The Ineffability of Induction

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Abstract

My first goal is to motivate a distinctively metaphysical approach to the problem of induction. I argue that there is a precise sense in which the only way that orthodox Humean and non-Humean views can justify induction is by appealing to extremely strong and unmotivated probabilistic biases. My second goal is to sketch what such a metaphysical approach could possibly look like. After sketching such an approach, I consider a toy case that illustrates the way in which such a metaphysics can help us make progress on the problem of induction.

1. Introduction

Every time we eat bread, it nourishes. Every time we drop an apple, it falls at 9.8 m/s^2. Those who haven't felt the force of skeptical arguments might find these facts to be fairly mundane. However, for those who have experienced the inductive vertigo that Hume famously did, these facts are shocking. After all, we can certainly imagine that the next time we eat bread, it might poison us. The next time we drop an apple, it could very well fall *up* at 9.8 m/s^2. There are an infinity of ways in which the world could go completely haywire in the next second: gravity might reverse, tigers might start popping into existence, or the whole planet might disappear in a puff of smoke. What reason do we have for thinking that the world won't go haywire in the next second? The problem of induction, at least on one formulation, is the problem of giving some sort of story as to why we're justified in thinking that the world will continue to go on as we expect it to.

I have two main goals in this paper. My first goal is to formulate a mathematically precise, probabilistic version of the problem of induction (§§2-4). My formulation will take the form of an inconsistent triad: a set of three premises, each of which seems very plausible, that together imply a contradiction. This more precise version of the problem of induction has two main virtues. First, it gives a certain sense of *urgency* to the problem of induction. As we will see, the only way to recover anything like our inductive practices is either to swallow some extremely strong and seemingly unmotivated probabilistic assumptions or to pursue an ambitious rationalistic metaphysical project, akin to the kind of project that Descartes carried out in his *Meditations* to ward off his own skeptical doubts. Second, the inconsistent triad provides a taxonomy of ways one might respond to the problem of induction. The three main ways philosophers have tried to respond

to the problem of induction nicely correspond to the three different premises one might deny in the inconsistent triad.

My second goal is to make some initial progress towards providing a distinctively metaphysical solution to the problem of induction (§§5-9). Although my remarks won't amount to anything like a complete solution to the problem, I conclude by illustrating how it might work in a very simple, toy case.

2. The Informal Problem of Induction

We can break up the inductive skeptic's argument into two parts. First, there is the claim that there are an infinity of possible ways that the future might deviate in strange ways from the past. Apples might suddenly start rising, and bread might suddenly start poisoning. Second, there is the claim that we have no good reason for thinking that the actual world won't deviate from the past in one of these strange ways. The skeptic might try to justify this point in different ways. For example, the skeptic might claim that there is nothing we could say to convince the *counter-inductivist*, someone who makes the 'opposite' inferences about the future than the inductivist. After all, the standard circular justification in favor of induction ('induction has always worked before!') can also be given by the counter-inductivist ('since counter-induction has horribly failed in the past, it will surely work next time!'). Ultimately, the skeptic says that our inductive inferences are simply based on the assumption, the faith, that the world is simple or law-like or uniform. Given that we don't have any good reason to make these arbitrary assumptions, the skeptic says that we should revise our beliefs about the future. For example, we should abandon our belief that the sun will rise tomorrow.

The first step of the skeptic's argument is crucial. As a parody argument, suppose a mathematical skeptic argued as follows:

> You should abandon your belief that 2+2 =4. After all, there are an *uncountable infinity* of possibilities in which 2+2 isn't 4. For example, for every real number *r*, there is a possibility in which 2+2 = *r*. Given all of these possibilities, what reason could we have for thinking that we aren't in one of the worlds where 2+2 isn't 4? The assumption that we are in such a world is simply an arbitrary bias in favor of the number 4.

This skeptical argument isn't going to be keeping anybody up at night. We should of course simply deny that there are any possibilities where 2+2 isn't 4. The reason why inductive skepticism is so much more gripping is because it does seem like a genuine metaphysical possibility that the world could go completely haywire tomorrow. If these sorts of worlds are genuinely possible, then it seems like we need some reason to think that the actual world isn't one of these possible worlds.

Still, even though the problem of inductive skepticism is more compelling, the vast majority of philosophers have not become converted skeptics.[1] In part, this is because it is unclear what positive *argument* there is to think that induction is irrational. The skeptic simply challenges us to provide a justification of induction that would convince the skeptic or other fanciful characters like the counter-inductivist. But why think that we must be able to convince the skeptic in order for induction to be rational? We might not be able to convince the flat-earther that the earth is round. Should we therefore abandon our belief that the earth is round? Roger White (2015) has coined the phrase 'the problem of the problem of induction' to refer to the problem of figuring out what exactly is the skeptic's positive argument against the rationality of induction. In the absence of a precisely formulated positive argument, it is easy to be dismissive of the skeptic. In the next section, I try to formulate a more compelling, probabilistic challenge to our inductive practices, which focuses on our inductive evidence for the fundamental laws of physics.

3. An Inconsistent Triad

I will start with a certain fanciful thought experiment. Suppose God presents you with two books. Both books contain maximally specific descriptions of a way for the world to be. They include, for example, two alternative complete descriptions of space-time and its material occupants. God assures you that both books describe genuine metaphysically possible worlds, and he reveals to you that *one of the books describes the actual world*. After spending some time reading the two books, you realize that they agree on all matters concerning the present and the past. However, one of the books describes a world that goes on to behave regularly into the future, and the other book describes a world that goes 'haywire' at a certain point in the future. Question: what credence should you have that the 'regular' book describes the actual world?

There are two competing pressures here. On the one hand, the totality of your evidence doesn't discriminate between the two books. After all, both books entail your evidence (which is only about the past and present) with certainty.[2] Suppose we let Cr be your prior probability function, E be your evidence concerning the past, and Cr_E be your prior probability function conditioned on your evidence. Furthermore, let's call 'Regular' the proposition that the regular book describes the actual world and 'Irregular' the proposition that the non-regular book describes the actual world. In a Bayesian framework, since both Regular and Irregular entail your evidence, we have that Cr(Regular | Regular or Irregular) = Cr(Regular | E and (Regular or Irregular)) = Cr_E(Regular |

[1] According to the philpapers survey conducted by Bourget and Chalmers (2014), 81.6% of philosophers endorse 'non-skeptical realism' about the external world.

[2] Some philosophers would disagree that our evidence is only about the past and present. For example, one might think that our evidence is just our knowledge and that we know things about the future (e.g. see Williamson (2000)). In response, one can modify the case so that the two books agree on the totality of our evidence, whatever it is. So long as our evidence leaves open an uncountable infinity of future possibilities, the three premises of the inconsistent triad can be easily reformulated.

Regular or Irregular). In other words, your evidence about the past is entirely *neutral* with respect to whether Regular or Irregular is true. So, if you are to assign a higher probability to Regular, it must be for some wholly *a priori*, non-evidential reason. Since your evidence doesn't count in favor of either possibility, a natural thought is that we should apply the Principle of Indifference and assign a 0.5 credence to both Regular and Irregular.[3] According to one formulation of the Principle of Indifference, you shouldn't assign *different* probabilities to possibilities which are 'evidentially symmetric', where two possibilities are evidentially symmetric just in case you have *no more reason* to suppose that one is true rather than the other (White, 2010). In this case, since we have no evidence that has any bearing on the question, it is natural to think that we have no reason to privilege either one of these possibilities.

The most powerful objection to the Principle of Indifference is the 'multiple partitions' problem, which claims that one can get contradictory verdicts from the Principle of Indifference by assigning equal probabilities to different partitions of the space of possibilities.[4] However, there is no multiple partitions problem here. There are only two ways for the world to be! So, since your evidence is entirely neutral with respect to Regular and Irregular and there is one unique way to 'partition' these two possibilities, there is at least some pressure to assign a 0.5 credence to both Regular and Irregular.

Alternatively, one could violate the Principle of Indifference and 'skew' one's probabilities in favor of Regular, perhaps because Regular is more 'simple' or 'natural'.[5] Of course, the inductive skeptic will be suspicious of these wholly a priori skewings of one's probabilities in the absence of any evidence. Moreover, such skewings seem entirely arbitrary. Exactly how much should we skew our probabilities? 60-40? 90-10?

Perhaps we should be somewhat biased towards simpler possibilities. Still, given that we have no relevant evidence for or against Regular or Irregular, we shouldn't be *too* biased. Here is one natural way to precisify this thought. Say that some credence function Cr satisfies *Weak Regularity* if and only if it obeys the following principle:

> Weak Regularity: For any evidence E, given that w_1 and w_2 are maximally specific metaphysical possibilities that entail E, $Cr_E(w_1 \mid w_1 \text{ or } w_2) \neq 1 \neq Cr_E(w_2 \mid w_1 \text{ or } w_2)$.

Intuitively, a credence function satisfies Weak Regularity just in case it isn't *maximally* biased towards one possibility over another in the absence of any relevant evidence.

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[3] See van Inwagen (1996) for an explicit defense of the claim that maximally specific possible worlds should be assigned the same probability.

[4] For different responses to the multiple partitions problem, see White (2010) and Huemer (2009).

[5] See Sober (2015) for an overview of the uses of simplicity in epistemology, and see Bradley (2020) for a recent approach to the problem of induction that favors natural hypotheses. Hedden (2015) argues that we should be biased towards possibilities that are more explanatory.

The first premise of our inconsistent triad merely makes the following claim:

1. It is rationally permissible to satisfy Weak Regularity.[6]

You don't need to be a fan of the Principle of Indifference to find this first premise attractive. All this premise really says is that it is permissible not to do the *exact opposite* of what the Principle of Indifference recommends (by assigning all of your credence to one of two possibilities in the absence of any evidence).

Let us now turn to a second thought experiment. Imagine the following evidential situation that we might find ourselves in. Suppose that the community of theoretical physicists has unanimously decided on the true deterministic laws of physics, L, describing our universe. Suppose, for example, that billions of years pass without a single counterexample, any measurement can be predicted to arbitrary degrees of precision, the laws are breathtakingly elegant and simple, and physics departments are forced to close down because there is no work left for theoretical physicists to do. Fundamental physics is finally complete! Given this evidential situation, E*, it seems that the scientists are rational in having very high credence that the true deterministic laws of physics are L. Moreover, suppose that IC is some maximally specific characterization of the initial conditions of the universe, and let w_{ICL} be the unique world in which IC describes the exact initial conditions and the deterministic laws of physics L holds. Given that $Cr_{E*}(L)$ should be very high, scientists should also assign a similarly high credence to $Cr_{E*}(w_{ICL} \mid IC)$. After all, if they were convinced of the truth of L on the basis of E*, then given that the initial conditions of the universe are exactly described by IC, they should also be convinced that the actual world was w_{ICL} on the basis of E*.

The second premise of our inconsistent triad also makes an extremely weak claim about this sort of thought experiment:

2. Given E*, one *shouldn't* set $Cr_{E*}(L) = 0$. So, neither should one set $Cr_{E*}(w_{ICL} \mid IC) = 0$.[7]

[6] This claim is *far* weaker than the claim that it is a rational requirement to obey the principle of 'Regularity', according to which one should always assign a non-zero credence to any possibility that is compatible with one's evidence. First, this claim only makes a claim about what is permissible rather than a claim about what is required. Second, this claim avoids the main objection towards Regularity, according to which one *must* assign a credence of zero to possibilities that are compatible with one's evidence if there are uncountably many such possibilities. This problem is avoided by limiting the principle to *pairwise* comparisons of different possibilities. See Easwaran (2014) for more discussion on the principle of Regularity.

[7] As long as one doesn't take IC to be evidence *against* the truth of L, the second claim follows from the first. Here is a proof. Assume that $Cr_{E*}(L \mid IC)$ is at least as great as $Cr_{E*}(L)$. We know that $Cr_{E*}(L \mid IC) = Cr_{E*}(w_{ICL} \mid IC)$, since the conjunction of L and IC are equivalent to w_{ICL}. So, supposing it were rational to assign $Cr_{E*}(w_{ICL} \mid IC) = 0$, then it would be rational to assign $Cr_{E*}(L \mid IC) = 0$. By our assumption, this would force one to assign $Cr_{E*}(L) = 0$. This, however, is impermissible. In fact, in order to run the argument we only need to assume that there exists *one* maximally specific hypothesis about the initial conditions that isn't evidence against the truth of L.

All this premise says is that one shouldn't believe the *exact opposite* of what all the scientific experts believe. If all the scientific experts assign high credence to L given E*, you shouldn't be maximally confident that L is false given E*. Similarly, if all the scientific experts believe in global warming, you shouldn't assign a credence of 0 to global warming.

The final premise of our inconsistent triad appeals to the Humean thought that there are an uncountable infinity of ways in which the world may go haywire tomorrow. For example, suppose I am about to drop an apple. Perhaps we may expect it to fall at 9.8 m/s^2, but we cannot rule out a priori that it falls at some other rate. It seems like, for every real number $r \in [0, 10]$, there is a world just like this one up to now, except the apple drops at exactly r m/s^2 when I let it go. In other words:

3. For any initial segment of some world, there are an uncountable infinity of metaphysically possible worlds that exactly match that initial segment and deviate afterwards.

Surprisingly, these three premises imply a contradiction.[8] I will bring out this contradiction by arguing that 1 and 3 entail the falsity of 2. In particular, I will argue that, given 1 and 3, it is rational to set $Cr_{E^*}(w_{ICL} \mid IC) = 0$.

Before presenting the formal argument, it will be useful to provide an informal gloss. The intuitive idea behind the argument is just that the scientist's evidence E* leaves open an uncountable infinity of worlds that start out in conditions IC (by premise 3). Only *one* of these worlds will be w_{ICL}. By premise 1, it is rational not to be 'infinitely' biased towards w_{ICL}: when making a pairwise comparison of the plausibility of w_{ICL} against one of the other worlds left open by the scientist's evidence, one doesn't have to be certain that w_{ICL} is the actual world. However, if one is only 'finitely' biased towards w_{ICL}, because there are *so* many alternative possibilities that are left open (an uncountable infinity of them), the probability calculus forces one to assign a credence of 0 to w_{ICL}.

Here is the more formal argument (readers may skip to the next section to avoid these formal details). Using 3, let $S = \{w_i \mid i \in I\}$ be the uncountably infinite set of worlds that satisfy both E* and IC, where I is some index set.[9] By 1, let Cr be some rational prior credence function such that, for any world $w_i \in S$ distinct from w_{ICL}, $Cr_{E^*}(w_{ICL} \mid w_{ICL} \text{ or } w_i) \neq 1 \neq Cr_{E^*}(w_i \mid w_{ICL} \text{ or } w_i)$. For

[8] One might be skeptical that this puzzle essentially involves reasoning about infinitary matters, which notoriously leads to all sorts of paradoxes. However, in §§8-9, I will illustrate how my preferred response to the problem of induction has advantages over orthodox Humean and non-Humean views even when applied to certain (toy) finitary cases.

[9] What if there are too many such worlds to form a set? It will suffice for the proof for S to be merely uncountable. So, if there are too many such worlds to form a set, let S be some arbitrary uncountable set-sized collection of worlds that includes w_{ICL} and satisfies E* and IC.

every $i \in I$, let r_i be such that the *ratio* of $Cr_{E*}(w_{ICL} \mid w_{ICL}$ or $w_i)$ to $Cr_{E*}(w_i \mid w_{ICL}$ or $w_i)$ is equal to the ratio of 1 to r_i. In other words, let r_i satisfy the following equation:

$$\frac{Cr_{E*}\ (w_{ICL} \mid w_{ICL} \text{ or } w_i)}{Cr_{E*}\ (w_i \mid w_{ICL} \text{ or } w_i)} = \frac{1}{r_i}$$

For any positive natural number n, let $S_n = \{w_i \mid r_i > 1/n\}$. Since S is uncountable and equal to the union of each of the S_n, there must be some m such that S_m is infinite.[10]

Abusing notation, let us also treat S (and S_m) as the proposition that the actual world is one of the worlds in S (or S_m). Then, $Cr_{E*}(w_{ICL} \mid IC) = Cr_{E*}(w_{ICL} \mid S)$, since S is the same set of worlds as the ones that satisfy E* and IC. We also have that $Cr_{E*}(w_{ICL} \mid S_m) \geq Cr_{E*}(w_{ICL} \mid S)$, since S_m eliminates more worlds distinct from w_{ICL} than S does. To simplify things further, let us also let S_m* be some arbitrary *countable* subset of S_m that includes w_{ICL}. Again, we have that $Cr_{E*}(w_{ICL} \mid S_m^*) \geq Cr_{E*}(w_{ICL} \mid S)$, since S_m* eliminates more worlds distinct from w_{ICL} than S_m does. So, in order to show that $Cr_{E*}(w_{ICL} \mid IC) = 0$, it suffices to show that $Cr_{E*}(w_{ICL} \mid S_m^*) = 0$.

Let us label the worlds in S_m* as follows: w_{ICL}, w_1, w_2, w_3, w_4, … It is a theorem of the probability calculus that $Cr_{E*}(w_{ICL} \mid S_m^*) = Cr_{E*}(w_{ICL} \mid w_{ICL}$ or w_1 or w_2 or …$) = 1 / (1 + r_1 + r_2 + \ldots)$. Since each of these r_i is at least 1/m, it follows that $Cr_{E*}(w_{ICL} \mid S_m^*) = 0$, as desired.

4. Three Ways Forward

How should we respond to this contradiction? There are three ways out, each of which is revisionary of a different aspect of our theorizing about the world.

First, consider premise 1. The primary motivation for premise 1 appealed to the way we should reason about some space of possibilities. Given that we have no evidence favoring either maximally specific possibility, it should at the very least be *permissible* not to be maximally confident in either one! In some ways, denying premise 1 corresponds to the standard way philosophers have tried to respond to the problem of induction. Many philosophers have thought that we should be biased in favor of hypothesis that are natural, simple, or explanatory over ones that are gerrymandered or complex. However, it is easy to feel that it is far too dogmatic to assign *probability 1* to the regular possibility in the absence of any evidence, especially in the absence of some sort of explanation as to why we should expect the world to be regular *a priori*. Let's call those who respond to the inconsistent triad by denying premise 1 *Dogmatists*.

[10] This is the only step where we use the assumption that S is uncountable. The proof could work equally well for countable S so long as we assume that there is some infinite S_n. For example, if one thinks there are countably many 'symmetric' ways the world could deviate from w_{ICL}, and one thinks that one should assign an equal ratio between w_{ICL} and each of these symmetric deviant worlds, then the proof would work just the same.

Next, consider premise 2. The primary motivation for premise 2 appealed to a certain first-order judgement. If the experimental evidence E* for L was so good that every physicist unanimously endorsed L, then at the very least we shouldn't be *certain* that L is false! Giving up on premise 2 corresponds to a kind of skepticism about inductive reasoning, since inductive reasoning is supposed to align with how scientists actually reason. In fact, denying premise 2 is analogous to claiming that induction is no better than counter-induction. After all, if premise 2 is false, having the exact opposite views as the scientific community (with respect to the laws of physics) is perfectly rational. Let's call those who respond to the inconsistent triad by denying premise 2 *Skeptics*.[11]

Lastly, consider premise 3. Premise 3 is a metaphysical claim which is supported by Hume's conceivability argument. Descartes is an example of a philosopher who might have denied premise 3. According to Descartes, there is a priori reason to believe in the existence of a perfect God, in the form of the ontological argument. Since a perfect God is not a deceiver, there is a priori reason to doubt the metaphysical possibility of worlds where we are radically deceived, such as irregular worlds where apples start falling up for no apparent reason.

One might also think that contemporary non-Humeans, who believe in fundamental laws, necessitation relations, or causal powers, would deny premise 3.[12] However, contemporary non-Humeans typically don't argue for the *impossibility* of Humean worlds, which lack such primitive non-Humean posits. Typically, non-Humeans only argue that we have good reason to think that the *actual* world is governed by (say) primitive laws. Since standard non-Humean views don't identify any flaws in Hume's conceivability argument, they are not able to rebut the main argument in favor of premise 3. Why can't the world simply *lack* primitive laws or (say) second-order necessitation relations between universals? The non-Humean needs to provide some reason to think that the source of natural necessity in the world can be found in all possible worlds.[13]

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[11] One might think that this skeptical argument isn't too worrying because it still makes induction rationally *permissible*. However, an argument for the irrationality of induction isn't too far off. If one strengthens premise 1 to claim that Weak Regularity is rationally required, then one can weaken premise 2 to claim that it is rationally permissible to assign $Cr(L \mid E^*) > 0$. This modified version of the inconsistent triad would still be an inconsistent triad, and the first and third premises would entail that it is irrational to believe in accordance with the community of scientists.

[12] For an overview of contemporary non-Humean views, see Hildebrand (2020).

[13] A small minority of non-Humeans, such as Wilson (2013) and Bird (2007), have defended 'strong' necessitarian views, according to which the actual laws of physics govern every possible world, which would make Humean worlds impossible. However, rather than responding to Hume's conceivability argument, these views typically reject *a priori* modal epistemology altogether. There is therefore a worry that these views cannot help with the problem of induction, if the only grounds for believing that every possible world is governed by regular laws presuppose that induction works for discovering the laws of the actual world. The view I will end up defending is at least in principle compatible with the kind of *a priori* modal epistemology that is defended by Chalmers (2002). In fact, it will crucially utilize what Chalmers calls 'open inconceivabilities' (pp. 186-188).

Let's call those who respond to the inconsistent triad by denying premise 3 *Rationalists*. From the Rationalist perspective, we should view this inconsistent triad as having a similar structure to the so-called 'fine-tuning' argument.[14] The fine-tuning argument begins with a certain (alleged) empirical observation: the fact that the universe is able to support life depends very delicately on certain physical parameters. When this empirical fact is supplemented with certain plausible probabilistic principles in epistemology, we are led to surprising metaphysical conclusions, such as the existence of God or a multiverse. When faced with this kind of argument, we have two choices: we can either reject these plausible probabilistic principles or revise our metaphysics (by positing a cosmic designer or the existence of a multiverse). Fans of the fine-tuning argument say that we should accept these plausible probabilistic principles, and thereby accept the revisionary metaphysical consequences. The structure of the problem of induction is similar.[15] The urgency of the problem of induction is motivated by an empirical observation: the universe is an extraordinarily regular place, which is governed by precise and exceptionless physical laws.[16] When this empirical observation is supplemented with certain plausible probabilistic principles (namely, premises 1 and 2), we are led to a revisionary metaphysical conclusion (namely, the denial of premise 3). We can either reject these plausible probabilistic principles, or we can revise our metaphysics. Either way, something has to give.

Should we be Dogmatists, Skeptics, or Rationalists? It seems to me that we should at least *try* to be Rationalists. Skepticism more or less amounts to giving up on the scientific enterprise. Because Dogmatism posits extremely strong probabilistic biases that don't seem to have an adequate

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[14] For overviews of the fine-tuning argument, see Manson (2009) and Friederich (2018).

[15] Of course, the substantive probabilistic principles and associated metaphysical conclusions differ between the two arguments. For example, the fine-tuning argument needs to be supplemented with principles of 'anthropic' reasoning concerning the epistemology of self-locating beliefs (e.g. see White (2000) and Sober (2003, 2009)). The argument I have presented does not rely on any such principle. Moreover, if the fine-tuning of the universe is to motivate the existence of God, it needs to be supplemented with certain prior probabilities concerning 'divine psychology' (e.g. see Weisberg (2010, 2012) and Hawthorne and Isaacs (2018)). The argument I have presented does not rely on any such principle either. The most important similarity between the two arguments is that they can both be motivated by a kind of indifference reasoning. However, our inconsistent triad only needs an extremely weak principle in the vicinity of indifference reasoning, namely Weak Regularity.

[16] The way I have made this somewhat vague empirical observation precise is by focusing on one particular aspect of physical laws: the fact that they are deterministic. An immediate worry that one might have here concerns quantum mechanics: haven't we discovered that the laws of quantum mechanics are indeterministic? I have two replies to this worry. First, two of the three main approaches to interpreting quantum mechanics, namely Bohmian Mechanics and Everettian Quantum Mechanics, are fully deterministic, while 'spontaneous collapse' approaches are indeterministic. See Maudlin (2019) and Norsen (2017) for a survey of these three main proposals. As Wallace (2020) has emphasized, a main drawback of spontaneous-collapse theories (as well as Bohmian theories) is that they cannot adequately account for the full range of applications of quantum theory, since they are largely limited to the non-relativistic quantum mechanics of particles. Second, and more importantly, the inconsistent triad does not assume that the *actual* laws of physics are deterministic. Accepting premises 1 and 3 entail that it is *impossible* for it to be the case that we should have non-zero credence in any hypothesis about the deterministic laws of physics, no matter what possible world we inhabit.

explanation, Dogmatism more or less amounts to giving up on a satisfactory epistemology of induction. However, for those philosophers who are committed Humeans, Dogmatism is perhaps the most natural horn to take. Dogmatists pay the cost of having an implausible epistemology in order to have an (allegedly) plausible modal metaphysics. When all is said and done, it might turn out that this cost is worth paying. Still, it is worth inquiring into whether we need to pay this epistemological cost. Perhaps the metaphysical price of rejecting premise 3 isn't as steep as it may initially seem.

Here is what the Rationalist needs to do. First, the Rationalist needs to provide a coherent metaphysical account that responds to Hume's conceivability argument and casts doubt on premise 3. Second, the Rationalist should try to avoid the main drawback of the Dogmatist account by showing how induction could be vindicated *without* biasing or skewing one's probabilities in arbitrary ways. In what follows, I will try to provide the very beginnings of such an account.

The Rationalist approach to induction I will defend involves two key steps. First, in §§5-7, I will present and motivate a metaphysical picture on which premise 3 is false.[17] At this stage, my goal isn't to argue that such a metaphysics is *true*, but merely to argue that it cannot be ruled out *a priori*: such a metaphysics deserves to be a serious and live epistemic possibility. Many other philosophers have given arguments for the different parts of the metaphysics that I will describe, but my main goal will simply be to lay out the different interacting parts of the metaphysical picture. Next, in §§8-9, I argue that the epistemic viability of such a metaphysics may open up a non-Dogmatist approach to induction. I do this by considering a very simple toy case, which illustrates the advantages of the approach over standard Humean and non-Humean approaches to induction.

5. The Inscrutability of Matter

According to many philosophers, science only gives us a very limited picture of the physical world. This view has been held in different guises by Kant, Russell, and Lewis, as well as contemporary Structuralists and Russellian Monists.[18] On this view, science only reveals the abstract causal

[17] I do not wish to argue that the metaphysics that I will describe is the *only* way to deny premise 3. I am skeptical that non-Humean theories that are based on primitive laws or necessitation relations between universals can reject premise 3, because there doesn't seem to be any reason to think that these non-Humean features are present in every possible world. However, non-Humean views which locate the source of natural necessity in the nature of physical properties themselves have a better shot of rejecting premise 3, since every possible world with a similar past to our own must have some physical properties.

[18] Langton (2001, 2004) defends an interpretation of Kant in which we can never have knowledge of things 'in themselves', and Lewis (2008) endorses a similar conclusion. Contemporary Russellian Monists, such as Strawson (2006), follow Russell (1927) in endorsing a similar conclusion. For an overview of Structural Realism, see Ladyman (2016).

structure of reality, rather than its *intrinsic nature*. For example, science only tells us that electric charge is whatever it is that plays a certain causal role (e.g. it attracts opposite charges and repels like charges). Likewise, mass is whatever it is that attracts other massive objects and resists acceleration. However, science leaves us completely ignorant about the intrinsic nature of (say) mass and charge.

Consider, for example, the following, allegedly complete, description of a possible world:

> Structuralist World: There is a single entity *x* which has some property or other, call it F. *All there is to say* about F is that it makes things that have it have some other property, call it G, at the next time. *All there is to say* about G is that it makes things that have it have the property of being F at the next time. This cycling goes on forever.

To many philosophers, it seems like this cannot be a complete description of a possible world. The description leaves out the intrinsic nature of F and G, because it only describes the causal *relations* between F and G. Some have thought that in a structuralist world such as this one, the nature of any property would circularly depend on the nature of other properties. Since the nature of F is wholly exhausted by how it effects the nature of G, it seems like to understand the nature of F we would first have to understand the nature of G. But, similarly, since the nature of G is wholly exhausted by how it effects the nature of F, it seems like to understand the nature of G we would first have to understand the nature of F![19]

To get a better grip on these 'intrinsic natures', consider the following analogy. There are two ways of describing phenomenal properties, which specify *what it's like to be* something. Functionally, pain is whatever it is that occupies a certain causal role. For example, it is typically caused by tissue damage and typically causes avoidance behavior. However, there is also the intrinsic nature of pain – how it feels, or its 'phenomenal character'. There is what pain *does* on the one hand, and what it is *intrinsically like*, on the other hand. According to many philosophers, the same goes for matter. Physics only describes what physical properties *do*, but not what they are *intrinsically like*.

What are these intrinsic natures of fundamental physical properties like? Philosophers who have advocated for this view typically are skeptical that we can know what they are like. Continuing with the analogy of phenomenal properties, many have thought that phenomenal properties that are radically different than the ones we have experienced are *ineffable* to us. For a blind person, it is hard to see how the nature of phenomenal colors could be adequately described. Similarly, if we were to meet a radically alien intelligent species, we couldn't begin to describe what their phenomenology is like. Our situation isn't that there is a range of perfectly well-understood options

[19] This circularity worry has been advanced by Russell (1927), Robinson (1982), Blackburn (1990), Armstrong (1997), Heil (2003), Lowe (2006), and Goff (2017). It is primarily directed towards 'pure powers' theorists, such as Bird (2007), who believe that the nature of a physical property is wholly exhausted by its causal powers.

for what the alien's phenomenology could be like, and we are simply ignorant of which is the correct option. Rather, the complete truth about the alien's phenomenology is just not describable using the concepts that we have. Similarly, it is natural to think that the intrinsic nature of matter is ineffable to us. It is not that we have a range of perfectly well-understood options for what the intrinsic nature of matter could be like, and we are simply ignorant of which is the correct option. Rather, it seems like the complete truth about the intrinsic nature of matter is just not describable using the concepts we have.

These considerations motivate the following metaphysical thesis, which many philosophers have argued is ultimately an a priori truth:

> NATURE: Necessarily, all fundamental physical properties have some intrinsic nature.[20]

By appealing to NATURE, we can already see that there is a problem with Hume's conceivability argument. When we are conceiving of irregular worlds, where apples start rising for no apparent reason, we are not conceiving of a *complete* possible world, since we are not conceiving of the underlying intrinsic nature of the apple and its surroundings. To continue with the analogy of phenomenal properties, when we are watching a movie, the movie does not reveal the *phenomenology* of the people inside the movie. At best, we can only infer their phenomenology from what the movie shows. Similarly, when we conceive of an apple rising for no apparent reason, it is as if we are watching a mere 'movie' of the apple rising inside of our minds, which leaves out facts about the intrinsic nature of the apple and its surroundings.

Say that an ideally conceivable *structural* possibility is some ideally conceivable maximal specification of the spatiotemporal and causal structure of a world.[21] Say that an *intrinsic* possibility is some maximal specification of a metaphysically possible world, including its intrinsic nature.

> Question: Are all ideally conceivable *structural* possibilities realized by some *intrinsic* possibility?

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[20] Different philosophers use different terms of art that correspond to the phrase 'intrinsic nature', but each of these terms has various connotations that I would like to avoid. For example, some philosophers may describe these intrinsic natures as *quiddities*. However, Hildebrand (2016a) draws an important distinction between 'bare quiddities' and 'qualitative quiddities'. Bare quiddities only differ from other bare quiddities by being primitively distinct. Qualitative quiddities differ from other qualitative quiddities by being qualitatively distinct. I am using the phrase 'intrinsic nature' synonymously with Hildebrand's notion of a qualitative quiddity. Jacobs' (2011) notion of a 'thick quiddity' is also synonymous with my use of 'intrinsic nature'. Other philosophers may use the term 'categorical property' to describe these intrinsic natures. However, some philosophers (e.g. see Bird (2007)) stipulate that 'categorical properties' cannot necessitate a corresponding disposition, but I am using the phrase 'intrinsic nature' in such a way so that it is an open question whether some intrinsic nature necessitates a corresponding disposition (see §6).

[21] For much more on ideal conceivability, see Chalmers (2002).

If the answer is 'no', then it might well be that the conceivable *structural* possibilities where things go 'haywire' may not be genuinely metaphysical possible after all.

6. Powerful Qualities

We can distinguish two views about the intrinsic nature of physical properties. On one view, these intrinsic natures are *powerful*, and on another view, they are *powerless*. To say that an intrinsic nature is powerful is to say that it grounds a corresponding disposition or causal power. Otherwise, it is powerless.

Again, we can consider an analogy with phenomenal properties. According to some, phenomenal properties are powerful. This view has been defended in different ways by Mørch (2014, 2017, 2019a, 2019b, 2020), Langsam (2011), and Builes (2020).[22] While a full defense of the Phenomenal Powers view is far beyond the scope of this paper, some initial motivation for the view can be found by reflecting on our own conscious experiences. It is natural to think, for example, that *pain* makes subjects who experience it try to avoid it simply in virtue of how bad it feels. *Pleasure* might make subjects who experience it try to pursue it simply in virtue of how good it feels. Someone who feels *tired* or *exhausted* might be disposed to stay in bed simply in virtue of how tired they feel. These connections between these experiences and their effects are certainly defeasible. Of course, in our own case, human subjects endure pain for all sorts of reasons. Someone might endure short-term pain in order to avoid more pain in the future (e.g. going to the dentist), or in order to experience a greater pleasure (e.g. masochism), etc.[23] However, in the *absence* of any interfering causes like these, it seems like pain has a certain kind of default power to dispose subjects to at least *try* to avoid it. Similarly, throwing a ball at a window might cause the window to break, but only in the absence of any interfering causes. Of course, the wind might blow the ball away before it hits the window, or the window might be shattered by a rock before the ball gets to it, etc.

It is important to note that the claim that the intrinsic natures of physical properties are powerful doesn't need to be associated with consciousness or phenomenology in any way. Many

[22] Goff (2017, 2020) also argues that 'consciousness+' properties – properties which have both phenomenal and non-phenomenal aspects – ground a corresponding disposition.

[23] One common objection to the claim that pain grounds avoidance-dispositions is the phenomenon of pain asymbolia. Those who have pain asymbolia may experience pain without the corresponding feeling of unpleasantness, so they are not motivated to avoid the pain. For this objection to go through, it would have to be maintained that pain experiences for those who have pain asymbolia have the very same phenomenal character as ordinary experiences of pain. However, this is doubtful. It is natural to think that the *unpleasantness* of pain is part of the phenomenal character of ordinary experiences of pain. On this view, what the phenomenon of pain asymbolia shows is that ordinary phenomenology of pain has two components, a sensory component and an affective component. For those who have pain asymbolia, these two components come apart, and they only experience the sensory component without the affective component. For much more on this, see Grahek (2007) and Mørch (2019a).

metaphysicians, including Heil (2003, 2012), Martin (2008), Jacobs (2011), and Taylor (2013), have argued in favor of a general 'Powerful Qualities' view, according to which the intrinsic nature of physical properties are both qualitative *and* dispositional.[24]

Other philosophers have argued in favor the so-called Eleatic Principle, which roughly states that in order for any entity to exist, it must have causal powers.[25] This principle would preclude the existence of entities which were entirely causally inert, perhaps because their intrinsic nature is entirely powerless.

Building on these views, here is a speculative metaphysical hypothesis:

> POWER: The possible intrinsic natures of fundamental physical properties are all powerful.

Ultimately, what we should think about POWER will turn on various difficult and controversial metaphysical debates. For our purposes, however, we won't need the claim that POWER is particularly plausible. In fact, as we will see below, it is fine if POWER is fairly *im*plausible. All we will need at this point is that POWER *cannot be ruled out a priori*. Given that POWER concerns a realm of properties that are entirely ineffable to us, it's not clear how we could possibly rule this out *a priori*, since we don't have a positive conception of *any* of the possible intrinsic natures of fundamental physical properties. Because of this, it seems safe to say that POWER cannot be ruled out a priori.

7. Regular Powerful Qualities

We've now reached our final section on speculative metaphysics. If POWER is true, what kinds of powers can these possible intrinsic natures give rise to? Can they give rise to entirely 'gerrymandered' powers? Consider the power*: disposed to play the charge-role before 2020 and the mass-role afterwards*. Could there be any intrinsic nature that gives rise to this power?

Again, if we consider the analogy with phenomenal properties, none of the (allegedly) powerful phenomenal properties we are acquainted with are anything like this. Pain, for example, disposes one towards avoidance behaviors regardless of where or when it happens. Similarly, if you feel

[24] The Powerful Qualities view is usually associated with the claim that qualities are *identical* to dispositions, whereas I have formulated the claim that qualities (or 'intrinsic natures') are powerful as the claim that intrinsic natures *ground* a corresponding disposition. For further reason to reject the identity view, see Taylor (2019). However, for our purposes, these metaphysical details will not be relevant. So long as the intrinsic nature of a physical property necessitates a corresponding disposition (whether this is by grounding or identity), the epistemological pay-offs will be similar.

[25] Armstrong (1978) and Ellis (1990, p. 22) endorse the Eleatic principle, and Field (1980) can also be interpreted as an Eleatic. See Colyvan (1998) and Cowling (2015) for discussions of the Eleatic Principle.

exhausted, this isn't going to motivate you to stay in bed on Mondays and jump out of bed on Tuesdays. On reflection, it's hard to see how an intrinsic nature *could* give rise to such a gerrymandered power. Reflecting on our experience motivates the following speculative metaphysical hypothesis, which builds on POWER:

> REGULAR: The only ideally conceivable structural possibilities realized by an intrinsic possibility are regular.

If all intrinsic possibilities contain intrinsic natures that are powerful in regular ways, then such intrinsic possibilities will only ever realize regular structural possibilities, instead of structural possibilities that go 'haywire' in various ways. Again, we will not be needing the claim that REGULAR is particularly plausible. As we will see below, we will only need the claim that REGULAR cannot be ruled out a priori.

An obvious clarificatory question to ask of REGULAR is what 'regular' means. Although there is some intuitive, vague content to which structural possibilities are regular, the phrase is meant to be a placeholder that must be filled in by different precise physical principles. An important question is exactly how to precisify it. Given that we are speculating about the possible ineffable intrinsic natures of things, it's hard to know exactly how it should be filled. One way it could be filled in is by saying that the only structural possibilities realized by an intrinsic possibility are ones that are governed by our actual physical laws, such as the Schrödinger equation in quantum mechanics. However, this can seem fairly ad hoc. What could explain why every possible intrinsic nature must conform to Schrödinger's equation?

A more promising route is to look to the long history of both physicists and philosophers who have advanced purportedly *necessary* constraints on the laws of physics of a very general form. In his recent book, Darrigol (2014) surveys and assesses many of these necessary principles, ranging from the attempts of pre-Newtonian philosophers such as Descartes and Leibniz, to present day rational reconstructions of Quantum Mechanics. Ultimately, the most plausible ways to precisify 'regular' will come from the kind of rationalistic investigation carried out by these physicists and philosophers. Briefly, however, let us go through two simple and non-technical examples of how such purportedly necessary principles may be motivated.

Some philosophers and physicists have thought that certain kinds of *conservation laws* are necessary constraints on the laws of physics.[26] Lange (2007, 2012) has also argued that conservation laws are distinctive because they should be treated as 'meta-laws': laws that constrain the 'first-order' laws of physics. We might therefore conjecture that one principled way of filling in 'regular' is as follows:

[26] See Darrigol (2014, Ch. 3)

> CONSERVATION: The only ideally conceivable structural possibilities realized by an intrinsic possibility conform to various conservation laws (e.g. conservation of energy, conservation of linear and angular momentum, etc.)[27]

Rationalist philosophers such as Descartes and Leibniz typically argued for the necessity of conservation laws on theistic grounds.[28] However, in modern times a plausible a priori case can be made for CONSERVATION by appealing to certain mathematical results proven by Emmy Noether connecting conservation laws to symmetry principles. Using these mathematical results, it can be shown that conservation of energy follows from the fact that the laws are invariant across time, and conservation of linear and angular momentum follow from the fact that the laws are invariant across spatial translations and rotations. We have already seen that the causal powers of (say) pain seem to be invariant across time and space. Whether or not pain causes avoidance behavior is insensitive to where or when that pain is instantiated. But, we can go further. If the causal powers of physical properties are to be *fully grounded* in their intrinsic natures, then these causal powers cannot be sensitive to anything *but* these intrinsic natures. As a consequence, they cannot be sensitive to where or when these intrinsic natures happen to be instantiated. Otherwise, the causal powers of physical properties would only be *partly* grounded in their intrinsic natures and *partly* grounded in where or when they happen to be instantiated. At least given POWER, then, it seems like a plausible a priori case can be made in favor of CONSERVATION.

Another kind of principle that has been pervasive in our physical theories is a principle of *continuity*. Can a physical system transition from one state to another, without traversing states that are intermediate between the two? One way to make this principle precise is as follows:

> CONTINUITY: The only ideally conceivable structural possibilities realized by an intrinsic possibility are ones whose trajectory across phase space is continuous.[29]

One might also consider different strengthening of this principle:

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[27] The details of exactly how to formulate these different conservation laws will sensitively depend on the physical framework that they apply to (for example, these conservation laws look very different in General Relativity than in Newtonian Mechanics). Although these physical details are metaphysically important, they won't matter for the general epistemological upshots we will discuss later. The main purpose of this section is merely to illustrate some possibilities for how to precisify REGULAR, and so I will consider the simplified case of Newtonian mechanics.

[28] See Garber (1992, Ch. 7) for a discussion of Descartes' arguments for conservation principles, and Garber (1995) for a discussion of Leibniz's arguments. The modal status of Leibniz' arguments for conservation laws is controversial. In the *Theodicy*, Leibniz wrote, '[The laws of motion] do not derive entirely from the principle of necessity, but from the principle of perfection and order; they are an effect of the choice and the wisdom of God'. Leibniz scholars disagree about whether Leibniz is best interpreted as thinking that God could have chosen to make a different world than the actual world (e.g. see Griffin (2012)).

[29] Different physical theories have different phase spaces. The *phase space* of a physical theory represents all of the physically possible states of a system, where each point represents a possible state. Each axis of a multi-dimensional phase space corresponds to one of the degrees of freedom of a system (e.g. a particle's position or momentum).

> DIFFERENTIABILITY: The only ideally conceivable structural possibilities realized by an intrinsic possibility are ones whose trajectory across phase space is differentiable.
>
> SMOOTHNESS: The only ideally conceivable structural possibilities realized by an intrinsic possibility are ones whose trajectory across phase space is smooth (i.e. infinitely differentiable).

These kinds of continuity principles were perhaps most famously defended by Leibniz (*NE*), who wrote that 'Nothing takes place suddenly, and it is one of my great and best confirmed maxims that *nature never makes leaps*. I call this the Law of Continuity' (p. 56). One can try to motivate CONTINUITY on the grounds that, given POWER, it seems like small changes in the intrinsic nature of a physical system should only give rise to small changes in the kind of effects that those intrinsic natures give rise to. Otherwise, it would seem that the power of that physical system cannot be intelligibly traced back to its intrinsic nature. Suppose, for example, that some physical system evolved continuously within the interval of time $[t_1, t_2]$, but then sharply and discontinuously 'leapt' to some other state right after t_2. Then, the intrinsic nature of the system at t_2 would have made the system 'leap', but the intrinsic nature of the system at any time arbitrarily close to t_2 did *not* make the system leap! This would therefore be a case where arbitrarily similar intrinsic states of a physical system (the state at t_2 compared to the state at any time arbitrarily close to t_2) give rise to radically different kinds of causal effects (leaps vs non-leaps). A very natural hypothesis is that none of the possible intrinsic natures of matter can be like this.[30]

Of course, much more should be said about what kinds of physical principles should constrain modal space according to REGULAR (e.g. see Darrigol 2014). For our epistemological purposes, we will only need the claim that it is possible to understand REGULAR in a precise and principled way, and it is not an a priori truth that REGULAR is false.

8. Our Predicament: A Toy Case

Having finished describing a metaphysics on which premise 3 is false, let us finally turn back to our inconsistent triad. Orthodox modal metaphysics, inspired by Hume's a priori conceivability argument, endorses the following:

> PLENITUDE: Every ideally conceivable structural possibility is realized by a genuine metaphysical possibility.

[30] In contemporary physics, there are some interpretations of quantum mechanics that seem to violate these continuity principles (such as objective collapse interpretations like GRW), but there are also popular interpretations of quantum mechanics that are perfectly consistent with these kinds of principles (such as Bohmian Mechanics and the Many Worlds Interpretation). See Maudlin (2019) and Norsen (2017) for an introduction to these three different interpretations of quantum mechanics.

Because of PLENITUDE, orthodox metaphysics implies that premise 3 in our inconsistent triad is an a priori truth:

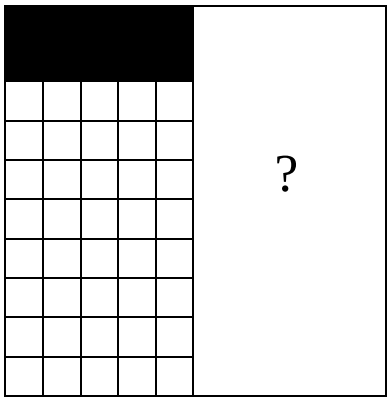
3. For any initial segment of some world, there are an uncountable infinity of metaphysically possible worlds that exactly match that initial segment and deviate afterwards.

I have argued that PLENITUDE is not an a priori truth. Hume's conceivability argument fails because NATURE is an a priori truth, and we fail to conceive of the intrinsic natures of things when we are conceiving of possibilities in which things go 'haywire'. In contrast to PLENITUDE, I have put forward a metaphysical picture in which REGULAR is true, which builds on NATURE and POWER. While I have argued that REGULAR cannot be ruled out a priori, I don't think that we are in a position to know that REGULAR is true a priori either. While many philosophers have given a priori arguments that support principles like NATURE, POWER, and REGULAR, the truth of REGULAR ultimately turns on the possible ineffable intrinsic natures of physical properties, which we are largely ignorant of. Since there are principled metaphysical pictures which give rise to both PLENITUDE and REGULAR, I believe we should have non-zero credence in both pictures.

However, if we don't know REGULAR a priori, how does this help with the problem of induction? Do we still need to 'skew' our probabilities towards regular possibilities to secure the rationality of induction? One of the main motivations for pursuing a Rationalist response to inductive skepticism was precisely to avoid the Dogmatist reply to our inconsistent triad, which needed to arbitrarily skew our prior probabilities in extremely strong ways.

I believe that once REGULAR is open to us, there is hope for recovering induction without having to skew our probabilities at all. Perhaps we could recover induction by simply being *indifferent* among the possibilities within any given Modal Space. Here is a very toy example that illustrates this hope:

> Grid Modal Space: Suppose that every possible world was a 10x10 grid. Each square may be black and white, and "times" are represented by the different columns. Suppose the actual world is such that the first five columns are white except for the top two squares, which are black. What will happen in the future?



In this situation, the analog of PLENITUDE is the hypothesis that every combination of white and black, all 2^{100} of them, are genuine metaphysical possibilities. Just to run the example, let us suppose that REGULAR corresponds to a regular modal space where *Inertia* is true: the color distribution of every column is identical to the color distribution of the first column.

There are three different background metaphysical approaches one might have to Grid Modal Space. I will discuss the epistemological consequences of each in turn.

Suppose, first, that we were convinced of a 'Humean' metaphysics, according to which all there is to any possible world is the distribution of colors. Then, there would be exactly 2^{100} worlds in our modal space. Natural indifference reasoning gives us that there is a $1/2^{50}$ chance that the regularity will continue to hold, since only 1 of the 2^{50} possible futures correspond to a grid where only the top rows are black. This is a chance of ~0.0000000000000009. Of course, insofar as one follows the Dogmatist in skewing one's prior probabilities in favor of induction friendly worlds, one will reach more inductively friendly conclusions.

Next, suppose we were convinced of an underlying modal space analogous to the typical Non-Humean position. On this view, there are all the worlds that the Humean countenances, but there are also *additional* regular worlds that are governed by fundamental laws. More precisely, for every grid that obeys Inertia, there is a corresponding Humean world *and* a corresponding non-Humean world that is governed by fundamental laws. On this view, there are exactly $2^{100} + 2^{10}$ worlds (since there are 2^{10} grids that obey *Inertia*). Applying natural indifference reasoning to this modal space gives us that there is a $2/(2^{50} + 1)$ chance that the regularity will continue, since there are two grids (a Humean one and a Non-Humean one) in which the regularity continues as before. This is a chance of ~0.000000000000002. Unfortunately, the Non-Humean position barely helps at all with the problem of induction! Again, one could always skew one's prior probabilities in favor of induction friendly worlds in response to this problem. The more one is willing to skew one's prior probabilities, the more inductively friendly conclusions one will reach.

Finally, here is the suggestion that I think we ought to adopt. Suppose one thinks that there are two epistemic possibilities for what the true metaphysical modal space consists in. One epistemically possible modal space obeys PLENITUDE and the other obeys REGULAR (i.e. *Inertia* is true). On this approach, we first need to assign prior probabilities to PLENITUDE and REGULAR. The appropriate probabilities to assign to these metaphysical hypotheses will crucially turn on the metaphysical issues we were surveying before. Insofar as the a priori metaphysical arguments in favor of principles like NATURE, POWER, and REGULAR are persuasive, we should assign higher probability to REGULAR. Insofar as they are unpersuasive, we should assign lower probability to REGULAR. Just to make things difficult, let us suppose that these metaphysical arguments aren't all that strong, and so one finds REGULAR to be very implausible. To make things precise, suppose one thought that there was a *one in a million* chance that REGULAR was true. After one assigns probabilities to REGULAR and PLENITUDE, one should proportion one's credence of 0.000001 indifferently among the REGULAR worlds, as well as one's credence of 0.999999 indifferently among the PLENITUDE worlds. Conditional on the truth of REGULAR, one should be indifferent among the various possibilities in REGULAR, and conditional on the truth of PLENITUDE, one should be indifferent among the various possibilities in PLENITUDE. By doing this, because there are *so* many more worlds in PLENITUDE than in REGULAR, any particular world in REGULAR will be assigned *much* more credence than any particular world in PLENITUDE. After crunching the numbers, it turns out that observing the first five columns of the grid makes the chance that the regularity will continue to be ~0.999999!

This strategy recovers everything we wanted in inductive inference. First, we don't want to be *certain* that the world won't go haywire tomorrow. We should always leave that possibility open. Second, we want to be very confident that past regularities will continue into the future. Third, we don't want to have to skew our probabilities arbitrarily in favor of regular worlds. All three of these desiderata are perfectly captured by this sort of approach!

It is important to note that this approach uses a version of the principle of indifference over *metaphysical* possibilities rather than *epistemic* possibilities. Here are two conflicting constraints one might place on rational prior probabilities:

> Epistemic Indifference: For any two maximally specific epistemically possible worlds w_1 and w_2, one should assign $Cr(w_1 \mid w_1 \text{ or } w_2) = 0.5 = Cr(w_2 \mid w_1 \text{ or } w_2)$.
>
> Metaphysical Indifference: Given that it is epistemically possible that M describes the correct space of metaphysically possible worlds, for any two worlds w_1 and w_2 within M, one should assign $Cr(w_1 \mid M \text{ and } (w_1 \text{ or } w_2)) = 0.5 = Cr(w_2 \mid M \text{ and } (w_1 \text{ or } w_2))$.

Epistemic Indifference fails because we may have reason to favor w_1 over w_2 insofar as we think that it is more likely that w_1 is metaphysically possible. For example, suppose I have some a priori reason to assign a credence of 0.9 that w_1 is metaphysically possible and a credence of 0.1 that w_2 is metaphysically possible, even though both worlds are epistemic possibilities for me. Perhaps,

for example, I have good reason to suspect that there is some subtle logical inconsistency in the description of world w_2, even though I'm not *sure* that there is. Clearly, I should not be *neutral* with respect to w_1 or w_2! This is a straightforward counterexample to Epistemic Indifference. Moreover, because the ultimate truth about modal space will turn on the ineffable intrinsic natures of things, even *ideal* reasoners should not be certain about which epistemic possibilities are genuine metaphysical possibilities.

Metaphysical Indifference does not have this flaw. Once one supposes that both possibilities are genuine metaphysical possibilities, there doesn't seem to be any reason to favor one possibility over another in the absence of any empirical evidence, and so it is natural to apply the principle of indifference.

According to this Metaphysical Indifference approach to the problem of induction, not only does our metaphysics help our epistemology, but epistemology greatly helps our metaphysics! In our toy case above, the empirical evidence of regularity constituted an *enormous* amount of evidence that the true metaphysical space of possibilities is given by REGULAR. In fact, the probability of REGULAR jumps from one in a million to ~0.999999! If the most plausible explanation for REGULAR involves the claim that there are ineffable intrinsic natures of physical properties that are powerful in non-gerrymandered ways, then we also have an extraordinary amount of purely empirical evidence for this highly abstract, metaphysical claim. One might have thought that arcane debates in modal metaphysics are entirely insensitive to ordinary empirical findings. But on the Metaphysical Indifference approach, ordinary empirical observations like an apple falling at 9.8 m/s^2 might have direct bearing on the ultimate nature of modal space.

9. A More Tractable Grue Problem

I will close by considering a natural objection one might raise to this kind of inductive strategy, which is closely related to Goodman's (1955) infamous problem of 'gerrymandered' properties such as *grue*. In the above analysis, I considered two salient (epistemically) possible modal spaces, namely PLENITUDE and REGULAR. These are perhaps the two most natural hypotheses about modal space that one might consider. On the first hypothesis, 'anything goes' so far as possible worlds are concerned. Possible worlds can be as unnatural and gerrymandered as one likes. On the second hypothesis, only a privileged class of especially natural and uniform worlds are genuinely possible. However, it seems like we can at least entertain many other kinds of 'gerrymandered' modal spaces, and such gerrymandered modal spaces threaten to block the kind of inductive reasoning I defended above.

For example, let HALF-REGULAR be the hypothesis that all possible worlds must be regular and uniform for the first five columns of our black and white grid, however they are allowed to go 'haywire' in any possible way afterwards. Our empirical evidence of the regularity present in the

first five columns might strongly support REGULAR over PLENITUDE, but it does not support REGULAR over HALF-REGULAR. After all, both hypotheses *entail* that there will be regularity in the first five columns. So, if we assign roughly equal prior probabilities to REGULAR and HALF-REGULAR, then we should no longer be especially confident that the regular pattern will continue in the grid.

While *grue* is an example of a particular gerrymandered property (which 'changes' between green and blue at a particular time), HALF-REGULAR is an example where *modal space itself* is gerrymandered, in which the metaphysical necessity of regularity holds up to some particular time and then 'changes' when it comes to later times.

In a sense, these kinds of grue-like problems are pervasive, and they are problems for everyone when it comes to the problem of induction. The ordinary grue problem is this: how can we be confident that the *actual* world isn't 'gerrymandered' (e.g. where the laws of physics inexplicably 'change' at some future point), given that there are countless gerrymandered possible worlds? The grue problem faced by my approach is this: how can we confident that *modal space itself* isn't gerrymandered?

If there really are countless gerrymandered metaphysically possible worlds, then the first problem seems to me to be insoluble. There can be no reason for thinking that the actual world is one of the few non-gerrymandered possibilities. However, the modalized version of the grue problem seems much more tractable. Many philosophers have defended conceptions of modal space where PLENITUDE and REGULAR are true, however to my knowledge no philosopher in history has provided a defensible account of modal space on which something like HALF-REGULAR is true.[31] Gerrymandered modal spaces like HALF-REGULAR seem to involve completely arbitrary and inexplicable restrictions on modal space (e.g. why should the necessity of regularity change after the first *five* columns rather than the first *seven* columns?), and many philosophers have defended the claim that metaphysical necessities cannot be completely arbitrary and inexplicable in this way, on entirely *a priori* grounds. While there may be plenty of brute contingencies, there cannot be brute necessities.[32] If these kinds of *a priori* arguments are on the right track, then we

[31] For example, Wilson (2013) and Bird (2007) defend the claim that the actual laws of physics govern all possible worlds, which entails REGULAR. It is also natural to interpret certain theistic views as endorsing REGULAR over PLENITUDE. Hildebrand (2016b) argues for the related view that the best account of Non-Humean necessary connections will be *timeless* rather than time-limited.

[32] For an overview of the literature on brute necessities, see Van Cleve (2018) and the references therein.

should have a high prior probability against the (epistemic) possibility that modal space is gerrymandered in this way.[33,34]

10. Conclusion

I have argued that orthodox Humean and non-Humean views cannot recover the kinds of inductive inferences that physicists make (§§3-4), and I have put forward an alternative approach to induction that avoids the problems with these orthodox views and can plausibly recover what we want out of inductive inference in an idealized, toy case (§§5-9). This alternative approach to inductive inference seeks to reconcile inductive-reasoning with indifference-reasoning, and it transforms the infamous 'grue' problem into the more tractable problem of justifying the claim that modal space itself cannot be gerrymandered.

All this being said, the approach I have developed here is far from complete. Nowhere have I talked about falling apples or rising suns. There are of course many other problems that would need to be addressed before this kind of approach can be extended to physically realistic situations.[35] Still, before we tackle the problem of justifying why an ordinary piece of bread will continue to be nourishing tomorrow, we should at least have a sketch of how an approach to induction could possibly be made to work in very simple, toy cases. My main goal here has been to motivate and develop a distinctively *metaphysical* approach to the problem of induction, which is the only hope we have of avoiding the twin horns of Dogmatism and Skepticism.[36]

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[33] In Beebee's (2011) influential critique of Non-Humean approaches to the problem of induction, she also appeals to time-limited natural necessities like HALF-REGULAR. However, while it may be plausible that HALF-REGULAR could be a contingently true *natural* necessity, it seems far less plausible to suppose that time-limited regularities like HALF-REGULAR could be *metaphysically* necessary.

[34] It should be noted that this kind of approach does assume that there is an objective distinction to be drawn between properties like green and grue. Perhaps only one is natural, or only one corresponds to a universal, or only one is counterfactually sensitive to observation, or only one is partly grounded in what time it is, etc. However, the problem of grue involves two distinct components: (i) drawing an objective distinction between natural and unnatural properties and (ii) arguing that natural regularities involve natural properties rather than gruesome ones. The approach developed here is only meant to make the second component more tractable.

[35] One of the most pressing problems concerns how we should apply indifference reasoning to uncountably infinite spaces of possibilities. This kind of problem has perhaps been most discussed in the foundations of statistical mechanics, where some philosophers and physicists have already argued that standard uniform measures that physicists use over the space of nomological possibilities can be justified by indifference reasoning (e.g. see Meacham (2010) and references therein). Another pressing problem is whether high-level regularities in the special sciences can be accounted for by fundamental physical regularities. For more on this problem, see Loewer (2020) and Gómez Sánchez (2020).

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