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What could be objective about probabilities?☆

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Abstract

The basic notion of an objective probability is that of a probability determined by the physical structure of the world. On this understanding, there are subjective credences that do not correspond to objective probabilities, such as credences concerning rival physical theories. The main question for objective probabilities is how they are determined by the physical structure.

In this paper, I survey three ways of understanding objective probability: stochastic dynamics, humean chances, and deterministic chances (typicality). The first is the obvious way to understand the probabilities of quantum mechanics via a collapse theory such as GRW, the last is the way to understand the probabilities in the context of a deterministic theory such as Bohmian mechanics. Humean chances provide a more abstract and general account of chances locutions that are independent of dynamical considerations.

Keywords: Probability; Typicality; Stochastic dynamics; Bohmian mechanics

1. Objective probability 1: Stochastic dynamics

Systems evolving in time are governed by a dynamics: Laws concerning how the state changes with time. In a deterministic system, specification of the state of the system at one time together with the dynamics determines the state at later times.[1] In an indeterministic system, the state of a system at one time and the laws are jointly compatible with different

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[1]There are all sorts of subtleties here that will not much concern us. The *locus classicus* for a discussion is John Earman's *A Primer on Determinism* (1986).

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states at later times. In a stochastic dynamics, these various possible evolutions of the system are assigned different probabilities.

Stochastic dynamics has been most strongly associated, in the history of physics, with quantum theory ("God plays dice"). And many of the ways of understanding that theory (although not all) do employ a stochastic dynamics. It is often said, for example, that there is absolutely no preceding feature that determines exactly when a radioactive atom will decay: Two such (isolated) atoms could be *perfectly identical in all physical respects* at one time yet decay at different times in the future. If so, then their dynamics is indeterministic.

There is, however, still a probabilistic law that is supposed to govern these decays. In particular, there is supposed to be a fixed probability density (i.e., a fixed probability per unit time) that an atom will decay. Such a fixed probability density leads to the usual exponential decay formula, and underwrites the assignment of a *half-life* to each species of radioactive atom. The half-life is the period of time, from a given starting point, it takes for the atom to have had a 50% chance of decay.

This probability is postulated to be an objective feature of the physical system, independent of the strength of anyone's belief in anything, and so independent of any subjective credence. It is supposed to have a precise value, for which one seeks experimental verification. One might quibble about whether there is a precise real number that can be assigned to the probability density, but one cannot deny that half-lives are determined, experimentally, to within parts-per-ten-thousand. The half-life of tritium, for example, is about 4499 days.[2] Further experimentation could refine the number by some orders of magnitude, if not indefinitely. What one appears to be finding out about by these experiments has nothing to do with the existence of cognizers and their beliefs.

The most straightforward account of this probability density appeals to fundamentally stochastic dynamical laws. Doubtless the behavior of tritium is a consequence of the laws governing its sub-atomic constituents, but that complication need not detain us: If the fundamental laws are irreducibly stochastic, then they can either directly assign or indirectly entail a probability density for decay, and hence allow one to calculate the likelihood of decay for any tritium atom over a specified period of time. The laws would allow initially identical tritium atoms to decay at different times, assigning a probability to a decay within any specified period. The probabilities involved, as they are *transition chances*, are *conditional* probabilities: They specify how likely it is that a system will evolve in a certain way *given that it started in a particular physical state*.

At this point in the narrative, the usual philosophical move would be to allow that the notion of irreducibly stochastic dynamical laws is clear enough for the practical uses of physicists, but still involves some deep metaphysical questions, or confusions, or unclarities, which is the job of the philosopher to articulate and resolve. I hold no such brief. I think that the notion of irreducibly stochastic dynamical laws, as postulated by physicists, is perfectly clear and requires no philosophical elucidation at all. It is rather the other way around: The evident coherence and clarity of the notion of fundamental transition chances can be used to help diagnose philosophical confusions.

What does the physicist do with a postulated stochastic dynamics? The game, once the dynamics is postulated, is to assign probabilities to various possible physical histories, given an initial state. In the case of the single tritium atom, this means assigning probabilities to decays in any specified interval of time, which we know how to do. Any

[2] See Lucas & Unterweger (2000). The value seems to lie between 4499.3 and 4499.6 days.