beliefs at any moment. In this talk, I will try to shore up these ideas by showing what quantum mechanics looks like when represented using probability simplexes rather than Hilbert spaces. It can be done, and when done, one starts to get a feeling for how little quantum theory deviates from Bayesianism after all.