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How to Make Possibility Safe for Empiricists

John D. Norton[1]
Department of History and Philosophy of Science
University of Pittsburgh
http://www.pitt.edu/~jdnorton

Abstract

What is possible, according to the empiricist conception, is what our evidence positively allows; and what is necessary is what it compels. These notions, along with logical possibility, are the only defensible notions of possibility and necessity. In so far as nomic and metaphysical possibilities are defensible, they fall within empirical possibility. These empirical conceptions are incompatible with traditional possible world semantics. Empirically necessary propositions cannot be defined as those true in all possible worlds. There can be empirical possibilities without empirical necessities. The duality of possibility and necessity can be degenerate and can even be falsified.

1. Introduction

What are "small-e" empiricist[2] philosophers of science, like me, to make of possibilities? They are central to science. Our best theories of gravity and stellar structure tell us that it is

[1] My thanks to Yemima Ben-Menahem, Jeremy Butterfield, Carl Hoefer, Edouard Machery, Brian McLoone, James Norton, Bryan Roberts, Margot Strohminger and Jim Woodward for helpful discussion. They bear no responsibility for the content of this paper other than for failing to talk me out it.

[2] A "small-e" empiricist holds that we can only learn contingent truths of the world from experiences of the world. A "big-E" Empiricist holds the stronger view that these experiences are all we can learn.

possible for a sufficiently massive star eventually to collapse under its own gravity to form a black hole. These same theories tell us that it is impossible to for you or me to escape any of these black holes, once we have passed the event horizon. These claims are truths of our best science, even though almost all of them describe situations that we will never experience and may never be actualized. Since, we can never have direct experience of them, how are empiricists to understand them?

We look for help in answering to the existing philosophical and metaphysical literature on modality. The results are disappointing. From abstract reflections on possibility and necessity, in work extending back to the scholastics, traditional metaphysics calls the extraordinary into existence. There are contingent beings. Their existence is possible, but not necessary. It follows, we are to infer, that some being exists necessarily to bring them about. The existence of this necessary being can in turn be inferred simply from reflection on the concept of perfection itself. The greatest perfection, supposedly, necessitates existence. Whatever notions of possibility and necessity are employed here, they are not amenable to empiricists, who require that contingent truths of the world be derived from experience.

While it is now generally conceded that these traditional metaphysical reflections fail, they retain a place in present philosophy, along with the hope that, somehow, they might be made to work.[3] However, an extraordinary faith in the creative powers of possibility and necessity persists. It has found new life in the talk of "possible worlds" that has recently come to dominate the modality literature. The precise nature and import of these worlds are debated. In the most extreme case, we are assured by David Lewis (1986) that these many possible worlds exist and are as real as our own, even while they may include strange fantasies of the imagination like talking donkeys and magic mountains.

Other avenues now popular are equally puzzling to the empiricist. We are told in an authoritative source[4] that gold must necessarily be the element with atomic number 79 and could

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[3] The two arguments are the "cosmological" and the "ontological" arguments for god's existence. Van Inwagen (2009, Ch. 6-7) provides a contemporary formulation and discussion. He coincedes (p. 141) that all versions of ontological argument depends on some logical error or unsupported premise.

[4] Kripke (1980), pp. 123-25.

not possibly be anything else, such as iron pyrites ("fool's gold"). But these assertions of possibility and necessity merely record our human use of the word "gold." They require no necessities, but merely the empirical discovery of chemists that elements happen to divide by atomic number. Had we decided that "gold" can also designate iron pyrites, our decision would in no way oblige the world to change the possibilities afforded by its chemistry.

To someone with modest empiricist leanings, interested in understanding what is possible in our world, this literature fails to provide an empirically responsible notion of possibility. Indeed, it is both astonishing and alarming for its excesses. It is not a safe place for empiricists.

The present paper has two goals. First, it will seek to provide a lean account of possibility that is amenable to an empiricist and avoids the fantasies rife in the present literature. Second it will argue that this sense of possibility is adequate for scientific applications and that proposals to go beyond it cannot be justified. There are just two notions of possibility: logical and empirical possibility. Section 2 below sketches briefly the logical notion. Since the notion of empirical possibility sought is of possibilities in the world, Section 3 requires in advance that any definition of it must be free of dependencies on our thoughts, beliefs and accidents of our language. Section 4 specifies the defining properties of empirical possibility. The guiding principle is that what is possible is what our evidence positively allows; and what is necessary is what our evidence compels. Since evidential support comes in varying degrees or varying strengths, empirical possibility inherits corresponding gradations.

Sections 5 to 8 develop further properties of this empirical conception. The present literature flattens this inherently gradational notion into just two conditions, possibility *simpliciter* and necessity *simpliciter*. This flattened representation is poorly adapted to the empirical notion and, as a result, familiar truisms of the present literature fail. There can be cases in which there are empirical possibilities, but no empirical necessities other than logical consequences of the evidence. The familiar duality of possibility and necessity proves fragile. There are natural conceptions of empirical possibility in which some proposition can be empirically necessary and its negation may also be empirically possible. "Necessary" is not always "not-possibly-not." Since empirical necessities need not be true in all possible worlds, as standardly defined, familiar possible world semantics fails always to apply. There seems to be no way to restore it without destroying the simplicity essential to its appeal.

Section 9 begins the defense of the second major claim of this paper: that logical and empirical possibilities are all that can be employed responsibly. It lists the main alternative conceptions, several of which are already subsumed by logical and empirical possibilities. The more complicated cases are addressed in subsequent sections. Section 10 argues that empirical possibility is distinct from epistemic possibility. The latter violates a requirement of Section 3: it is defined in terms of beliefs; and it derives possibility from mere ignorance, where empirical possibility requires positive evidence. In Section 11, it is argued that nomic possibility and necessity are properly understood as hypothetical or counterfactual versions of empirical possibility and necessity.

Section 12 addresses metaphysical possibility. Much of what is now described as metaphysics is merely the reporting of results of empirical science. Thus the possibilities provided by this empirical metaphysics lie within the compass of empirical possibility. If metaphysics is to supply a notion of possibility that goes beyond it, the notion has to be derived from a non-empirical body of metaphysical knowledge. I recall the familiar empiricist complaint, tracing back to Hume's fork, that contingent facts cannot be known non-empirically. Further, non-empirical metaphysics attempts an impossible task. It seeks to abstract away the particulars of many cases to recover a universal and enduring conception of some metaphysical category. However, since the variety of cases grows as we learn more of the world, the prospects of a single, unifying conception is correspondingly, continually reducing. Non-empirical metaphysics has insufficient resources to deal with this empirically fueled growth, precisely because it must draw its insight from a non-empirical body of knowledge. A concluding Section 13 speculates on the origin of the present disarray in the philosophical literature on modality.

While there has been little empiricist reaction to the excesses of the present philosophical literature on modality, a welcome exception is Ismael's (2017) "An Empiricist's Guide to Objective Modality." My approach has close affinities with hers. We both offer an empiricist understanding of modality in terms of inductive inference. The main difference lies in our areas of focus. I am more concerned with broader possibility claims made in the general scientific context on the basis of actual evidence. Ismael's focus is on modalities as they appear in the formulation of scientific theories. She writes (p.119):

> Scientific models—on the local and global scale—are embodiments of our very best inductive practices. I am suggesting that the modal content of our models—the

> overlay of laws, dispositions, capacities, and potencies—are to be understood in terms of their role guiding prediction and decision.

This is a welcome perspective which I will use in Section 11 below in the analysis of nomic possibility.

2. Logical Possibility

The empiricist account of possibility to be developed here employs just two senses of possibility: logical and empirical. A proposition is logically possible with respect to the propositions of some body of evidence just if a contradiction cannot be deduced from their conjunction. A proposition is logically necessary with respect to some body of evidence just if the propositions of that body of evidence deductively entail the proposition.

Here, deductive entailments derive from the meaning of the terms used in the propositions. The case of connectives is the most familiar. If "*A* and *B*" is true, it follows logically from the meaning of "and" that *A* is true. There is no need to restrict this sense to connectives. It applies more generally. If Atlas is an intact quadruped, it follows from the meaning of "quadruped" and "intact" that Atlas has four legs. This usage leads directly to cases of logical possibility and necessity. It is logically possible that some quadruped is a four-legged dog. However, a legless snake cannot possibly be a quadruped; that is, it is a logical necessity that it is not a quadruped.

This conception of logic loosely follows the Humean tradition that divides propositions into "relations of ideas" and "matters of fact." The first fits with the conception of deductive logic here. Of it, Hume (1777, p. 18) writes: "Propositions of this kind are discoverable by the mere operation of thought, without dependence on what is any where existent in the universe." The latter "matters of fact" will be associated with empirical possibility.

This sense of logical possibility should be distinguished from a narrower sense in which logical possibility is confined to possibilities authorized by some formalized logic. The first difficulty with this conception is its narrowness. Since there is, as far as I know, no formal logic of quadrupeds, the Atlas inference would be excluded. The second problem is that the set of inferences authorized by extant formal logics is not fixed. It changes whenever someone invents a new formal logic. Finally, its content is not univocal. Truth functional logics admit inferences

that are precluded by relevance logics. Some formal logics eschew contradictions; paraconsistent logics do not. Most curiously, standard modal logics include the duality "possibly = not-necessarily-not." We shall see that this standard identification can fail in the account of empirical possibility developed below.

3. Requirements for an Empiricist Account of Possibility

What I shall call "empirical possibility," the notion defined in an empiricist account of possibility, must satisfy the following requirements.

Empirical possibility is relational.

Since empirical possibility is to express a contingent fact of the world, an empiricist requires that such facts be supported by experience. (Here and henceforth, by "contingent fact" I mean one that is true, but is not a logical truth; that is, it is not true in virtue of the meaning of the terms employed in it.) Since different experiences would in general support different possibilities, these possibilities cannot be made absolute by detaching them from the evidence that supports them.[5]

Empirical possibility is independent of our thoughts and beliefs.

While empiricists hold that we learn of contingent facts of possibility through experience, the notion of possibility sought is of possibilities in the world, independent of what we think, believe and may or may not know. Consequently, empirical possibility, understood as an objective relation among propositions, must be independent of these thoughts and beliefs. An empiricist does expect such facts of possibility to inform our beliefs, so that empirical possibilities should have a central role in belief formation. However they play that role in a subsequent step in the epistemological analysis and is not engaged here. The present goal is to understand empirical possibilities. They are, like the world, independent of our beliefs and thoughts.

Empirical possibility is independent of our language.

While we may use language to express empirical possibilities, the contingent facts expressed should not be facts of language or depend essentially on them. For then they are no longer simply facts of the world. Our use of language can require certain facts of the world to obtain. That the

[5] The standard philosopher's understanding of experience as that which we sense directly is wholly inadequate to explicate how evidence from the world is used in science. Boyd (2018) provides a serviceable, updated account.

element with atomic number 79 has metallic properties follows from the quantum mechanics of its electronic structure. Such a fact is required if the element is to be designated by the word "gold," where gold is presumed to be metallic. But that we use the word this way remains a conventional fact of our language. The view that we cannot separate facts in the world from those of our language is at best a form of epistemic skepticism and at worst a form of idealism. Since both excesses can be avoided, we should.

4. Empirical Possibility

The guiding principle for the notion of empirical possibility is this: what is possible is what our evidence positively allows; and what is necessary is what our evidence compels. A version of this notion, restricted to deductive relations, had already been identified by Lewis and Langford (1959, p. 161) in their work which introduced the modal logic S5. They distinguish the strictly logical notion of possibility in their treatment from the "colloquially more frequent," relative conception:

> In this second sense, "possible" means "consistent with the data" or "consistent with everything known"; "impossible" means "not consistent with the data, or with what is known"; and "necessary" means "implied by what is given or known."

The notion is implemented here as a relation defined on some set of propositions over which there are relations of inductive support. Some subset of the propositions comprises the evidence and other propositions, commonly but not always outside the set, enter into the relation of empirical possibility with them. This relation has the following properties.

> *Empirical possibility is evidential support.* A contingent[6] proposition is a possibility with respect to the propositions of a body of evidence just in case the evidence provides inductive support for the proposition to any extent, or, optionally, sufficient[7] inductive support.

Here inductive support is understood in the general sense of ampliative inference. It is an objective relation over propositions, understood as abstract, specifications of states of affairs, and

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[6] A contingent proposition is here taken to be one that may be either true or false according to the state of the world. That is, its truth or falsity is not compelled by the meaning of the terms in the proposition.

[7] This option concerning a sufficient level of inductive support will be elaborated below.

obtains whether humans know of them or not. In this sense it satisfies the conditions of Section 3.

In a common Bayesian account of inductive support, a proposition is supported by a body of evidence to the extent that the evidence increases the probability of the proposition; or alternatively accords non-zero probability to it. This account, I have argued at length elsewhere[8], is only one of many accounts of inductive support, where the choice of the applicable account is determined by the prevailing background facts of the particular situation. These background facts may not warrant the introduction of probabilities, but some other inductive logic. In general, there is no universally applicable logic of induction. The warrant for an inductive inference or relation of inductive support resides in the facts of the domain of application.

> *Empirical possibility comes in degrees or varying strengths.* This follows since empirical possibility is measured by inductive support, which comes in varying degrees or strengths that need not be numerical.

Relative to the evidence of how stars form, it is possible that two stars in some neighborhood of a galaxy have the same mass, within some narrowly specified window of error. The possibility strengthens successively as we consider larger and larger neighborhoods of the galaxy. This follows since the evidence of how stars form provides successively stronger support for the proposition of equally massive stars as the neighborhood grows.

A notion of empirical necessity can be introduced as:

> *Empirical necessity is evidential compulsion.* A contingent proposition is empirically necessary with respect to the propositions of a body of evidence if its inductive support rises above some high but otherwise arbitrarily chosen threshold.

There is a further natural property of empirical necessity:

> *Empirical necessity includes logical necessity as a limiting case.* If the evidence deductively entails a contingent[9] proposition then, by empiricist lights, it is supported in the strongest way.

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[8] In Norton (manuscript) and earlier papers cited there.

[9] The restriction to contingent propositions is needed since it is usually held that any body of evidence deductively entails a tautology. Without the restriction, we could then find that, on the evidence of a coin toss, it is empirically necessary that either dinosaurs once lived or dinosaurs

However logical compatibility without inductive support is not included as a limiting case of empirical possibility. For a proposition can be logically compatible with a body of evidence while the evidence is irrelevant to the proposition. (This point will be developed further below in Sections 6 and 10.2.)

Assigning mere empirical possibility to some proposition, without inclusion of the strength of support, discards much of the useful content of empirical possibility. The same label—"empirical possibility"—would be assigned to a proposition that has only the slenderest of support on the evidence; and to one that enjoys strong support. It fails to separate the barely possible from the quite possible. The present literature[10] employs this flattened notion. More precisely, it represents the great variability of possibility inadequately by reducing the variability to two modes only: possibility and necessity. These states are treated as interdefinable, dual quantities, connected by the duality relations for any proposition *P*:

possibly *P* iff not necessarily not *P*

necessarily *P* iff not possibly not *P*

These duality relations need not be satisfied by the notions of empirical possibility and necessity as defined so far. While we shall see that failure below in Section 7, in order to maintain continuity with the present literature, we can optionally add further conditions that enable the notions of empirical possibility and empirical necessity to satisfy these duality relations in many cases. This is achieved by invoking the "sufficiency" option offered above. That is, we require a minimum threshold for the inductive support accrued to a proposition before it is declared empirically possible:

> *Optional possibility threshold.* A contingent proposition is empirically possible with respect to some specified body of evidence if its support rises above some low, but otherwise arbitrarily chosen threshold of support.

The duality relations are realized by requiring the threshold for empirical necessity to be adapted to the threshold for empirical possibility in just the way the duality relations require:

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once did not live. This awkward result would arise in a set of propositions concerning coin tosses and dinosaurs, but where the evidence consists only of propositions about coin tosses.

[10] Kment (2014, p.2) is a welcome exception in the literature that allows for degrees of possibility.

Optional threshold matching for duality relations. The thresholds for empirical possibility and empirical necessity are set such that: (i) the negation of any empirically necessary proposition in not empirically possible, and (ii) the negation of any empirically possible proposition is not empirically necessary.

These thresholds are most easily defined when support is probabilistic. However non-numerical senses of strength of support can still be strong enough to sustain this sense of empirical necessity.

In the probabilistic case, we might choose a threshold of 0.001 for probability. Then, given the evidence of ten, independent, fair coin tosses, it is not empirically possible that there are no heads among the ten tosses and it is empirically necessary that there is at least one head.[11] Probabilistic measures for the thresholds are not needed, however. On the collected evidence of the energetics of ordinary systems, it is very likely that a proposed designed for perpetual motion machine will fail. That is the failure is empirically necessary and, under the matching condition, its functioning as designed is impossible. This judgment is readily made without the need for any assignment of probabilities.

It is best not to become too attached to this implementation of the duality. We shall see below in Section 7 that this implementation is fragile. The duality is degenerate in cases in which there are possibilities but not necessities. If we drop the requirement of a threshold for possibility, then we can have cases in which the duality is contradicted. The better notion is just that of possibility, where possibility comes in varying strengths according to the strengths of support provided by the evidence. Necessity is still the case of very high support, but possibility and necessity need no longer conform with the duality relations.

This much already provides a serviceable account of possibility. However, it is unable to preclude fantasies like the possibility of magical wizards in other universes with powers of levitation. The proposition of such wizards is possible in relation to a fantasy body of evidence from such universes, replete with reports of caped figures with mysterious powers. To preclude such cases, to put "empirical" firmly into the account, there is a final condition:

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[11] The probability of no heads in ten tosses is $(1/2)^{10} = 0.0009766$ and of at least one head in ten such tosses is $1 - (1/2)^{10} = 0.9990234$.

Evidential actuality: The relation of empirical possibility only employs bodies of evidence that report actual experiences.

The overall import is that we preclude fantasies like these other-wordly, magical wizards from the propositions over which empirical possibility is defined. For the assumption, at the outset, was that empirical possibility is defined over a set of propositions for which inductive relations are also defined. Our experience fails to provide inductive support for or against proposition asserting the existence of such other-worldly, magical wizards.

The restriction to actual bodies of evidence does not preclude the relation from ascribing empirical possibility to propositions describing situations that will never be actualized. For actual bodies of evidence can provide inductive support for many propositions, most of which will never be actualized. One might, nonetheless, think that actual experiences can only support actualities but not non-actualized possibilities. That thought is mistaken, as has been argued convincingly by Strohminger (2015) and Roca-Royes (2017).[12]

There is a place for hypothetical and counterfactual possibilities in the account if we relax this evidential actuality condition. A *counterfactual possibility* is defined as one that derives inductive support from a body of evidence in contradiction with the evidence provided by experience. A *hypothetical possibility* is defined as one that derives inductive support from a body of evidence not fully recovered from experience but logically compatible with it. These options will prove useful below in Section 12 where the modal content of scientific theories is recaptured in inductive terms.

5. The Modest Semantics of Empirical Possibility

This account of empirical possibility is quite modest in the resources needed to give its assertions of possibility a clear meaning. To say that a proposition P is possible or necessary, on some body of evidence E, just means that it accrues some or very high inductive support from the evidence E. To interpret this last assertion, we require only what is already in a philosopher's

[12] Roca-Royes (2017) develops an empiricist epistemology of *de re* possibility (but not necessity). Her project differs from that of this paper in that it is epistemic. It concerns how we come to know some possibilities inductively. Here those possibilities are reduced to the inductive relations themselves.

toolkit. We need to know what it is for a proposition *P* to be true or not in the actual world; and we need some serviceable account of inductive support. The account needs no notion of modality as a primitive.

In this way, the present account escapes the enduring woes faced by the larger modality literature in determining the meaning of an assertion of a possibility. Modality is, we may be asked to believe, some sort of primitive aspect of the world whose reach extends well beyond the actual. We may even be lured to accept that there is more in our basic ontology than the actual. It also contains real possibilities. They hover about in some manner, real but forever invisible, like ghostly spirits in a paranormal fable, and in extravagantly greater number than actualities.

These difficulties arise most pointedly through the need to provide some meaning for possibilities that cannot be actualized, but are nonetheless conceived as somehow possible. Here one might think of the possibility of talking donkeys (which is a running example in Lewis (1986)) or, more exotically, of the other-worldly, magical wizards mentioned above.

The present literature in modality has been hard pressed to give meaning to such possibilities. The notorious and extreme case is David Lewis' (1986) modal realism. According to it, other worlds with all manner of fantasy situations are as real as our world. "… absolutely *every* way that a world could possibly be is a way that some world is." (p. 2) Ours is distinguished only by indexicality (pp. 92-93): it is actual only in so far as it happens to be our world.

An empiricist can only stand aghast at this explosion of worlds whose real existence is beyond the reach of any possible experience. Many modal theorists also react with incredulity, generating what Lewis (1986, p. 133) calls the "incredulous stare." A more modest proposal—decried by Lewis (1986, Ch.3) as "ersatzism"—seems to have become a routine default. A possible world is just an exhaustive, consistent assignment of truth values to some set of propositions.[13] The most minimal conception of possible worlds halts at that bare propositional conception. The conception has become more prominent in ordinary philosophical discourse from its role in the semantics of formal modal logic. Hence Kripke, whose (1959) completeness

[13] "To say that a world *w* is a *complete* way things might have been is to say that for each proposition in the sphere of discourse under discussion, *w* either verifies or falsifies that proposition;…" From the entry "Possible Worlds," in Kim (2009, p. 502, emphasis in original).

proof reinvigorated work in formal modal logic, is most direct: "A possible world is *given by the descriptive conditions we associate with it*." (1980, p. 44, his emphasis). His disagreement with modal realism is stated tersely: "'Possible worlds' are *stipulated*, not *discovered* by powerful telescopes." (p. 44, his emphasis) We may wish to trim even further. We may drop the possible world talk and just posit that there are possibilities residing in some factual realm that extends beyond the actual. We eschew giving any further account of it.

However even this most minimal position, welcome for its modesty, is troubled. For what in it precludes propositions asserting talking donkeys and magical wizards? In the possible world picture, they are possible in the sense that truth is assigned in some valuation to the propositions asserting their existence. The natural response is that propositions in the realm of the possible should be restricted by some sort of reasonable accommodation to the world. What better restriction than to require the propositions to be within the scope of what our actual experience supports evidentially? Indeed, what *other* restriction is there? If modal theorists agree with this restriction, I welcome them. Their view is functionally equivalent to empirical possibility, as defined here. It has become tacitly relational, since the judgments of possibility are now dependent on some body of evidence. If they wish to use some other restriction or none at all, then I am left to wonder what could sustain their alternative. We shall return to this problem in Section 9 and later, where alternative conceptions of possibility are considered.

6. Properties of Empirical Possibility

The evidential actuality condition precludes some judgments of possibility that we would otherwise find natural. To illustrate, take our present body of evidence concerning our solar system. It contains the proposition that the earth has one moon. It is not possible in relation to this body of evidence that our earth could have two moons. This conclusion conflicts with the natural intuition that two moons are, in some sense, a possibility for the earth. That intuition can be accommodated in the present account in two ways. In one, we reduce the body of evidence so that it no longer contains the fact that our earth actually has only one moon (and other associated facts). Then, relative to this reduced body of evidence, an earth with two moons is something that could be the actual case. In another approach, we replace the earth-moon system with a surrogate. We consider some distant sun-like star about which an earth-like planet orbits. We do not know whether the planet has moons at all. On that evidence, we can say that it is empirically

possible for this planet to have one moon; or two moons. There is no need to add to the actuality of our earth's single moon, an invisible second moon brought into being by the powers of primitive possibility.

The more striking properties of empirical possibility come from the extreme cases. As the body of evidence grows, many propositions can be judged less and less possible, while support grows for one possibility. Thus the errant motion of Mercury was over a century ago good evidence for the possibility of another planet orbiting within the orbit of Mercury. That changed when observations failed to detect the planet and the accumulating evidence focused support on the possibility of gravity deviating from Newtonian theory.[14]

Given this dynamic, a body of evidence is modally weakened as it grows. Greater possibility accumulates on fewer propositions, with the remainder accorded less and less possibility. In the limit, a body of evidence becomes modally inert once it contains all the propositions of the set over which the possibility relation is defined. For example, take the set of propositions to consist of all actual facts of our solar system and take the evidence set to be that totality. It follows that there are no unactualized possibilities concerning our solar system. For, by supposition, there are no propositions in the set that are not already contained within the evidence.

A similar effect occurs at the opposite extreme when we have no evidence at all. Empirical possibility is a relation between a proposition and a body of evidence. If there is no evidence, then one of the relata is missing and the relation cannot be defined. There is no empirical possibility.

Closer to this extreme is the case of evidence that is so thin that it provides equal support to all possibilities. An example of this is the "completely neutral support" developed in Norton (2010). It would arise in some novel physical theory with a characteristic parameter "*h*" as follows. We assume the evidence tells us merely that *h* has some value greater than zero, but it tells us nothing more. Then I show that we must assign equal support to the parameter lying in each of the intervals (0,1), (1,2), (2,3), … However we must also assign the same support to it lying in each of the intervals (0,1), (1,2), (1,3), (1.4), …, (1,∞).[15] That is, all contingent, non-

[14] For one account of this episode, see Norton (manuscript, Ch. 9, Section 7).

[15] This is not a typographical error. For justification, see Norton (2010).

empty[16] intervals accrue the same minimal level of support. Assuming that this one level of support exceeds the threshold required for possibility if there is one, all these intervals are empirically possible.

This extreme case of weak evidence still assures us that a parameter value in these intervals is possible. The evidence, while extremely weak, is still relevant to the parameter. This case is distinct from one in which the evidence is irrelevant to the proposition. The conception of empirical possibility is of possibilities that can be inductively supported to some extent, even if small, from the evidence of experience. If the evidence is irrelevant to the proposition, no relation of empirical possibility or necessity can be established. Thus, as noted in Section 4 above, the evidence of some coin toss is irrelevant to whether dinosaurs ever lived on earth. Relative to that evidence, no assertion of past dinosaurs' empirical possibility can be made.

7. Failure of the Duality of Possibility and Necessity

The duality relations for possibility and necessity in Section 4 are fragile when applied to the empirical notions. The relations can become degenerate or fail entirely.

In the first case, the relations become degenerate when we have empirical possibilities but no empirical necessities, beyond what is deductively entailed by the evidence. These cases arise whenever the evidence is unable to provide inductive support for any proposition that rises above the necessity threshold, without the proposition being a deductive consequence of the evidence.

The coin toss example of Section 4 illustrates how this can happen. On the evidence of ten independent coin tosses and the threshold of necessity of probability 0.999, we saw that it is empirically necessary that there is at least one head. Matters are otherwise in the case of nine independent coin tosses if we use the same thresholds of probabilities 0.001 for empirical possibility and 0.999 for empirical necessity. For then it is empirically possible that we have no heads in nine tosses. But it is not empirically necessary that we have at least one head in the nine tosses.[17] More generally, consider any contingent proposition P not entailed by the evidence in

[16] An interval (x, y) is non-empty just if $y > x$.

[17] The probability of no heads in nine tosses is $(1/2)^9 = 0.001953$; and the probability of at least one head in nine tosses is $1 - (1/2)^9 = 0.998047$.

the Boolean algebra of propositions of nine-coin toss outcomes. The probability of *P* cannot rise above 0.999.[18] It follows that there are no empirically necessary proposition *P* that are not entailed by the evidence.

In this example, the duality relations can still obtain, but at best in a degenerate or vacuous sense, since there are no empirically necessary propositions not entailed by the evidence. That is, for any contingent proposition *P* not entailed by the evidence, it is always the case that *P* is empirically possible, but never the case that *P* is empirically necessary. That is, we never have "necessarily *P*." However, for each of these *P*, we do have "not necessarily *P*" and "possibly not *P*." The duality relations survive in the specific form "not necessarily iff possibly not."

The duality relations fail directly, however, if we drop the requirement that there is a minimum threshold of inductive support for empirical possibility. It is natural to drop this requirement since empirical possibility is a permissive notion. All that it requires is that the evidence positively favors the proposition, no matter how weak the favoring. This does mean that some propositions with very weak support will be deemed empirically possible. Since the notion is always qualified by its degree, this inclusion is not troublesome. To preserve the duality, the corresponding adjustment to empirical necessity would require that the threshold to be passed is that of complete support. This is clearly too high a standard. For then propositions very strongly supported by the evidence would cease to be empirically necessary. For example, our accumulated evidence of energetic processes very strongly supports the necessary failure of a perpetual motion machine, while not precluding the extremely unlikely possibility of exceptions.

Without the minimum threshold for empirical possibility, we readily arrive at cases in which all contingent propositions are empirically possible, while at the same time there are also empirically necessary propositions not entailed by the evidence. The ten coin toss case of Section 4 illustrates this. The proposition *P* that there is at least one head in ten coin tosses is empirically necessary since its probability is greater than the threshold 0.999. However, its negation, not *P*, is also empirically possible, since it accrues non-zero probability. Thus, we have for *P* both

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[18] The atomic propositions specify a specific sequence of nine coin toss outcomes, each with $(1/2)^9 = 0.001953$. So the most probable proposition not entailed by the evidence is just a negation of a single atom, which has probability $1 - (1/2)^9 = 0.998047$.

necessarily P and possibly not P

in contradiction with the duality relations. A second and more extreme example arises in the case of completely neutral support, just developed. For no contingent proposition in the outcome space of non-empty intervals gains more inductive support than the minimum support accrued just to the narrow outcome of the parameter h lying in (0,1).

In these cases, the duality relation can no longer be used to define a possibility as the dual of necessity, as does the axiom system of Kripke (1959, p.1).

8. Failure of Possible World Semantics

The possible world semantics employed widely in the philosophical literature is admirably simple. It is based on the notion of a possible world, where, minimally, a possible world just is a maximal, consistent set of truth value assignments to some set of propositions. The set of possible worlds is just the set of all such assignments. A proposition is necessary if it is true in all the worlds of the set. A proposition is possible if it is true in at least one of the worlds of the set.

This semantics is ill-suited to empirical necessity, since it is inhospitable to a gradational conception of necessity. Under this definition of possible world, there will be many cases of empirically necessary propositions that are not true in all possible worlds. For example, the failure of all perpetual motion machines is very likely on the present evidence of energetic systems. That is, the failure is empirically necessary. However, it is not absolutely assured. Unlikely as it is, the evidence cannot preclude absolutely some novel physical interaction, in some situation remote from our evidential probes, in which the conservation of energy fails. The propositions defining the pertinent set of possible worlds would include the proposition "There is no other, as yet unknown interaction that violates energy conservation." Since we generate possible worlds by assigning all possible truth values to these propositions, there is a possible world in which this proposition is false, even though the evidence makes it very unlikely. The result is that the empirical necessity of the failure of perpetual motion machines is not captured by the truth of the proposition in all possible worlds. It fails in some possible worlds.

This semantics automatically instantiates the duality relations of Section 4, which are here a version of the duality of universal and existential quantification in predicate logic.

Necessity is instantiated as "For all possible worlds…" and possibility as "There exists a possible world…" This instantiation brings further problems for possible world semantics if we consider cases in which these relations fail. In those cases, as we saw in Section 7, we can have an empirically necessary proposition *P* whose negation is also empirically possible. Possible world semantics cannot accommodate this case.

It is disappointing to lose the familiar possible world semantics. For that semantics reduces initially perplexing questions of possibility and necessity to simpler questions of set theory. It may seem that a simple adjustment to possible world semantics adapts it to empirical necessity. In it, we require that necessity not be attributed to propositions true in *all* possible worlds, but only to those true in *most* possible worlds. If we employ a threshold for possibility, then possibility is attributed not just to propositions true in at least one possible world, but to those true in *sufficiently many*. If each specific sequence of ten-coin toss outcomes is a possible world of the coin toss example above, then in over 99.9% of them, there is at least one head. Thus, an outcome of at least one head is empirically necessary. In fewer than 0.1% of them, there are no heads, so the outcome of no heads is not empirically possible.

This stratagem will work sometimes, such as in this coin toss example. What enables it to work is that meanings for "most" and "sufficiently many" are provided by the example's probability measure. It is not merely that at least 99.9% of the toss outcomes have at least one head. It is that each toss outcome has equal probability, so that their combined probability is at least 0.999. This is an exceptional case. As I have argued at length in Norton (manuscript, Ch. 10-16), probabilities are not in general available. Sometimes a probabilistic meaning can be given to "most"; and sometimes not.

One might hope that there are surrogates available, such as a mere counting of the number of favorable and unfavorable outcomes. However, that counting can give unexpected results. If the outcome set is countably infinite, cardinalities do not match our normal intuitions about "most." We would want to say that most natural numbers are not powers of ten: {10, 100, 1000, …}. However, there are in cardinality just as many powers of ten as there are numbers that are not powers of ten.

Even when natural measures are available, they may give results incompatible with empirical necessity. In the example of the unknown positive real-valued parameter *h* above, that *h* lies in the interval $(1,\infty)$ accrues infinite Lebesgue measure, far exceeding the zero measure of

(0,1). However, as a case of completely neutral support, each interval (0,1) and (1,∞) accrues that same measure.[19] Both are merely empirically possible. Neither is empirically necessary.

In sum, the appeal of possible world semantics is lost. Questions of possibility and necessity can no longer be reduced to simple questions in set theory. If we persist in using this amended possible world conception, in each case we will have to ascertain whether some measure is available and, if so, which it is. It is simpler to address the question of empirical necessity within the particular inductive logic that happens to be applicable to the case at hand. We only create more problems if we try to find some set theoretic implementation of that particular logic. There may be no simple one.

9. And Nothing More

This empirical notion of possibility conforms with the requirements laid out in Section 3. Together with the logical notion sketched in Section 2, it is, I believe, all that an empiricist needs to accommodate possibilities. Moreover, I shall now argue, it is all that anyone needs, in so far as the analysis of possibility is made responsibly. To establish this "and nothing more" claim, the following reviews accounts of possibility that may go beyond the logical and empirical and argues that they are either actually already subsumed by them; or, if not, they are not cogent.

The philosophical literature reports many varieties of possibility. A fairly good list is:

logical possibility, conceptual possibility, metaphysical possibility,
nomic possibility, physical possibility and epistemic possibility.

Several of these need only a brief mention since they are already within the scope of logical and empirical possibility as defined above.

Conceptual possibilities are those arising from the meaning of the relevant concepts. That makes them a version of logical possibility. They have no special powers to create possibilities in the world. We may conceive in fiction of a Pegasus, a horse that by our conception can fly. That we conceive it makes it no more possible that there are flying horses than if we had never conceived it. Our concepts of perfection similarly have no power to bring things into existence.

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[19] How can this be? Very briefly, given the paucity of evidence, we do not know if the correct representation of the parameter is h or $1/h$. The conditions $0<h<1$ corresponds to $1<1/h<\infty$; and $0<1/h<1$ corresponds to $1<h<\infty$.

In the optimistic conception, existence increases perfection. In the pessimistic conception, existence decreases perfection, for the real thing always falls frustratingly short of the perfections we imagined for it. The optimistic conception assures us of the existence of the most perfect and the nonexistence of the least perfect. The pessimistic conception reverses these judgments. Creative powers cannot be attributed to mere conceptions on pain of inconsistency.

Physical possibility refers to mundane possibilities learned through the routine operation of science. They are empirical possibilities. Nomic possibilities, those authorized by scientific laws, are similar in that they are also derived through the routine empirical investigations of scientists. However, since one might imagine that this law-based notion is somehow more elevated and thus distinct, in Section 11 below, I argue otherwise. Epistemic possibilities are those left open by what we do not know. While its name suggests that it is a version of empirical possibility, I argue in Section 10 below that the notion is distinct from empirical possibility and violates one of the requirements laid out in Section 3.

The most troublesome entry to address in the list is metaphysical possibility. It is troublesome since there is an enormous literature declaring all manner of possibilities and necessities on its authority. Yet there is little agreement on exactly what it is. In Section 12 below, I will separate notions of metaphysical possibility into two types. First are possibilities authorized by empirical science. While they may be called "metaphysical," they conform with empirical possibility precisely because of their empirical foundations. Second are notions of metaphysical possibility that go beyond logical and empirical possibility. Precisely because they lack proper empirical foundation, they are all "sophistry and illusion," or so I will argue.

10. Empirical Possibility is not Epistemic Possibility

Among existing accounts of possibility in the philosophical literature, epistemic possibility comes closest to the presently defined notion of empirical possibility. For both are motivated by the question of what we can know to be possibly the case. However, the similarity stops there. The two notions differ greatly in how the question is answered. In brief, first, epistemic possibility is defined in terms of the knowledge of agents. It requires there to be agents with thoughts and beliefs to know things or not to know them. Empirical possibility is defined as an inductive-logical relation over propositions, independent of agents with thoughts. Second, epistemic possibilities are defined negatively, in terms of ignorance, as scenarios that the agent's

knowledge cannot rule out. Empirical possibilities are defined positively, as propositions accruing some inductive support, even if small, from a designated body of propositional evidence.

In both aspects, epistemic possibility fails to satisfy the requirement of Section 3 that its judgments are independent of our beliefs and knowledge[20] and thus fails as a conception of possibility in the world.

10.1 Dependence on Beliefs and Knowledge of Agents

In their synoptic introduction to the volume *Epistemic Modality*, Weatherson and Egan (2011, p.1) give this formulation as a starting point that requires many qualifications:

> A possibility is an epistemic possibility if we do not know that it does not obtain.

The characterization seems fairly stable in the literature. For example, Chalmers (2011, p. 60, his emphasis) has a similar starting point: "We normally say that it is *epistemically possible* for a subject that *p*, when it might be that *p* for all the subject knows."

These opening definitions make clear that epistemic possibility is *defined* in terms of the beliefs and knowledge of specific agents, in contradiction with the requirement of Section 3. While many refinements of the conception follow, the dependence on an agent's knowledge remains at the core of the notion. That fact produces problems that occupy the literature. Weatherson and Egan (2011, pp. 4-17), for example, note that the starting formulation makes no explicit reference to relata that must tacitly be there. Their list of candidate relata is "a person, group, evidence set, or information state." They then offer three options as expansions of the opening definition: the context in which the agent makes the assertion ("contextualism"); variations in how different agents use terms to refer ("relativism"); and that assertions of possibility are simply direct expressions by agents of uncertainty ("expressivism"). These sorts of worries are long-standing. Writing decades earlier, DeRose (1991, p. 584) sought to determine whether *S* can assert some epistemic possibility just if *S* does not know of its falsity; or whether the assertion requires that no one in the relevant community knows of its falsity. Then we must deal with the awkward problem of determining just what counts as the relevant community.

[20] Of course, theorists of epistemic possibility know this, but that does not ameliorate the failures.

Recall the question asked: what possibilities can we know? My concern has been to find an answer that is independent of the vagaries of our thoughts and beliefs and how we may happen to use language. Of course, these vagaries will be a part of a full account of how some particular agent or some community comes to know some possibility. But whether the evidence is known by a single agent, or a relevant community, or expressed in language understood differently by different agents in different contexts—none of these vagaries are constitutive of what possibilities in the world we can know. Unfortunately, the epistemic possibility literature has allowed itself to become dominated by these vagaries.

The notion of empirical possibility arises when we take a different course and strip away all these distractions. We just ask a question in inductive logic: given this evidence, what is possible? How some agent or some community or some idiosyncratic language user might exploit the answer goes well beyond the original question.

10.2 Dependence on Ignorance

These last remarks suggest that epistemic possibility might become empirical possibility if we replace the real, cognitively limited agents of the standard account by ideal reasoners (such as is included in the definition by Kment (2017, §1)). That is not the case, for the epistemic possibility literature has been diverted from answering the question of what possibilities we can know. Epistemic possibility is defined in an obliquely negative manner. The starting definition above says "we do *not* know that it does *not* obtain." That is, the epistemically possible is delimited by what we cannot positively rule out.

Unless one has exaggerated confidence in the creative powers of our ignorance, this definition is vastly too permissive. Its embrace includes an unimaginable plethora of situations that we do not now know and could never know to be the case. By deriving possibility from ignorance, it allows the assertion of possibilities where prudence would dictate silence. For example, nothing that we know rules out levitating wizards living in magic mountains in other universes, disconnected fully from ours. Their possibility is allowed by this notion of epistemic possibility; and they are given the same label--"epistemically possible"—as is the supposition (prior to the Apollo missions) that there are mountains on the other, hidden side of the moon.

The notion of empirical possibility handles these cases very differently. Its concern is what we can positively come to know. As empiricism dictates, it delimits the possible according to whichever body of evidence is at hand. In the absence of any evidence pertaining to magic

mountains in other universes, it allows no assertion of empirical possibility. However, we have a substantial body of evidence concerning our moon and the formation of mountains on its visible surface. That body of evidence allows the assertion of the empirical possibility of mountains on the hidden side of the moon.

11. Nomic Possibility

Empirical possibility, as defined here, is a relation between our actual evidence and a proposition. Theories in science routinely make claims of possibility and necessity that are detached from any particular body of evidence. According to general relativity, it is possible for black holes to form; and it is impossible to escape them once the event horizon is passed. According to thermodynamics, it is possible to convert heat into work, but perpetual motion machines fail of necessity. These are law-based—nomic—notions of possibility and necessity. Since they are detached from evidence, are they a non-empirical notion of possibility? Does that mean scientific theories employ modality as an irreducible primitive? They are not, I now argue.

First, I do not accord scientific laws any special status qualitatively in comparison with other contingent facts. They are not some higher order of truth beyond ordinary contingent truths. They are merely contingent truths of very broad scope. None that we know has universal application.[21] Thus they can afford us no notion of possibility and necessity that is distinct from that afforded by ordinary contingent truths. They merely do so with greater scope.

After that qualification, I follow Ismael's (2017) analysis. The modal aspect of scientific theories is, when examined more closely, are captured fully with inductive notions. Ismael (2017, pp. 119-20) describes that content as "partially prepared solutions to frequently encountered problems." In my rendition, a scientific theory is simply a large collection of possibility and necessity claims, often encoded elegantly in quite compact statements. In their domain of application, they assert propositions of the form "If this happens, then that may

[21] In physics, where we might hope to find universal truths, we know of none. General relativity is our best account of space, time and gravitation, but it fails in the very small. Quantum theory is our best account of matter in the very small, but it fails where general relativity thrives, in domains of very strong gravity.

possibly ensure, or that other may necessarily ensue, but that other again necessarily cannot ensue." Propositions of this form are inductive statements. They can be restated as "If this happens, then there is some evidence for that; and compelling evidence for that other, etc." That is, they are large collections of propositions that lie within the compass of empirical or logical possibility. Since most of the "this's" will not describe our actual evidence, these propositions almost all assert hypothetical or counterfactual possibilities (as defined in Section 4 above).[22] There is nothing primitively modal about them. To imagine that there is anything more in them is superfluous to their function. There is no need to declare their primitive modality, that is, irreducible, or worse to reify their possibilities.

I cannot resist likening a theory to a restaurant menu. It is a collection of "if…then…" propositions: "if you order the Reuben sandwich, then this rye bread sandwich will be prepared and brought to you." The assertion made does not require a distinct notion of culinary modality to give it meaning. And it certainly does not require that every meal on the menu is already prepared in advance and that all will be discarded, save the one that you happen to order.

12. Metaphysical Possibility

12.1 The Grand Promise

The promises made on behalf of metaphysical possibility are grand, even grandiose. Gendler and Hawthorne (2002a, pp. 4-5) put it this way:

> The notion of metaphysical possibility, meanwhile, is standardly taken to be primitive.[23] It is taken as the most basic conception of "how things might have been"--gestured at by talk of how "God might have made things" or "ways it is possible for things to be."

Fine (2002, p. 278) continues the theological metaphor:

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[22] This holds of a case examined in more detail by Ismael (2017, p.116): theories based on physical chances, formulated in terms of probabilities. For they just tell us that the evidence of the antecedent supports various consequents according to the inductive strengths of the associated probabilities.

[23] Their footnote: "In contemporary discussions, at any rate."

> There appears to be an intuitive difference to the kind of necessity attaching to metaphysical and natural necessities (granted that some natural necessities are not metaphysical). The former is somehow "harder" or "stricter" than the latter.[24] If we were to suppose that a God were capable of breaking necessary connections, then it would take more of a God to break a connection that was metaphysically necessary than one that was naturally necessary.

Our expectations are now set very high as we seek distinctive examples of metaphysical impossibilities challenging even to the gods. Instead, aside from empirically dubious cases like the necessary existence of the most perfect being, we find (Sider, 2003, pp. 181-82):

> Examples [of metaphysical impossibilities] might include the existence of a round square, someone's being taller than himself, someone's being in two places at once, George W. Bush being a donkey, there existing no numbers, and there existing some water that is not made of H_2O. Exactly what is metaphysically impossible beyond logical and analytic contradictions is unclear; this unclarity is what makes the analysis of metaphysical possibility and necessity so difficult.

If these are the best illustrative examples of distinctively metaphysical impossibilities, we must begin to suspect that it is an inchoate idea that can admit no good examples. All of these examples are problematic. Round squares are only impossible contingently if space happens to be Euclidean. Other geometries admit round squares. If we define a square as a figure bounded by four straight lines and symmetric under rotation by a right angle about its center, then, in the spherical geometry of the surface of a sphere, the equator ABCD in Figure 1 is both a square and a circle with center O. If our three-dimensional space has a spherical geometry, as present cosmology might allow, then there are round squares in our space.

[24] Fine's footnote: "It seems to be something like this that [Kripke (1980, p.99)] has in mind when he talks of necessity 'in the highest degree.' "

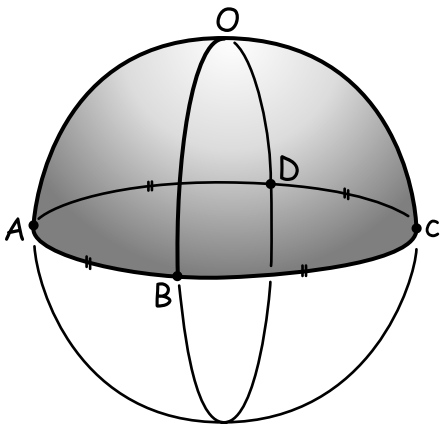

Figure 1. A round square

Being taller than oneself is a logical contradiction following from the meaning of "taller." Electrons in quantum theory can be in two places at once,[25] as can larger configurations of particles like people, absent quantum measurement. The being designated by "George W. Bush" is a convention of our language. Plausibly, someone, somewhere has so named their cat. Whether numbers exist is something that philosophers of mathematics continue to debate. The question is unhelpful as an instructive example. Finally, that water is necessarily H_2O alludes to Kripke's celebrated analysis of necessity (as does the proper name, George W. Bush).

Kripke's analysis has an outsized role in the present literature and many favorite examples of metaphysical necessity derive from it. The difficulty is that Kripke's analysis treats the terms appearing in science on the model of proper names.[26] This is a poor starting place and was fated not to end well. The reference of proper names depends essentially on the conventions

[25] An electron in a bimodal well can be present equally in both, even if the wells are separated by great distances. This impossibility required no god to break it, but merely Erwin Schroedinger.

[26] Kripke (1980, p. 127) "According to the view I advocate, then, terms for natural kinds are much closer to proper names than is ordinarily supposed."

of a group of language users. Whatever necessities they bring are not facts in the world, independent of us and our use of language.[27] The requirements of Section 3 are violated.

The most familiar necessities (e.g. Kripke, 1980, p. 116) in this literature are that water is necessarily H_2O;[28] and that gold is necessarily the element with atomic number 79.[29] There are two sorts of facts here. First are the empirical facts discovered by chemists that substances are naturally divided best according to atomic numbers for elements and molecular formulae for compounds. Second is a convention of language concerning the words we choose to use to label the divisions found empirically. There are no necessities in these two facts that outstrip empirical and logical necessities. Nothing in our society obliges a community of language users to use the words in this way. Nothing compels nature to provide us substances formed from elements with atomic natures and discrete atomic numbers. Nature may not oblige. The latter happens with another of Kripke's (1980, p. 99) necessities:

> …characteristic theoretical identifications like "Heat is the motion of molecules", are not contingent truths but necessary truths, and here of course I don't mean just physically necessary, but necessary in the highest degree--whatever that means.

Heat is simply the motion of molecules only in the special case that most occupied the nineteenth century physicists, ideal gases. In other cases, heat is not simply molecular motion, but the energy of that motion plus other forms of energy. In a classically modeled crystal, heat resides in the kinetic and potential energy of the vibrating atoms bound in the lattice. The dominant form of heat in the early universe resides in the energy of radiation. This necessity "in the highest

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[27] A growing body of empirical evidence, such as in Machery at al. (2004), shows that there is nothing fixed and thus nothing necessary about these conventions. They vary with the culture of the language users.

[28] Putnam is also celebrated for the claim that "water" rigidly refers to H_2O. He, however, seems to defer to Kripke for the claim that there is a metaphysical necessity to the rigidity. See Putnam (1975, p. 151).

[29] Kripke (1980, pp. 35-36) identifies the sense of necessity explicated as metaphysical: "The second concept which is in question is that of necessity…. what I am concerned with here is a notion which is not a notion of epistemology but of metaphysics, in some (I hope) nonpejorative sense."

degree" is not broken by the exertions of a powerful god, but merely by consulting a physics textbook.

Perhaps a more charitable reading is needed here. The exact nature of heat is a topic for specialists in thermal and statistical physics. Kripke is not one.[30] Might the unfortunate remark be more properly rendered as "Heat is necessarily whatever our best science tells us it is (and I am told that it is molecular motion)." The reformulation does not save this notion of necessity. It now just gives us an empirical necessity, for science determines the nature of heat by empirical investigations. Unless the added qualification "necessarily" is merely an empty flourish, it asserts an unrevisability of scientific findings incompatible with the history of science. If we once thought that heat is necessarily identical with the motion of molecules, we have since learned that it is not necessarily so.

12.2 Empirical Metaphysics

These last examples show that the literature has faced great difficulties in providing cogent examples of possibilities and necessities that outstrip the logical and the empirical. Are these failures merely failures of exposition? Perhaps eager authors are oversimplifying their examples to connect more easily with novice readers? Whether such failures must happen depends on the deeper question of whether metaphysics has within its scope the capacity to provide modalities that go beyond the logical and the empirical.

To answer, we ask "what is metaphysics?" A clear answer proves elusive. Discourses on metaphysics routinely begin by admitting the difficulty of identifying just what metaphysics is.[31] This has not discouraged metaphysicians from writing treatises on the subject. A standard starting point in historical surveys, such as Simmons (2009, p. 3), is Aristotle's definition of metaphysics as the study of "being *qua* being." It agrees in general import with what van Inwagen (2009, p.1) calls "the best definition of metaphysics I have seen," that is, "metaphysics is the study of ultimate reality." This goal of metaphysics then aligns well with that of my small-e empiricism--to learn about reality--unless the qualification "ultimate" hides some evasion.

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[30] The admission is explicit for a neighboring science: Kripke (1980, p. 117) writes "… I don't know too much chemistry."

[31] Van Inwagen and Sullivan (2020)'s first sentence is: "It is not easy to say what metaphysics is."; and the first section begins: "The word 'metaphysics' is notoriously hard to define."

For me, empirical science is our best attempt at learning about reality. For the nature of space and time, we look to special and general relativity. For the nature of matter, we look to quantum theory. For the nature of life, we look to biology. For the nature of mind and thought, we look to cognitive science and neuroscience. A great deal of what passes as metaphysics in the present literature is simply reporting what our best science tells us. Since all these metaphysical investigations fall within ordinary empirical science, the associated notions of metaphysical possibility and necessity fall within the empirical conception developed here.

This empirically grounded metaphysics is diffused throughout the metaphysics literature, as a scan of collections like Loux and Zimmerman (2003), Kim et al. (2009) and Le Poidevin et al. (2009, Part III) shows. Finding clean examples, however, is difficult, since metaphysics with and without empirical foundations are routinely mingled. For example, the present literature on the metaphysics of time makes heavy use of empirical science in its reliance on special relativity, its representation in a four-dimensional Minkowski spacetime and its extension to gravity in general relativity. See for example Loux and Zimmerman (2003, Part IV), Hawley (2009) and Ney (2014, Ch. 5). But these ideas are freely intermingled with conceptions with no empirical manifestations, such the distinction between eternalism and presentism; and between perdurantism and endurantism.[32]

12.3 Non-Empirical Metaphysics

Our present concern, however, is to see if there is a defensible notion of metaphysical possibility that extends beyond the logical and the empirical. If there is such a thing, it must be supplied by a body of metaphysical knowledge that is not derived from empirical sources: "non-empirical metaphysics." That such a non-empirical body of knowledge is viable has been subjected to an enduring critique.

Hume's fork (Hume, 1777, Section IV), as it is commonly called,[33] tells us that all we can know derives either from logical inference ("relations of ideas") or from experience ("matters of fact"); and nothing more. It supports his celebrated, closing riposte against any work that consists of propositions of neither kind (Hume, 1777, p. 120): "Commit it then to the flames: For it can contain nothing but sophistry and illusion." The fork has been a fixture, in one form or

[32] For the complaint that these distinctions lack empirical manifestations, see Norton (2015).

[33] Editor's notes, p. xxxv in Hume (1777).

another, in empiricist thinking to the present day. It was foundational for the logical empiricists. They took it to a dangerous extreme as giving the only basis on which propositions could be meaningful. Hempel's (1965, p. 101) treatment of cognitive significance begins with a version of the fork. It allows sentences to be cognitively significant only if they are logical truths or empirically testable. A continuation of this literature now distinguishes empirical metaphysics from non-empirical metaphysics. Ladyman and Ross (2007, pp. 7-10) denounce the latter as "Neo-Scholastic metaphysics." Bryant (2020) calls the latter "free range metaphysics" and finds it epistemically inadequate.[34]

12.3 Fatal Abstraction

Here I sketch a version of this traditional empiricist critique of non-empirical metaphysics that focusses on a foundational assumption of metaphysics. That assumption was in place at the outset. Simons' historical survey (2009, p. 4) reports of Aristotle's conception of metaphysics:

> Unlike other branches of knowledge, which concern themselves with part of what there is, metaphysics is universal: it is about absolutely everything, not with every detail, but only those matters which all things share.

The same assumption persists in modern accounts of metaphysics. Le Poidevin (2009, p.xx) gives it as:[35]

> So far, then, we have characterized metaphysics as concerned with what it is to be or be real, with what things there are, with the way that they are, and with the connection between the way things are and what things there are. And all this is pursued at a higher level of abstraction than typifies any of the special sciences like physics, geology or chemistry.

The assumption is that it is possible to abstract away the specifics of the treatments of the various sciences and be left with non-trivial content of enduring, universal applicability. For example,

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[34] For a more equivocal appraisal of the two approaches, see Guay and Pradeu (2020).

[35] Ney (2014, p. xiii) gives a similar characterization: "Unlike the natural and social sciences that seek to describe some special class of entities and what they are like – the physical things or the living things, particular civilizations or cultures – metaphysicians ask the most general questions about how things are, what our universe is like."

each of the sciences gives an account of how the entities in its domain interact. Abstract away the specifics of the individual sciences and what should remain is a universal metaphysics of causation.

It was, perhaps, once a reasonable conjecture that there might be non-trivial content at this general level of abstraction. It had to be a conjecture since there is no prior guarantee that such content is there to be found. It might fail. The developments recorded in the history of science point to failure. They show that the many aspects of the world come in a great variety. The more we learn of them, the greater becomes the variety and less commonality can be found within it.

Developments in our theories of matter illustrate this continually growing variety. In the seventeenth century, matter came to be regarded as consisting merely of corpuscles in space. The problematic question was whether they could be attributed further properties beyond their occupation of some small volume of space, such as an active power of gravitational attraction. In the course of the nineteenth century, this corpuscular conception of matter was supplemented by, and even sometimes fully replaced by, a field conception. This additional form of matter is not localized in the manner of corpuscles. The electric field of a single charge can pervade all of infinite space. In the twentieth century, in Einstein's general theory of relativity, the strict division between space the container and matter the contained began to break down. The gravitational field, with its material energy-momentum, was now merged into the geometrical structure of spacetime itself. Einstein's unified field theory program sought a theory in which this breakdown would be complete, embracing all matter. There would be no distinction between matter and spacetime. At the same time, the new quantum theory brought different conceptions of matter that we still find problematic today: matter is not particle-like or wave-like, but both at the same time. Its matter is non-local in the sense that each particle may have no definite position and that entangled particles remain so even when separated by astronomical distances. Quantum field theory then breaks down the idea of individual particles. They are merely excitations in a quantum field and we can have states with particles but no definite number of them. These results seem extraordinary on first acquaintance, but they soon become everyday facts of familiar physics. Theories of quantum gravity promise that this parade of the extraordinary is far from complete.

This growing variety is typical in science. As we learn of the ever-greater extent of it, the scope for commonalities reduces. Where does it end? We must take seriously the possibility that there is no non-trivial commonality among all the instances that do now and will in future fall under some metaphysical category. They may just be individual cases bundled together by us since they seem similar to us. If those similarities are merely superficial, then abstracting away the specifics of the individual cases will leave nothing. There will be no non-trivial content in common and no metaphysics. The abstraction would be fatal.

One can only feel sympathy for a metaphysics trying to recover an enduring notion for some metaphysical category, such as substance, when faced with this history. It is forever chasing a moving target. New science repeatedly produces new results that outstrip our old imaginings. Empiricist metaphysics has some chance of coping. It can accommodate this endlessly growing variety by restricting itself to what can be learned responsibly from the empirical evidence and by making no immutable pronouncements. Non-empirical metaphysics, however, cannot do this. By definition, it cannot draw on this new empirical evidence. It is in an impossible position. It must somehow have already divined a place for the latest novelty in its conceptions from a fixed body of metaphysics that cannot be informed by new experiences. It is trapped in an ill-fated attempt to do a priori science.

The history of these efforts in non-empirical metaphysics has been one of persistent failure, as one would surely expect for any attempt at a priori science. I have investigated one case in greater detail and believe the mode of failure I found there will be found throughout non-empirical metaphysics. Norton (2003) traces the long history of the failure of metaphysics to identify non-trivial, universal truths of causation. Time and again, it would pronounce with great certainty some universal, causal truth, adapted to the then present understanding of processes. Subsequent developments in science would overturn it.[36] Since causal relations underwrite many claims of possibility and necessity, this failure of causal metaphysics is automatically also a failure of modal metaphysics.

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[36] These continuing corrections to causal metaphysics are unlike the continuing corrections within science. For the corrections in science derive from the science itself through the epistemic power of its empirical methods. Causal metaphysics has no corresponding power and no means for finding its own errors. The corrections are imposed from the outside.

Another ready candidate for fatal abstraction is the current literature on "grounding." It seeks to abstract away all the specifics of particular cases in which something depends upon something else. The goal is to find a universal, non-trivial notion of grounding. However, what is debated is whether there even is just one notion of grounding.[37]

This analysis of this section indicates that a non-trivial, non-empirical metaphysics is impossible. If this is so, it follows that metaphysics can provide no support for metaphysical possibilities and necessities that outstrip the logical and the empirical. In this conclusion, I concur with Callendar's (2014, p.44, his emphasis) remark:[38]

> … there is no interesting species of metaphysical modality that is largely immune to science. Our modal intuitions are historically conditioned and possibly unreliable and inconsistent. The only way to weed out the good from the bad is to see what results from a comprehensive theory that seriously attempts to model some or all of the actual world. If the intuitions are merely 'stray' ones, then they are not ones to heed in ontology. *In metaphysics we should take possibilities and necessities only as seriously as the theories that generate them.*

13. Conclusion: How did this Happen?

To an empiricist, the convolutions of the philosophical literature on modality are bewildering. The ideas are, for the empiricist, so simple. What is possible is what our evidence positively allows. What is necessary is what our evidence compels. How much more can there be to say?

Let me raise a conjecture on how the modality literature arrived at its present disarray. It is a broth touched by too many cooks. First, there are the traditional metaphysicians, long criticized by empiricists as far back as Hume. These metaphysicians mistakenly but tenaciously believe it is possible to know profound, contingent truths of the world through means other than

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[37] For a sketch of the debate, see Bliss and Trogdon (2016, Section 1).

[38] For a further critique, see Clarke-Doane (2019) who argues that metaphysical possibility lacks the absoluteness routinely claimed for it.

experience. By mere reflection, we can know that there is a necessary being in the world. They offer us an epistemic free lunch.

This old-fashioned metaphysics has been overlaid by philosophers who take the reach of formal, modal logics to extend too far beyond the refined realm of abstract logic. In their work in which the popular modal logic S5 was introduced, Lewis and Langford (1959, p. 160) went to some pains to emphasize that their notion of possibility was narrowly logical: "Thus [possibly] *p* means '*p* is self-consistent' or '*p* does not imply its own negation.' " They distinguished it from the more colloquial notion that is related to data or what is known (quoted in Section 4 above).

The explicit narrowness of their conception is prudent. The world is greatly varied in its states and properties. A notion of possibility that can go beyond pure logic and capture this variety must itself be greatly varied. In this regard, formal modal logics are a meager resource. The major claims of a modal logic reside in a few postulates, such as the few axioms of the logic S5. The expectation has now become that this one, logically motivated size will somehow fit all cases. The characterization of possible worlds in the later formal semantics is, by design, as lean as possible, so as to ensure the widest application. These logics are at best a convenient starting point for a richer notion of possibility, while in need of extensive supplementation; or at worst, a misdirection at the outset.

In autobiographical reflections, Kripke (1980, pp. 3-6) recalled doubting his claims on the necessities associated with rigid designators in natural language. His confidence in the claims was restored by "(self-evident) theses of philosophical logic independent of natural language."[39] They were, it now seems, an unreliable guide concerning the necessities of the physical world.

The mathematical demands of formal logic encourage oversimplification. Possibilities range from the wildly unlikely to the expected; and the gradations in between really do matter. A mere assertion of possibility crams them all together. Why use it? It is easy to formalize. The duality of possibly as not-necessarily-not mimics the duality of existence as not-all-not that is so

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[39] In his demonstration of the completeness of the modal logic $S5^{*=}$, Kripke (1959, p.2) defines a subformula *B* as necessary if it is assigned **T** by every member of some set of interpretive assignments **K**. Crucially, if *B* contains free individual variables $x_1, \ldots, x_n$, each must be assigned the same individual in the domain **D** by every assignment of **K**. Williamson (2013, p. 120) describes this as "treating variables as rigid designators."

familiar and comfortable in ordinary predicate logic. The result is that the subsequent modality literature largely limits itself to these flattened notions of possibility and necessity.

These flattened notions of possibility and necessity also support a simple semantics in the formal logic: *P* is possible if it is true in at least one possible world, where a "possible world" is an abstract entity within the structures of formal modal logic. Of them, in his treatment of the modal logic modal logic $S5^{*=}$, Kripke (1959, p. 2) writes:

> The basis of the informal analysis which motivated these definitions is that a proposition is necessary if and only if it is true in all "possible worlds." (It is not necessary for our present purposes to analyze the concept of a "possible world" any further.)

But now we need to give some meaning to natural language assertions of possibility and necessity and we do need to analyze the concept of a possible world. It is all too tempting to remove the talk of "all possible worlds" from the artificial environment of a formal logic and, without much further analysis, treat them as a notion fully intelligible in a more general discourse. We may even succumb to the temptation to reify them. They are all real, so now the semantic manipulations of the formal logic can be carried over to natural language as well. This, in spite of Kripke's (1980, p. 48, fn) admonition:

> The apparatus of possible words has (I hope) been very useful as far as the set-theoretic model-theory of quantified modal logic is concerned, but has encouraged philosophical pseudo-problems and misleading pictures.

Conveniences designed to ease the construction of a formal logic have become foundational philosophical principles.

The final spice added to the broth comes from a sound literature that simply reports what our latest science tells us about foundational matters. The well-meaning philosophers who undertake this last project have started to call their efforts "metaphysics." Yet as long as they draw the authority of their results from the idea that our best science is so because it has the strongest empirical support, their project is distinct from the traditional metaphysician's and the modal logician's.

These three approaches are mixed indiscriminately in the literature. The result is bewilderment when an empiricist opens a new work proclaiming metaphysical possibilities in some area. Of what sort are they? Are they more *a priori* muddles of the traditional analysis? Are

they misidentifications of conventions of language or formal conveniences as metaphysical necessities? Or are they merely a benign empiricist analysis of our current science? And do any of the claims, if made responsibly, require anything more that the two notions of logical and empirical possibility articulated here?

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