

## Naturalism, Functionalism and Chance: Not a Best Fit for the Humean<sup>1</sup>

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### 1. Introduction

How should we give accounts of scientific modal relations, such as laws and chances?

According the Humean, we should do so by reducing these relations to parts of non-modal actuality: typically, patterns in actual events, where the relevant events do not metaphysically necessitate each other or ‘build in’ facts about modality.<sup>2</sup> Modal relations are nothing ‘over and above’ the non-modal.

Here are three motivations for being Humean. Firstly, one might be worried about admitting ‘mysterious’ elements into one’s ontology (Loewer 2012, p. 121). Modal relations are strange. Humean accounts reduce modal relations to the non-modal. They provide a straightforward account of what modal relations are and their relation to the non-modal. If we take modal relations as primitive, by contrast, we seem saddled with strange entities, and have to explain their connection to actual events.

Secondly, one might be motivated by a kind of functionalism. One may wish to account for modal relations by considering the *role* such relations play in our lives and scientific theorizing. Perhaps chance, for example, should be accounted for by identifying something that plays its role of guiding credences, and so forth. It might seem that Humean accounts are particularly well suited to meet this aim, since they can use the role of modal relations to specify what non-modal relations scientific modal relations reduce to. We’ll see some examples below. The association between Humeanism and functionalism has become so strong that even *non*-Humeans take it that Humeans are uniquely interested in showing why modal relations are fit to play their roles (Hall 2015), and that Humean explanations are of a

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<sup>1</sup> My warm thanks to the following people for comments and discussion: Elizabeth Miller, Michael Hicks, Nina Emery, David Albert, Barry Loewer, Alastair Wilson, Michael Janssen, Catherine Kendig, Yann Benetreau-Dupin, Matthew Brown, Anjan Chakravartty, Edouard Machery, Sharon Crasnow, and Greg Frost-Arnold.

<sup>2</sup> I use ‘reduction’ to refer to whatever metaphysical dependency relation the Humean adopts. I won’t discuss how the non-modal ‘Humean base’ should be characterised—see Maudlin (2007, Ch. 2), Miller (2014) and Bhogal (2017, pp. 457–9) for discussion.

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kind that even non-Humeans should adopt (Ismael 2015). Recent Humean accounts have been particularly explicit in their functionalist motivations. While Lewis (1983, 1994) was largely content to appeal to broad criteria such as generality and simplicity in his analysis of laws, recent accounts (Hicks 2018, Dorst 2019, Jaag and Loew 2020) have focused on refining these criteria and justifying their relevance by arguing that we need laws to be simple, general, and satisfy other criteria, if they're to be useful to us. If one has functionalist motivations, and Humeanism is required to meet those, one has strong reason to be Humean.

Thirdly, one might be motivated towards Humeanism by naturalism of a kind of that envisages a close connection between science and metaphysics. The general thought is that metaphysics shouldn't attempt to replace science or revise it in its image—'[metaphysics] should wherever possible prefer scientific explanations over metaphysical postulation' (Loewer 2012, p. 136). Instead, metaphysics is constrained by science and provides accounts of the kinds of relations and entities that science is concerned with. I'll develop this idea further below. It may seem that, by being functionalist, Humean accounts can deliver the modal relations used in science—those that feature in scientific derivations and explanation. If so, Humeanism may seem like a good choice for those wanting a naturalistic metaphysics.

The argument of this paper is that two of these motivations do *not* count in favour of Humeanism. If one is motivated by functionalism, one has no reason to adopt Humeanism over its rivals. If one is motivated by a naturalist connection between science and metaphysics, one has reason to *reject* Humeanism. Motivations of the first kind (finding modal entities strange) may still lead one to Humeanism. But for those more concerned with the function of modal relations and the fit between science and metaphysics, one should look elsewhere.

To make this argument, I will focus on the case of chance: objective probabilities that apply in the single case. In [Section 2](#), I discuss the positive claims made by Humeans: that Humean accounts fit well with science, and that *only* Humean chances can be shown to play the role of chance. In [Section 3](#), I examine recent attempts to show Humean chances satisfy the chance role and show how they rely on indifference reasoning. In [Section 4](#), I argue that,

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notwithstanding this concern, Humeans have no special advantage when it comes to showing that chances are fit to play the chance role. In [Section 5](#) I consider whether the Humean can respond by advocating a revision of science—and argue this response fits ill with naturalism. In [Section 6](#), I argue that there is a deeper tension: Humeanism implies a disunity between science and metaphysics of a kind that naturalists should reject. In [Section 7](#) I offer a brief sketch of an alternative naturalist justification.

## 2. The Humean's Claimed Advantages

Humeans claim their accounts can recover the chances used in science—they can recover the particular *values* of these chances, and their features, such as their *objectivity*. Regarding the first, Loewer (2001, 2004), Albert (2015, Ch. 1), Frigg and Hoefer (2015), Hoefer (2019, Ch. 7) and Schwarz (2016) claim that Humean chances will have values matching those used in science, including those of classical statistical mechanics. While my arguments don't rest on there being chances if the laws are deterministic, classical statistical mechanics will serve as a useful example.<sup>3</sup> In Boltzmannian classical statistical mechanics, as explicated by Albert (2000), even though the laws are deterministic, probabilities play an essential role in scientific derivations of macroscopic behaviour. Loewer claims that only Humean can account for probabilities in these deterministic settings (2001, p. 619). They may do so, for example, using a 'Best Systems' account, according to which chances derive from the true axiomatic system that best balances *simplicity* (in its number of axioms and their complexity) against *strength* and *fit* (how much information the system provides about actual events) (Lewis 1986; Loewer 2001). In the case of statistical mechanics, including a simple probability measure over initial states allows one to derive a range of macroscopic behaviour that wouldn't otherwise be derivable. So, the probability measure is plausibly included in the Best System.

Humeans also claim that because patterns in actual events are *objective*, and not mere recommendations for belief, Humean chances can feature in scientific explanations and derivations (Albert 2000, p. 64; Loewer 2001, pp. 611–2). Humean accounts deliver

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<sup>3</sup> For arguments we need statistical-mechanical chances, see Loewer (2001), Glynn (2010), Handfield and Wilson (2014), Emery (2015, 2016). For a non-Humean account, see also Demarest (2016).

objective statistical-mechanical chances that can explain macroscopic behaviour and the Second Law of thermodynamics.

Another major motivation for Humeanism is functionalism. Humeans have argued that, in order to give an adequate account of chance, one must be able to show why chances, understood in those terms, play the *role* of chance—why they satisfy chance—credence principles like the Principal Principle, for example, (Lewis 1986). While the exact form of the chance—credence principle is controversial (Section 5), there is broad agreement that we should align our credences in some way to what we take the chances to be (perhaps conditional on further information), given we have no evidence that overrides our use of chance-based reasoning. According to Lewis’ Principal Principle (PP) (1986), for example, we should align our credence that an event occurs,  $\text{Cr}(\mathcal{A})$ , to its chance of occurring,  $\text{Ch}(\mathcal{A})$ , as follows (where  $X$  is the proposition that  $\text{Ch}(\mathcal{A}) = x$ , and  $E$  is any ‘admissible’ evidence):<sup>4</sup>

$$\text{PP: } \text{Cr}(\mathcal{A} | XE) = x$$

Our credence in an event, conditional on what we take its chance to be (and any other admissible evidence) should equal what we take its chance to be. Evidence counts as admissible if it provides information about  $\mathcal{A}$  only by providing information about  $\mathcal{A}$ ’s chance. Assuming the chance theory of a world ( $T$ ) is admissible, and a particular specification of what further information is admissible ( $G$ ):

$$\text{PP: } \text{Cr}(\mathcal{A} | ET) = \text{Ch}_G(\mathcal{A})$$

Some take the task of giving an account of chance be to show that chance—credence principles are *justified*, given what chance is (Strevens 1999, p. 256; Hoefer 2007, 2019). Others take chance—credences principles as primitive. The task is then to show that chance can play the role specified by these principles (Lewis 1986; Loewer 2004; Ismael 2011;

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<sup>4</sup>  $\mathcal{A}$  is the proposition that a particular event occurs, but I also talk loosely of events having chances. Following Meacham (2005) and Handfield and Wilson (2014), I won’t explicitly index chances to times.

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Schwarz 2014). I will refer to the criterion in either case as showing that the chance role is *satisfied* or that the account of chance is *justified*.

Humeans have claimed that Humean chances are *uniquely* well-placed to satisfy the chance role (Lewis 1994, p. 484; Loewer 2004, pp. 1121–3; Hoefer 2007, p. 595). Lewis thinks he sees ‘dimly but well enough’ how a Humean justification might go, but sees no prospects for other accounts (1994, p. 484). Loewer (2004, p. 1123) claims that any attempted justifications by propensity theorists will be illicitly question-begging. Hoefer (2007, p. 595) claims *only* Humeans chances can be shown to ‘deserve to guide action under circumstances of ignorance’. Humeans claim what I call a ‘*special advantage*’: Humean chances can be shown to be fit to play the chance role in a way not available to other accounts. The usual contrast is with propensity accounts. Because Humean chances reduce to patterns in events, and because we can be shown to be at least *reasonable* in aligning our credences to (appropriately related) patterns in actual events, Humean chances can be shown to be suitable for guiding credences. Moreover, *only* Humean accounts can show that chance satisfies chance–credence principles, since only they reduce chance to patterns in actual events.

If the above claims are right, those motivated by naturalism and functionalism have strong reason to adopt a Humean account of chance, independently of their prior metaphysical commitments.

### **3. Humean Justifications**

In this section I show how Humean justifications rely on a) a reduction of chance to patterns in actual events, and b) indifference reasoning. While this is not my major argument, for those with qualms about indifference reasoning, its role in these justifications should give them pause.

While Lewis suggests there will be rational constraints for belief based on knowledge of frequencies and symmetries (1994, p. 484), I’ll focus on Schwarz’s more explicit justification. Using indifference principles, Schwarz (2014) argues that agents are required to assign the same credence to event-sequences with the same proportion of event-types (‘exchangeability’). This requirement implies that one’s credence in an event of a given type

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at a particular point in the sequence should equal the proportion of events of that type in the whole sequence (the relative frequency). So, beliefs in relative frequencies rationally constrain credences. Provided Humean chances are appropriately related to relative frequencies, they constrain credences. Schwarz then argues that the *expected* value of the chance assigned by a Best System should equal the *expected* relative frequency (since we have no reason to believe a Best System would assign a higher or lower value—a second application of indifference reasoning (ibid., p. 98). Even if one accepts indifference reasoning in general, this second application is especially problematic—it would imply a random probability generator could equally well constrain rational credences. Arguably one needs a closer connection between Best Systems' chances and relative frequencies.

Loewer (2001, 2004) aims to avoid indifference reasoning in justifying his Best Systems Account. But indifference reasoning turns out to be unavoidable. Loewer argues that agents are rationally required to align their credences to what they take the Best Systems chances to be, since a Best System, by definition, provide the best combination of simplicity and informativeness about actual events (2004 p. 1123; see also 2001 p. 617, n. 9). This argument depends on indifference reasoning. Firstly, informativeness of a system overall does not imply informativeness with respect to a *particular* event or chance setup. I may be rationally required to follow what I take to be informative about this very box of gas, but not what I take to be informative across all spacetime. Moreover, a Best System aims for the *best* balance between simplicity and informativeness. A system could be more informative than the Best System (while being simple enough to use), even though it doesn't deliver the best overall balance. Indifference principles might require agents to assign the same chance to events of a given type across spacetime (similar to Schwarz's 'exchangeability'). But without indifference reasoning, agents do not have a compelling reason to follow what they take the Best Systems chances to be.

Hoefer (2007, 2019, Ch. 4) might seem to avoid some of these problems, since he relates chances more closely to relative frequencies. Chances paradigmatically derive from relative frequencies in event sets that satisfy certain properties, such as 'looking chancy' and having stable distributions across time, space, and naturally selected subsets. (Otherwise, chances derive from relative frequencies from structurally similar chance setups.) Hoefer argues that

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agents are at least reasonable to align their credences to the chances, since, ‘at *most* places and times in world history’, the relative frequency of A outcomes in a short run will approximate the relative frequencies overall (the chances) (2007, p. 582; 2019 p. 102). Agents do as well as they reasonably can over these short runs when they align their credences to the relative frequencies since, absent very detailed information about the past, or information about the future, both of which are inaccessible in ordinary situations, the best they can hope to do is to group events by type and align their credences to the relative frequency. The justification then applies in the single case: if setting one’s credence to the chance is reasonable over a short run, it is reasonable at any step of which the short run is composed.

Hoefer does not invoke indifference principles directly. Instead what plays a similar role in his justification is the limit on how well agents can be expected to predict events. Agents can’t be expected to predict all events correctly, since chances that would allow them to aren’t knowable. If agents can’t usefully distinguish between events of a given type, it seems the best they can do is have a single credence in events of that type. Given this constraint, setting your credences to the relative frequencies is a better strategy than any other (at most times and places). There is still, however, a problematic use of indifference reasoning elsewhere. What would be a reasonable strategy across most times and places determines what is a reasonable strategy here and now. This use of indifference makes Hoefer’s account vulnerable to the same kind of objection as above. On any single trial, or short run, an agent may do better (and may believe they’ll do better) by aligning their credences to a significantly different single value. While Hoefer’s statistical conditions limit the amount of variance, they don’t exclude variance altogether. Unless we *require* credences to take the same single value over *all* short runs of a given type (indifference reasoning), Hoefer’s justification fails.

While the details of these Humean approaches differ, there are general lessons to draw. Firstly, some form of indifference reasoning is unavoidable for Humean justifications. There needs to be some way of generalizing from what is rational across time and space to what is rational here and now. If one is wary about use of indifference principles, their use here is a serious concern. Secondly, Humean justifications rely on the reduction of chance to patterns in actual events. The reduction is what limits the potential divergence between relative frequencies and chances and is supposed to provide Humean accounts with their unique

advantage. In the [next section](#), I argue that considering the scientific use of chance undercuts this claimed advantage.<sup>5</sup>

#### 4. The Undercutting Argument

One way in which Humeans might be thought to have no unique advantage in showing the role of chance is satisfied is that chance–credence principles are *epistemic* principles. They tell us how we should align our credences, given *what we take the chances to be*—not what the chances actually are. Different accounts can agree on how we reason to chances, so none has any advantage. But I don't think this fully answers the Humean. The Humean will say that only they have a good *metaphysical* account of how chances are ultimately evidenced by the relative frequencies—because they reduce chances to patterns in actual events (see, for example, Schwarz, this volume). Still, the epistemic response reminds us of something important—the Humean justification cannot rely merely on how we ordinarily reason using chances, absent the story about reduction.

Instead, my argument makes use of 'undermining worlds'—worlds that have a chance of occurring, but, were they actual, the chances would be different at those worlds (given a Humean account). I explore that relation to more standard undermining worries below ([Section 5](#)). To begin, consider how we reason using chances. Say you've constructed an appropriate chance set up involving tossing a coin. You toss the coin a large number of times. The relative frequency of heads is 0.5, and the sequence 'looks random'. You reason that the chance of heads is 0.5. You're then told you will be offered a series of bets on a finite series of subsequent tosses. If you have no inadmissible evidence, and reason using the Principal Principle, your credence in heads will be 0.5. You're now asked, "Will you do well to align your credence to what the chances are, or what you take them to be?". You reason as follows. Say you're right about the chances. Then there is a *high chance* that you'll do better to align your credences to the chances than another single value. But it is by no means *guaranteed* you will. Every coin toss may come up tails. A similar point holds for what you take the chances to be—there is a high chance that the relative frequencies in a sufficiently long run indicate the chances, but no guarantee. If this use of chance-based reasoning is

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<sup>5</sup> For other concerns with Humean justifications, see Hall (2004) and Strevens (1999).



correct, the Humean is wrong to look for a guarantee that agents will do well to align their credences to the chances (or what they take them to be)—at best there is a high chance of doing well.

For simplicity, the case above used a local finite chance set up. The Humean might argue it is only at the global level, for *most times and places*, that Humean chances are guaranteed to play the chance role. Let's construct a global case. Say the conditional chances of our world are those of classical statistical mechanics (using Albert (2015) and Loewer's (2004) 'Mentaculus' account of chance), or a collapse version of quantum mechanics (say GRW). Using these chances, conditional on the initial macrostate of the universe and the macrostate of an appropriate chance set up, there is a non-trivial chance that the chances and relative frequencies diverge to arbitrarily high degrees.<sup>6</sup> There is, for example, a non-trivial chance that, at most times and places, agents will *not* do well to align their credences to what the chances are. Whether chances are determined by a Best Systems account (Schwarz, Loewer), or tied more closely to relative frequencies (Hofer), there is a non-trivial chance that *all* agents at *all* times and places do poorly.

The Humean may point out that agents will still do well to align their credences to what they *would take* the chances to be in worlds where the frequencies and chances diverge. But, recall, the Humean justification can't simply rest on how we ordinarily reason to chances if they're to claim an advantage over their rivals.

So far, I have only claimed that how we reason using chances, particularly in scientific contexts, allows for the frequencies and chances to diverge. I take this claim to be a non-controversial feature of our reasoning with chance. Ismael describes potential divergence as 'part of the logic of those [modal] concepts' (2015, p. 190). In [Section 5](#) I'll consider how the

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<sup>6</sup> By non-trivial, I mean such outcomes are not ruled out. If the universe is infinite, and one employs probabilities of 0, the highest degree of divergence may have chance 0. But then chance 0 would not rule out an outcome, since the actual history of the universe would also have chance 0.

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Humean may recommend a revision of this practice. For now, I want to consider how this use of chance reasoning creates trouble for the Humean.<sup>7</sup>

The concern for the Humean is as follows. Humeans aim to deliver chances that a) reduce to patterns in actual events, and b) are *used* in science. In attempting to show the chance role is satisfied, these two aims come into conflict. The Humean needs the reduction to limit the divergence between chances and frequencies. But, if Humean accounts deliver chances as they are used in science, then the above ‘scientific route’ becomes available for considering whether agents will do well if they align their credences to the actual chances. In this use of chance reasoning, there is *no guarantee that agents will do well*—there is a merely a high chance they will. Divergences between the actual chances and possible relative frequencies must be allowed when reasoning *using* chances. My argument is that this ‘scientific’ use of chance *undercuts* the metaphysical guarantee claimed by the Humean.

For example, say we take Schwarz’s exchangeability approach (for simplicity, applied to a relative frequency account). Even if principles of rationality require agents to treat certain event sequences as exchangeable, and thereby align their credences with what they take the relative frequencies to be, there is a non-trivial chance that they’ll do poorly by doing so. Say we take Loewer’s informativeness approach. Even if agents take the Best System at their world to be informative, there is a chance that what is the Best System at our world *won’t be* very informative at all. Say we take Hofer’s approach, which relies on the claim that, at most times and places, the Humean strategy will do as well as any other single credence strategy over short runs. There is a chance that, at most times and places, the Humean strategy does *worse* than a single credence strategy over short runs. In each of these cases, if we align our credences to the chances in the way the Principal Principle requires, we’ll have a positive credence that agents will do poorly when they follow the Principal Principle. So, whether we reason externally (Hofer) about the actual chances, or internally (Schwarz, Loewer) about what we believe about the actual chances, *when we reason using chances, there is no guarantee that we will do well to follow the Principal Principle.*

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<sup>7</sup> My argument shares features in common with Strevens’ (1999, p. 255). But it avoids Hofer’s (2007, p. 583) response, since it relies on naturalism and the fact that Humean accounts attempt to deliver chances as used in science.

My claim is that this *use* of chance reasoning undercuts the metaphysical guarantee provided by the Humean reduction. Once we acknowledge the chance-based possibility of agents doing poorly, we have no reason to be moved by the Humean's metaphysical guarantee. The scientific perspective in which we *use* the chances trumps the metaphysical guarantee. Science and its use of chance reasoning is our best guide to what we should believe about empirical matters—such as whether agents will do well to align their credences to the chances. Our credences should be guided by these chances, in the way science suggests, and not by anything else. In claiming science has priority over metaphysics, I'm adopting a kind of naturalism that the Humean was aiming towards—metaphysics does not attempt to replace science. So, when metaphysical and scientific explanation potentially compete, it is the metaphysical explanation that has to give way.

More is needed defend this argument. I'll begin with a few quick objections. Firstly, one might worry that an application of the Principal Principle is needed to reason from a belief in a *chance* that agents may do poorly to a *credence* that agents may do poorly. This is true. But the Principal Principle is not in question here—just a particular Humean route to showing the chance role is satisfied.

Secondly, the chance of the relative frequencies and chances diverging significantly is small. One might therefore argue that we can neglect this possibility. However, a chance being small doesn't license its neglect; small probability events should sometimes be taken *very* seriously. Moreover, if small chances *could* be neglected, there would still be no unique advantage for the Humean over their rivals.

Thirdly, the Humean might complain that I am begging the question. The Humean justification relies on the Humean reduction of chance *ruling out* cases where the chances and frequencies diverge. By allowing the chances and frequencies to diverge, aren't I simply assuming the Humean reduction fails? No. The undercutting argument *does not* assume that the *actual* chances and *actual* frequencies can diverge in non-Humean ways. The argument was that by considering a strategy where one aligns ones credences to what the *actual* chances are, there is a chance-based possibility that the frequencies *may* diverge from what the actual

chances *are*—not from what the chances *would be at those worlds*. I am not assuming the Humean metaphysics is false.

Surely, the Humean goes on, showing the role of chance is satisfied requires considering whether one would do well to align one credences to what the chances *would be*—not what they *actually are*. I'm not so sure. As far as I can tell, the question of justification admits of both readings—one in which one aligns one credences to the actual chances ('rigid reading'), and one in which one aligns ones credences to what the chances would be ('non-rigid'). I can see nothing so far to decide between the two. Neither reading is more general. Using the rigid reading, you can still consider how successful one would be, given different chances were actual. Moreover, even if the Humean insists on the non-rigid reading, trouble remains.

The undercutting argument can still be given, as soon as the Humean explains how Humean chances are 'held fixed' in scientific reasoning. In scientific contexts, we don't take the chances to vary as the relative frequencies do. Instead, we standardly hold the chances 'fixed' at their actual values. For example, on being told the chance of the coin landing heads is 0.5, you consider possibilities on which the coin always lands head, and take it that the chance would still be 0.5, if this possibility were to obtain.<sup>8</sup> When reasoning 'metaphysically', and assuming the Humean reduction holds, you may reason that the chances would be different. But, in scientific contexts, the chances are held fixed.

Moreover, it is Humeans themselves who have sometimes recommended holding the chances fixed in this way. Humeans have responded to worries about how Humean laws and chances can explain—the 'explanatory objection'—by distinguishing between scientific and metaphysical explanation. According to the objection, Humean laws aren't sufficiently independent of the actual events so as to explain them (Dretske 1977, p. 267; Armstrong 1983; Maudlin 2007, Ch. 6; Lange 2013; Shumener 2017). If the laws are explained by actual events (the Humean reduction), then the laws can't explain those same events—this would

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<sup>8</sup> See Demarest and Miller (this volume) for formulations of the relevant counterfactuals, and discussion of how undermining worries may generalise. While we have similar aims, some of the differences between our views are: a) I rely more on the use of chances in scientific practice, and less on the intuitive truth of certain counterfactuals, b) I don't think the Humean has a particular problem with higher-level science generalities—I take these to derive from fundamental physics.

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be circular. Various responses have been made. The most popular relies on distinguishing between metaphysical and scientific explanation (Loewer 2012; Miller 2015; Hicks and van Elswyck 2015; Bhogal forth.)—see Emery (2019) for discussion. The thought is that while actual events *metaphysically* explain the laws, ‘this metaphysical explanation doesn’t preclude [Humean]-laws playing the usual role of laws in scientific explanations.... [scientific and metaphysical explanation] are different enterprises’ (Loewer 2012, p. 131). What has made this response appealing is, I suggest, the fact that the Humean typically aims to *recover* scientific practice and leave it untouched by their metaphysics. (I’ll consider more revisionary responses below.) If Humean laws are, when reasoning scientifically, independent of the actual events so as to be able to explain them, they are ‘held fixed’, even as the actual events vary.

Humeans make a similar move in response to another standard objection: that Humean laws don’t allow the initial conditions or other states to vary independently of the laws, as is standard in science (Tooley 1977; Carroll 1994; Maudlin 2007, p. 68; Bhogal forth.). Some, including Humeans, answer this concern by appealing to forms of contextualism or projectivism (Halpin 2003; Ward 2003; Roberts 2008, Ch. 10; Loew and Jaag 2020; Dorst forth.). In its strongest form, *any* set of true axioms can be ‘projected’ onto the Humean Mosaic, and taken as the laws, depending on our context and interests. In a weaker form, the actual Humean laws are held fixed as the initial conditions (or other states) are allowed to vary.

If either of these responses is right, Humean chances are ‘held fixed’ in scientific reasoning. Even under a non-rigid reading, there is a chance that agents will do poorly by aligning their credences to what the chances *would* be. So, Humean accounts are open to the undercutting argument that, when reasoning scientifically, there is no guarantee agents will do well to align their credences to what the chances would be. If the Humean recovers the scientific practice of holding the laws and chances fixed, there becomes a straightforward scientific possibility of agents doing poorly. The claim is that this scientific use of chance undercuts the Humean’s metaphysical justification. The Humean loses their special advantage in showing that the chance role is satisfied.

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The Humean might instead try to explain why it merely *seems* Humean chances are held fixed in scientific contexts, even though they're not. One suggestion is that, in large universes, the Humean chances aren't sensitive to changes in frequencies in small local systems. So, in local cases, we assume the relative frequencies can vary entirely independently of the chances (Loewer 1996, p. 117). But this strategy is not well suited to all contexts in which statistical-mechanical explanations are applied. Loewer (2012) and Albert (2000) apply the statistical-mechanical probability distribution to the initial macrostate of the whole universe. If standard statistical-mechanical explanations are to work, the chances must still be held fixed even though we're no longer considering changes to the relative frequencies in small local systems.

## 5. Revising Science

The undercutting argument above is related to standard undermining arguments against Humeans. Lewis notes that the possibility of chances being otherwise than they are creates trouble for Humean accounts when combined with the Principal Principle—the 'Big Bad Bug' (1986, 1994). The worry is that the Principal Principle will give contradictory advice: the chances being what they are (and Humeanism being true) metaphysically rules out certain possibilities that the 'scientific' use of chance (the Principal Principle) rules in. My argument also exploits the gap between the Humean metaphysics and the scientific use of chance. But while I think standard solutions to the Big Bad Bug (Thau 1994; Lewis 1994; Hall 2004) are enough to remove the threat of contradiction, they don't help the Humean produce a satisfactory account of chance—or at least this is what I will now argue.

The Humean can respond to the Big Bad Bug by being revisionist about how we use chance-based reasoning. According to the revisionary Humean, the Humean reduction limits the possibility space used when reasoning *using* chances in ways that go beyond the limits provided by probability theory. Say you know the chance of the coin landing heads on each toss is 0.5, say this is the only thing going on in a universe, and I ask you (even in a scientific context) whether it is possible for the coin to land heads every time it is ever flipped. The answer is no, it is not. The fact that the (Humean) chance is 0.5 rules this possibility out.

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This ‘revisionary’ Humean response is successful against the ‘Big Bad Bug’. We were wrong to think we should align our credence in an event (conditional on what we take its chance to be and any other admissible evidence) to what we take its chance to be. Instead, we should align our credence in an event (conditional on the same) to what we take chance to be *conditional on the complete chance theory of a world* (I). According to the ‘New Principle’ (Lewis 1994; Thau 1994; Hall 1994, 2004):

$$\text{NP: Cr}(A|ET) = \text{Ch}_G(A/T)$$

By conditionalising chances over the complete chance theory (I), the New Principle rules out cases where the chances are ‘undermined’: where events (that have some chance of occurring) would make the Humean chances otherwise than they are. Because the New Principle excludes the possibility of the chances and relative frequencies diverging greatly, even when we reason *using* chances, it excludes the possibilities used to undercut the Humean justification.

An alternative revision is to revise what the *chances* themselves are (Arntzenius and Hall 2003; Schaffer 2003). According to this revision, the chances are the Humean chances conditional on the complete theory of chance—thus conditionalising out the possibility of undermining. Under either of these responses, there is only a small modification to the credence recommended (in local setups) compared to standard scientific practice. If so, perhaps this revision is of no great concern.

My response to these and other revisions (Hofer 2019) is as follows. If the Humean is claiming a *unique* advantage in showing the chance role is satisfied, then the first revision is untenable. If the New Principle replaces the Principal Principle, we no longer have a theory-neutral criterion by which to judge accounts of chance. The New Principle implies that when we use chance to guide our beliefs, we should bracket out the possibility (one consistent with the Humean metaphysics) of the chances being otherwise than they are. But if the New Principle is designed as a fix for the Humean, it’s not a theory-neutral criterion by which to

judge accounts of chance. It doesn't matter if only Humean accounts can be shown to satisfy the New Principle.<sup>9</sup>

Hall (2004) argues the New Principle isn't simply a fix for the Humean—it is a principle we should all adopt. Chance, he thinks, is like an 'analyst-expert': an expert who is extremely good at evaluating the relevance of one proposition for another. When you ask such an analyst-expert for advice, you want her advice conditional not only on what evidence you happen to have, but on whatever conditions would be necessary and sufficient for her to *count* as being an expert—evidence contained in T and evidence that she might not have herself (ibid., p. 103). So, all should accept the New Principle. But Hall's reasoning relies on the possibility of there being evidence that is sufficient for someone to *count* as being a chance expert. The non-Humean has good reason to deny this: while there might be evidence for the chances from actual events, no evidence about actual events *guarantees* the truth of a chance theory. The non-Humean should keep to the Principal Principle.

Regardless of whether the Humean claims a unique advantage, there are two further concerns with these responses. The first concern is about simplicity—see also Schwarz (2016). One of the claims of the Best Systems Humean program was that scientific modal relations were to derive from simple and general axiomatic systems. One of the hallmark features of laws (and chance functions) that the Humean account is supposed to deliver is that they are *simple*—simple in form, and simple to apply. But, while the above revisions to the Principal Principle or the chances may be quantifiably small in the difference in chance *values*, they add significantly to the *complexity* of the chance function or its employment. Consider again the case of employing the statistical mechanical distribution to the initial macrostates of the universe. According to the above response, the conditional chances that should guide our derivations and predictions aren't those given by the standard statistical mechanical distribution, but those conditionalised on whatever must be the case for those to

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<sup>9</sup> Lewis thought that Humean chances might be the closest thing that could play the role of chance given by the Principal Principle, so it wouldn't matter that they didn't strictly satisfy it (1994). But, as Arntzenius and Hall (2003) argue, there are things that satisfy the Principal Principle perfectly—they just don't look like chances. See also Schaffer (2003).



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be the Best Systems chances. The simplicity of probability assignments and their employments is gone.

The second concern is that a Humean that recommends revising scientific practice has to give up a strong claim to be *recovering* scientific practice. Even if the revision is quantifiably small, it's still a revision. I don't think scientific practice is sacrosanct. There are cases where philosophical reflection on science leads to fruitful revision. But in this case, unlike others, scientific practice itself doesn't seem to be in trouble—it's not contradictory or incomplete. The Humean can still claim an ontological advantage—they reduce chance to something less mysterious. But this ontological advantage comes at a naturalistic cost. Naturalism and functionalism combined, moreover, provide no reason to adopt a Humean account.

## 6. The Deeper Tension

I have argued that Humeans have no advantage in showing chance satisfies its role. I'll now argue that undermining worries point to a deeper naturalistic tension between Humean metaphysics and science.

Following Loewer (2012, p. 131), take the distinction between science and metaphysics to concern the explanatory relations used. The explanatory relations used in science are relations such as laws, chances and causation. An explanation is partly scientific when these relations are *used* as explanatory relations. In metaphysics, the relevant explanatory relations are of other kinds—such constitution, (metaphysical) reduction, ground, nature or essence. An explanation is partly metaphysical when these relations are *used* as explanatory relations. Scientific laws and chances can still feature in purely metaphysical explanations, provided they aren't appealed to *as* explanatory relations. The Humean, for example, can give a *metaphysical* explanation of why the chances don't diverge too much from the relative frequencies, because they don't employ chances as explanatory relations in this setting. I take it Loewer has this in mind when he claims that only scientific relations may be 'probabilistic' (ibid., p. 131). He is not claiming probabilities can't feature in metaphysical explanations, but that the metaphysical explanatory relations won't themselves be probabilistic.

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My concern with the Humean explanation of why chance satisfies its role is *not* that the explanation is metaphysical. My concern is that the Humean explanation *competes* with scientific explanation in a way that prevents us combining metaphysics and science into a single unified explanatory practice.

One way to bring this worry out is to consider contrast cases. In other cases, metaphysical and scientific explanations can be fruitfully combined.<sup>10</sup> We explain the movement of a limb, by considering how the movement of its *constitutive* parts is *caused*. We explain why a mercury column counts as a thermometer, by considering what *constitutes* a mercury column and the *required role* (perhaps *nature*) of a thermometer and using scientific laws to explain how the mercury column is able to function as a thermometer. A typical ‘functional justification’ is partly metaphysical (in virtue of using constitutive relations, and (perhaps) natures, or essences) and partly scientific (in virtue of using laws and other scientific relations).

But this patently not what’s going on in the case of the Humean justification. In the Humean justification, the laws and chances are not used as explanatory relations. The Humean justification can, in fact, proceed *entirely independently of what the laws and chances actually are*. All one needs to offer the Humean justification is the metaphysical reduction of chance to patterns in actual events. Nothing about the actual laws or chances is needed in order to generate the ‘possibility space’ within which the Humean justification operates. It can include worlds with laws and chances that are vastly different from our own, that have entirely different structural features from our own, and that are even too disordered to have chances (or laws)—and still the relative frequencies will approximately match the Humean chances (when they exist).

Some might see this lack of dependence on the actual chances and laws as an advantage. What I see it as doing as making clear that the actual Humean chances aren’t used as explanatory relations within the Humean justification. This is a problem. At best what the Humean can do is *overlay* the Humean metaphysical justification on top of the scientific use of chance. But this doesn’t make the chances required in the justification. They remain

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<sup>10</sup> Bhogal (forth.) discusses such cases under the label of ‘chaining’.

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redundant. There is no deeper unity between the scientific and metaphysical parts of the explanation. What this means, in turn, is that chances, taking the values they do, *aren't* doing their usual work of guiding credences and explaining within the Humean justification. That work is instead by the nature of chance, combined with principles of indifference.

There is something decidedly odd about all this. The Humean, having shown that chances (and laws) are fit to guide credences, and scientifically explain, abandons them when it comes to explaining how chances are fit to play their roles. This is not how metaphysics should operate. The metaphysical natures of things should combine coherently with science-based reasoning to offer explanations and justification.<sup>11</sup>

This objection does not depend on assumptions about explanation involving metaphysical dependency. While I agree with Emery (2019) on the need for science and metaphysics to combine, one doesn't need metaphysical grounding to make this claim. There is value in science and metaphysics cohering, independently of one's metaphysical commitments. The value of this coherence may even be explicated in purely instrumental terms—it is *useful* to have practices that combine. For this reason, the Humean can't defend the lack of cohering by appealing to the fact that (scientific) explanation has only instrumental value, while metaphysical explanation aims at 'elucidating underlying structure' (Bhogal forth.). Ultimately there are both theoretical and instrumental advantages to explanatory practices that combine, reasons that metaphysics is answerable to.

The upshot is that Humean metaphysics introduces a worrying disconnect between metaphysics and science. This is the deep tension I alluded to earlier between recovering the scientific use of chance and providing a reductive account of modality. If the Humean recovers the scientific uses of chance, they recover something explanatorily disconnected from their own metaphysics. For those motivated by the form of naturalism I begun with,

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<sup>11</sup> Other coherence problems arise if a metaphysics of chance builds in features that science should explain. Taking chances to be intrinsically temporally or causally asymmetric, for example, as under traditional propensity accounts, prevents any temporal or causal asymmetries in chance being explained in scientific terms.

this is a serious concern. While the Humean can recommend a revision of scientific practice, the worried I raised above (Section 5) still hold—such a revision fits ill with naturalism.

## 7. Science Justifies Science

To end, let me offer a brief sketch of how one might use scientific relations to show how chance is fit to play its role. One option is to mimic a Humean justification, and argue there is a *high chance* that the relative frequencies approximate the chances over long runs (the weak law of large numbers).<sup>12</sup> So, there is a high chance that, by aligning your credences to the chances, you will do reasonably well at predicting events over long runs.<sup>13</sup> This option uses indifference reasoning. But there is an alternative that avoids indifference reasoning.<sup>14</sup>

In any given case where you choose how to act based on credences, you have a *higher chance* of doing well if you align your credences to the chances than to any other value. Doing worse is possible, but unlikely. For example, say you know there is to be only one coin toss of a fair coin, and you adopt credences based on the chances (conditional on known information).<sup>15</sup> The coin toss is fair, in the sense that its chance of landing heads conditional on the macroscopic characterisation of the chance setup is 0.5. If you don't know the exact microstate of the chance setup now (or have any other information about the outcome of the coin toss), the relevant chances are 0.5. If you align your credences to these chances, you will only accept bets at odds of higher than 1:1 on heads, and odds of higher than 1:1 on tails—and will be indifferent to or reject all other bets.<sup>16</sup>

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<sup>12</sup> One needs a version of the weak law that applies in the finite case.

<sup>13</sup> For a proof of this chancy justification of the principle, see Strevens (1999, Appendix B). For discussion of related attempts, see Mellor (1971, pp. 55–6) and Strevens (1999, p. 27 n. 11).

<sup>14</sup> For a related projectivist alternative using credences, see Ward (2005).

<sup>15</sup> Following Hall (2004), my preferred account of chance dispenses with admissibility. The conditional probabilities are still as objective as the laws—they take the value they do, independently of what anyone wants or thinks about the matter. Alternatively, one can assume one has no inadmissible evidence. See Elga (2007, pp. 114–5) for the physics behind such chance setups, and why we typically don't have such evidence. My thanks to Michael Hicks for discussion.

<sup>16</sup> If you do have information about the exact microstate or other information about future outcomes, then the chance conditional on this information may be different. For example, if the information implies that the coin will land heads, the chance of its landing heads (conditional on that information) is 1—and you will accept all bets on heads, and no bets on tails.

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Adopting the strategy of aligning your credences to the chances (conditional on known information) implies that, for any bet that you will accept, there is a higher chance that you will gain money than that you will lose money. For any bet that you reject, there is a higher chance that you would lose money than that you would gain money. For any bet you are indifferent about, there is equal chance of losing or gaining money. Provided the credences and chances are conditional on the same evidence each time, there is always a higher chance you gain money rather than lose it. Applying the Principal Principle, you should have a higher credence that you gain money rather than lose it. So, you are justified in aligning your credences to the chances, in both the ‘internalist’ and ‘externalist’ sense. The same kind of reasoning also works for what you take the chances to be. So, chance is fit to play the chance role.

Some have argued that chances can’t be used to justify the Principal Principle, or show chance is fit to play its role (Strevens 1999, p. 255–6; Hoefer 2007, p. 588; 2019, Ch. 1). It might seem that, by using chance, *any* account of chance can be justified—making giving an adequate account of chance too easy. As Loewer puts it, ‘Without relying on the PP there is *no* non-question begging reason to think that setting one’s degrees of belief by propensity chances will result in having high degrees of belief in truths and low degrees of belief in falsehoods’ (2004, p. 1123).<sup>17</sup> The implication is one should *not* rely on the Principal Principle. Loewer goes on (2004, p. 1123):

...since propositions about propensity chances are facts logically completely distinct from the propositions they assign chances to it is *utterly mysterious* why they should tell us anything about what degrees of belief to have in those propositions.

This kind of reasoning relies on chance being initially suspect: guilty until proven innocent. We’re not entitled to appeal to chance reasoning, including assigning chances and using them to guide our credences, until we’ve a) said what chances are, and b) shown that they can appropriately guide our credences. Without the former, chance remains metaphysically

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<sup>17</sup> See also Hoefer (2019, p. 43). For similar concerns with respect to laws, see Lewis (1994, p. 484), and van Fraassen’s (1989) inference and identification problems.

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mysterious. Without the latter, we either don't know the Principal Principle is justified, or don't know that the account of chance is adequate.

We should resist this stance. We don't come to the project of accounting for chance unsure of our entitlement to assign chances and use chance reasoning. We don't have to earn our entitlement to reason using the Principal Principle. While it's reasonable to wonder what might justify it, its actual use is not in question.

There would be greater concerns, if the chance role were shown to be satisfied in a genuinely trivial way—a way that *anything* could satisfy. But this is not the case. The above justifications require there to be a *higher* chance that an agent will do well than otherwise. While this is a relatively weak constraint, it is still a constraint—one not met by many functions we might otherwise identify as chance functions. It is not merely by *identifying* something as chance that it is shown to play the chance role—as identifying someone as Armstrong might seem to imply they had large biceps. A chancy justification is not a case of 'premise circularity' where the conclusion is trivially derivable from a limited number of the premises. Instead it is analogous to a case of 'rule circularity'—chance reasoning is used in justifying chance reasoning.<sup>18</sup> The chancy justification shows there is coherence in our theories and beliefs about chance. This is not to say that the *source* of the justification is the coherence—that any coherent package would be equally well justified. But the way to give justifications is always to work from within the package of theories and beliefs we already accept. We revise these as required, when incoherencies are met.

The approach is naturalist, insofar as it takes science as our best guide to the empirical world. It is both functionalist and naturalist in that it uses science to explain how scientific relations are able to perform their functions. The program shares much in common with Quinean naturalism, as explicated by Verhaegh (2018). We do not look to justify science 'from the outside'; instead, we use our developing knowledge of science to explain how we come to think scientifically and what function such thinking (and such relations) serve.

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<sup>18</sup> Thanks to Alastair Wilson for the suggestion.

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A variety of accounts of chance will be compatible with a chancy justification of chance, including metaphysically minimal accounts such as ‘pragmatist’ propensity accounts (Peirce 1910; Levi 1990) and Sober’s ‘no-theory theory’ of chance (2010). These accounts rely on our use of chance reasoning in science to provide the only account of what chance is and are my preferred option. I have concerns with attempts to provide a more robust metaphysical account of chance by appeal to causal and temporally properties—as standard propensity accounts do (see footnote 11). But these arguments are not my focus today. Instead I have been concerned to explicate a tension between the Humean’s reductive metaphysics and the scientific use of chance—a tension that is independently problematic, and that undercuts the Humean’s claim to provide a unique satisfaction of the chance role.

## 8. Conclusion

Humeans are right to be interested in showing how modal relations like chance satisfy their roles. But they go wrong in thinking this should be achieved by reducing modal relations to actual events. The scientific use of chance reasoning undercuts the metaphysical justification provided by the Humean. This undercutting argument points towards a deeper tension between the Humean reduction of chance, and the use of chance reasoning in science—the Humean either must accept a strong disconnect between science and metaphysics or seek an unwarranted revision of science. None of this is to say one *cannot* be Humean—but these are heavy naturalistic costs to bear.

There is an alternative. One can show how chance is fit to play its role using chance-based reasoning—by reasoning *scientifically* about science. According to this naturalistic functionalist approach, one can use the resources of science to explain why scientific modal relations are fit to play their roles. While I have not pursued the details here, I take it this is a more promising approach to the metaphysics of scientific modal relations.<sup>19</sup>

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<sup>19</sup> See Fernandes (2017) for such an approach in the case of causation.

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