The World Is (Almost Surely) a Strange Place

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1 Introduction

How complex is the world? Many thinkers — philosophers and scientists alike — have believed that, in various respects, the world is relatively simple. Indeed, this belief boasts quite an impressive pedigree,[1] and its application is all but a staple in the contemporary methodology of the sciences and metaphysics.[2] Other thinkers have stayed silent on whether the world is *in fact* simple but have argued that we ought to view the world as simple for various practical reasons.[3]

In this paper, I wish to set aside the question of what practical benefits may be derived from simple worldviews and focus squarely on the question of whether the world is *actually* simple. I shall argue, against the deeply ingrained tradition, that there are important metaphysical respects in which we should not believe that the world is simple. Rather, in those respects, we should be extremely confident that the world is extraordinarily complex.

Here is an intuitive gloss of my argument (which I shall make much more precise over the course of this paper):

[1]The list includes historical greats — e.g., Occam, Newton, Leibniz, and Kant (see Baker 2010 for discussion); Nobel-laureate physicists — e.g., Einstein (1934), Feynman (1964), and Wilczek (2012); as well as prominent contemporary philosophers — e.g., Sober (1981), Lewis (1986), Sider (2012), and Schaffer (2015).

[2]See Huemer (2009) and Baker (2010) for examples.

[3]See Quine (1966) and Harman (1999).

1. There are very many ways the world might be (for all we know).
2. There are many, many more complex ways the world might be (for all we know) than there are simple ways the world might be (for all we know).

It is much, much more likely that the world is complex than simple.

Call this the 'Complexity Argument'.[4] Although the argument may not (as presently stated) strike one as terribly convincing, I shall argue that it can be developed into a form in which it is quite powerful. Hints of this argument have been observed by others,[5] but to my knowledge it has never been made precise nor has anyone defended it. I shall do both such things in this paper.

In particular, I shall focus on the question of how *ontologically* complex the world is. This naturally divides into two subquestions:

1. How *quantitatively* complex is the world's ontology? That is, how many things exist in total?

2. How *qualitatively* complex is the world's ontology? That is, how many kinds of things exist?

In this paper, I shall argue that we should be extremely confident that the world's ontology is extraordinarily quantitatively complex as well as extraordinarily qualitatively complex. More precisely, I shall argue for the following thesis:

- **Complexity.** For any (finite or infinite) cardinality κ, we should be at least 99.99999% confident that there exist more than κ-many things in total as well as more than κ-many kinds of things.[6]

I emphasize at the outset that I will not argue that the world is likely complex in every imaginable respect.[7] Nor will I argue against the alleged

[4]'Likely'-talk (and related constructions) is shorthand here, and in what follows, for talk of rational degrees of confidence. Thus, to say that the world is likely to be complex is to say we ought to be *confident* that the world is complex. Similarly, to say that the world is *extremely* likely to be complex is to say that we ought to be *extremely* confident that the world is complex.

[5]See White (2005), p. 207, and Huemer (2009), §§II.2-3.

[6]'99.99999%' can be replaced with any real number greater than 0 and less than 1.

[7]For example, my argument is neutral with respect to the question of how empirically complex the true "theory of everything" (if such there be) is. Thus, my argument is

pragmatic virtues of simple worldviews; plausibly, there are many. I shall only argue that, in two specific respects — the aforementioned quantitative and qualitative ontological respects — the world is extremely likely to be extremely complex.

Also, I will not be criticizing any extant arguments that the world is (relatively) ontologically simple.[8] Instead, I will offer a novel argument in favor of extreme ontological complexity that may be assessed independently of arguments in favor of ontological simplicity. With that said, the plan for the paper is as follows.

In §2, I discuss some preliminary notions and assumptions that will be necessary to formulate the Complexity Argument more precisely. In §3, I present the argument for extreme *quantitative* ontological complexity. In §4, I present the argument for extreme *qualitative* ontological complexity. Finally, in §5, I close with some remarks about the import of the Complexity Argument for the methodology of science and metaphysics.

2 Preliminaries

In this section, I describe some notions that will be necessary to spell out the Complexity Argument. I also lay out some assumptions that the argument will depend on. Only one of these assumptions is of a "metaphysical" sort; the others are assumptions about epistemic rationality. Although it will take some time to go through these preliminaries, the Complexity Argument will quickly fall into place once we have them before us.

2.1 Worlds and Worldly Complexity

Most of us are uncertain about what the world is like in its entirety. We have uncertainty about various coarse-grained features of the world — what kinds of things exist, how many things exist, and so on. And we have uncertainty about more fine-grained features — what the complete collection of uttered sentences looks like, what the average molecular weight of molecules in our

not incompatible with Kelly's (2010) argument (and its variants) that, of those empirical theories which fit our empirical data, we should be most confident in the simplest such theories.

[8]For objections to various such arguments, see Huemer (2009), Kelly (2010), and Willard (2014).

last-eaten slice of pizza is, and so on. Indeed, for all that we know with certainty, there are many ways the world might be — the world might obey some particular laws of physics with some particular set of physical constants, it might obey those same laws but with those physical constants increased by 10^{-842} percent, some kind of dualist metaphysics might be true, some *other* kind of dualist metaphysics might be true, and so on.

Call an **epistemically possible world** a maximally specific way that the (actual) world might be, for all that we know with certainty.[9] To say that a given epistemically possible world is actual is to settle all questions that might be asked about the world — about what exists, about how many things exist, and so on.[10] Further, call a **logically possible world** a maximally specific way that is merely *logically* possible for the world to be. In what follows, I will ascribe complexity to both epistemically possible worlds and logically possible worlds, though the former will play a particularly important role in the Complexity Argument. When my discussion is neutral between the two types of world, I will simply talk of "worlds". As I said, I am particularly interested in two measures of worldly complexity.

First, the **quantitative ontological complexity** of a world w is simply the number of things[11] in total that exist at w — e.g., 19, 12 trillion, $|\mathbb{N}|$-many, $2^{|\mathbb{R}|}$-many, and so on. Second, the **qualitative ontological complexity** of w is the number of *kinds* of things that exist at w — e.g., 19, 12 trillion, $|\mathbb{N}|$-many, $2^{|\mathbb{R}|}$-many, and so on. As a matter of sociology, most philosophers tend to believe that, though the quantitative ontological complexity of the world is high (though just how high is unclear), its qualitative ontological complexity is quite low. The upshot of the Complexity Argument is that we should be extremely confident that the quantitative ontological complexity *and* the qualitative ontological complexity of the world are extraordinarily

[9] I am thinking of epistemically possible worlds in the same vein in which Chalmers (2011) understands 'scenarios' (in particular, scenarios corresponding to what Chalmers calls the 'Cartesian' sense of epistemic possibility). However, in what follows, I shall stick to the term 'epistemically possible world'. Also, I will not adopt any of Chalmers' specific proposals as to what the nature of these entities is; my discussion will be neutral among multiple such accounts.

[10] In what follows, I will often use 'the world' and 'the actual world' interchangeably.

[11] I use 'thing' as a maximally broad term for simply that which exists at a world — including what exists in space and/or in time (if such there be at that world) as well as what does not. Thus, I take concrete objects to be things, as well as properties, relations, space, time, spacetime, mathematical entities, non-physical souls, God, facts, events, states of affairs, and possibilia. The reader may include additional items to the list if she so desires.

high.[12]

Note that, for both of these complexity measures, there is plausibly a lower bound — but no upper bound — on the complexity of epistemically possible (as well as logically possible) worlds. For example, in the quantitative case, it is not epistemically possible for fewer than 0 things in total to exist, but plausibly for every infinite cardinality κ, it is epistemically possible for exactly κ-many things in total to exist.[13] Since there is no maximal cardinality,[14] there is no upper bound on the quantitative ontological complexity of epistemically possible worlds. By analogous considerations, it also follows that there is a lower bound — but no upper bound — on the *qualitative* ontological complexity of epistemically possible worlds. This feature of ontological complexity will play a crucial role in the Complexity Argument.

2.2 An Assumption about Logical Structure

In what follows, I will assume — without defense — that the world has some sort of ontology. That is, I will assume that the world has some sort of ontological *structure* — that the notion of existence "carves reality at the joints" (to use the popular metaphor).[15] For example, it is common to hold that electrons and quarks are part of the world's ontological structure but that *electron-or-quarks* and *turkey-or-trouts* are not. I will not assume anything about electrons or trouts in what follows, but I will assume that there is an objective fact of the matter as to what the ontological structure of the world is. In particular, I will assume that there is an objective fact of

[12]Mathematical platonists — in particular, platonists about the so-called "cumulative hierarchy" — already believe that, for any cardinality κ, there exist more than κ-many sets and, thus, more than κ-many things in total. So, my argument about the quantitative ontological complexity of the world may not come as a surprise to them. Nonetheless, I will also argue that, for any cardinality κ, we should be extremely confident that there exist more than κ-many *kinds* of things — and, thus, that there exist more than κ-many kinds of things that are different from sets. This conclusion may yet come as a surprise to mathematical platonists (as well as others who endorse views according to which there exist very many things of a relatively small number of kinds).

[13]See Pruss (2013), §3, for arguments to this effect; see also Chalmers (2011), §9.

[14]At least, I will assume so in what follows; this assumption is in accord with the most widely accepted set theories (ZF and ZFC). That there is no largest cardinality is not true according to such theories as Quine's New Foundations (Quine 1937) and its variants.

[15]More precisely, that *some* notion of "existence" carves reality at the joints. See Sider (2012) for a prominent defense and elaboration of this view.

the matter as to how many things exist in total as well as how many kinds of things exist.

More generally, I will assume that reality has some sort of *logical* structure — that there is a unique class of *logical* concepts that carve reality at the joints. I will not assume anything about the precise nature of these logical concepts — whether they include 1st-order concepts, or 2nd-order modal concepts, and so on. However, I will assume that the logical structure of reality is such that the (actual) world is completely characterized by its **domain** — that is, the set of things that (actually) exist — as well as its **relation set** — that is, the set of relations that hold at the (actual) world.[16]

Note that this assumption is neutral among an extremely broad class of hypotheses concerning the logical structure of reality. For example, if reality (fundamentally) has a 1st-order logical structure, then the actual world is characterized by some domain D as well as some relation set in which monadic relations are representable as subsets of D, binary relations are representable as subsets of D^2, and so on. Similarly, if reality (fundamentally) has a 2nd-order variable-domain S4 logical structure, then the actual world is characterized by some domain as well as some relation set in which the set S of 1st-order relations that hold are representable as before and in which the 2nd-order monadic relations that hold are representable as subsets of S, the 2nd-order binary relations that hold are representable as subsets of S^2, and so on.[17] A similar story holds for many other types of logical structure frequently discussed by philosophers and logicians.

One consequence of the assumption that the actual world is characterized by its domain and relation set is that every epistemically *possible* world is also characterized as such. Note that the domain of a given epistemically possible world may contain a variety of things — physical things, abstracta, non-physical souls, and so on. Similarly, its relation set may contain a variety of relations. Two types of relations are particularly relevant for the Complexity Argument.

First, an **empirical relation** is one whose relata are a subject and the

[16]I use 'reality' to mean not only what actually exists but also what possibly exists (if such there be). For example, if there exist a plurality of metaphysically possible worlds, then these worlds are part of reality, but they are not part of the actual world. Thus, I use 'reality' in a slightly more general fashion than 'the (actual) world' or 'the world'.

[17]Additionally, if reality fundamentally has this structure, then it contains a plurality of metaphysically possible worlds, of various different domains, that bear some transitive "accessibility" relation to one another (representable in the familiar set-theoretic fashion).

contents of an experience (broadly construed) had by that subject. For example, I figure in an empirical relation whenever I have an experience of a green after-image as well as whenever I blissfully enjoy a Mahler symphony.[18] The Complexity Argument is compatible with a number of more precise accounts of 'empirical'. For example, we may adopt an "internalist" construal of the term and take an empirical relation to involve a subject and the phenomenal character of an experience she has. Or we may go "externalist" and take an empirical relation to involve a subject as well as some external-world thing (or things) that she *observes*.

Second, an **explanatory relation** holds between one relation (or set of relations) and another relation (or set of relations) whenever the former *partially explains* the latter. For example, the empirical relation that is my experiencing a green after-image at 3 pm today may be partially explained by an apple's having sat beside me then as well as by my having previously stared at that apple for several minutes. Of course, there may be still other relations that figure in the *overall* explanation of my experiencing the green after-image (e.g., my long-wavelength cone cells' being fatigued then); the aforementioned relations only *partially* explain it. The Complexity Argument is compatible with a number of ways of understanding "partially explain". For example, we may understand "partially explain" causally (a la Salmon 1984) or in terms of grounding (a la Fine 2001). In what follows, however, I will take "partially explain" to be a kind of relation that holds *out there in the world*. It is not merely a concept that we *apply* to the world.

Another concept in the vicinity of logical structure that will be relevant for the Complexity Argument is that of an *enriched world*. Call a world w^+ an **enrichment** of w just in case (i) everything that exists at w also exists at w^+, (ii) every relation — including every empirical relation and every explanatory relation — that holds at w also holds at w^+, and (iii) at least one thing that does *not* exist at w exists at w^+ or at least one relation that does *not* hold at w holds at w^+.[19] Intuitively, w^+ is an enrichment of w just

[18] As I will use the term 'relation', I figure in different relations each time I have such experiences. Thus, on my usage, relations are *instances* and not *universals*. However, I certainly do not rule out the epistemic possibility that universals of some sort exist.

[19] I will not take a stand here on the issue of "trans-world identity" — that is, on the question of what it takes for a given thing to exist, or for a given relation to hold, at two worlds — though the Complexity Argument is compatible with a number of possible accounts. In particular, the Complexity Argument is compatible with merely identifying (a la Lewis 1986) things and relations across worlds with their corresponding *counterparts*.

in case w^+ has all of the structure of w — and then some.

The assumption that the world has some type of logical structure is the only substantive "metaphysical" assumption that I will make in this paper. The next four are assumptions about epistemic rationality.

2.3 Epistemic Modesty

Here is a preliminary version of the next assumption:

> **Epistemic Modesty*.** Unless we have (what we can recognize to be) an overwhelmingly strong argument that proposition q is true, we should be less than 99.99999% confident that q is true.[20]

Epistemic Modesty* is as intuitively plausible a principle as any. Indeed, I am inclined to regard it as a fundamental principle of rationality in the sense that it cannot be justified on the basis of other principles of rationality. That said, it can still be motivated by considering simple cases.

Suppose you enter a fair lottery in which exactly one of a billion tickets will be drawn, and you buy exactly one ticket. Then, quite plausibly, you do not have an overwhelmingly strong argument that you will win. (Indeed, you have an overwhelmingly strong argument that you *won't* win — namely, there are very many tickets, so yours is overwhelmingly unlikely to be chosen.) Quite plausibly, then, you should be less than 99.99999% confident that your ticket will win. Alternatively, suppose you had a friend who was 99.99999% confident in the Number-Spaghetti Identity Thesis — i.e., the thesis that every number is identical to some bit of spaghetti — yet didn't have a very powerful argument for it. Clearly, your friend would be suffering from irrationality (and perhaps other ailments as well). Both of these cases are in accordance with **Epistemic Modesty***.

In the Complexity Argument, I shall employ an equally plausible but suppositional analogue of **Epistemic Modesty***:

> **Epistemic Modesty.** Say we do not have (what we can recognize to be) an overwhelmingly strong argument for q that pro-

[20] I leave 'overwhelmingly strong' deliberately vague here. The cases discussed below, as well as in the Complexity Argument, will clarify what is meant. Also, the 'should' here is that of *epistemic* rationality; I stay neutral whether there are propositions for which we do not have any overwhelmingly strong argument but are such that it is *practically* rational to be extremely confident in them.

ceeds from the supposition that p is true.[21] Then, if we *were* to suppose that p is true, we should be less than 99.99999% confident in q.

Epistemic Modesty can be motivated in much the same way as **Epistemic Modesty***. For example, consider a modified version of the lottery case in which you don't actually buy a ticket. Instead, you merely suppose that you bought exactly one ticket. Then, obviously you do not have an overwhelmingly strong argument that you will win that proceeds from this supposition — after all, each of the billion tickets that might be drawn is equally likely. (Indeed, as before, you have an overwhelmingly strong argument that you *won't* win that proceeds from this supposition.) Thus, it is plausible that, if you *were* to suppose that you bought exactly one ticket, you should be less than 99.99999% confident that you will win — exactly in accordance with **Epistemic Modesty**.

2.4 An Additivity Principle

Terminological Note. In what follows, I will (for convenience) sometimes use 'world'-talk as shorthand for a respective 'proposition'-talk. For example, 'being confident in world w' will be shorthand for 'being confident in the *proposition* that w is actual'. Additionally, I will sometimes talk of classes of worlds (or propositions) as though they are existential propositions. For example, 'being confident in class S of worlds' will be shorthand for 'being confident in the *proposition* that there is some world in S that is actual'. Context will make clear which senses I am employing.

To spell out the next principle, say that proposition p_1 is **epistemically terrible** relative to proposition p_2 just in case: if we were to suppose that p_1 or p_2 is true, then we should be less than 0.00001% confident that p_1 is true. Further, say that p_1 is **epistemically non-terrible** relative to p_2 just in case: if we were to suppose that p_1 or p_2 is true, then we should be at least 0.00001% confident that p_1 is true.

In what follows, I will assume two epistemic principles that are, in a sense, "additivity" principles. Here is the first one:

Additivity$_1$
Suppose:

[21] The argument may — in addition to p — employ various beliefs we hold, epistemic norms we accept, as well as any other items to which we have epistemic access.

1. w is an epistemically possible world.
2. R is an infinite class of worlds.
3. Every world in R is epistemically non-terrible relative to w.

Then: w is epistemically terrible relative to R.

Informally, **Additivity**$_1$ says that as long as R is infinite and we should have at least a small bit of confidence in every world in R as compared to w, then we should be comparatively much more confident in R than in w. I am inclined to view **Additivity**$_1$ as another fundamental (or near-fundamental) principle of rationality, but it can be motivated in a couple of ways. Here, I present a brief intuitive motivation. In the Appendix, I provide a more probabilistic motivation.[22]

Suppose the above Conditions 1–3. By Condition 3, we may be comparatively much more confident in w than in any world in R — but less than 99.99999% confident by comparison. Additionally, we may be comparatively much *less* confident in any world in R than in w — but we must be at least 0.00001% confident in the former as compared to the latter. Now, since there are infinitely many worlds in R, the small bits of confidence we may have in the worlds in R "add up" in a big way. In particular, they plausibly add up in such a way that, overall, we should be more confident in R than in w: 0.00001% confidence in a given world in R (as compared to w) may seem quite small, but the sheer size of R plausibly outweighs the comparatively high degree of confidence we may have in w. Indeed, even if R contained just 10,000,000 worlds, this conclusion would be plausible.[23] The fact that R contains infinitely many worlds suggests that we should be comparatively *much* more confident in R than in w — that is, that w is epistemically terrible relative to R. Hence, **Additivity**$_1$.

2.5 Another Additivity Principle

To spell out the next principle, first say that propositions p_1 and p_2 are **mutually incompatible** just in case we know with certainty that it is not

[22] As I show there, a finitary analogue of **Additivity**$_1$ is a theorem of the axioms of (Kolmogorovian) probability theory. Additionally, I show that, though **Additivity**$_1$ is consistent with the axioms of probability theory, it is logically independent of them. Thus, **Additivity**$_1$ can be probabilistically motivated but cannot be (completely) probabilistically *justified*.

[23] Note that 1/10,000,000 = 0.00001%. See also the Appendix.

the case that both p_1 and p_2 are true. For example, the proposition that there are exactly $|\mathbb{N}|$-many things and the proposition that there are exactly $|\mathbb{R}|$-many things are mutually incompatible (since $|\mathbb{N}| < |\mathbb{R}|$). At most, one of these propositions is true.

In what follows, I will also assume the following principle:

> **Additivity$_2$**
> Let Q and R be classes of mutually incompatible propositions.[24]
> Suppose:
>
> 1. Q has a smaller size than R, and R is infinite.[25]
> 2. For every q in Q and every r in R, we should be (strictly) more confident in r than in q.
>
> Then: Q is epistemically terrible relative to R.

Note that if Q is smaller than R and R is infinite, then there is a sense in which R is infinitely many *times* bigger than Q.[26] Thus, informally, **Additivity$_2$** says that if R is much bigger than Q and we should be more confident in every member of R than in every member of Q, then we should be *much* more confident in R than in Q. I am inclined to regard **Additivity$_2$** as yet another fundamental (or near-fundamental) principle of rationality. However, as with **Additivity$_1$**, it can be motivated in a couple of ways. Here, again, I offer a brief intuitive motivation. In the Appendix, I provide a more probabilistic motivation.[27]

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[24]More precisely, any two distinct propositions in Q are mutually incompatible, any two distinct propositions in R are mutually incompatible, and any proposition in Q is mutually incompatible with any proposition in R.

[25]Q may or may not be infinite. Also, if Q and R are both sets, then let 'Q has a smaller size than R' mean that the cardinality of Q is less than that of R. Further, I shall later have occasion to allow R to be a proper class while Q is a set. In such a case, R does not, strictly speaking, have a cardinality. Nonetheless, there is still clearly a sense in which R is "bigger" — indeed, much bigger — than Q. So, I shall still say that Q has a smaller size than R in such a case.

[26]In particular, if Q and R are both sets, then $|Q| \cdot \kappa < |R|$ for every infinite cardinal κ that is less than $|R|$ (assuming the axiom of choice). If R is a proper class while Q is a set, then, for every infinite cardinality κ, there is some set S of members of R such that $|Q| \cdot \kappa < |S|$.

[27]As I show there, a finitary analogue of **Additivity$_2$** is a theorem of the axioms of probability theory, just as a finitary analogue of **Additivity$_1$** is such a theorem. Addi-

I shall motivate **Additivity$_2$** through a series of steps. First, let Q and R be finite sets of propositions, and let $|Q| = |R|$. Further, suppose we should be equally confident in every member of Q and of R. That is, for every member q of Q and every member r of R, we should be equally confident in q and r. Then, quite plausibly, we should be equally confident in Q and R. Now, suppose — as in Condition 2 — that we are more confident in every member of R than in every member of Q. Then, quite plausibly, we should be *more* confident in R than in Q. Next, keep Condition 2 true, but let Q be finite and R infinite. Then, since there are infinitely many more members in R than in Q, we should be *much* more confident in R than in Q. Finally, let Condition 1 be true in full generality. Then, if Q be infinite, R will still be infinitely many times bigger than Q. So, we should still be much more confident in R than in Q. That is, Q is epistemically terrible relative to R. Hence, **Additivity$_2$**.

2.6 Disjunctive Confidence

Here is a first approximation of the final principle I will assume:

> **Disjunctive Confidence***
> Let Q and R be classes of mutually incompatible propositions.[28]
> Suppose:
>
> 1. There is some bijection $f : Q \to R$ such that, for every q in Q, we should be more confident in $f(q)$ than in q.
>
> Then: we should be more confident in R than in Q.

Although I will soon point a problem with **Disjunctive Confidence***, it can be intuitively motivated as follows.

Let q_1, q_2, and q_3 be arbitrary members of Q, and let $r_1 = f(q_1), r_2 = f(q_2)$, and $r_3 = f(q_3)$ be their corresponding members of R. Since we should be more confident in r_1 than in q_1 and more confident in r_2 than in q_2,

tionally, I show that, though **Additivity$_2$** is consistent with the axioms of probability theory, it is logically independent of them. Thus, as with **Additivity$_1$**, **Additivity$_2$** can be probabilistically motivated but cannot be (completely) probabilistically *justified*.

[28]More precisely, any two distinct propositions in Q are mutually incompatible, any two distinct propositions in R are mutually incompatible, and any proposition in Q is mutually incompatible with any proposition in R.

clearly we should be more confident in the *disjunction* $r_1 \vee r_2$ than in the *disjunction* $q_1 \vee q_2$. Similarly, since we should be more confident in r_3 than in q_3, clearly we should also be more confident in the disjunction $r_1 \vee r_2 \vee r_3$ than in the disjunction $q_1 \vee q_2 \vee q_3$. **Disjunctive Confidence** is simply the infinitary generalization of these finite cases — namely, that we should be more confident in the *infinite* disjunction $r_1 \vee r_2 \vee r_3 \ldots$ than in the *infinite* disjunction $q_1 \vee q_2 \vee q_3 \ldots$ Equivalently (or if we do not permit talk of infinite disjunctions), we should be more confident *that* there is some member of R that is true than *that* there is some member of Q that is true.

That said, **Disjunctive Confidence*** has a major shortcoming — it faces the risk of being inconsistent. For suppose there is indeed some bijection $f : Q \to R$ such that, for every q in Q, we should be more confident in $f(q)$ than in q. Then, by **Disjunctive Confidence***, we should be more confident in R than in Q. However, if there is some additional bijection $g : Q \to R$ such that, for every q in Q, we should be more confident in q than in $g(q)$, then **Disjunctive Confidence*** also entails that we should be more confident in Q than in R. Contradiction. Since cases of this sort do not seem ruled out in principle, **Disjunctive Confidence*** is unacceptable as it currently stands.

Fortunately, the intuitive motivation for **Disjunctive Confidence*** provided above can be restored if we make the additional stipulation that there is *not* any "bad" bijection $g : Q \to R$ such that, for every q in Q, we should be more confident in q than in $g(q)$. Here is an improved formulation of the principle:

> **Disjunctive Confidence**
> Let Q and R be classes of mutually incompatible propositions. Suppose:
>
> 1. There is some bijection $f : Q \to R$ such that, for every q in Q, we should be more confident in $f(q)$ than in q.
> 2. There is no bijection $g : Q \to R$ such that, for every q in Q, we should be more confident in q than in $g(q)$.
>
> Then: we should be more confident in R than in Q.

As with the previous epistemic principles, I am inclined to regard **Disjunctive Confidence** as a fundamental (or near-fundamental) principle of rationality. I will assume it in what follows.

3 The Quantitative Complexity Argument

We are now in a position to state the Complexity Argument. In this section, I present the argument for extreme *quantitative* ontological complexity. In §4, I present the argument for extreme *qualitative* ontological complexity.

To begin with, let C_1 and C_2 be arbitrary cardinalities such that C_1 is smaller than C_2 and C_2 is infinite.[29] For example, C_1 might be 38, and C_2 might be $|\mathbb{R}|$. Also, call a 'C_1-world' any world at which there exist exactly C_1-many things in total, and call a 'C_2-world' any world at which there exist exactly C_2-many things in total.

The argument extreme quantitative ontological complexity proceeds in three phases. Here is an overview.

- **Phase 1.** Intuitively, this phase argues that, for any world w, there are infinitely many worlds that are more ontologically complex than w but are epistemically non-terrible relative to w.

  More precisely, consider an arbitrary epistemically possible C_1-world w_1. As I will argue, there are infinitely many C_2-worlds that are similar to w_1 in a variety of respects that are commonly taken to have evidential relevance. In particular, there are infinitely many C_2-worlds that are (*inter alia*) "empirically indistinguishable" from w_1 and have just as much "explanatory power" as w_1. Let $f(w_1)$ be the class of such C_2-worlds. The fact that any one of these C_2-worlds is more complex than w_1 may make it is less likely to be actual than w_1, but plausibly we do not have any *overwhelmingly* strong argument that favors w_1 over any of these worlds. Using **Epistemic Modesty**, then, it will follow that every world in $f(w_1)$ is epistemically non-terrible relative to w_1. Similarly, for any other epistemically possible C_1-world w_2, I will argue that there are infinitely many *other* C_2-worlds that are epistemically non-terrible relative to w_2. Hence:

  – **Epistemic Non-Terribleness.** For any distinct epistemically possible C_1-worlds w_1 and w_2, $f(w_1)$ and $f(w_2)$ are infinite, disjoint classes of C_2-worlds that are epistemically non-terrible relative to w_1 and w_2 (respectively).

[29] C_1 may or may not be infinite.

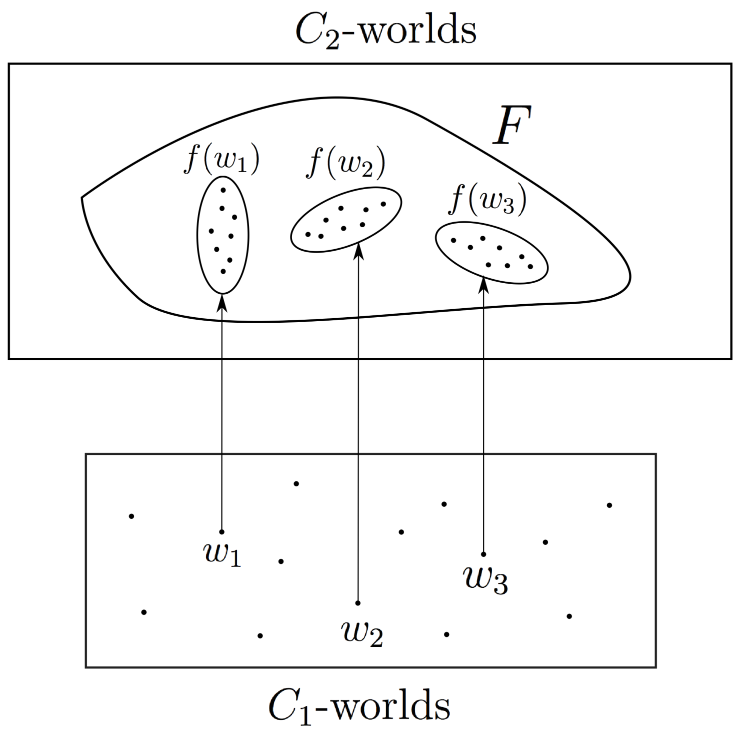

Figure 1: For every epistemically possible C_1-world w, there are infinitely many C_2-worlds that are epistemically non-terrible relative to w.

- **Phase 2.** Intuitively, this phase argues that we should be more confident that the world is ontologically complex than ontologically simple.

  More precisely, consider an arbitrary epistemically possible C_1-world w_1. By **Additivity**$_1$ and **Epistemic Non-Terribleness**, we should be more confident in $f(w_1)$ than in w_1. So, for any distinct epistemically possible C_1-worlds $w_1, w_2, \ldots$, we should be more confident in $f(w_1)$ than in w_1, more confident in $f(w_2)$ than in w_2, and so on. Now let F be the class of every $f(w)$. That is, for every epistemically possible C_1-world w, let $f(w)$ be in F; and let nothing else be in F. Then, using **Disjunctive Confidence**, it will follow that we should be more confident in $f(w_1) \vee f(w_2) \vee \ldots$ than in $w_1 \vee w_2 \vee \ldots$ That is, we should be more confident that there is some world C_2-world in some $f(w)$ in F that is actual than that there is some epistemically possible C_1-world that is actual. However, since F is "contained" in the space of all C_2-

worlds, we should be at *least* as confident that there is some C_2-world that is actual than that there is some C_2-world in some $f(w)$ in F that is actual. Thus, we should be more confident that there is some C_2-world that is actual than that there is some C_1-world that is actual. Hence:

  - **Comparative Complexity.** We should be more confident that there exist exactly C_2-many things in total than that there exist exactly C_1-many things in total.

- **Phase 3.** Intuitively, this phase argues that we should be extremely confident that the world is extraordinarily ontologically complex.

  More precisely, let κ be an arbitrary cardinality, and let q_κ be the proposition that there exist exactly κ-many things in total. It is a fact of set theory that there are more cardinalities greater than κ than cardinalities less than or equal to κ. So, the class R of propositions of the sort q_{κ_2}, where $\kappa_2 > \kappa$, is larger than the class Q of propositions of the sort q_{κ_1}, where $\kappa_1 \leq \kappa$. Further, by **Comparative Complexity**, we should be more confident in any member of R than in any member of Q. Using **Additivity**$_2$, it will then follow that we should be *much* more confident that there is some member of R that is true than that there is some member of Q that is true. That is:

  - **Complexity**$_{quantitative}$. For any (finite or infinite) cardinality κ, we should be at least 99.99999% confident that there exist more than κ-many things in total.

I now spell out these phases in full detail.

3.1 Phase 1: Epistemic Non-Terribleness

As before, let C_1 and C_2 be arbitrary cardinalities such that C_1 is smaller than C_2 and C_2 is infinite. Also, let w_1 be an arbitrary epistemically possible C_1-world, and call an 'enriched C_2-world' any logically possible C_2-world that is an enrichment of w_1.

Next, call a thing **needy** just in case it essentially figures in at least one relation that involves exactly C_2-many things; it is in its *nature* to figure in at least one C_2-ary relation. Needy things are, to be sure, a strange class of entities, and we might antecedently regard their existence as quite unlikely.

Nonetheless, it is difficult to deny that the existence of needy things is, at the very least, logically possible — for example, no logical contradiction seems to arise in positing their existence. However, once we countenance their logical possibility, it follows that there are infinitely many enriched C_2-worlds at which (1) the only things that exist in addition to what exists at w_1 are needy things and (2) the only relations that hold in addition to what holds at w_1 are relations that involve at least one needy thing. Here is an argument.

First, let D_1 and R_1 be the domain and relation set, respectively, of w_1. Since it is logically possible that needy things exist, plausibly it is also logically possible that *all* that exist are C_2-many needy things as well as the things in D_1 — again, no logical contradiction seems to arise in positing that this is the case. Similarly, plausibly it is logically possible that (i) all that exist are the things in D_1 as well as C_2-many needy things, (ii) every relation in R_1 holds, and (iii) some C_2-ary relation R^* involving all and only needy things holds such that, for every needy thing x, the only essential feature of x is that x bears R^* to all needy things. Again, although such needy things are quite bizarre, no logical contradiction seems to arise in positing their existence. Let w_1^+ be an arbitrary enriched C_2-world at which (i)–(iii) hold, and let D_1^+ be its domain.

Next, since there are infinitely many — in particular, C_2-many — needy things in D_1^+, there are infinitely many — in particular, 2^{C_2}-many — subsets of D_1^+ that contain at least one needy thing. Now recall (cf. §2.2) that the 1st-order monadic relations that hold at a world are representable simply as subsets of that world's domain; many other kinds of relations are representable as similar set-theoretic constructions. So, at the very least, there are infinitely many logically possible 1st-order monadic relations that involve at least one needy thing in D_1^+. (Plausibly, there are infinitely many logically possible relations of other kinds that involve at least one needy thing in D_1^+ as well.) Thus, there are infinitely many *sets* of such relations. Now, for each set S of such relations, plausibly there is a logically possible world at which all that exist are the things in D_1^+ and at which the only relations that hold are the relations in R_1, the relations in S, and R^*. Since every world is characterized by its domain and relation set (cf. §2.2), it therefore follows that there are infinitely many enriched C_2-worlds at which (1) the only things that exist in addition to what exists at w_1 are needy things and (2) the only relations that hold in addition to what holds at w_1 are relations that involve at least one needy thing. Call any enriched C_2-world at which (1) and (2) hold a 'C_2^*-world'.

I will now argue that there are infinitely many C_2^*-worlds that are similar to w_1 in a variety of respects that are commonly taken to have evidential relevance. Whether all of these respects should be regarded as evidentially relevant is a question that I will address in §3.1.6. As I will argue, however, not regarding all of them as evidentially relevant will only strengthen my argument for **Epistemic Non-Terribleness**.

3.1.1 Empirical Respects

Note that, since every relation that holds at w_1 holds at every enriched C_2-world, every empirical relation (cf. §2.2) that holds at w_1 also holds at every enriched C_2-world and, thus, at every C_2^*-world. Further, there are plausibly infinitely many non-empirical relations that hold at C_2^*-worlds but not at w_1.[30] So, there are infinitely many sets of such relations. Since, again, a world is characterized by a domain and relation set, it follows that there are infinitely many C_2^*-worlds at which the only relations that hold are the empirical relations that hold at w_1 as well as a variety of non-empirical relations (including all of those that hold at w_1). Thus, there are infinitely many C_2^*-worlds that are "empirically indistinguishable" from w_1.

3.1.2 Explanatory Respects

Note that, since every relation that holds at w_1 holds at every C_2^*-world, every explanatory relation (cf. §2.2) that holds at w_1 also holds at every C_2^*-world. Thus, every C_2^*-world has at least as much "raw explanatory power" as w_1.

Further, it is plausible that there are infinitely many C_2^*-worlds that are empirically indistinguishable from w_1 and have exactly as much raw explanatory power as w_1 — that is, C_2^*-worlds at which the only empirical and

[30] More precisely, there are infinitely many non-empirical relations such that, for every such relation R, R does not hold at w_1 but there is some C_2^*-world at which R holds.

Argument. Plausibly, there is some C_2^*-world w_1^+ at which infinitely many needy things that are not subjects or contents of experience exist. Note that any relation borne by such things is a non-empirical relation. For example, if w_1 has spatiotemporal structure, then any spatiotemporal relation borne among such needy things that exist at w_1^+ is a non-empirical relation. For reasons analogous to those given in the previous argument, plausibly there are infinitely many logically possible relations involving all and only these things. Thus, plausibly there are infinitely many non-empirical relations that hold at C_2^*-worlds but not at w_1.

explanatory relations that hold are those that hold at w_1.[31] So, the only relations that hold at such worlds but not at w_1 are of a *non*-empirical, *non*-explanatory nature. Now consider an arbitrary such C_2^*-world w_1^+. Plausibly, there is some C_2^*-world w_1^{++} that is an enrichment of w_1^+ and is such that every needy thing that exists at w_1^+ — and, thus, also exists at w_1^{++} — figures in *some* relation which partially explains some empirical relation that holds at w_1^{++}. Once again, no logical contradiction seems to arise in positing that this is the case. That is, plausibly there is some C_2^*-world w_1^{++} at which (i) no needy thing that exists is "explanatorily idle" — because every needy thing that exists at w_1^{++} figures in at least one explanatory relation; and (ii) every needy thing that exists is an "empirical" thing — because every needy thing at w_1^{++} figures in at least one relation that partially explains at least one empirical relation.[32]

Since w_1^+ was arbitrary — and since there are infinitely many such C_2^*-worlds that are empirically indistinguishable from w_1 and have exactly as much raw explanatory power as w_1 — it therefore follows that there are infinitely many C_2^*-worlds that (1) are *empirically indistinguishable* from w_1, (2) have exactly as much *raw explanatory power* as w_1, (3) are such that exactly as many *explanatorily idle* things exist at them as at w_1, and (4) are such that exactly as many *non-empirical* things exist at them as at w_1.

3.1.3 Complexity-Related Respects

Needy things are quite different from anything that exists at w_1. For the sake of argument, I will regard them as different in kind from anything that exists at w_1; not regarding them as such will only strengthen my argument for **Epistemic Non-Terribleness**. Thus, I will grant that every C_2^*-world that satisfies (1)–(4) has a slightly greater *qualitative* ontological complexity than w_1. However, it is plausible that there are infinitely many C_2^*-worlds that satisfy (1)–(4) and are such that, at every such world, only *one* kind of needy thing exists — every such world is simply such that many instances of a cer-

[31] Once we grant that there is at least one such C_2^*-world — which seems difficult to deny — the argument of the previous footnote can be immediately refashioned to show that there are infinitely many such C_2^*-worlds.

[32] For example, consider a world at which electrons, quarks, and a zoo of other microscopic particles exist. Although we cannot see these particles with the naked eye, they are still arguably "empirical" things because they figure in relations that partially explain our having certain kinds of experience at that world.

tain kind of needy thing exist at it. Thus, there are plausibly infinitely many such C_2^*-worlds that have only slightly greater qualitative ontological complexity than w_1. However, since more things exist in total at every C_2^*-world than at w_1, every C_2^*-world that satisfies (1)–(4) has a greater *quantitative* ontological complexity than w_1.

Now consider an arbitrary C_2^*-world w_1^+ that satisfies (1)–(4). Recall that every needy thing that exists at w_1^+ figures in some relation which partially explains some empirical relation that holds at w_1^+. However, since every explanatory relation that holds at w_1 also holds at w_1^+, it follows that there are *more* things that figure in explanatory relations that hold at w_1^+ than there are things that figure in explanatory relations that hold at w_1. Thus, there is a sense in which w_1^+ — as well as every other C_2^*-world that satisfies (1)–(4) — is more *explanatorily* complex than w_1.

Unsurprisingly, then, every C_2^*-world that satisfies (1)–(4) is more complex than w_1 — both ontologically and explanatorily.

3.1.4 Other Evidential Respects

For comprehensiveness, I note two more salient respects that are sometimes taken to be evidentially relevant. First, the C_2^*-worlds that satisfy (1)–(4) are more complex than w_1 and are such that those bizarre entities I call 'needy' things exist at them. As such, it might be thought that, for any such C_2^*-world w_1^+, it is less *intuitively plausible* that w_1^+ is actual than that w_1 is actual. For similar reasons, it might be thought that the proposition that w_1^+ is actual is less *aesthetically virtuous* than the proposition that w_1 is actual.

3.1.5 Summary

I have argued that there are infinitely many C_2^*-worlds that are similar to w_1 in four respects that are commonly taken to have evidential relevance. In particular, there are infinitely many C_2^*-worlds that:

(1) are *empirically indistinguishable* from w_1,

(2) have exactly as much *raw explanatory power* as w_1,

(3) are such that exactly as many *explanatorily idle* things exist at them as at w_1, and

(4) are such that exactly as many *non-empirical* things exist at them as at w_1.

To be fair, every C_2^*-world that satisfies (1)–(4) also differs from w_1 in some respects that are commonly taken to have evidential relevance. In particular, every such C_2^*-world:

(5) has slightly greater *qualitative* ontological complexity than w_1,

(6) has greater *quantitative* ontological complexity than w_1,

(7) is more *explanatorily complex* than w_1,

(8) is less *intuitively plausible* than w_1, and

(9) is less *aesthetically virtuous* than w_1.

Let $f(w_1)$ be the class of C_2^*-worlds that satisfy (1)–(9). I will now argue that every world in $f(w_1)$ is epistemically non-terrible relative to w_1.

3.1.6 Epistemic Non-Terribleness

Consider an arbitrary world w_1^+ in $f(w_1)$, and suppose that w_1 or w_1^+ is actual.

Question: How confident should we be that w_1 is actual?

The answer to this question depends on just how much evidential value we ought to accord to those respects in which w_1^+ differs from w_1 — that is, to respects (5)–(9). Now, while extant arguments that some or all of these respects have evidential value may carry some force,[33] it is implausible that any such argument (or combination of such arguments) can be appropriated to the present context to constitute an *overwhelmingly* strong argument that w_1 is actual.

For one, the conclusions of such arguments are typically rather modest — e.g., to the effect that, when "all other things are equal", we should merely be "more confident than not" that the world is ontologically simple (or comports

[33]See Baker (2010) for a review of arguments in favor of the evidential value of simplicity (both ontological and explanatory). Defenders of the evidential value of intuition include Bealer (1998), Sosa (1998), and Goldman (2007).

with our intuitions, etc.).[34] As such, when these arguments are considered together and appropriated to the present context, they cannot even *purport* to constitute an overwhelmingly strong argument that w_1 is actual.

Second, there are a number of extant objections to many of these arguments.[35] Of course, the mere existence of these objections does not demonstrate that all of these arguments are *bad*; all things considered, they may still be relatively good. However, even if we adopt a very weak attitude of epistemic deference towards the objections to these arguments, it becomes implausible that any of these arguments constitutes an *overwhelmingly* strong case for the evidential value of ontological simplicity (or of intuition, etc.). Thus, plausibly, we do not have an overwhelmingly strong argument that w_1 is actual.

Now, although I have considered what I take to be the main respects that might reasonably be thought to have evidential relevance to the question of which of w_1 or w_1^+ is actual, I grant that I may have neglected additional evidential respects that favor w_1 over w_1^+. However, for the same reasons as those I rehearsed above, it seems quite implausible that consideration of any additional evidential respects would enable us to construct an *overwhelmingly* strong argument that w_1 is actual. Moreover, if we deny that some of the respects I have considered are evidentially relevant, then it becomes all the more plausible that we that we do not have an overwhelmingly strong argument that w_1 is actual, for then w_1^+ is plausibly even more evidentially similar to w_1.[36]

[34]For example, Nolan (1997), who appeals to cases from the history of science to argue for the evidential value of quantitative ontological simplicity, says: "I find these cases reasonably convincing in support of the view that quantitative parsimony [i.e., quantitative ontological simplicity] is sometimes a consideration in theory formation, and that in general one ought to be more quantitatively parsimonious when all other things are equal." (342) Clearly, Nolan does not think that these cases constitute *overwhelming* support for favoring quantitatively parsimonious theories.

[35]See Huemer (2009), Kelly (2010), and Willard (2014) for various objections to arguments for the evidential value of simplicity in metaphysics; many of their objections apply at either the ontological or explanatory level. Lewis (1973) is a notable defender of the evidential value of *qualitative* ontological simplicity but not of *quantitative* ontological simplicity. See Kornblith (1998), Dickson (2007), and Stich (2009) for arguments against the evidential value of intuition.

[36]Indeed, the most controversial of the evidential respects I have considered are arguably intuitive plausibility and aesthetic virtue, followed by quantitative ontological simplicity, followed by qualitative ontological simplicity and explanatory simplicity. Note that these are all of the aforementioned respects in which w_1 and w_1^+ differ.

By **Epistemic Modesty** (cf. §2.3), then, we should be less than 99.99999% confident that w_1 is actual.[37] Equivalently, we should be at least 0.00001% confident that w_1^+ is actual. Thus, w_1^+ is epistemically non-terrible relative to w_1.

3.1.7 Conclusion

Consider two distinct epistemically possible C_1-worlds w_1 and w_2. I will now show that there is no world that is in both $f(w_1)$ and $f(w_2)$.

Suppose for reductio that there is indeed some world w in both $f(w_1)$ and $f(w_2)$. Since w_1 and w_2 are distinct worlds — and every world is characterized by its domain and relation set (cf. §2.2) — it follows that (i) there is at least one thing that exists at w_1 but not at w_2 (or vice versa), or (ii) there is at least one relation that holds at w_1 but not at w_2 (or vice versa). Let us consider each case in turn.

- Case (i). Let A be something that exists at w_1 but not at w_2. Since w is an enrichment of w_1, A also exists at w. Further, since w is in $f(w_2)$ — and, thus, is a C_2^*-world — everything that exists at w either exists at w_2 or is a needy thing. Next, recall that every needy thing essentially bears at least one relation to exactly C_2-many things. Since fewer than C_2-many things exist at every C_1-world (since C_1 is smaller than C_2) and A exists at w_1, it follows that A cannot be a needy thing. But then A must exist at w_2. Contradiction.

- Case (ii). Let R be some relation that holds at w_1 but not at w_2. Since w is an enrichment of w_1, R must also hold at w. Further, since w is in $f(w_2)$ — and, thus, is a C_2^*-world — every relation that holds at w either holds at w_2 or involves at least one needy thing. However, since R holds at w_1 and no needy thing exists at w_1, R cannot involve any needy things. But then R holds at w_2. Contradiction.

Hence:

[37] Note that even it were thought that we should be, say, 98.5% confident that w_1 is actual, that degree of confidence would still be less than 99.99999% — which is all that the Complexity Argument requires (i.e., that we adopt at least a modest amount of epistemic modesty towards whether w_1 is actual).

- **Epistemic Non-Terribleness.** For any distinct epistemically possible C_1-worlds w_1 and w_2, $f(w_1)$ and $f(w_2)$ are infinite, disjoint classes of C_2-worlds that are epistemically non-terrible relative to w_1 and w_2 (respectively).

3.2 Phase 2: Comparative Complexity

As before, let C_1 and C_2 be arbitrary cardinalities such that C_1 is smaller than C_2 and C_2 is infinite. In this section, I argue for the following claim:

- **Comparative Complexity.** We should be more confident that there exist exactly C_2-many things in total than that there exist exactly C_1-many things in total.

First, a few preliminaries. Let W_{C_1} be the class of all epistemically possible C_1-worlds. Also, let F be the class of every $f(w)$. That is, for every epistemically possible C_1-world w, let $f(w)$ be in F; and let nothing else be in F. Although, strictly speaking, W_{C_1} is a class of worlds and F is a class of *classes* of worlds, I will sometimes (cf. §2.4) refer to them as classes of 'propositions' in what follows.

I now present, in four steps, the argument for **Comparative Complexity**. The first three steps consist in arguing that W_{C_1} and F satisfy the antecedent of **Disjunctive Confidence**. The last step employs **Disjunctive Confidence** to argue that we should be more confident in F than in W_{C_1} before finally arguing for **Comparative Complexity**.

3.2.1 Step 1. W_{C_1} and F are classes of mutually incompatible propositions

In this step, I argue that W_{C_1} and F are classes of mutually incompatible propositions.

First, because worlds are maximally specific (cf. §2.2), there is only one world that is actual. As a result, any two distinct worlds are mutually incompatible (cf. §2.5) because we know with certainty they are not both actual. So, every world in W_{C_1} is mutually incompatible with one another. Second, consider any two distinct epistemically possible C_1-worlds w_1 and w_2. By **Epistemic Non-Terribleness**, $f(w_1)$ and $f(w_2)$ are disjoint. In particular, there is no epistemically possible world that is in both $f(w_1)$ and $f(w_2)$. So, we also know with certainty that $f(w_1)$ and $f(w_2)$ are not both the case. Thus, every proposition in F is mutually incompatible with one another as well. Finally, since we know with certainty that there does not exist exactly C_1-many things in total as well as exactly C_2-many things in total (since $C_1 < C_2$), it follows that every world in W_{C_1} is mutually incompatible with every proposition in F.

3.2.2 Step 2. We should be more confident in $f(w)$ than in w

In this step, I argue that, for every epistemically possible C_1-world w, we should be more confident in $f(w)$ than in w.

Consider an arbitrary epistemically possible C_1-world w. By **Epistemic Non-Terribleness**, $f(w)$ is an infinite class of C_2-worlds that are epistemically non-terrible relative to w. So, by **Additivity**$_1$ (cf. §2.4), w is epistemically terrible relative to $f(w)$. That is, we should be much more confident in $f(w)$ than in w on the supposition that one of them is the case. Thus, since w is epistemically possible, plausibly we should be more confident in $f(w)$ than in w *simpliciter*.[38]

3.2.3 Step 3. The are no "bad" bijections from W_{C_1} to F

By **Epistemic Non-Terribleness** and **Step 2**, $f : W_{C_1} \to F$ is a bijection such that, for every w in W_{C_1}, we should be more confident in $f(w)$ than in w. In this step, I argue (cf. §2.6) that there is no "bad" bijection $g : W_{C_1} \to F$ such that, for every w in W_{C_1}, we should be more confident in w than in $g(w)$.

Suppose for reductio that there is indeed some such bijection g. Then, there is some world w_2 in W_{C_1} such that $g(w_1) = f(w_2)$. Since we should be more confident in w_1 than in $g(w_1)$, we should be more confident in w_1 than in $f(w_2)$. However, by **Step 2**, w_2 is epistemically terrible relative to $f(w_2)$. As a result, w_2 is also epistemically terrible relative to w_1, since we should be even more confident in w_1 than in $f(w_2)$. Thus, for every epistemically possible C_1-world w_1, there is some epistemically possible C_1-world w_2 such

[38] If w were not epistemically possible — so that we knew with certainty that w is not actual — then the mere fact that w is epistemically terrible relative to $f(w)$ would not make it plausible that we should be more confident in $f(w)$ than in w simpliciter. For if $f(w)$ were also epistemically impossible — so that we knew with certainty that $f(w)$ is not the case — then we should be equally confident in w and $f(w)$. In particular, we should have no confidence at all in either w or $f(w)$.

that w_2 is epistemically terrible relative to w_1. As I will argue, however, this is an implausible consequence.

Note that many of the evidential respects I considered in §3.1 are such that there are some worlds that fare maximally well by them. First, there are some worlds — in particular, those worlds at which exactly one kind of thing exists — that fare maximally well by the lights of *qualitative ontological simplicity*. That is, other things being equal, if exactly one kind of thing exists at w_1 and exactly two kinds of things exist at w_2, then we should be more confident in w_1 than in w_2 (if we take qualitative ontological simplicity to be evidentially relevant). Second, plausibly there are some worlds that fare maximally well by the lights of *empirical adequacy*. That is, there are some worlds at which we have exactly all of the experiences we know with certainty we have actually had (whatever those experiences may be). Third, plausibly there are some worlds that are maximally *explanatorily adequate* in the sense that all of those relations we wish to have explained are indeed explained (in some manner) at those worlds. Fourth, plausibly there are some worlds at which there exist no *explanatorily idle* nor *non-empirical* things. Call those epistemically possible C_1-worlds that fare maximally well by these respects — or, at least, as well as any C_1-world does indeed fare by them — the 'epistemically great' C_1-worlds.

Let w_1 be an arbitrary epistemically great C_1-world. Then, as I argued above, there is another epistemically possible C_1-world w_2 such that w_1 is epistemically terrible relative to w_2. However, w_1 already fares so well with respect to a number of evidential respects that it is implausible that w_1 could be epistemically *terrible* with respect to any epistemically possible C_1-world. Although there may be some epistemically possible C_1-worlds that fare better than w_1 with respect to other evidential respects, it is implausible that we should be *overwhelmingly* more confident in any such world than in w_1.

For example, suppose that w_1 is an enrichment of some other epistemically great C_1-world w_2 and that exactly one additional thing exists at w_1.[39] Then, if we regard quantitative ontological simplicity as evidentially relevant, we should (other things being equal) be more confident in w_2 than in w_1. However, surely w_1 is not epistemically *terrible* relative to w_2; after all, there is only one additional thing that exists at w_1. Even if there were C_1-many additional things that existed at w_1, it would (for reasons of epistemic mod-

[39]This is only possible if C_1 is infinite; otherwise, the domains of w_1 and w_2 would have different cardinalities.

esty analogous to those of §3.1.6) still be implausible that w_1 is epistemically terrible relative to w_2. Similarly, if there are other epistemically great C_1-worlds that are explanatorily simpler than w_1, then we should (other things being equal) be more confident in any of them than in w_1 (provided that we regard explanatory simplicity as evidentially relevant). However, again, it is implausible that w_1 is epistemically *terrible* relative to any such world. Analogous considerations plausibly hold for any other evidential respects we might consider. Thus, it is implausible that there is any epistemically possible C_1-world w_2 such that w_1 is epistemically terrible relative to w_2. Hence, by reductio, there is no such bijection g.

3.2.4 Step 4. Comparative Complexity

By **Step 1**, W_{C_1} and F are classes of mutually incompatible propositions. By **Step 2**, $f : W_{C_1} \to F$ is a bijection such that, for every w in W_{C_1}, we should be more confident in $f(w)$ than in w. By **Step 3**, there is no bijection $g : W_{C_1} \to F$ such that, for every w in W_{C_1}, we should be more confident in w than in $g(w)$. Thus, by **Disjunctive Confidence** (cf. §2.6), it follows that we should be more confident in F than in W_{C_1}. More precisely, we should be more confident that there is some C_2-world in some $f(w)$ in F that is actual than that there is some epistemically possible C_1-world that is actual.

Note that every $f(w)$ in F contains only C_2-worlds of a specific variety — namely, those that are specific sorts of epistemically non-terrible enrichments of epistemically possible C_1-worlds (cf. §3.1.5). However, there may be (and plausibly are) C_2-worlds that are not of this variety.[40] Thus, we should be *at least* as confident that there is some C_2-world that is actual than that there is some C_2-world in some $f(w)$ in F that is actual. Since we should be more confident in the latter than that there is some epistemically possible C_1-world that is actual, it follows that we should be more confident that there is some C_2-world that is actual than that there is some epistemically possible C_1-world that is actual. Hence:

- **Comparative Complexity.** We should be more confident that there exist exactly C_2-many things in total than that there exist exactly C_1-many things in total.

[40] For example, there may be C_2-worlds that are epistemically *terrible* enrichments of epistemically possible C_1-worlds as well as C_2-worlds that are epistemically non-terrible relative to epistemically possible C_1-worlds of which such C_2-worlds are *not* enrichments.

3.3 Phase 3: Complexity$_{quantitative}$

Let κ be an arbitrary cardinality. For every cardinality κ_1 such that κ_1 is finite or less than or equal to κ, let q_{κ_1} be the proposition that there exist exactly κ_1-many things. Similarly, for every infinite cardinality κ_2 strictly greater than κ, let r_{κ_2} be the proposition that there exist exactly κ_2-many things. Also, let Q be the class of every such q_{κ_1}, and let R be the class of every such r_{κ_2}. Note that, for any distinct cardinalities κ_1 and κ_2, we know with certainty that there does not exist exactly κ_1-many things as well as exactly κ_2-many things. So, Q and R are classes of mutually incompatible propositions.

Now it is a fact of set theory that the class of infinite cardinalities greater than κ is infinite and of a greater size than the class of cardinalities that are finite or less than or equal to κ.[41] So, Q has a smaller size than R, and R is infinite. Also, by **Comparative Complexity**, for every q in Q and every r in R, we should be more confident in r than in q. Thus, by **Additivity**$_2$ (cf. §2.5), Q is epistemically terrible relative to R. That is, if we were to suppose that Q or R is true — in other words, that there is an objective fact of the matter as to how many things exist in total — then we should be less than 0.00001% confident that Q is true. However, since we are indeed supposing that there is an objective fact of the matter as to how many things exist in total (cf. §2.2), it follows that we should be less than 0.00001% confident that Q is true. That is, we should be less than 0.00001% confident that finitely many or at most κ-many things in total exist. Thus, we should be at least 99.99999% confident that infinitely many and more than κ-many things exist in total. Hence:

- **Complexity**$_{quantitative}$. For any (finite or infinite) cardinality κ, we should be at least 99.99999% confident that there exist more than κ-many things in total.

4 The Qualitative Complexity Argument

The argument for extreme *qualitative* ontological complexity is structurally identical to the argument for extreme quantitative ontological complexity. Here I present a sketch of this argument.

[41] In particular, there are proper-class-many infinite cardinalities greater than κ but only set-many cardinalities that are finite or less than or equal to κ.

As before, let C_1 and C_2 be arbitrary cardinalities such that C_1 is smaller than C_2 and C_2 is infinite. Also, let w_1 be an arbitrary epistemically possible world at which exactly C_1-many *kinds* of things exist, and let $g(w_1)$ be the class of worlds such that, for every world w_2 in $g(w_1)$: (i) exactly C_2-many kinds of things exist at w_2 and (ii) w_2 is similar to w_1 in all of those respects discussed in §3.1 that are commonly taken to have evidential relevance.

Note that the argument for **Epistemic Non-Terribleness** in the quantitative case can be readily adapted to show that, for any distinct epistemically possible worlds w_1 and w_2 at which exactly C_1-many kinds of things exist, $g(w_1)$ and $g(w_2)$ are infinite, disjoint classes of worlds that are epistemically non-terrible relative to w_1 and w_2 (respectively). For example, we can now appeal to enriched worlds with "qualitatively needy" things — things that essentially figure in at least one relation that involves C_2-many *kinds* of things. Nearly all of the other features of the argument hold here as well.[42] Similarly, the argument for **Comparative Complexity** in the quantitative case can be readily adapted to show that we should be more confident that there exist exactly C_2-many *kinds* of things than that there exist exactly C_1-many kinds of things. For example, the appeal to qualitatively needy things ensures that, for any two distinct epistemically possible worlds w_1 and w_2 at which exactly C_1-many kinds of things exist, no world is in both $g(w_1)$ and $g(w_2)$. All of the other steps go through as before as well. Finally, the argument for **Complexity**$_{quantitative}$ can be readily adapted to show:

- **Complexity**$_{qualitative}$. For any (finite or infinite) cardinality κ, we should be at least 99.99999% confident that there exist more than κ-many kinds of things.[43]

Combining **Complexity**$_{quantitative}$ and **Complexity**$_{qualitative}$ then yields:

- **Complexity.** For any (finite or infinite) cardinality κ, we should be at least 99.99999% confident that there exist more than κ-many things in total as well as more than κ-many kinds of things.

[42] The one notable exception is that the enriched worlds that must be considered here are more *qualitatively* ontologically complex than the enriched worlds considered in the quantitative argument. However, as before, there are no overwhelmingly strong arguments for the evidential value of qualitative ontological simplicity, so the considerations of epistemic modesty hold as before.

[43] For example, for every cardinality κ_1 such that κ_1 is finite or less than or equal to κ, we can now let q_{κ_1} be the proposition that there exist exactly κ_1-many *kinds* of things and define every r_{κ_2} analogously.

5 Conclusion

I have argued that we should be extremely confident that the world is extraordinarily ontologically complex. The world might be relatively ontologically simple (for all we know with certainty), but we should be extremely confident that it is not. This conclusion naturally follows from a minimal realism about logical structure, a few basic principles of rationality, and a wholesome attitude of epistemic modesty — including the recognition that (1) we ought not form strong beliefs in the absence of strong arguments and (2) the space of epistemic possibilities is *vast*. Understandably, a number of questions emerge in light of this conclusion. I will address a few of them in these closing remarks.

First, what should we make of contemporary scientific and metaphysical practice? Our most popular scientific and metaphysical theories ascribe relatively low ontological complexity to the world. Believing in such theories obviously conflicts with **Complexity**, but they remain very popular. Why is this the case? Additionally, the incredible empirical success of our most popular scientific theories is undeniable. Is **Complexity** in tension with this success?

My first response is flatfooted: our most popular scientific and metaphysical theories are, very probably, just false with respect to the question of the ontological complexity of the world. However, this does not mean — and I certainly do not wish to claim — that such theories are false with respect to various *empirical* questions. In particular, **Complexity** is perfectly consistent with the epistemic rationality of believing — indeed, being extremely confident — that the empirical predictions of our best scientific theories are (approximately) true. If our most cherished theories entail that we should expect to have experiences of "apples falling down from trees" with durations governed approximately by Newtonian gravitational theory, then we should expect this.[44] If our most cherished theories entail that we should expect the combination of "water" and "sodium" to result in our having an experience of "extreme explosiveness", then we should expect this. **Complexity** is in no tension with the empirical success of the sciences. We *should* expect the

[44] I use scare quotes to emphasize that I do not doubt the *empirical* content of such theories; I only doubt their popular, ontologically simple interpretations. Although 'apples' and 'trees' and the rest might still refer to objects in the world, I wish to remain neutral as to whether they refer to the kinds of common-sensical objects to which they are ordinarily taken to refer.

True Theory of Everything to be at least as empirically successful as our currently best scientific theories. But we should also expect it to ascribe immense ontological complexity to the world.

As for why so many scientists and philosophers believe that the world has relatively low ontological complexity, I can only speculate. Perhaps it is in virtue of having a good argument for the epistemic — as opposed to merely pragmatic — rationality of this belief. But I doubt it.[45] More likely, it seems to me, is that there is some kind of *selection bias* at work. Our (finite) minds, for whatever reason, seem predisposed to entertain theories that are relatively simple. Because such theories are more readily salient to us, we are predisposed to treat them as the only "live possibilities". As a result, we tend to treat simple theories as more likely to be true than complex theories. Of course, once we recognize that this bias does not have an overwhelmingly strong epistemic basis (if any), we are already well on our way to **Complexity**.

Given that considerations of ontological simplicity have played such an important role in the history of scientific and metaphysical inquiry,[46] one might also wonder how those lines of inquiry ought to proceed in light of **Complexity**. As I indicated above, **Complexity** has little (if any) bearing on how *scientific* inquiry should proceed, provided that we do not attempt to "read off" an ontology from the empirical content of our scientific theories. Unfortunately, traditional metaphysical inquiry emerges in a much less favorable light. In particular, if **Complexity** is true, then common appeals to ontological simplicity in metaphysics — for example, to argue for physicalism as opposed to dualism about the mind, or to argue for nominalism as opposed to platonism about numbers — have been misguided. So, it might be worried that if we can't appeal to ontological simplicity as a substantive constraint in metaphysical inquiry, then there is little we *can* appeal to. The Complexity Argument shows that this worry is misplaced, for there are (at the very least) a number of formal epistemic principles we can still appeal to — for example, **Epistemic Modesty**, **Additivity**$_1$, **Additivity**$_2$, and **Disjunctive Confidence**. It remains to be seen what further metaphysical conclusions can be drawn on the basis of such principles.

Complexity, I am well aware, is a strange philosophical thesis. Thus,

[45] In particular, I find the objections I cite in fn. 35 to demonstrate, at the very least, that there are no good *extant* arguments for the epistemic rationality of this belief.

[46] Again, see Huemer (2009) and Baker (2010) for examples.

one might think it is particularly susceptible to the Incredulous Stare.[47] Indeed it is. But that is no count against it. If anything, the Stare confirms **Complexity** — for if **Complexity** is true, then the world *is* almost surely a strange place. Anyone who embraces a modest amount of epistemic modesty shouldn't be too surprised by this conclusion. For what could ever justify the view that the world isn't mind-bogglingly strange?

6 Appendix. Probabilistic Motivations for Additivity$_1$ and Additivity$_2$

In this Appendix, I provide probabilistic motivations for **Additivity**$_1$ and **Additivity**$_2$. I emphasize at the outset that these principles — when probabilistically interpreted — are not, in their full generality, consequences of the axioms of probability theory.[48] Indeed, as I will show, they are logically independent of the axioms of probability theory. Nonetheless, I will show that special, finitary analogues of **Additivity**$_1$ and **Additivity**$_2$ are indeed consequences of the axioms. I take this fact, along with the intuitive motivations provided in §§2.4–2.5, to constitute good reason to accept these principles in their full generality.

6.1 Probabilistic Motivation for Additivity$_1$

For reference, here is the statement of **Additivity**$_1$ again:

Additivity$_1$
Suppose:

1. w is an epistemically possible world.
2. R is an infinite class of worlds.
3. Every world in R is epistemically non-terrible relative to w.

[47] *A la* the foe of Lewis (1986).

[48] That is, the Kolmogorov axioms. I assume only finite additivity in what follows (but see fn. 50). Additionally, I assume that for any probability function P, $P(A|B)P(B) = P(A \cap B)$. This equation is a generalization of the traditional ratio formula for conditional probability, according to which $P(A|B) = P(A \cap B)/P(B)$ when $P(B) > 0$. It applies even when $P(B) = 0$ and, as noted by Easwaran (2014), is implied by all major theories of conditional probability that allow for $P(A|B)$ to be defined when $P(B) = 0$.

Then: w is epistemically terrible relative to R

Now let P be a probability function that represents the degrees of confidence we ought to have in those propositions (and worlds) towards which we have doxastic attitudes. The following is a probabilistic interpretation of **Additivity**$_1$:

Probabilistic Additivity$_1$
Suppose:

1. w is an epistemically possible world.
2. R is an infinite collection of worlds.
3. For every w' in R: $P(w'|w \cup w') \geq 0.00001\%$.

Then: $P(w|w \cup R) < 0.00001\%$.

Although **Probabilistic Additivity**$_1$ is not — in its full generality — a consequence of the axioms of probability theory, I will now describe a finitary version of it that is.

To begin with, let R be a finite collection of worlds, and assume Conditions 1 and 3. Further, suppose that $P(w) > 0$, and let $|R| = N$ for some positive integer N. Now let w^* be a least-probable member of R. Then,

$$\begin{aligned} P(w^*|w \cup w^*) &= \frac{P(w^* \cap (w \cup w^*))}{P(w \cup w^*)} && (1) \\ &= \frac{P(w^*)}{P(w \cup w^*)} && (2) \\ &= \frac{P(w^*)}{P(w) + P(w^*)}, && (3) \end{aligned}$$

using finite additivity and the fact that w and w^* are disjoint.[49] By Condition 3, $P(w^*|w \vee w^*) \geq K$, where $K = 0.00001\%$. After a bit of rearranging, this entails that $P(w^*) \geq \frac{K}{1-K} P(w)$. Next, by finite additivity, $P(R) \geq NP(w^*)$.

[49]Recall (cf. §2.4) that I will often treat worlds as though they are propositions. So, I use 'w' and 'w^*' as shorthand here for the propositions that w is actual and that w^* is actual, respectively. Additionally, I will treat propositions as classes of worlds in what follows. Thus, any two distinct worlds (*qua* distinct singleton propositions) are disjoint.

So,

$$\begin{aligned}
P(w|w \cup R) &= \frac{P(w \cap (w \cup R))}{P(w \cup R)} && (4)\\
&= \frac{P(w)}{P(w) + P(R)} && (5)\\
&\leq \frac{P(w)}{P(w) + NP(w^*)} && (6)\\
&\leq \frac{P(w)}{P(w) + N\frac{K}{1-K}P(w)} && (7)\\
&= \frac{1}{1 + N\frac{K}{1-K}}. && (8)
\end{aligned}$$

Thus, $P(w|w \cup R) < K$ provided that $\frac{1}{1+N\frac{K}{1-K}} < K$. After a bit of rearranging, this entails that $N > (\frac{1-K}{K})^2$. So, for sufficiently large N, $P(w|w \cup R) <$ 0.00001%. That is, when $P(w) > 0$ and R is a sufficiently large finite set of worlds, the axioms of probability theory entail **Probabilistic Additivity**$_1$.

By contrast, if we retain the assumption that R is finite but relax the assumption that w has positive probability, then it is no longer a consequence of the axioms of probability theory that $P(w|w \cup R) < 0.00001\%$. To see this, first note that the assumption that $P(w) = 0$ entails that every member of R also has zero probability. This follows from the fact that, for every member w' of R, $P(w'|w \cup w')[P(w) + P(w')] = P(w')$. Since $P(w) = 0$, $P(w'|w \cup w')P(w') = P(w')$. However, since $P(w'|w \cup w') \geq 0.00001\% > 0$, it follows that $P(w') = 0$. Next, by finite additivity and the fact that $P(w') = 0$ for every w' in R, $P(R) = P(w) = 0$. Now observe that $P(w|w \cup R)$ must satisfy $P(w|w \cup R)[P(w) + P(R)] = P(w)$. Since $P(w) = P(R) = 0$, any value for $P(w|w \cup R)$ satisfies this equation. As a result, when R is finite but $P(w) = 0$, the axioms of probability theory provide no (non-trivial) constraints on $P(w|w \cup R)$.

Additionally, if we allow R to be infinite — but let $P(w) > 0$ — then the stipulation that $P(w'|w \cup w') \geq 0.00001\%$ for every w' in R does, in conjunction with the axioms, place constraints on the probabilities of the members of R. However, the axioms no longer place non-trivial constraints on $P(R)$, as the probability of an infinite set is not determined by "adding up" (a la finite additivity) the probabilities of its members.[50] As a result, the

[50]Of course, if we admit countable additivity into the axioms, then the axioms do (non-

axioms are silent on whether $P(w|w \cup R) < 0.00001\%$. For similar reasons, in the most general case — in which R is infinite and $P(w)$ need not be positive — the axioms are silent on whether $P(w|w \cup R) < 0.00001\%$. This is why I call **Additivity**$_1$ an "additivity" principle. It is intended to supplement finite additivity (as well as countable additivity, if we so countenance it) in particular infinitary cases.

In sum, then, **Probabilistic Additivity**$_1$ is logically independent of the axioms of probability theory. Nonetheless, the axioms do entail a finitary version of **Probabilistic Additivity**$_1$.[51] As the intuitive considerations from §2.4 show, **Additivity**$_1$ is a natural generalization of this basic result.

6.2 Probabilistic Motivation for Additivity$_2$

For reference, here is the statement of **Additivity**$_2$ again:

> **Additivity**$_2$
> Let Q and R be classes of mutually incompatible propositions. Suppose:
>
> 1. Q has a smaller size than R, and R is infinite.
> 2. For every q in Q and every r in R, we should be (strictly) more confident in r than in q.
>
> Then: Q is epistemically terrible relative to R.

Here is a probabilistic interpretation of **Additivity**$_2$:

> **Probabilistic Additivity**$_2$
> Let Q and R be classes of mutually incompatible propositions. Suppose:
>
> 1. Q has a smaller size than R, and R is infinite.
> 2. For every q in Q and every r in R: $P(r) > P(q)$.

trivially) constrain $P(R)$ if R is countable. However, if R is uncountable, then they do not. So, in general, the axioms do not (non-trivially) constrain $P(R)$ if R is infinite.

[51] It may be that certain extensions of the Kolmogorov axioms — for example, extensions that allow for probabilities to take on a range of infinitesimal values — entail additional cases of **Probabilistic Additivity**$_1$. However, whether any such extension entails **Probabilistic Additivity**$_1$ in its full generality is beyond the scope of the present paper.

Then: $P(Q|Q \cup R) < 0.00001\%$.

As with **Probabilistic Additivity**$_1$, **Probabilistic Additivity**$_2$ is not — in its full generality — a consequence of the axioms of probability theory. However, I will now describe a finitary version of it that is.

To begin with, suppose that R is finite, R is larger than Q, and $P(R) > 0$. Further, let $|Q| = M$, $|R| = N$, $p_1 = \frac{P(Q)}{M}$, and $p_2 = \frac{P(R)}{N}$, and $K = 0.00001\%$. By Condition 2 and the assumption that $N > M$, it follows that $p_2 > p_1$. Next, note that $\frac{P(R)}{P(Q)} = \frac{Np_2}{Mp_1} > \frac{Np_2}{Mp_2} = \frac{N}{M}$. So,

$$P(Q|Q \cup R) = \frac{P(Q)}{P(Q) + P(R)} \tag{9}$$

$$= \frac{1}{1 + \frac{P(R)}{P(Q)}} \tag{10}$$

$$< \frac{1}{\frac{N}{M} + 1}. \tag{11}$$

After a bit of rearranging, it follows that, when $N > M\frac{1-K}{K}$, $P(Q|Q \cup R) < K$. Thus, for sufficiently large R, $P(Q|Q \cup R) < 0.00001\%$.

If we relax the assumption that R has positive probability — but still let R be finite — then, by finite additivity, it follows that every member of R has probability 0 as well. As a result, no member of R has greater probability than any member of Q, and Condition 2 cannot be satisfied. Thus, in such a case, the axioms vacuously entail **Probabilistic Additivity**$_2$.

By contrast, if we allow R to be infinite, then Condition 2 is satisfiable, but the axioms no longer place any (non-trivial) constraints on $P(R|Q \cup R)$. Although Condition 2 places constraints on the relative unconditional probabilities of the members of Q and of R, it does not place any constraints on $P(R)$. The reason is the same as that discussed in the previous section: when R is infinite, $P(R)$ is not determined by "adding up" (a la finite additivity) the probabilities of the members of R. Since $P(R|Q \cup R)$ is related to $P(R)$ via $P(R|Q \cup R)[P(Q) + P(R)] = P(R)$, it follows that the axioms are silent on whether $P(R|Q \cup R) > 99.99999\%$. This is why I call **Additivity**$_2$ an "additivity" principle. It is intended to supplement finite additivity (as well as countable additivity, if we so countenance it) in particular infinitary cases.

In sum, then, **Probabilistic Additivity**$_2$ is logically independent of the axioms of probability theory. Nonetheless, the axioms do entail a finitary version of **Probabilistic Additivity**$_2$. As the intuitive considerations from §2.5 show, **Additivity**$_2$ is a natural generalization of this basic result.

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