Abstract: According to Humean theories of objective chance, the chances reduce to patterns in the history of occurrent events, such as frequencies. According to non-Humean accounts, the chances are metaphysically fundamental, existing independently of the "Humean Mosaic" of actually-occurring events. It is therefore possible, by the lights of non-Humeanism, for the chances and the frequencies to diverge wildly. Humeans often allege that this undermines the ability of non-Humean accounts of chance to rationalize adherence to David Lewis' Principal Principle (PP), which states that an agent's degrees of belief should match what they take to be the objective chances. In this paper, I propose two approaches to justifying (PP) for non-Humean chance, hence defusing the Humean objection. The first approach justifies (PP) via the role it plays in informing outright beliefs about long-run frequencies. The second approach justifies (PP) by showing that adherence to (PP), even for non-Humean chance, maximizes expected epistemic utility according to the actual objective chance function. I then address an objection to this approach, concerning the alleged circularity of the derivations.

Rationalizing the Principal Principle for Non-Humean Chance

The major divide in the metaphysics of chance is between Humean accounts, which hold that the objective chances reduce to patterns in the history of occurrent events, such as frequencies, and non-Humean accounts, which hold that chances are somehow irreducibly modal features of the world, such as brute propensities, chancemaking relations between universals, or constituents of fundamentally stochastic dynamical laws.[1] But whatever chances turn out to be – and whatever the direction of *metaphysical* explanation between chances and occurrent events – they play an important role in explaining statistical regularities and licensing scientific explanations. At the same time, it is widely believed that chances should somehow constrain our credences: on pain of irrationality, agents ought to match their credences in certain propositions to what they believe to be the chances of those propositions. This idea is captured by David Lewis' Principal Principle (PP_i)[2]:

[1] I will hereby refer to propensity theories, and, following Gillies (2000), I will consider propensity theories, broadly construed, as any objective, non-frequency, non-reductive theory of probability. More specifically, propensities are thought of as *intrinsic dispositions*, logically distinct from the frequencies, to generate events with a particular probability. These probabilities are taken to *explain* the observed relative frequencies.

[2] See Lewis 1980.

$$(PP_i) \quad Cr(A \mid X \wedge E) = x.$$

Here, *Cr* is a rational initial credence function, X is a proposition to the effect that the chance of A is x, where $x \in [0,1]$, and E is any admissible proposition. Admissibility is difficult to define, and Lewis offers no precise definition. However, he does offer a characterization of admissibility: admissible information informs us about a proposition only by way of telling us about the *chance* of that proposition. On this characterization, for example, the reading of a crystal ball that carried future information about the outcome of a chancy event would be inadmissible. Moreover, Lewis offers two sufficient conditions for admissibility. Firstly, *historical* information up to a time *t* is admissible at *t*. Secondly, the general chance theory of a world – namely a set of history-to-chance conditionals which give an account of which antecedent conditions give rise to which chance distributions – is always admissible. Therefore, (PP_i) can be refined to include these sufficient conditions for admissibility, where H_{tw} is the history of world w up to time t, T_w is the theory of chance that holds at w, and P_{tw} is the probability function for w at t generated by w's theory of chance:

$$(PP) \quad Cr(A \mid H_{tw} \wedge T_w) = P_{tw}(A).$$

Informally, (PP) says that agents ought to match their degrees of belief to what they take to be the objective chances.

Despite their intuitive force, chance-credence norms like (PP) turn out to be somewhat difficult to derive. The issue becomes especially pressing insofar as it encroaches on the aforementioned metaphysical debates about chance. That *some* chance-credence norm holds seems to be an indispensable aspect of the chance-role, and the proponents of any metaphysical account of chance had better be able to explain why their candidate filler of the chance-role is up to the task of constraining rational credence. Lewis (1994, 484) famously quipped that it was utterly mysterious how the "unHumean whatnots" posited by his opponents could constrain rational credence. That non-Humean accounts of chance are unable to rationalize adherence to

(PP) has since become a common argument in the literature that such accounts are unsatisfactory.

This paper attempts to defuse this argument, proceeding as follows. First, I will review the informal statements of the credal argument and offer a more substantive formulation (sec. 1). Second, I will offer two separate vinidcations of (PP) for non-Humean chance, attempting to defuse the argument (sec. 2), arguing first that adherence to (PP) can be rationalized based on its implications for an agent's outright beliefs about frequencies (sec. 2.1) and second that adherence to (PP) can be rationalized in terms of its implications for the accuracy of an agent's credence function (sec. 2.2). Finally, I will consider an objection and offer replies (sec. 3).

1. The Credal Argument Against Non-Humean Chance

Lewis never clearly formulated his argument that non-Humean accounts of chance failed to rationalize adherence to (PP). His complaint is raised only in the following passage:

> Be my guest – posit all the primitive unHumean whatnots you like. (I only ask that your alleged truths should supervene on being.) But play fair in naming your whatnots. Don't call any alleged feature of reality "chance" unless you've already shown that you have something, knowledge of which could constrain rational credence. I think I see, dimly but well enough, how knowledge of frequencies and symmetries and best systems could constrain rational credence. I don't begin to see, for instance, how knowledge that two universals stand in a certain special relation N* could constrain rational credence about the future coinstantiation of those universals (1994, 484).

Lewis' complaints here have intuitive pull, but he gives little by way of further argumentation. Luckily, his objection has been rendered much more precise by Loewer (2004), Eagle (2004), and Hall (2004).[3] Loewer offers a compelling statement of Lewis' objection to non-Humean chance:

[3] 2004 was a rough year for propensity theorists!

> 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. And 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 (2004, 1123).

Eagle formulates the objection in a similar fashion:

> Severing the constitutive link between frequencies and chances means that we have no logical connection between the concepts of probability and rational expectation. Since, as we have seen, the events that occur in a world and the chances of those events are not logically related, why should knowledge of the chances tell us anything about which events to expect to occur? There seems no way that these single case propensities can rationalise adherence to Lewis' Principal Principle or anything like it; but without the Principal Principle we have no link between the two major uses of probability (2004, 401).

And yet the clearest formulation of the objection emerges out of a question posed by Ned Hall: can we show that a chance-credence norm like the Principal Principle follows from a set of normative constraints on our beliefs and credences over the purely categorical features of the world? Hall answer this question in the negative:

> If the correct account of the metaphysics of objective chance is a thoroughgoing non-reductionist account – that is, an account according to which the categorical facts about a world place virtually no constraints on the ur-chance function for that world – then the answer is clearly `no'. For that is a metaphysics of objective chance that gives the categorical constraints no purchase. Commit yourself to such a metaphysics, and it

> appears that you must introduce the Principal Principle as a *sui generis* normative principle governing rational credence (2004, 107).

It will be especially fruitful to adapt Hall's formulation of the problem as I address this putative challenge for non-Humean views, since it most clearly establishes why the connection between non-Humean chance and rational expectation is, at first glance, so mysterious. The sorts of propositions about which our beliefs and credences can be vindicated are ordinarily just those propositions that concern categorical features of the world. What (PP) aims at – alignment of credence with objective chance – is not the sort of thing that can be vindicated in the ordinary, alethic sense. Hence, it turns out to be structurally quite different from norms that aim to promote nonmodal features of the target doxastic states, such as truth or accuracy. If we want to bring (PP) into the fold of our other rationality principles, we want to show that it follows from categorical constraints on our credences.

With this in mind, we can more clearly formulate the argument against non-Humean chance in terms of the putative inability of non-Humean accounts to derive (PP) from constraints on rational belief that range only over the categorical, nonmodal features of the world.[4] The argument goes as follows:

> *Credal Argument against Non-Humean Chance*:
> (P1) Non-Humean accounts of chance are unable to derive (PP) from categorical prior constraints on rational belief and credence.
> (P2) A satisfactory account of chance should be able to explain why (PP) is vindicated by such categorical constraints.
> (∴) Non-Humean accounts are unsatisfactory.

[4] It should be noted that Hall does not himself necessarily subscribe to the following argument, because it is not clear that he subscribes to (P2). Nevertheless, he clearly does subscribe to (P1), which is what I will dispute.

I would like to concede (P2), which I consider to be well-motivated: (PP) doesn't seem like a basic constraint on rational belief. The reason we are interested in obeying (PP) is that we think it will aid us in forming rational expectations about the events that we actually come to observe, and about which our beliefs and credences can achieve alethic vindication. Therefore, (PP) really should follow from other principles that we take to inform us as to what we should believe about these categorical features of the world.

The sticking point is (P1). Here, non-Humean accounts of chance are supposed to compare unfavorably with Humean accounts, on which it is possible to derive (PP) from other principles of rationality. Hoefer (2019), for instance, argues that (PP) follows, for Humean accounts of chance, from a consistency requirement on an agent's credence function, while Schwarz (2014) attempts to derive (PP) from a principle of indifference, and Hicks (2017) vindicates (PP) from an accuracy norm of rational credence.

2. Vindicating (PP)

My goal, then, is to show that (PP) is vindicated, on a non-Humean account of chance, by independently plausible categorical constraints on rational belief or credence.

2.1. Outright beliefs about frequencies

My first attempt at deriving (PP) in a propensity-friendly manner will rely on three assumptions, each of which carries independent plausibility. The first assumption is what I will call:

> *Chance Reliabilism*: Agents should adopt the belief-formation processes which have the highest objective chance of producing belief sets with high ratios of true to false belief.

Call any belief set with a high ratio of true to false belief an *optimal* belief set. Chance Reliabilism states that what makes a belief rational is that it was formed by a process which has a high chance of producing an optimal belief set. What might motivate the adoption of such a principle?

Reliability is often understood, in the literature on epistemic justification, as high objective probability of producing an optimal belief set.[5] The informal statements of the credal argument seem to suggest that the issue with non-Humean chance is that, since the *logical* connection between chance and frequency has been severed, we similarly cannot draw any logical connection between chance and rational expectation. On a Humean view, chances supervene on the actual history of occurrent events, and so facts about the chances just are, in some way, facts about the history of occurrent events.[6] Thus, an agent who has a grasp on what the chances are, and thereby adjusts their credences to the chances, has a kind of *guarantee* that their credences will be accurate and their outright beliefs will be true. If their expectations about the frequencies turn out to be incorrect, it is merely because they had false beliefs about the chances. For Humeans, (PP) appears iron-clad.

But the underlying account of epistemic rationality will be too strong if it assumes that what counts as a rational expectation is one that guarantees epistemic success. Such an emphasis on guarantees of truth or accuracy can only capture half of the story behind (PP). This is because (PP) is itself a conditional principle of rationality: *given* your belief that a particular chance function obtains, you should match your credences to that chance function. But, as Schroeder (2021) has emphasized, part of what gives us subjective reasons for belief is that our own internal doxastic circumstances lead us to believe the world to be such that we have objective, external reasons to believe certain propositions. This, at any rate, is what seems to be going on with (PP): *given* our belief that a particular probability function accurately specifies the objective chances, we believe that we have a compelling objective reason to adopt a particular credence function. Consequently, the principles of rationality that we employ in vindicating (PP) must also be able to secure our rational access to the objective chances, if they are to bridge the gap between the internally relevant facts (i.e., concerning our beliefs about the chances) and externally relevant facts (i.e., concerning the chances themsevles). But there is no logical or constitutive guarantee of epistemic success when it comes to our beliefs about the chances.

[5] See Alston (1988), Pettigrew (2021), and Comesaña (2018), for example.

[6] See, again, Hoefer (2019).

Imagine asking a Humean how an agent is to rationally form beliefs about the objective chances. This agent, after all, does not have epistemic access to the entire actual history of occurrent events taken to subvene on the Humean chances. The agent's total evidence *indicates*, but does not *guarantee*, that the global frequencies, and so the objective chances, have certain values. Thus, while a Humean could say that adherence to (PP) guarantees success *conditional* on one's knowing what the chances are, the underlying account of epistemic justification must not forbid this antecedent condition from coming to bear.[7]

This point can be strengthened by considering a plausible constraint on normative theories.

> *Transparency*: A normative theory is adequately guiding only if, whenever it requires you to φ, you are in a position to know that it requires you to φ.

The idea behind Transparency is that a normative theory can only be adequately action-guiding if its requirements are epistemically transparent or *luminous* (in Williamson's (2000) phrase). Transparency is itself controversial – see Hughes (2022) for criticism – and may be too strong. This is because, arguably, we are rarely in a position to know that *any* non-trivial condition obtains, including constraints imposed by a normative theory.[8] However, we can consider a modified version of the principle:

> *Transparency**: A normative theory is adequately guiding only if, whenever it requires you to φ, you are in a position to permissibly believe that it requires you to φ.

[7] Fernandes (forthcoming) makes this point vividly. First, locally speaking, there is some non-trivial chance that the local frequencies in a given region will diverge from the global frequencies. Secondly, there is even a small chance that the global frequencies will diverge from the Humean chances in the case of undermining futures.

[8] See Srinivasan (2015).

Something in the ballpark of this constraint has been advocated, inter alia, by Kiesewetter (2016).[9] If the antecedent rationality principles we employ in justifying (PP) require that our belief-formation processes guarantee truth or accuracy then we will have to say that agents are required to adopt a particular credence function without being in a position to permissibly believe that they ought to do so. This is because their being in a position to know which credence function they should adopt requires that they know which credence function is the chance function. Yet, the observed relative frequencies accessible to ordinary agents never actually guarantee what the global frequencies are, or even what the region-specific frequencies for an extra-frequency-tolerant Best Systems view of Humean chance are, just as the observed relative frequencies could never guarantee what the propensity chances are.

Humeans should lower their standards. In particular, they should de-emphasize the supposed guarantee of success that the chances are supposed to bring about, and accept that our justification of (PP) may reasonably make reference to which belief- and credence- forming processes have the highest objective chance of performing well over the long run.[10] Chance Reliabilism, therefore, is a more plausible starting point than any norm which demands a guarantee of epistemic success. Prominent contemporary theories of rationality often have it

[9] Schroeder (2021) argues against *Transparency** for normative theories of action, but agrees that it obtains in the case of epistemic normativity.

[10] There may, however, be other ways to go for the Humean. For instance, one could apply self-locating indifference reasoning. One imagines that the global frequencies, and so the Humean chances, have certain values. Then, one applies a restricted indifference principle to obtain a uniform self-locating credence function over possible regions of the Humean Mosaic. One would thereby have high credence in the proposition that they find themselves in a typical region where the frequencies match the Humean chances. Yet, as Ismael (2009) points out, it is somewhat puzzling why one would be indifferent between what they did not already think were equiprobable outcomes, and, moreover, such a strategy does not eliminate the possibility of undermining futures. And, in the end, a justification of (PP) which treats such an indifference norm as bedrock is not obviously going to be more satisfying or less controversial than one which starts from reliabilist truth- or accuracy- norms, given the well-known problems with indifference principles.

that objective chance lies at the foundation of epistemic normativity. The aim, then, is to offer an account of how chances provide external reasons – via principles like Chance Reliabilism – which allows us to derive (PP) without circularity. My goal here is to offer a sketch of such an account.

One may worry, instead, not that non-Humeans are unable to offer a guarantee of truth or accuracy, but rather that the rationality principles behind any non-Humean justification of (PP) will be forced to sneak in some non-categorical content, in violation of (P2) in the Credal Argument.[11] Chance Reliabilism appears clearly to smuggle in non-categorical facts, namely facts about which belief-formation processes are objectively likely to produce optimal belief sets.[12]

However, I take it that the Credal Argument's second premise does not forbid the invocation of principles which in *any* way refer to non-categorical properties, but rather that it forbids the invocation of principles whose epistemic prescriptions *range* over the non-categorical features of the world, by which I mean that categorical constraints aim at promoting some non-dispositional features of the target doxastic states, such as truth or accuracy or consistency, rather than alignment with the objective chances. (PP), then, is a non-categorical constraint insofar as it essentially aims at alignment of your doxastic states with the objective chances and says nothing about accurate credence or true belief in categorical propositions. Yet, our reason for obeying (PP) is supposed to be that we think it will assist us in forming rational expectations about the categorical facts we will actually encounter. If we are going to rationalize adherence to (PP), therefore, we need some principle(s) which will bridge the manifest divide between the categorical events that we actually observe, on the one hand, and the chances that underlie them, on the other. But to insist that our most fundamental rationality principles can have no dispositional content whatsoever is to rule out some of our best contemporary theories

[11] One may also worry that these appeals to what belief-formation processes are likely to yield true belief and accurate credence are *circular*, when applied to discussions of chance. I will address this worry in the third section.

[12] Thanks to [OMITTED FOR BLIND REVIEW] for pushing me to clarify this point.

of rationality. Though Chance Reliabilism is ultimately cashed out in dispositional terms, it aims at promoting a non-dipsositional feature of the target states, namely truth.

With that, the second assumption that I will make concerns the probabilistic connection between chances and frequencies, as observed in the well-known Weak Law of Large Numbers (WLLN):

$$\lim_{n\to\infty} \mathrm{P}(|f_\phi - ch(\phi)| < \varepsilon) = 1$$

Here, ϕ is a repeatable proposition-type concerning independent and identically distributed (i.i.d.) events (e.g. that a fair coin will land heads), f_ϕ is the frequency of ϕ in a sequence of n trials, $ch(\phi)$ is the single-case objective chance of ϕ, and ε is an arbitrary constant. WLLN is a theorem of the probability calculus which says, intuitively, that the objective probability that the frequencies and the chances will diverge approaches zero as the number of trials gets infinitely large.[13]

One may understandably wonder whether WLLN holds for propensity accounts. I take it that the notion of single-case propensity, and the way in which propensities "govern" or "constrain" chancy events, is brute for the non-Humean, and not subject to any further metaphysical explanation. Single-case propensities then ground propensities for aggregations of events, in accordance with WLLN. It is here that I can see legitimate worries about the potentially mysterious character of single-case propensities, but this is not an objection concerning the ability of propensity theories to rationalize adherence to (PP). It is rather an expression of skepticism about their foundational metaphysical plausibility. It is, therefore, a story for another day: I am concerned, here, with whether we can rationalize adherence to (PP) *given* that a propensity account – or any other non-Humean interpretation of chance – happens

[13] Standardly, WLLN is formulated in terms of the probability that the sample mean $\bar{x}$ will diverge from the population mean μ. The formulation above adapts the standard formulation for the ensuing discussion of chances and frequencies. See Ballentine (2016) for an application of the Law of Large Numbers for propensity chance.

to be true. And if one cannot, this would of course count against propensity analyses' overall plausibility, as it would undermine their ability to satisfy a manifest aspect of the chance-role.

WLLN, as stated above, is a statement about the objective probabilistic connection between chances and frequencies. However, there is a related aspect of WLLN of which I will also make use: WLLN itself functions as a kind of normative constraint on our credences. Conditional on an agent's having a particular degree of belief that some event will occur, they ought to expect that the frequency of that event-type in the relevant reference class is approximately equal to their single-case credence. Call this epistemic version of WLLN the Subjective Law of Large Numbers (SLLN):

$$\lim_{n\to\infty} Cr\left(\left|f_{\phi} - \mathrm{x}\right| < \varepsilon \;\middle|\; Cr(\phi) = \mathrm{x}\right) = 1$$

SLLN is, again, meant to apply to repeatable and i.i.d. events, and it merely demands of agents that their credence function be probabilistically coherent, since SLLN is just the credal analogue of WLLN, which is a theorem of the probability calculus. Both WLLN and SLLN play important roles in the first vindication of (PP) for propensity chances that I will offer.

The last assumption I will make is known as

> *Lockean Thesis*: If one's credence in p is sufficiently high, then one should take up the outright belief that p.

There are a number of different versions of Lockean Thesis. It is sometimes taken that sufficiently high credence is necessary and sufficient, or just necessary, for outright belief. For my purposes, suitably high credence will need to be sufficient, but not necessary, for rational outright belief. How to understand "sufficiently high" is also a point of contention in the literature. Some, for instance, take it that there is a fixed threshold for sufficiently high credence,

while others take it that the relevant threshold is context- and proposition- dependent.[14] For whatever level of credence $1 - \varepsilon$ one thinks is suitably high to justify application of Lockean Thesis, one simply needs to consider a sample size sufficiently large to generate a divergence of single-case and long-run credence of less than ε via SLLN.

Given these three assumptions, we can see how a non-Humean about chance would be able to justify (PP). First, as an example, consider a sufficiently long sequence of chancy events: tosses of a fair coin, where $ch(\mathrm{H}) = 0.5$, let's say. If an agent S obeys (PP), and thereby generalizes their credence function $Cr(\text{-})$ via SLLN from single events to long sequences, we will have:

$$Cr(f_H \approx 0.5) \approx 1.$$

This is because, given an arbitrarily small constant ε, as the number of trials approaches infinity, SLLN instructs agents to set their credence that the frequency of heads differs from their single-case credence $Cr(\mathrm{H})$ by a factor of ε or greater equal to zero. Thus, for any ε, there is a finite – but perhaps very long – sequence, such that an SLLN-obeying agent will assign a credence of approximately 1 to the proposition that the frequency of heads will be within ε of 0.5.

It follows from WLLN that for any ε, there is a large enough value of n such that, in a sequence of n trials, there is a chance of approximately 1 that the frequency of heads will be within ε of 0.5. Consequently, given a sufficiently small ε-value, and a correspondingly long sequence, we can obtain:

$$ch(f_H \approx 0.5) \approx 1.$$

Since S has a credence in $f_H \approx 0.5$ of approximately 1, application of Lockean Thesis yields the result that S believes outright that the frequency of heads will be approximately 0.5. Consequently, by substitution, it follows that ch(S's belief is true) is *also* approximately 1.

[14] See Jackson (2020) for an overview of the Lockean Thesis, and see Dorst (2019) for a recent argument to the effect that adherence to the Lockean Thesis maximizes expected epistemic utility.

It is similarly clear, moreover, that an agent who adopts a non-PP-obeying credence function will have a much lower chance of believing the truth about the frequency of heads over long sequences. For instance, imagine an agent S* with credence function Cr^* such that $Cr^*(\mathrm{H}) = 0.8$. Similarly, S* obeys SLLN. S* will consequently disbelieve truths and believe falsehoods with a very high objective probability. This is because S* will have a very high credence in the proposition that the frequency of heads is approximately 0.8:

$$Cr^*(\mathrm{f_H} \approx 0.8) \approx 1,$$

This occurs for just the same reason that S, above, had a credence of approximately 1 in the proposition that the frequency of heads is approximately 0.5. As before, if S* obeys Lockean Thesis, then S* will believe outright that the frequency of heads is approximately 0.8. Yet, the objective chance that this belief is true will be incredibly low:

$$ch(\mathrm{f_H} \approx 0.8) \approx 0.$$

S* will similarly have a credence approximating zero in the proposition that the frequency of heads is approximately 0.5, and thus disbelieve outright that the frequency of heads will be approximately 0.5. As established above, the objective chance of this proposition is very high, so it is very likely that S* will disbelieve a true proposition (and believe a false one).

The above example, I hope, begins to make lucid why agents who fail to obey (PP) are objectively unlikely to form true beliefs about frequencies, while those who succeed in obeying (PP) are objectively likely to do so. It can also be shown more generally that *any* credence function which differs non-trivially from the objective chances is in this sense unreliable. Suppose $Cr(\mathrm{H}) = ch(\mathrm{H})$ and $Cr^*(\mathrm{H}) = ch(\mathrm{H}) + \varepsilon$, for an arbitrary ε. Then, by WLLN and uniform substitution of identicals, as the number of sequences gets sufficiently large:

$$ch(|\mathrm{f_H} - Cr(\mathrm{H})| < \varepsilon) \approx 1.$$

However, in order that $|f_H - Cr^*(H)| < \varepsilon$, it must be the case that $|f_H - ch(H)| > \varepsilon$, since $ch(H)$ and $Cr^*(H)$ differ by a factor of ε. Therefore, by WLLN, as the number of sequences gets sufficiently large:

$$ch(|f_H - Cr^*(H)| < \varepsilon) \approx 0.$$

Cr obeys (PP) by assigning a credence of 0.5 to the proposition that the coin will land heads. *Cr**, on the other hand, fails to obey (PP). Consequently, *Cr* is almost certain to converge with the frequencies in a long enough sequence of trials. *Cr**, by contrast, has the opposite result. Therefore, an agent who obeys (PP) by setting their credence function equal to the objective chance function will, in the long run, have an objective chance approximately equal to 1 of having their credences fall within some arbitrarily small interval from the frequencies. Consequently, they will be very likely to possess accurate outright expectations about the frequencies, via adherence to both SLLN and Lockean Thesis. An agent who adopts a credence function such as *Cr**, on the other hand, has a very low objective chance of yielding accurate expectations about the frequencies.

Therefore, an agent who fails to adhere to (PP) is much less likely to yield optimal-ratio belief sets than an otherwise similarly situated agent who does.[15] Moreover, Chance Reliabilism is only concerned with outright belief – that is, the probability that one will believe truths or falsehoods outright – rather than credence. Therefore, when it comes to the sorts of credences that we should have, Chance Reliabilism instructs us only with regard to the *outright* beliefs that can be generated from our credences, via adherence to Lockean Thesis. In the chancy cases,

[15] It is important to note that this will only apply when the belief sets are defined over the same reference class as the chance function.

these are (ordinarily) just the cases that involve long sequences.[16] Consequently, what has just been established is sufficient to rationalize adherence to (PP) via Chance Reliabilism.[17]

One may reasonably object that Chance Reliabilism appears to rationalize alignment of our credences with the *actual* objective chances, rather than our beliefs about the objective chances, as (PP) requires. After all, (PP) crucially instructs agents with misleading evidence about chance hypotheses *not* to set their credences equal to the actual objective chances. However, the basic reply is that Chance Reliabilism should be understood to emphasize reliable belief-formation processes sufficiently broadly, and that the above argument establishes merely that an agent who has *already* reliably obtained information about the objective chances will have a high chance of epistemic success if they adhere to (PP). Hence, we can rationalize

[16] There are a few exceptions, such as single cases involving statistical-mechanical probabilities that approximate 1 (e.g., that the gas will spread throughout the box when a divider is removed). In such cases, again, application of Lockean Thesis in conjunction with adherence to (PP) will generate outright beliefs which are virtually certain to be true.

[17] The scope of this justification of (PP) can be extended to non-repeatable, non-i.i.d., and non-long-run cases, given a few plausible additional assumptions. Take a proposition like P = <Democrats will hold the Senate in 2024>. If a propensity account of chance is correct, then whether P obtains will presumably supervene on chancy events that occur at a more fundamental level, such as wavefunction collapses for many of the universe's elementary degrees of freedom. These events are very plausibly repeatable, unlike some of the macroscopic events that they together realize. As a result, (PP) picks out a rational credence function for them. We then only need to add the assumption that, if *Cr* is your credence function and φ and χ are mutually entailing, where χ is the non-i.i.d. proposition and φ is a disjunction of subvening i.i.d. propositions, then it should be the case that $Cr(\chi) = Cr(\varphi)$, to obtain the result that your credences in non-repeatable, non-i.i.d. propositions ought to obey (PP) as well. If there are events which neither belong to repeatable i.i.d. reference classes *nor* have very high (or very low) single-case propensities, *nor* supervene on i.i.d. events, then this justification of (PP) would be somewhat inapplicable to them, save for the fact that adherence to (PP) is a *globally* reliable strategy, and it would simply be easier for agents to apply such a strategy across the board, including for those extremely rare chance events which might have no connection whatsoever to some or other i.i.d. events.

adherence to (PP) conditional on our having prior beliefs about the chances which are, according to Chance Reliabilism, themselves formed via a reliable process.

Beliefs about the objective chances are typically informed by updating on evidence obtained from observing relative frequencies, via rules like Bayes' Theorem. While I can't give a comprehensive reliabilist justification of conditionalization here, it seems relatively straightforward how such an account would go: first, the objective chance function *ch* makes certain relative frequencies for i.i.d. propositions – those which approximately mirror *ch* – very likely. Agents who conditionalize on those frequencies will thereby obtain a high credence that *ch* (approximately) matches the true objective chances. Hence, *ch* assigns a high probability to the proposition that an agent adhering to an updating rule will come to believe that *ch* itself is the objective chance function.[18] Hence, Chance Reliabilism can only be employed to justify (PP) in two steps: first, by considering that agents who conditionalize on observed frequencies are likely to form true beliefs about the chances themselves, and second, by demonstrating that, once an agent has gotten a handle on what the chances are, matching their credences to the chances will reliably yield epistemic success. This two-step justification is appropriate, because there is no operationalizable process that agents with misleading evidence can be expected to follow in order to match their credences to the actual objective chances.

2.2. Accuracy

Before getting into the crux of my case about accuracy, and the assumptions I will make in giving the argument, I will give some background regarding the notions of accuracy and vindication.

In the literature on accuracy measures for credence functions, we start out with a *fully vindicated*, i.e. maximally accurate, credence function. In particular, for a world w, the fully vindicated credence function is just the truth-function, v_w, which assigns 1 to all truths and 0 to

[18] See also the next subsection, for more details on how to connect a reliabilist account of conditionalization with my vindications of (PP).

all falsehoods.[19] With this, we can define a particular credence function's accuracy in terms of its distance from vindication, where the distance between two credence functions is often defined as the sum of the squared distances between the credences in each function:

$$D\left(Cr_j, Cr_k\right) = \sum_{\gamma \in \Gamma} (Cr_j(\gamma) - Cr_k(\gamma))^2$$

where Γ is a finite set of propositions. We can then define the inaccuracy of any given credence function, Cr, at a world w, in terms of its distance from the vindicated credence function v_w, called its Brier Innacuracy:

$$I(Cr, w) = \sum_{\gamma \in \Gamma} (Cr(\gamma) - v_w(\gamma))^2$$

[19] Hicks (2017) derives (PP) for Humean accounts of chance on accuracy grounds. Hicks defines Humean chance as the maximally accurate credence function which respects a particular constraint called *Evidential Equivalence*, which says that if no evidence can distinguish E from E*, then *ch*(A | E) = *ch*(A | E*). So, the chance function is the "most accurate credence function that obeys the same evidential constraints that we do" (942). If an agent fails to satisfy (PP), then, they are either failing to obey Evidential Equivalence, or they have a credence function which is accuracy-dominated. Since chance is defined in terms of accuracy, one can clearly show why adherence to (PP) is rational, via an accuracy norm of belief. This derivation is unobjectionable, as far as I can tell, save for the fact that just as with the other Humean derivations of (PP), it seems to apply most naturally to agents who already possess knowledge of the objective chances. On Hicks' view, an agent who obeys (PP) is guaranteed to have an accurate credence function, *conditional* on their beliefs about the objective chances being true, since it is only the actual objective chance function which accuracy-dominates alternative credence functions. It may be, then, that a unified answer to the questions of (1) how agents should form beliefs about the chances and (2) how agents should set their credences in chance propositions *given* those beliefs, may invoke reliabilist truth- or accuracy- norms. At any rate, it is unclear that a reliabilist answer would be any less satisfying than the few conceivable alternatives.

I can now present the central assumption in my second attempt to justify (PP). It is a modification of Chance Reliabilism to accommodate accurate credence rather than true belief:

> *Accuracy Reliabilism*: Agents should adopt the credence-forming processes which have the highest objective chance of producing accurate credences, subject to the constraint that the processes be sufficiently operationalizable.

While the imposed operationalizability constraint is vague, what is important to note is that a credence-forming rule such as "set your credences equal to the actual objective chances" is exceedingly difficult to operationalize, given that it fails to instruct agents as to how they should gain epistemic access to the actual objective chances, while rules like "set your credences equal to what you *take* to be the objective chances" as well as "update your credences in candidate chance theories by conditionalizing on observed frequencies" are both reasonably operationalizable.

The most straightforward way to cash out Accuracy Reliabilism in more formal terms is that it instructs agents to minimize *ch*-expected inaccuracy:[20]

[20] This is similar to the principle invoked in Pettigrew's (2016) second argument for (PP). Pettigrew suggests that, for any two credence functions *Cr* and *Cr**, where *Cr* obeys (PP) and *Cr** does not, $\text{Exp}_{\mathfrak{u}}(Cr|ch(-|E)) > \text{Exp}_{\mathfrak{u}}(Cr^*|\ ch(-|E))$ for any possible ur-chance function *ch*, where $\mathfrak{u}$ is an epistemic utility function. The only thing that should be clarified about Pettigrew's approach is that it seems to me that (PP)-adhering credence functions do not strictly *ch*-dominate alternative credences functions according to every possible *ch*. Holding fixed the credence function *Cr* which adheres to (PP) in the actual world, but letting the chance function vary, there will be an alternative credence function *Cr** that does not adhere to (PP) for the *actual* chance function, but does adhere to (PP) for some alternative chance function *ch**, such that *Cr** does *ch**-dominate *Cr*. *Accuracy Reliabilism*, though, does not face this difficulty, since it merely requires of agents that they adhere to credence-forming processes which maximize *ch*-expected accuracy for the *actual* objective chance function. And this is why I aim to vindicate a credence-forming strategy which combines (PP) and conditionalization: it won't just be that agents minimize expected inaccuracy according to the chance function they *believe* obtains, but they will also have a

$$EI_{ch}(R, \mathcal{F}) = \sum_{\langle w, Cr \rangle} ch(w) I(Cr, w) ch(Cr|R)$$

Here, $\mathcal{F}$ denotes an algebra of propositions, w denotes a possible world belonging to a set W of classically consistent assignments of truth-values to the propositions in $\mathcal{F}$, Cr denotes a credence function belonging to the set $\mathbf{C}$ of possible credence functions, and R denotes a credence-forming process. Essentially, EI_{ch} is the measure defined over possible world-credence function *pairs* which expresses how inaccurate the actual objective chance function expects your credence function to be, *given* that you are adhering to some credence-forming process R. The reason for defining *ch*-expected inaccuracy in this manner is that we are interested in credence-forming processes, which don't necessarily pick out a single unique credence function, but rather render it more or less likely that an agent obeying that process will end up with a certain credence function.

Now, while Brier Innacuracy is the most popular scoring rule for credence functions, it turns out that the justification of (PP) that I offer will apply to any scoring rule which adheres to the following constraint:

> *Strict Propriety*: A scoring rule is strictly proper if, for any two distinct probability functions P and P^*, where at least P is probabilistically coherent:
>
> $$\sum_{w} P(w) I(P, w) < \sum_{w} P(w) I(P^*, w),$$
>
> where $I(P, w)$ is the measure of inaccuracy on that particular scoring rule.

plausible means in which to form rational beliefs/credences over candidate chance theories. Consequently, I take it that such a vindication will have a broader scope than Pettigrew's, if I understand him correctly.

In other words, every coherent probability function expects itself to be the uniquely most accurate credence function, on any strictly proper measure of inaccuracy.[21] Now, we can introduce another, more standard measure of expected inaccuracy, defined for particular credence functions rather than processes:

$$EI^*_P(Cr, \mathcal{F}) = \sum_w P(w)I(Cr, w)$$

EI*$_P$ is just a measure of how accurate the probability function P expect some *particular* credence function Cr to be, and it is this this measure of expected inaccuracy that is implicated by *Strict Propriety*. And finally, we can introduce a measure, EI*$_{ch}$, of how accurate the actual objective chance function expects some credence function to be:

$$EI^*_{ch}(Cr, \mathcal{F}) = \sum_w ch(w)I(Cr, w)$$

Recall: I have been emphasizing that (PP), being a conditional norm of credence, will only be unconditionally vindicated to the extent that we can make plausible that our antecedent rationality principles offer agents a reasonably operationalizable means in which to gain epistemic access to the objective chances, such that the credence function they arrive at by obeying (PP) will be *unconditionally* rational. Thus, I want to make plausible three claims:

(1) Among the realistic and operationalizable updating strategies, conditionalizing on observed frequencies minimizes *ch*-expected inaccuracy with respect to credences defined over candidate chance theories.

[21] *Strict Propriety* is a popular constraint on scoring rules, to which an extensive literature is dedicated. See, for instance, Joyce (1998, 2009) and Pettigrew (2016, 2020).

(2) *ch* itself minimizes EI^*_{ch}, so that in the idealized case in which an agent has absolutely settled on the unique, true objective chance function via conditionalization, adherence to (PP) uniquely minimizes EI_{ch}.

(3) In the non-ideal case in which conditionalization does *not* uniquely pick out the single objective chance function, agents who adhere to (PP) + conditionalization are able to approximate the ideal case to a high degree.

First, suppose an agent assigns non-zero prior credence to the actual objective chance function. On any particular chance event, the actual objective chance that an agent will observe some event *E* is equal to *ch*(*E*). To the extent that they adhere to conditionalization (to be abbreviated COND), their posterior credence in the proposition that *ch* is the actual objective chance function is:

$$Cr(ch|E) = \frac{Pr(ch) * ch(E)}{Pr\ (E)},$$

where *Pr* is the agent's prior credence function. Moreover, as the agent accumulates more evidence of chancy events, certain stable relative frequencies will emerge, and from WLLN it follows that those frequencies will be very likely to approximate the chances. With access to stable enough frequencies, an agent obeying conditionalization will obtain a likelihood function *ch*(observed frequencies ≈ *ch*) which is very high for *ch* and for candidate chance theories which are close to *ch*, and get lower and lower as the candidate chance theories get further away from *ch*. This is because, as the agent acquires more robust evidence, it becomes likelier and likelier that the observed frequencies will in fact mirror the actual chances. Consequently, the final term in EI_{ch}, *ch*(*Cr* ≈ *ch* | COND & PP) – suitably adapted – is very high, because it is very likely that the agent will take *ch* to be the actual chance function via COND, and hence that they will set their credences approximately equal to *ch*, via (PP).

What has been established is only intended to make my first claim – that conditionalization renders it very likely that agents will assign high credence to true

propositions about the objective chances – plausible. It is difficult to decisively prove that COND is the unique updating strategy that does so, in part because of the vagueness of the operationalizability constraint in *Accuracy Reliabilism*. However, the only alternatives that I can envision are updating rules which are in some way biased towards the actual objective chances – for instance, an updating rule which tells agents to increase their credence that *ch* is the actual chance function, *no matter their evidence*. But such an updating rule would clearly be exceedingly difficult to operationalize, because the only evidence that can distinguish the different chance theories seems to come by way of the frequencies and, to an extent, observable one-shot chance events. Hence, it is plausible that an updating rule like COND will be the best option available to agents, given *Accuracy Reliabilism*.

It is very straightforward to prove claim (2). After all, it follows from any scoring rule which satisfies *Strict Propriety* that *ch* will itself minimize EI^*_{ch}. For example, take the case of Brier Inaccuracy, and suppose that that $ch_w(\phi) = \delta$. . Now suppose $Cr(\phi) = \delta$ and $Cr^*(\phi) = \delta + \varepsilon$. Consequently $|v_w(\phi) - Cr(\phi)|$ is δ with a chance of $1 - \delta$, and $1 - \delta$ with a chance of δ. Similarly, $|v_w(\phi) - Cr^*(\phi)|$ is $\delta + \varepsilon$ with a chance of $1 - \delta$, and $1 - (\delta + \varepsilon)$ with a chance of δ. Thus, on the Brier meassure of inaccuracy:

$$EI^*_{ch}(Cr, \mathcal{F}) = \big((1-\delta)\delta^2 + \delta(1-\delta)^2\big)\text{n}$$
$$EI^*_{ch}(Cr^*, \mathcal{F}) = \Big((1-\delta)(\delta+\varepsilon)^2 + \delta\big((1-(\delta+\varepsilon)\big)^2\Big)\text{n}$$

To ensure that $EI^*_{ch}(Cr, \mathcal{F}) < EI^*_{ch}(Cr^*, \mathcal{F})$, we need:

$$(1-\delta)\delta^2 + \delta(1-\delta)^2 < (1-\delta)(\delta+\varepsilon)^2 + \delta\big((1-(\delta+\varepsilon)\big)^2$$
$$\text{for all } |\varepsilon| > 0$$

Which simplifies to $\delta - \delta^2 < \delta - \delta^2 + \varepsilon^2$ and finally to $\varepsilon^2 > 0$, which is true for all $\varepsilon \neq 0$. Now, consider the following case.

Ideal Case. Suppose that an agent has conditionalized on enough evidence that they have settled on the single objective chance function. Consequently, $ch(Cr = ch \mid \text{PP}) = 1$, because the agent is certain that *ch* is the objective chance function, and therefore sets their credences equal to *ch* when they adhere to (PP). But then EI_{ch} simply reduces to EI^*_{ch} for *Cr*, because the former's $ch(Cr \mid R)$ term is equal to 1 for $Cr = ch$. Because *ch* uniquely minimizes EI^*_{ch} by *Strict Propriety*, it follows by substitution that *Cr* does as well. Thus, in the ideal case, adherence to (PP) + COND uniquely minimizes EI_{ch}, and is thus vindicated by *Accuracy Reliabilism*.

Hence, we have established claim (2).

Finally, it remains to at least make highly plausible that agents in ordinary epistemic circumstances who obey COND and (PP) can at least approximate the **Ideal Case**. Here, first, are two assumptions:

(i) $\sum_w ch(w)I(Cr, w)$ is minimized at $Cr = ch$ (which we have proved) and monotonically increases in either direction, as *Cr* moves away from *ch*.

(ii) $\sum_{Cr} ch(Cr \mid \text{PP \& COND})$ is maximized at $Cr = ch$ and monotonically decreases in either direction, as *Cr* moves away from *ch*.

Intuitively, (i) just says that while *ch* expects a *ch*-matching *Cr* to be the least inaccurate credence function, its expected inaccuracy for alternative credence functions increases monotonically as those credence functions move further away from the chances. (ii) merely says that, while the chance function expects that a conditionalizing agent adhering to (PP) is most likely to arrive at a credence function which matches the actual chances, they are monotonically less and less likely to arrive at a credence function the further it diverges from the chances. This follows from the fact that, the further the divergence between the frequencies and the chances, the less likely it is to occur, and the smaller a sample size needed to guarantee that such a divergence won't occur.

But now, we see that for the range of credence functions that COND renders reasonably likely, the *ch*-expected inaccuracy is very low. And for those credence functions for which the *ch*-expected inaccuracy is very high, conditionalization ensures that those credence functions are very unlikely! Hence, it is exceedingly plausible that ordinary agents adhering to PP + COND will be able to approximate the **Ideal Case**, for which it has been proved that (PP) satisfies *Accuracy Reliabilism*.

2.3. The argument reassessed

Note that, on either of the above approaches, we can restrict ourselves to the chance that agents will have of performing well over long sequences solely when it comes to their beliefs and credences about categorical features of the world, either because we are measuring the probability that an agent will have a true belief about the approximate relative frequencies, or because we are measuring a credence function's *ch*-expected inaccuracy*. Thus, even if we restrict our prior principles of epistemic normativity to our beliefs about those categorical features, we find that agents are epistemically obligated to obey (PP) for single-case chancy events.

Let's return, then, to the Credal Argument Against Non-Humean Chance. The argument's first premise fails to consider that, while non-Humean accounts indeed give these categorical features of reality no purchase in determining *what the chances are*, the non-Humean chances can still enter through the "backdoor," as it were, in determining what sorts of belief-formation processes count as reliable and in making certain relative frequencies objectively likelier than others. If one accepts Chance Reliabilism or Accuracy Reliabilism, then one accepts that at the bottom of prescriptive epistemic normativity lies an emphasis on the probabilistic disposition of certain doxastic behaviors to generate optimal belief sets. That adherence to (PP) is *likely, by the lights of the non-Humean chance distribution which accurately describes our world,* to generate optimal belief sets, or to yield accurate credences, is all that it takes to rationalize adherence to (PP).

One may understandably worry about these attempted vindications of (PP) that they are circular, or that they open the door to further problems. I will turn, in the next section, to anticipating some of these potential concerns and addressing them.

3. A Circularity Objection

The objection I would like to address, here, goes as follows. If one is trying to rationalize adherence to (PP) by defining reliability in terms of objective chance, they will have to assume (PP) in order to explain why reliability, so understood, matters in the first place. Why, after all, should agents expect that Chance Reliabilism (or Accuracy Reliabilism) is a sensible epistemic norm, without first assuming that a certain doxastic habit's having a high propensity to generate optimal belief sets thereby entices one to have a high degree of belief that said habit will generate optimal belief sets?

Let's pause to consider an illustrative analogy with another pressing issue in the philosophy of science, namely the asymmetry between our epistemic access to the past and the future. David Albert (2000, 2015) points out that there are two different ways to infer, from the state of the world at one time, the state of the world at another time. The first mode of inference employs prediction and retrodiction. Such an inference method takes the present total macro-state of the world at some time, t, along with a uniform probability distribution over the possible micro-states that could realize the macro-state at t and uses this information to make probabilistic predictions about the future or past via the time-evolved micro-states.

But Albert points out that we have another type of epistemic access to the past, which we lack toward the future: we can keep records of the past. The kinds of devices which are taken to keep records of the past (measuring devices, memories, and so forth) are taken to undergo a *dynamical* transition in the time interval between their ready state and their record-bearing state, which allows us to make inferences about what happened to the measured system within that time interval. In order for our records to be reliable, however, we need another physical system (for instance, our own memories) whose present state is a record of our first device's having been in a ready state a certain time ago. This initiates a "world-devouring regress" (Albert 2015, 38) of record-keeping systems which, so says Albert, bottoms out in the

Past Hypothesis, which says that our universe began in a macro-state of very low entropy. The Past Hypothesis is something which we are in a position to infer not solely because it follows from the sum total of our finite empirical evidence, but rather because it is confirmatory of our experience.[22]

But consider the kinds of evidence that we *do* have for the low-entropy initial state of the universe, as observed in the Cosmic Microwave Background. This data serves as a kind of record of the initial state, but its reliability *as* a record depends on the initial low-entropy state itself. This is not an instance of our record-based inferences being viciously circular: the Past Hypothesis is the objective feature of the world which *makes* our record-bearing devices reliable. This is so irrespective of our own *knowledge* of the Past Hypothesis. No one has to have studied statistical mechanics to reliably recall what they ate for breakfast this morning! The world has already settled that record-based inference is a reliable process, and it has done so in virtue of this low-entropy boundary condition. Now, agents are perfectly justified in exploiting this fact in order to extract reliable information about past states of the world, *including* the Past Hypothesis itself! In this sense, the connection between the Past Hypothesis and our inferences to past times is epistemologically *self-sustaining*.

The same is true, I think, for chance. The objective chances make certain belief-forming processes *objectively reliable*. That certain principles – those which are rationalized by Chance Reliabilism or Accuracy Reliabilism – are genuine requirements of rationality is made true by the objective chances, and they are made so *irrespective of anyone's particular degrees of belief*. An agent could, moreover, reason that (PP) is rationalized by Chance Reliabilism or Accuracy Reliabilism, *before* adopting any beliefs or credences over candidate chance functions. Agents, therefore, are permitted to take advantage of the resulting, Chance Reliabilism- and Accuracy Reliabilism- backed principles of rationality, even when it comes to connecting up the objective

[22] In particular, the Past Hypothesis is justified by its ability to reconcile the time-directed regularities of the macroscopic world (reflected in the Second Law of Thermodynamics) from the apparently time-reversal invariant dynamical laws of motion, and because it allows us to make successful statistical inferences about the future.

chances with what they should rationally expect about the future occurrence of chancy events. What would be circular, for instance, is if the rules employed to justify (PP) instructed agents to minimize expected inaccuracy according to their own credence function, along with the requirement that the EI-guiding credence functions match the objective chances; such a justification would have to invoke (PP) at the outset. But neither Chance Reliabilism nor Accuracy Reliabilism rests on the assumption that agents have a certain degree of belief that the relevant procceses will produce true beliefs or accurate credences. All of the normative work is done externally by the chances, rather than internally by an agent's credences in the truth/accuracy-conduciveness of the relevant formation processes.

One may, instead, worry not that the justification is circular, but that it leaves unexplained the justificatory status of the antecedent, chance-backed rationality principles. While this is true, the issue is whether Humeans can obviously do better. As I have emphasized, Humeans can only guarantee accuracy, truth, and the like, when their agents start off with knowledge of the objective chances. And as far as I can tell, a fully operationalizable justification of (PP) – one which explains both why agents should adhere to (PP) *and* how they should form justified beliefs or credences over candidate chance theories – is going to have to take as bedrock either (i) self-locating indifference reasoning (as in Schwarz 2014; though see Fernandes (forthcoming) for an argument that other extant Humean justifications rely on indifference reasoning)[23], or (ii) some chance-backed principle of truth- or accuracy-maximization.[24] And it isn't immediately obvious, absent further explanation, why we should

[23] Moreover, the indifference in question is not going to be the indifference we are accustomed to. Self-locating indifference usually pertains to agents who know what the universe looks like and are trying to locate themselves in it – for instance, in Everettian quantum mechanics. But here, an agent employs indifference to infer that their local frequencies are approximately equal to the global frequencies (and so the Humean chances). In other words, indifference reasoning aimed at inferring the global Humean chances would seem to get the process backwards, at least as we typically understand indifference reasoning. Many thanks to [OMITTED] on this point.

[24] The reason for this is that, while agents in fact obtain information about the objective chances by conditionalizing on observed frequencies, there is no guarantee that the observed frequencies will be

feel any queasier taking (ii) to be a brute principle of rationality than (i), especially given the well-known troubles with formulating a consistent and plausible principle of indifference. After all, appeals to which belief-formation processes are likely to yield epistemic success is already at the heart of reliabilist approaches to epistemic justification. I have shown that, if one's epistemology is reliabilist in character, then non-Humeans can justify (PP) from more basic reliabilist constraints – the kind of constraints that range over categorical features of the world, and which (one would hope!) can rationalize adherence to all sorts of other principles of epistemic normativity.

Humeans may worry that, even if both Humeans and non-Humeans were pushed to posit fundamental chance-involving norms, Humeans would still be better off in doing so, because what they mean by "chance" is just different from what non-Humeans mean by "chance." And what makes fundamentally chance-involving norms so problematic in the non-Humean case, the thought may go, is that there is just no explicable connection between making *P* likely and making *P* the case.[25] After all, the only reason we might think that these fundamental chance-involving norms are remotely plausible is *because* we believe that there is some such connection. I think Humeans would be right to push this line of reply. But for propensity theorists, there *is* a connection between making *P* likely and making *P* the case, it is just that this connection is metaphysically primitive. It seems to me that the extent to which one finds chance-involving norms plausible, where the chances involved are non-Humean in nature, is just a matter of how plausible one finds this brute connection. And consequently, the Humean objection should not be cast in terms of whether non-Humeans can offer a satisfactory

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representative of the objective chances. Non-Humeans and Humeans alike can appeal to the fact that agents who conditionalize on frequencies are objectively likely to form true beliefs about the chances, while only Humeans can appeal to self-locating indifference: one can reason that, whatever the global frequencies may be, the local frequencies will approximately match the global frequencies in most regions. Hence, an agent who is indifferent between being located in different regions of the mosaic will have a high credence that their observed frequencies are adequate guides to the objective chances.

[25] Many thanks to [OMITTED] on this point.

justification of (PP), but rather in terms of whether one is satisfied with a fundamentally dispositional, propensity-based *metaphysics*.

4. Conclusion

I want to emphasize that I have not, in this paper, attempted to issue a global defense of non-Humean accounts of chance. Rather, I have tried to show that one can vindicate the Principal Principle for non-Humean chance given some independently plausible background assumptions. Surely, though, one could dispute these principles. What I hope to have shown, however, is that the common assumption that non-Humean accounts of chance are unable to rationalize adherence to (PP) via consideration of categorical constraints on rational credence is too hasty. I think of the justification of (PP) given in this paper as a proof of concept that the connection between the irreducibly modal domain of non-Humean chance and the kinds of expectations we ought to have about the nonmodal domain of frequencies and the like, can *in principle* be made intelligible. Non-Humean accounts of chance, then, need not take (PP) as a primitive constraint on credence. At the very least, there are other options, and it may even be that both Humean and non-Humean theories of chance are on roughly equal footing, in that they must both posit some more basic chance-backed principles of rationality in order to fully rationalize adherence to (PP), though I don't take myself to have demonstrated this decisively.

This all opens up a puzzle for so-called *functional* analyses of probability, in particular functional analyses which restrict the chance-role to (PP) or similar chance-credence principles, so that chance is just whatever, in the world, plays the role of constraining rational credence in the right way. Lewis, for instance, thought that (PP) captures "all we know about chance" (1980, 266). But the argument advanced in this paper shows that any theory of chance, given some reasonably plausible antecedent principles of rationality, can justify (PP) *on its own terms*. And if this is true, then the chance-role, restricted to the chance-credence link, underdetermines our candidate theories of chance. It is necessary, then, to find another way to assess accounts of chance than via the ability of any given account to rationalize adherence to (PP). We must examine other potential aspects of the chance-role, and see how the competing theories shape up, lest we find ourselves in a dialectical impasse.

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