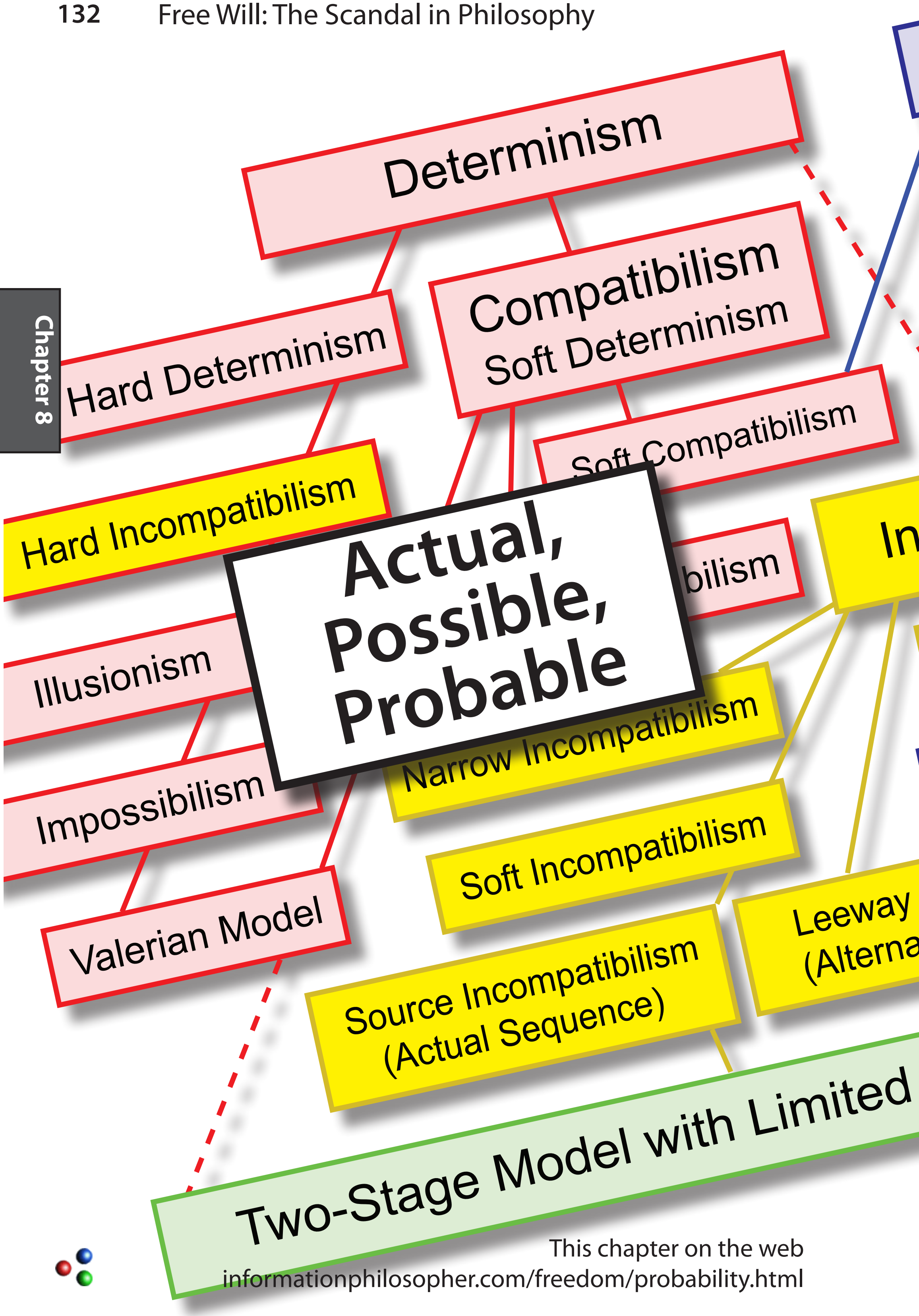
Actual, Possible, Probable



This chapter on the web
informationphilosopher.com/freedom/probability.html

Actual, Possible, Probable

As a philosopher who was trained in physics, I think I can see why philosophers trained in logic may be uncomfortable with libertarian solutions to the problem of free will that involve indeterminism and uncertainty, ontological and objective chance.

So, before we leave the history of our problem, let's take a brief look at the history of chance. I believe it can provide powerful insights for thinkers who work in logic and language alone.

At the very beginning of our problem, in the 5th century BCE, we find the first **determinist** philosopher, LEUCIPPUS, denying randomness and chance.

> "Nothing occurs by chance (μάτην), but there is a reason (λόγου) and necessity (ἀνάγκης) for everything." [1]

A century later, the first **indeterminist** philosopher, ARISTOTLE, embraced chance, but he worried that it was obscure and unintelligible. In the *Metaphysics,* Aristotle makes the case for chance and uncaused causes (*causa sui*).

"Nor is there any definite cause for an accident, but only chance (τυχόν), namely an indefinite (ἀόριστον) cause." [2]

Aristotle's description of chance as "obscure" (ἄδηλος) to reason led centuries of philosophers to deny the existence of chance:

> "Causes from which chance results might happen are indeterminate; hence chance is obscure to human reason and is a cause by accident (συμβεβεκός)." [3]

And another century later, we find the first **compatibilist** philosopher, CHRYSIPPUS, warning of the calamity that would happen if even one chance event were to occur.

> "Everything that happens is followed by something else which depends on it by causal necessity. Likewise, everything that happens is preceded by something with which it is causally connected. For nothing exists or has come into being in the cosmos

1 Leucippus, Fragment 569 - from Fr. 2 Actius I, 25, 4
2 Metaphysics, Book V, 1025a25
3 Metaphysics, Book XI, 1065a33

> without a cause. The universe will be disrupted and disintegrate into pieces and cease to be a unity functioning as a single system, if any uncaused movement is introduced into it." [4]

The cosmos that we have is actually built on top of a microscopic chaos that was the case from the beginning of the universe. The challenge for philosophy - and physics, one that is addressed by information philosophy, is to understand the cosmic creative process that has generated and maintained the visible macroscopic order, in the continuous presence of noise and irreducible chance in the microcosmos.

We shall see that the order is the result of laws of nature, as the ancients thought. But today laws are only probabilistic and statistical (I will define the difference between probability and statistics).

The laws only appear to be certain and deterministic because of the law of large numbers in probability and the correspondence principle (or law of large quantum numbers) in physics.

We saw that Heraclitus wanted a law or an account (logos) behind all change and that Anaximander said the universe must have a "cosmos-logos." Philosophers divided on the question of whether change (becoming) was real (being). Plato sided with Parmenides on the idea that Truth could not change. Some concluded that logically true statements could have controlling power over the future. The "dialectical" philosopher Diodorus Cronus developed his language game to show that the future is determined by true statements about it. Diodorus specialized in puzzles like the sorites paradox - how many grains does it take to make a heap.

But future contingency seemed more like a problem than a puzzle. It remains actively discussed as a defense of **fatalism** by philosophers like Richard Taylor, Peter van Inwagen, and David Foster Wallace.

Diodorus is an "**actualist**." His Master Argument (κύριος λόγος) can be translated as the "authorized, proper, real, or actual" argument. According to it, there is only one possible future. The Master Argument is the granddaddy of all logical, nomological,

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4 Chrysippus

and perhaps even theological arguments for determinism. The Greek for “Master” (κύριος) translates the Hebrew Ba’al (Lord) in the Bible.

The Actual

The first serious philosophical discussion of the actual and the possible was that of Aristotle, and it is the denial of the possible in Aristotle’s sense (the potential) that forms the core of my argument that is a scandal to deny this kind of potential to our students. So let’s look start with Aristotle’s concepts for the actual.

Aristotle uses two words for the actual (one he invented). They both have the sense of “realized.” The first is energeia (ἐνέργεια), which means an action that is the result of work (ἔργον) or a deed (as opposed to words - ἔπος). Energeia also has the meaning of modern energy (that does work). Its Indo-European root *werg-* is the source of our word for work (German Werk).

Aristotle’s invented word for action is entelecheia (ἐντελεχεία). He built it from en (in) + telos (end or purpose) + echein (to have). An act then has fulfilled and realized its end.

Note that an action has normally happened. One can talk about a hypothetical action in the future, of course, but Aristotle’s meaning carries the sense of something that is completed and is now in what modern philosophers call the “fixed past.” The actual contrasts with the possible, which is something that has not yet happened.

Actualists believe that everything that is going to happen is already actual in some sense (because it is a true statement that it will happen, because its cause is already present, because it is physically determined, because God foreknows it, etc.)

The Possible

Aristotle’s word for the possible was dynamis (δύναμις), power, capacity, or capability. The Romans translated it as *potentia*, thus our potential. Aristotle contrasts actuality to potentiality in Metaphysics, Book IX, saying that “we call a man a theorist even if he is not theorizing at the moment. He has the capacity to theorize.[5]

5 Metaphysics, IX, 1048a35

Aristotle chastises thinkers like Diodorus who say that an agent cannot act when he is not acting. They deny the potential for acting. They believe only the actual is possible. So an agent not acting cannot possibly act. Aristotle said it is easy to see the absurdity of this idea.

But ancient and modern actualists continued to pursue this absurd idea. Just as you cannot change the past, you cannot change the one possible future. "Change it from what to what?," asks Daniel Dennett, for example.

The Probable

The subtle difference between provable and probable marks a critical distinction between logical philosophers and mathematicians, on the one hand, and scientists on the other. The former is the realm of certainty, of absolute truths, of determinism. In the latter we find uncertainty, relative doubts, indeterminacy, and, above all, chance.

Both words derive from the same Latin verb, *probare*, to test, from the noun *probus*, good. The ancient Indo-European word is formed from two roots that mean pro (forward) and be (to be, to exist, to grow).

About the same time that Isaac Newton was discovering his laws that provided the foundation for physical determinism, mathematicians were discovering the laws of probability. One might think that studying the "doctrine of chances," they would have been circumspect about the certainty of their results. But, being mathematicians, they had no doubts whatsoever.

As hard as it seems to believe, the mathematicians who gave us probability did not think that objective, ontological chance was real. On the contrary, they believed deeply that chance was merely epistemic, human ignorance, the product of finite minds, by comparison with the infinite mind of God.

Chance is atheistic. It questions God's omniscience.

The Bernoullis, De Moivre, Laplace, Legendre, and Gauss all knew that random events are distributed in what Charles Sanders Peirce first called a "normal distribution," the familiar bell-shaped curve.

Abraham de Moivre (1667-1754) was regarded by Newton as the greatest mathematician in England, but being a French Huguenot refugee, he could not find work, so made his living selling a gambler's handbook entitled *The Doctrine of Chances*, in which he derived most of the famous formulas of probability that are associated with better known mathematicians like Laplace and Gauss. His first sentence tells us everything we need to know.

> "The Probability of an Event is greater or less, according to the number of Chances by which it may happen, compared with the whole number of Chances by which it may happen or fail." [6]

De Moivre's assumption is that the events are random, independent of one another, and that they are equiprobable. Equiprobability means that no information exists to make one more probable than another. This is sometimes called the principle of indifference or the principle of insufficient reason.

If contrary information did exist, it could and would be revealed in large numbers of experimental trials, which provide "statistics" on the different "states."

Probabilities are *a priori* theories.
Statistics are *a posteriori,* the results of experiments.

In his book, de Moivre worked out the mathematics for the binomial expansion of $(p - q)^n$ by analyzing the tosses of a coin.

If p is the probability of a "heads" and q = 1 - p the probability of "tails," then the probability of k heads is

$$Pr(k) = (n!/(n - k)!\, k!)p^{(n - k)}q^k$$

He also was the first to approximate the factorial for large n as

$$n! \approx (\text{constant}) \sqrt{n}\, n^n e^{-n}$$

6 De Moivre (1756) p. 1.

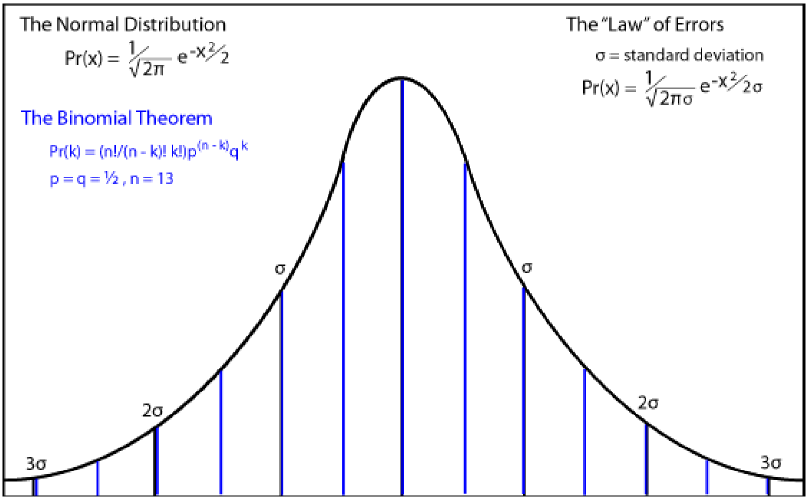

Figure 8-1. De Moivre's binomial expansion (vertical lines) and his continuous approximation, the normal distribution. This became the "law" of experimental errors.

De Moivre then fitted a smooth curve to the probabilities Pr(k) and was the first to derive the "normal" bell curve. [7] De Moivre also derived the "central limit theorem," that in the limit of large numbers of independent random events, the distribution asymptotically approaches the normal,

When social scientists started to collect statistics on various human activities like births, deaths, marriages, and suicides, they found distributions remarkably like the above curves. They might have concluded that individual human characteristics are distributed randomly, by chance. But they decided just the opposite. Perhaps seduced by the idea that the regularities they found were "lawlike," they illogically concluded that human characteristics must be determined, but some unknown laws, to produce these "lawlike" regularities.

Immanuel Kant argued this as early as 1784, suggesting that it undermines the concept of free will..

> "No matter what conception may form of the freedom of the will in metaphysics, the phenomenal appearances of the will, i.e., human actions, are determined by general laws of nature

7 For an animation of how discrete probabilities become continuous, see De Moivre's I-Phi web page. informationphilosopher.com/solutions/scientists/de_moivre

> like any other event of nature...Thus marriages, the consequent births and the deaths, since the free will seems to have such a great influence on them, do not seem to be subject to any law according to which one could calculate their number beforehand. Yet the annual (statistical) tables about them in the major countries show that they occur according to stable natural laws... Individual human beings, each pursuing his own ends according to his inclination and often one against another (and even one entire people against another) rarely unintentionally promote, as if it were their guide, an end of nature which is unknown to them." [8]

As we saw in Chapter 7 (p. 91) , the social scientists Adolphe Quételet and Henry Thomas Buckle developed this idea to claim that the "laws of human nature" are as deterministic as those of physical nature.

Then in the mid-nineteenth century, the scientists James Clerk Maxwell and Ludwig Boltzmann showed that, by analogy with the social laws, that the regular macroscopic properties of gases, including the "gas laws" describing pressure, volume, and temperature, could be derived on the assumption that the motions of individual gas particles were independent random events. The famous "Maxwell-Boltzmann distribution" is essentially identical to Figure 8-1.

At that point, some laws of classical physics appeared to be statistical laws only. And in the twentieth century, quantum mechanics showed that the laws of physics are irreducibly probabilistic.

So today, we can say that the laws of nature are fundamentally indeterministic, although chance shows up primarily in the microscopic world. Regularities that we see in the macroscopic world, including the laws of classical physics, are the results of the central limit theorem and the law of large numbers of independent physical events.

The information that we gain from probabilities in quantum physics turns out to be surprising and non-intuitive. Before we return to the subject of free will, we need to build on our

8 Idea for a Universal History with a Cosmopolitan Intent.

understanding of classical probabilities to explain the mysterious properties of quantum-mechanical wave functions, which some philosophers think can help us understand major philosophical problems like consciousness and free will.

Quantum Probabilities

The probabilistic nature of quantum physics is captured perfectly in the "wave function," which propagates in space and time to tell us the probability of finding a quantum particle at any given point and time. It is the quantum equivalent of Newton's equations of motion for a classical particle, which we imagine is localized at all times and is travelling in a well-defined path, like a billiard ball across a pool table.

The wave function, on the other hand, diffuses from a starting point where the particle is initially localized, travelling in many directions at the speed of light. In principle, given enough time, and without an experimental measurement that localizes the particle, the wave function fills all space. This means simply that there exists some probability of finding the particle anywhere within its relativistic light cone.

At the 1927 Solvay conference, Albert Einstein went to the chalkboard to complain that when a particle is measured, on the right side of the room, for example, the finite probability of finding it on the left side of the room, which existed an instant earlier, has collapsed at a speed faster than light to the right side.

Clearly, the new quantum mechanics violates his special theory of relativity, he said. Then, eight years later, he and his Princeton colleagues, Boris Podolsky and Nathan Rosen, argued that two particles initially localized at a central point and described by a single wave function propagating from that central point would have an even stranger property. If one particle was found, say again on the right side of the room, we would instantly know where the other particle was, on the left side.

How, they asked, could local information on the right side travel instantly to affect the distant particle on the left side, again, faster than the speed of light. Einstein suggested that quantum reality has a "non-local" property. Although Einstein never accepted this aspect of quantum theory, the non-locality has been confirmed in many experiments first suggested by John Bell as tests of his Bell's Theorem.

Let's see how information philosophy explains the apparent infinite speed of information transmission when a wave function "collapses. Figure 8-2 shows the famous "two-slit" experiment. The wave function for a particle is travelling through the two slits and interfering with itself, as waves do. The "interference pattern" at the screen predicts the likelihood of finding particles at different places along the screen. This pattern is statistically confirmed by thousands of experiments, one particle at a time.

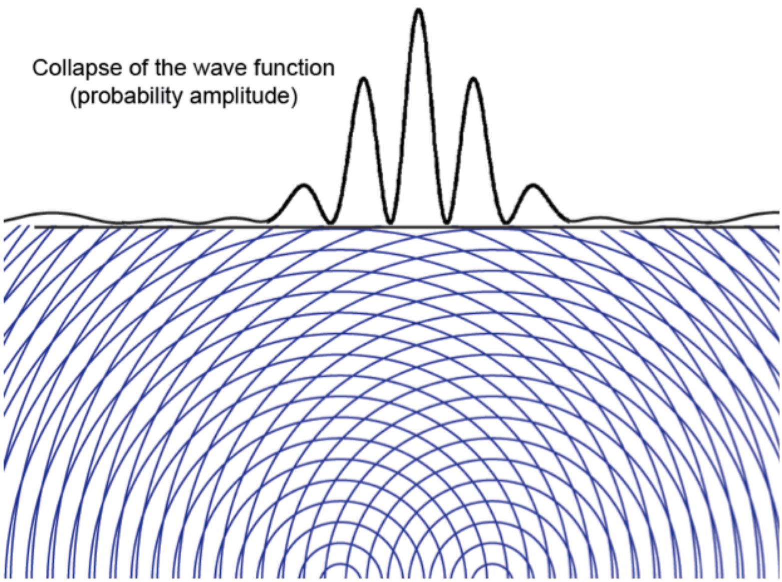

Figure 8-2. The two-slit experiment

Now what happens when the experiment captures a particle at a specific location on the screen, say on the right side somewhere. This experiment could be very large, in principle many miles across, as current tests of nonlocality are achieving. What happens to all that probability on the left side?

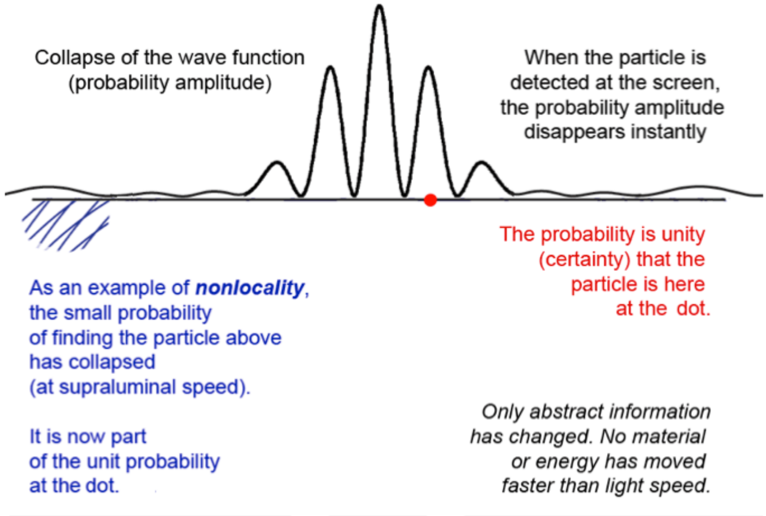

Figure 8-3. The wave function has collapsed.

The information philosophy explanation of the collapse of the wave function is that no matter or energy has been transferred from one place to another. It is only **information** about probabilities that changed. Note that the information has not been *transmitted* from one place to another. That would allow faster-than-light signalling.

New information enters the universe when a measurement is made that locates the particle at a specific point on the screen. At that moment, the probability of finding the particle anywhere else collapses to zero. We can better understand this by considering a macroscopic example. Consider a horse race.

When the nose of one horse crosses the finish line, its probability of winning goes to certainty, and the finite probabilities of the other horses, including the one in the rear, instantaneously drops to zero. This happens faster than the speed of light, since the last horse is in a "spacelike" separation from the first.

Figure 8-4. The probability of a trailing horse winning collapses instantly.

Note that probability, like information, is neither matter nor energy. When a wave function "collapses" or "goes through both slits" in the dazzling two-slit experiment, nothing physical is traveling faster than the speed of light or going through the slits. No messages or signals can be sent using this collapse of probability.

Actualism, Possibilism, and Probabilism

If actualism gives us only one possible future (and one universe), possibilism is the idea that there are an infinite number of possible futures, each with its own universe. It is ironic to find compatibilist philosophers who deny the **alternative possibilities** essential to libertarian free will, but who embrace David Lewis' picture of "nearby" possible worlds as philosophically important.

Probabilism is the idea that all our knowledge is contingent, based on empirical evidence, hence only statistical and probable. Without possibilities, there is no meaning to probabilities.

Information theory is based on the existence of different possibilities and their probabilities.

Can we see the history of the free will problem as being fought along the actualism-possibilism dimension? Looking back to the traditional determinism-libertarianism-compatibilism taxonomy[9] that we had before Peter van Inwagen changed it to compatibilism vs. incompatibilism, can we see this new dichotomy as justifying the traditional taxonomy?

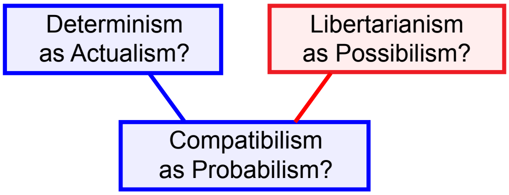

Figure 8-5. Justifying the traditional taxonomy.

In my view, libertarians need possibilism and the underlying indeterminism, uncertainty, and chance that provides our open futures. And compatibilists should consider probabilism.

9 See Chapter 6.