

Probability, Laws, and the Ultimate Fine –Tuning Argument

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Philosophy and Cosmology

- “There is no idea so absurd that it has not been seriously taught by some philosopher”
Rene Descartes
- “Cosmologists are often in error but never in doubt”
Lev Landau

The Ultimate Fine Tuning Argument

The argument that if the laws, constants and initial conditions of a theory that is proposed as a fundamental and complete physical theory of the universe are or have values that are fine-tuned for a salient phenomena (e.g. complexity, life) the theory is incomplete and that completing it may involve hypotheses that are not usually considered parts of science e.g. hypotheses that invoke design, a selector law, or a multiverse. In other words, an adequate theory of reality must leave no fine tunings unexplained.

Possible Universes

- Beginning with Leibniz philosophers have employed the idea of possible universes or worlds to explicate notions in metaphysics, semantics, and science. They also play a central role in discussions of fine-tuning arguments.
- A possible universe is described by a complete distribution of fundamental ontology (e.g. particles, strings, fields etc.) and their properties (e.g. mass, charge, field values etc.) in an n -dimensional manifold (that may have the metrical structure of a space-time) and laws that describe or govern the distribution of fundamental entities and their properties in the manifold. Laws imply true regularities in the distribution of fundamental ontology. All the non-fundamental truths that hold at a possible universe U are entailed by the description of the distribution of the fundamental ontology, properties and the laws at U (and that it is the full fundamental description).

Two Accounts of Possible Universes

- 1. Leibniz and the majority of contemporary philosophers think of possible universes as abstract entities (either complete sets of propositions or maximal properties) one of which describes or is instantiated by the uniquely existing concrete actual universe. So a set of propositions that specify the laws and for each region in the manifold what properties/relations/entities are instantiated at the region represents a possible universe.
- 2. A different view was proposed by David Lewis who argues that the best account of possible universes is that they are not abstract but concrete totalities – the manifolds with their laws and ontologies themselves- one of which is the universe we occupy that we call “the actual universe” while the occupants of other universes if any would be correct to call the universes they occupy “actual.”
- In my discussion I will mostly follow the majority view.

Number and Variety of Universes

- There is a vast number of possible universes -at least as many as the set of real numbers- and plausibly a much higher order of infinity. And there is an immense variety of universes. The laws, the manifold and the ontology and its distribution may differ from those of the actual universe in an enormous number of ways so there are universes that ground any propositions not excluded by logic or metaphysics. It is plausible that there are universes with any number of dimensions, with fields and particles unlike any of the actual world, universes that contain beings that appear to be dragons and talking donkeys, universes with objects that travel superluminally and universes that contain minds but no physical objects at all, universes with no laws, and so on and on and on,.... As long as a description of a distribution of fundamental ontology and laws is logically and metaphysically consistent it can be embedded in a description of a possible universe. The vast variety of possible universes will figure centrally in my reflections on fine tuning.

Why believe there are possible universes?

Philosophers posit possible worlds *not* as a part of a scientific theory intended to explain contingent events or features of the actual universe (as for example, the pocket universes of eternal inflation, the universe of the string landscape, and the worlds of Everettian QM) but rather to characterize the logic, semantics and truth makers of modal propositions- e.g. propositions about necessity, possibility, counterfactuals, probability and so on. They play a role in accounts of laws, causation, chance, fundamentality and, as we will see, in characterizing fine-tuning

Examples:

- a) necessity: It is metaphysically necessary that p iff p obtains in all possible universes;
- b) counterfactuals: if p had been q would have been iff in all worlds that are most similar to the actual world at which p obtains q also obtains.
- c) probability: $P(A)=x$ iff a certain measure on the class of universes at which A is true is x

The Actual Universe

- While the complete and correct account of the physics of the actual universe is not known (since there is no agreed on quantum theory of gravity) and may never be known current physics partly and approximately characterizes it as follows:
 - 1. Fundamental entities and properties: quantum mechanical states that describe entities (fermions, bosons) and fields of the standard model.
 - 2. space-time: described by the metric of general relativity
 - 3. laws: quantum field theory and general relativity (with a very small cosmological constant)
 - 4. Distribution: 14 billion years in the past the particles/fields in the currently observable universe or their precursors were concentrated in a very small rapidly expanding patch of space with a very low entropy distribution that evolved in conformity with the laws to the present state.*
- *If, as some cosmologists claim, there is a multiverse then the actual universe contains many pocket universes.

What are laws? Two views:

- 1. non-Humean: Laws are entities (different from physical entities) that *govern* the evolution of state so as to make certain generalizations (equations) true. (Maudlin, Armstrong)
- 2. Humean: Laws are regularities (equations) entailed by an idea true systematization (a systematization that optimizes scientific virtues; simplicity, informativeness, naturalness, minimizing fine tunings etc.) (Lewis, Hicks, Loewer). This account can be extended to include objective probabilities. The idea is that allowing laws to take the form of assignments of objective probability facilitates the simplicity and informativeness of a systematization.

Physicalism

- Physicalism is the view that there is a complete characterization of the fundamental ontology and properties of the actual universe in terms of physics and that this grounds all other facts about the universe. Some philosophers think there are aspects of the universe that are inevitably left out by physics- in particular aspects involving consciousness. If so then the actual universe contains fundamental mental or proto-mental ontology and/or properties in addition those of physics. But whether or not physicalism is true it is natural to wonder why the physics of the actual universe- the one that exists according to Leibniz- is the way it is. Why does it have the ontology, properties, and laws that it has? Why does its physical laws and ontology support intelligent life?

A Fortunate Universe?

- It may seem that given the vast number and variety of possible universes – many without beauty, intelligent life, life of any kind, or even without stars or anything complex -it is very fortunate that the actual universe has the laws, ontology, and distribution of its ontology that it does to permit the existence of beauty, intelligent life and so on. Luke Barnes in his excellent *A Fortunate Universe* shows that it is easy to describe counterfactual universes by altering the actual laws that would prohibit the existence of life or even complexity. Suppose, for example, that the cosmological constant were negative (the universe would collapse) or much larger (the universe would dilute before stars could form) or if the quark masses differed so the proton's mass were greater than the neutron's mass. In that case atoms would not form.

He asks:

- “if a universe were chosen at random from the set of universes, what is the probability that it would support intelligent life? If that probability is suitably (and robustly) small, then we conclude that that region of possible-physics-space contributes negligibly to the total life-permitting subset.” (Luke Barnes p.18 FT)
- Since Barnes thinks that the probability of selecting a universe with intelligent life is small he thinks that the actual universe is fine-tuned for the existence of intelligent life and this remarkable and fortunate fact cries out for an explanation.

Structure of a Fine Tuning Argument

- The claim that the probability of a salient phenomena E, e.g. the existence of intelligent life, is very low relative to background assumptions B and so “cries out” for an explanation motivates the search for an hypothesis H which explains E and when added to B renders the probability of E much higher i.e. $P(E/B) \ll P(E/B \& H)$. By ordinary Bayesian reasoning it follows from this that E confirms H. So a fine tuning argument for H proceeds by arguing from the fact that without H the allegedly fine tuned E is improbable but with H is probable to the conclusion that H is likely.
- But it doesn't follow that if one thinks that a phenomena cries out for an explanation that it has an explanation.

Bayesian inference

$$P(H/E\&B) = \frac{P(H/B) \times P(E/H\&B)}{P(H/B) \times P(E/H\&B) + P(-H) \times P(E/-H\&B)}$$

The probabilities that occur in Bayes theorem are epistemic (degrees of belief or credences). However for it to be objective that E confirms H the likelihoods $P(E/H\&B)$, $P(E/-H\&B)$ must be objective credences.

Two Faces of Probability
epistemic/physical
subjective/objective



Bayes' Theorem

- The fine tuning argument requires as an input to Bayes theorem not only probabilities of the hypotheses H , $\neg H$ but also an *objective* probability distribution over the set of possible universes (or over the set of universes with the actual laws and constants similar to the actual laws and constants different from their actual values) conditional which assigns a very small probability to E (the actual universe being hospitable to intelligent life) given H and given $\neg H$. These probabilities are supposed to represent the objective credences of a rational inquirer not the subjective credences of an actual inquirer since actual inquirers all assign credence 1 to the existence of life.

Scientific Explanations

- Since the fundamental laws and ontology of the actual world are not yet completely known it may be that some of the constants that appear in the laws and some of the laws in current physics that appear to be fine tuned are explained in terms of more fundamental laws and ontology. If there are fewer constants and laws in the explanans then this may reduce the extent of fine tuning. This is a perfectly acceptable scientific fine-tuning argument. But unless there is only one metaphysically possible set of laws and ontology—a very implausible prospect- there will always remain some constants/laws unexplained i.e. some appearance of fine tuning. So while scientific developments may reduce fine tuning it will not completely eliminate it.

Lewis' Account of Possible Universes and Anthropic Explanations

- On Lewis' account all possible universes exist as a matter of metaphysical necessity so any living being that inquires why she inhabits a life hospitable world has her question answered by "it couldn't be otherwise". However, since there are life hospitable possible universes with very different ontologies, laws, constants from each other there will be no explanations of fine tuning, if any, of these in virtue of there being life. i.e. one cannot conclude anything about the laws/constants merely from the fact that the inquirer exists except that they are compatible with her existence.

Scientific Multiverse and Anthropic Explanations

- The laws and conditions (and in particular eternal inflation) entail that the universe is a multiverse consisting of many “pocket universes” which vary in their initial conditions and values of the constants that occur in laws. The pocket universes correspond to a small proportion of all metaphysically possible universes. Among these “pocket universes” are some that are life hospitable and it is not surprising that we find ourselves in one of these.
- It is implausible that multiverse/anthropic explanations completely eliminate fine-tuning worries since the theories that lead to a multiverse themselves have laws, constants, and initial conditions. And the multiverse creates the problem that without a probability measure over the pocket universes the account is devoid of predictive and explanatory power.

Leibniz's Explanation: Design: The Best of all possible universes

- “God has chosen the most perfect world, that is, the one which is at the same time the simplest in hypotheses and the richest in phenomena, as might be a line in geometry whose construction is easy and whose properties and effects are extremely remarkable and widespread” “.....insofar as it is made up of minds, it is also the best republic, the republic through which minds derive the greatest possible happiness and joy”

Parfit's "selector law" explanation.

- The actual universe satisfies a "non-scientific" selector law. According to Derek Parfit and John Leslie there may laws that determine the nature of the actual universe. For example, a selector law might declare that the actual world is the world that maximizes the variety of kinds of phenomena along with the simplicity of laws that describe the phenomena.
- It is difficult to take seriously either Leibniz's design or Parfit's selector explanations. These laws seem to make false predictions and versions that avoid refutation are non-predictive.

- So neither multiverse nor theological explanations look like promising ways of accounting for fine-tuning for life.
- Rather than pursue them let's look at the presuppositions of the argument that the actual universe is fine-tuned for life and that this fact "cries out for explanation."

Presuppositions of fine tuning and the demand for it to be explained

- “however many ways there are of producing a life-permitting universe, there are vastly many more ways of making a life-prohibiting one. By the time we discover how our universe solves the cosmological constant problem, we will have compiled a rather long list of ways to blow a universe to smithereens, or quickly crush it into oblivion. Amidst the possible universes, life-permitting ones are exceedingly rare. This is fine-tuning par excellence.”
- Barnes argues that most counterfactual universes that are described by altering the fundamental constants that occur in the laws or the laws themselves are inhospitable to intelligent life (life, complexity, etc.) and concludes that life supporting universes are rare and so the probability that a randomly selected world supports intelligent life is very small. But this line of reasoning is doubly mistaken.

Mistake 1

- 1. It doesn't follow from the claim that counterfactual universes in which the constants that appear in the laws of the actual universe have values different from their actual values are inhospitable to life that most possible universes are inhospitable to life. There are infinitely many (at least the size of the set of reals) possible universes and of those there are just as many hospitable to life as inhospitable to life. Take any universe W inhospitable to life and add living creatures (even intelligent living creatures) to make universe W^* . This typically will involve altering the ontology and laws of W (not merely by altering the values of constants in the actual laws). But there is no logical or analytic contradiction in the description of W^* and I know of no metaphysical principle that rules out W^* . Barnes might be right that universes hospitable to life are rare among those that in which the constants that occur in the actual laws are altered but he is wrong that among all metaphysically possible universes the set of life-hospitable universes is smaller than the set of life-inhospitable universes.

Comment

- Barnes notes that his examples of fine tuning mostly involve worlds that are similar to ours....i.e. they consider universes with the same laws but different free parameters and wonders whether this biases the search. He says it does but biases it “in favor of finding life.” Just as its better to search for mushrooms near other mushrooms its better to search for life hospitable universes near the actual universe. But this isn’t correct. In the vast megaverse of possible universes the cardinality of the set of life hospitable universes is the same as the cardinality of life inhospitable universes. As long as laws and ontology can be altered along with the parameters there will be life hospitable worlds with the altered parameter values.

Mistake 2

- The second mistake is the presupposition that there is an objective probability distribution over possible universes and specifically that $P(E/B)$, $P(E/B\&H)$, $P(E/B\&-H)$ represent objective rational credences.
- There is no good reason to think that there is an objective probability distribution over all possible universes. i.e. over all possible laws, values of constants etc.

Two proposals for how a probability distribution can represent objectively rational credences

- 1. Physical probability: If there is a known physical probability $P(E/B)$ then $P(E/B)$ represents an objective rational credence. The link between a physical probability and a rational credences is called “The Principal Principle.”
- e.g. if the QM probability of an x-spin measurement resulting “up” is .5 then your credence should be .5.
- 2. Logic: There is a tradition (Keynes, Carnap, Jaynes) of attempting to characterize epistemically objective credences. An example is the principle of indifference e.g. if your complete information is that one of 3 people committed the murder you should assign equal credence to each.

There is no route to objective probability distribution over the set of universes.

- 1.The probabilities involved in the FTA are not physical probabilities specified by the laws of a true physical theory e.g. quantum mechanics or statistical mechanics since laws vary among the worlds. This is clear since the required probability distribution over worlds assigns probabilities to worlds whose laws differ from the actual laws.
- The FTA probabilities are not frequencies since the frequency of an infinite subset of an infinite set is not well defined.

Objective Bayesianism?

- 2. The principle of indifference leads to contradictions and/or doesn't determine a unique probability distribution when applied to infinite sets. Barnes references E.T. Jaynes' proposal of a sophisticated development of the indifference principle which claims that in certain situations the objective credence distribution is the one that maximizes entropy of a probability distribution subject to objective constraints. But it is not clear how Jaynes' approach applies to the set of *all* possible worlds and set of worlds with intelligent life or, for that matter, why it is rational to assign any probability distribution at all over these sets. The rational attitude seems rather to not assign any probability at all... or as David Albert puts it "I don't have a clue!"

Why we might have come to believe in objectively rational probability distributions.

- One often reads that the Boltzmann probability distribution that grounds statistical mechanical inferences is derived from the application of the principle of indifference. But this is a mistake. The statistical mechanical probability measure is the uniform measure on the phase space conditional on the Past Hypothesis (the proposition that specifies the macro state of the very early universe as having a very low entropy). It is best understood as an empirical probability along the lines of David Lewis' Humean Account of laws and probabilities.

Statistical mechanical probabilities

- Statistical mechanical probabilities match the credences determined by the principle of indifference and the maximum entropy principle in many situations. For example, it is plausible that the statistical mechanical probability of an ordinary symmetrical die landing showing any one of its six faces is $1/6$. I conjecture that we have grown so accustomed (by experience and by evolution) to using the statistical mechanical distribution that we come to believe in objective epistemic probabilities derived from rationality alone. But use of the principle to problems where statistical mechanics doesn't apply leads us astray. This is what happens when we think that rationality recommends a uniform distribution over all metaphysically possible worlds.

Conclusion 1

- The ultimate fine-tuning argument begins with the premise that alterations in the constants that appear in the laws or in the laws themselves yield many more metaphysically possible universes that are life prohibiting than are life hospitable. This is mistaken and based on a misunderstanding of metaphysical possibility. So it cannot be used to support a probability distribution over possible universes which assigns a higher probability to life prohibiting universes than to life hospitable universes. Nor can such a probability distribution be supported by physical probabilities derived from the laws nor are they supportable by a principle of indifference or any other principles of rationality. For these reasons $P(E/B\&H)$ and $P(B\&-H)$ that occur in Bayes theorem are not objective rational credences and the ultimate fine tuning argument collapses.

Conclusion II

- When a physicist sees laws, constants, initial conditions as being fine tuned it is as if she has an itch. Sometimes scratching it relieves the itch. This is what happens when a scientific theory explains the apparent fine tuning e.g. the explanation of why all the planets travel on orbits in the same direction. Sometimes scratching the itch just causes it to itch more. This is what may happen in the case of inflation which was proposed to solve fine-tuning problems of flatness and homogeneity but leads to fine-tuning problems of the inflaton field. And some times the itch is just in our minds. This is the situation of those who are seduced by the ultimate fine tuning argument into looking outside of science for relief.

Are all fine-tuning arguments bad arguments?

- Not all fine tuning arguments are bad

The best of all possible universes

Arguments from fine tuning

- A fine tuning argument points to a problem with a theory T by claiming that T has an explanatory deficit; it leaves something unexplained that should be explained. Consider some phenomenon or event *E* e.g. the existence of stars. Suppose it follows from T that for E to obtain a certain restricted small range of laws L or constants that occur in laws Q or initial conditions I must obtain. So had things been different with respect to these E would not have occurred. Some fine tuning arguments go on to claim that given T L or Q or I are improbable. Either the occurrence of *E* must be regarded as an unexplained coincidence, or else T must be modified or replaced by T* which renders *E* likely to occur rather than an unlikely coincidence.