Can Humeans be Scientific Realist?

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Abstract

Many philosophers who defend a Humean account of laws also endorse scientific realism, such as David Lewis and Barry Loewer. It seems as if scientific realism and Humean accounts of laws of nature are orthogonal to, and so are naturally compatible with, one another. I argue otherwise: Humean accounts of laws are at odds with scientific realism. In particular, I focus on two of the most prominent Humean accounts, Lewis' Best System Account and Loewer's Package Deal Account, and argue: the latter conflicts with standard scientific realism, while the former does not conform to scientific practice.

Many philosophers who defend a Humean account of laws of nature often endorse scientific realism as well, such as Lewis[1] and Loewer. In fact, according to the PhilPapers Surveys (Bourget and Chalmers 2009, 2020), most Humeans believe in scientific realism.[2] *Prima facie*, what laws of nature are and whether or not scientific realism is correct are two orthogonal questions: The answer to one doesn't affect the answer to the other. Hence there is nothing inconsistent about being both a Humean and a scientific realist. This paper calls into question the tenability of this position, and undertakes a close examination of the relation between Humean accounts and scientific realism.

Section 1 provides two motivations for doing so, which suggest that scientific realism is not something Humeans can just take for granted. Section 2 and 3 focus on two of the most prominent Humean accounts of laws: Lewis' Best System Account (BSA) and Loewer's Package Deal Account (PDA). I argue that these two Humean accounts are at odds with scientific realism. More specifically, the PDA conflicts with standard scientific realism, and the BSA does not conform to scientific practice.

To clarify, the purpose of this paper is not to argue that it is impossible to reconcile Humean accounts with scientific realism. Rather, the goal is to explore if scientific realism imposes any constraints on our understanding of laws as well as to explicate certain implications of Humean accounts that would be worrisome to those who want to be scientific realists. This paper also addresses the question: if Humeans want to be scientific realists, what kind of scientific realists can they be? I will show, to be more specific, that Humean accounts are in tension with scientific realism in such a way that it requires significant changes to the standard formulations of scientific

[1]Although Lewis does not explicitly defend scientific realism, it is not hard to find clues in his writing that indicates his realist position. As Nolan (2005, 10) points out, "Lewis's scientific realism seems to be grounded in his philosophical naturalism, which he shares with W. V. Quine".

[2]Interestingly, more non-Humeans are scientific realists than Humeans.

realism or of Humean accounts (or both) to reconcile the two.

1 Scientific Realism, Empiricism, and Objectivity: Two Motivations

Scientific realism is the view that scientific theories aim to tell us what the world is *really* like. Generally, it takes science seriously and takes scientific claims literally, as informing us about what the world is really like. More specifically, it holds that our best scientific theories are true (or at least approximately true) and that the theoretical terms employed in those theories refer to real objects, including unobservable ones, that exist in the world independent of the human mind. I concede that there isn't a consensus on how to characterize scientific realism or even what counts as scientific realism (van Fraassen 1980, 9; Chakravartty 2017, Sec. 1.1). But the characterization above is more or less the *standard* one. And what is most important to this paper is the idea that objects postulated or predicted by our best scientific theories, such as viruses, atoms, and electromagnetic fields, really exist in the world—their existence and properties are *independent of the human mind*, of how we think or theorize. Even though some of these objects are unobservable, they are not fictional entities introduced *by us* merely as instruments to systematize or make predictions for observable phenomena. It is far less contentious that standard scientific realism is committed to this idea of mind-independence. (Chakravartty 2017, Sec. 1.2).

Scientific realism is often considered to be challenged by the empiricist tradition, especially by logical empiricism and constructive empiricism. Empiricism holds the epistemic view that sense experience is the only (or primarily) legitimate source of knowledge. Following this tradition, critics of scientific realism argue that the existence of unobservable objects cannot be grounded in experience and thus should be rejected.

This tension between scientific realism and empiricism[3] is worth noting because Humean ac-

[3]For more discussions, see Boyd (1983) who emphasized this tension, and Chibeni (2005) who tries to accommo-

counts of laws are originally motivated by the empiricist view that we should not commit to the existence of something that goes beyond our sense experience.[4] The accounts are named "Humean" after the leading empiricist Hume for his renowned rejection of the unobservable necessary connections between cause and effect. Followers of Hume develop a reductive view about laws: Laws of nature do not exist independently of material objects, but are reduced to their patterns or regularities. In contrast, the opposed view—the Necessitarian accounts of laws—insist that laws are, or contain, necessary connections that cannot be reduced to regularities.

This empiricist origin does not necessarily compel Humean accounts of laws, or Humeanism in general (including Humean accounts of causation and of probability), to further reject the existence of scientific objects that are unobservable. It is, however, along the empiricist line of reasoning to question the status of those objects and reject their existence unless they can be accounted for by our experience. It is thus natural to ponder if Humean accounts and scientific (anti-)realism are indeed two orthogonal issues as they may appear to be. To dispel such concerns, Humeans need to address questions like, on what grounds they can treat necessary connections and scientific objects differently so that the existence of the former is rejected while of the latter is accepted. The Humeans cannot simply take scientific realism for granted. This, of course, is not by itself an argument that Humean accounts of laws are at odds with scientific realism. It nevertheless provides a motivation to examine their relation.

The second motivation arises from considering what constraints scientific realism poses on our understanding of laws of nature. Scientific realism as characterized earlier commits to the truth (or approximate truth) of scientific theories and the mind-independent existence of scientific objects, but does not make *explicit* commitments about laws. Nonetheless, scientific theories consist of more than theoretical objects. If laws are an essential component of scientific theories (at least

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date scientific realism within a Humean empiricist tradition.

[4] See, e.g., Bhogal (2020, 7).

in physics), then scientific realism requires one be *realist about laws* as well.[5] It can simply mean: laws succeed in describing some aspects of reality, or there are laws of nature in the world. This explication, however, leaves open in what sense there are such laws.

There has not been much discussion on this issue. One exception is Berenstain and Ladyman (2012). They argue that Humeansim is deeply at odds with scientific realism because the latter requires objective modality and particularly natural necessity, whereas the former rejects it. If theoretical terms should, as scientific realism requires, be taken literally as referring to objects (especially the unobservable ones) that do exist, "then too should claims about laws, causes, and other modalities" (ibid., 152). That is to say, if one is realist about unobservable scientific objects, then one should be realist about laws (and other modalities) in the same way as how one is realist about scientific objects. Thus scientific realism requires laws be taken literally as referring to something that exists in the world. This is exactly what Humeans reject.

For the purpose of this paper, I identify three realist views on laws that are *prima facie* compatible with scientific realism.

(RL1) The propositions that are laws in our best scientific theories are true (or at least approximately true).

(RL2) There is an objective, mind-independent matter of fact about which regularity or generalization counts as a law and which doesn't.[6]

(RL3) *Nonreductionist realism about laws*: Laws of nature are irreducible to categorical properties of material objects or any non-modal facts; e.g., Armstrong (1983), Carroll (1994), Maudlin (2007).

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[5]Cartwright (1983) challenges this and argues for a different version of scientific realism.

[6]Earman and Roberts (2005, 256), who defend their own Humean account, claim that realism about laws requires (RL2). They call it *semantic realism about laws*.

(RL1)–(RL3) are not mutually exclusive. Berenstain and Ladyman argue that scientific realism (together with its supporting arguments) implies (RL3). Humeans can, nonetheless, respond to their argument by denying such an implication and defend their scientific realist position by adopting (RL1).

In fact, the Humean Best System Accounts (BSA) associated with Mill, Ramsey, and Lewis do claim (RL1). According to the BSA, laws of nature are *true* generalizations of a special kind. More specifically, a generalization or regularity is a law iff it is a theorem or axiom of the deductive system of truths that achieves a best balance between simplicity and strength (Lewis 1973, 73; 1994, 478). Lewis' BSA has two components: (I) A metaphysical thesis that laws of nature supervene on, and are reducible to, categorical properties—it is this thesis that goes against (RL3). More specifically, what makes something a law is the fact that it belongs to a system that best satisfies *certain* standards, rather than some metaphysical machinery such as necessary connections or causal powers. In other words, such standards are constitutive of lawhood. (II) A guiding principle of identifying laws from non-lawful claims (in particular from accidental regularities) that specifies what the standards for the best system are: simplicity, strength, and their balance.

It is, however, disputable whether or not (RL1) is sufficient for Humean accounts of laws to be scientific realist. Even if scientific realism does not imply (RL3), one may argue that scientific realism requires (RL2) whereas it is questionable whether Humean accounts can, or should, maintain (RL2).

To see why scientific realism may require (RL2), consider Newtonian mechanics and one of its laws of motion, $F = ma$. The scientific theory, Newtonian mechanics, not only includes the first-order statement $F = ma$, but also the second-order statement that $F = ma$ *is a law*. Even if one denies the latter, it is hard to deny that $F = ma$ *is a law* is integral to science. Designating it as a law is not merely assigning a label. Laws play important roles in science in a way that accidental generalization like 'All spheres of gold are less than one mile in diameter' don't. Given

the important roles of laws in science, scientific realism requires one not only take $F = ma$ seriously, but also take *it is a law that* $F = ma$ seriously. That is to say, *it is a law that* $F = ma$ tells us something about the world that a mere regularity does not.

Furthermore, let's contrast realist views on laws with subjectivist or conventionalist views. The latter takes laws to be at least partially grounded in facts about us, facts about our beliefs and expectations, our inclination to organize or systematize our knowledge in certain ways, or our preferences to categorize various generalizations in certain ways. In particular, it is our different *epistemic attitudes* that mark the difference between laws and accidental regularities.[7] That is to say, according to subjectivist or conventionalist views, laws (or at least what counts as a law) are not *objective*—not in the sense of being entirely independent of the human mind, of how we think or theorize. In contrast, although it may be unclear what specific realist view on laws that scientific realism entails, it at least requires laws be objective: If the existence of scientific objects and their properties are, according to scientific realism, objective, then the way such objects behave and the laws to which they are subject should be objective as well.

It is debatable whether or not Humean laws are objective, which makes it difficult to pin down the tension between scientific realism and Humean accounts. Woodward (1992, 214), for one, regards Humean accounts as subjectivist: Insofar as Humeans think of laws of nature as something more than mere regularities, they will ground this additional content in facts about us. In particular, what counts as simplicity, strength, and their best balance depend on "the (possibly idiosyncratic) details of our epistemic practices and interests" (ibid., 182). Woodward is not alone. Humean accounts are often criticized for not being objective;[8] call this the *Objectivity Objection*. Even Lewis (1994, 479) himself acknowledges:

[7] For a characterization of such views, see Woodward (1992, 182). For specific examples, see Rescher (1969).

[8] See, e.g., Armstrong (1983, 67), Belot (2022).

> The worst problem about the best-system analysis is that when we ask where the standards of simplicity and strength and balance come from, the answer may seem to be that they come from us.

Some Humeans, nonetheless, insist that Humean laws are objective: It is an objective fact about the world that there are certain regularities, and "it is a fact about the world that some regularities form, *objectively*, a system" (Psillos 2002, 154). That is, it is an objective fact that the world has certain structure such that there exists an objectively best system of objective regularities.

I don't intend to settle the issue of whether or not Humean laws are objective here. Nor do I defend or oppose Berenstain and Ladyman's argument. It is not obvious to me that scientific realism requires any particular realist view on laws, either (RL2) or (RL3). The moral I want to draw here is: the open question of what realist view on laws is required by scientific realism along with the dispute on the objectivity of Humean laws give us the second motivation to investigate the relation between Humean accounts of laws and scientific realism. Given that scientific realism is supposed to provide a systematic view on how we should understand science and that laws of nature are an important part of science (at least in physics), attending to their relation could reveal that scientific realism imposes certain constraints on our account of laws and thus is not something Humeans can simply take for granted.

After presenting two motivations for examining the relation between scientific realism and Humean accounts of laws, I now move on to arguments that Humean accounts are at odds with scientific realism. Similar to Berenstain and Ladyman, my main argument in the next section picks up the idea that scientific objects and laws should be treated on an equal footing. Our difference is: Instead of requiring scientific realism imply a particular realist view on laws (which I find difficult to establish), my argument reads the implication of this idea in the other direction, that is, what Humean accounts of laws say about scientific objects.

2 Loewer's PDA: the Status of Scientific Objects and Laws

Let's consider Loewer's Package Deal Account (PDA) first (since it is supposed to be an improvement of Lewis's BSA and its tension with scientific realism comes out more sharply). The PDA can be seen as a version of the BSA in the sense that it also identifies laws as regularities in the best system. There are three ways in which the PDA departs from Lewis's BSA that are relevant to our discussion. First, while Lewis privileges perfectly natural properties which are metaphysically primitive and prior to laws, the PDA does not. According to the PDA, the fundamental ontology of the world (with its categorical properties) and laws of nature are specified together as a "package deal", and are metaphysically on a par (Loewer 2021). Second, the PDA expands the criteria for what counts as the best system that goes beyond simplicity and strength. Generally speaking, it does not use hypothetical or ideal criteria but attends to actual criteria used by physicists. Third, the PDA explicitly commits to relativism—its best system is best only relative to us (in particular, to our tradition of physics). The PDA-laws are thus to some extent anthropomorphic.

More specifically, the PDA associates each possible world W with a pair $< L, T >$, where L is a fundamental language and T is a fundamental theory.[9] A complete description of W can be given in L in terms of the instantiations or distributions of the fundamental predicates of L. For all such pairs $< L, T >$, one (or more) pair gives the theory T stated in L, $T(L)$, that best systematizes the fundamental truths of W. $T(L)$ is the best in the sense that it maximally satisfies the criteria of simplicity, informativeness, comprehensiveness, and *whatever other "requirements that the tradition and practice of fundamental physics puts on a fundamental theory of the world"* (Loewer 2007, 322). $T(L)$ is what the physicist Weinberg (1994) would call "the final theory of everything".

[9] In a more recent paper, Loewer (2020) associates W with a triple $< L, A, T >$, where A is a fundamental arena. The fundamental arena of the world is where fundamental properties are distributed. Since A doesn't play much role in our discussion, I leave it out for simplification.

Just like Lewis, Loewer focuses on the fundamental laws. It is an open question how their accounts accommodate laws of special sciences.

The fundamental predicates of L refer to the fundamental properties and relations of W, and the fundamental laws of W are propositions entailed by $T(L)$ (Loewer 2020). In this regard, the fundamental objects with their properties and the fundamental laws are given together as a package deal by the fundamental theory $T(L)$. Accordingly, the fundamental objects with their properties are not metaphysically primitive, given prior to any scientific theorizing. Rather, they and laws both are elements of a package (ibid.) that are metaphysically on a par.[10]

The PDA admits more than one optimal pair of $< L, T >$ that are equally good for the actual world. That means there can be multiple distinct sets of fundamental laws in the world. But how can that be? What does it mean for there to be more than one set of laws? How are different sets of laws related to one another? Do we need to employ all or only some of them to understand the world? There is a *prima facie* problem if our account of laws yields more than one set of fundamental laws, especially if they are not equivalent or translatable to one another. Loewer (2020, 17) acknowledges this problem. He even admits: "[t]his seems almost inevitable", since what is basic and simple in one language will be derivative and complicated in another language. This problem is not unique to the PDA, but shared by the BSA as well. Lewis's original solution is to take laws to be the theorems that are common to all optimal systems. He later admits: "in this unfortunate case there would be no very good deservers of the name of laws", but he doesn't think the case will ever arise (1994, 479). In contrast, Loewer (2020, 17) thinks "a better proposal is to accept that being a law is system relative".

This problem is closely related to but not exactly the same as the problem raised by the *Objectivity Objection* mentioned earlier (i.e., Humean laws are not objective). The former can be seen as a symptom of the latter. If there is only one set of fundamental laws, out there in the world, fully independent of how we think or theorize, just waiting for us to discover, why do we need to worry

[10]One may question if the PDA still count as a version of the BSA in the sense that its laws supervene on the Humean mosaic. I'll leave this question to defenders of the PDA.

about the possibility that we might end up with multiple sets of laws? We only need to worry if Humean laws are not objective but depend on who is doing the systematizing and what criteria they choose to judge what is best, which brings about the possibility for different investigators to arrive at with different sets of laws—especially if the chosen criteria depend on the cognitive capacities of the investigators, such as simplicity and informativeness.

Most, if not all, Humeans deny that the *Objectivity Objection* is a devastating threat.[11] There's, however, not much consensus as to why it is not devastating or in what sense Humean laws are objective. At least, Humean laws are clearly not *subjective* in the sense of being dependent on the idiosyncratic tastes, interests, or experience of *each individual* investigator. On the contrary to being subjective, the Humean standards of lawhood can be, in Jaag and Loew's (2018, 14) words, non-voluntary, robust, shared by all agents we know, and not likely to change over time. Moreover, even if the Humean standards (such as simplicity and informativeness) are not *objective in the sense of being completely independent of the human mind*, what is consequently not objective is only *what makes something a law* or *which regularity counts as a law*, not the content of the law (i.e., the regularity itself). Thus the truth values of laws are untainted and remain mind-independent. It is also mind-independent whether the best system satisfies the Humean standards. So is whether our world has such a system. Some Humeans believe these features make it sufficient for their laws to be objective.[12] (Other Humeans, nonetheless, take their laws to be more objective than that. I will address this position in 2.2.)

Importantly, such objectivity is not compromised by Humean laws being *relative to us*. Loewer (2007, 325) claims:

> it should be recognized that both Lewis's version of the BSA and the PDA say that laws

[11] See, e.g., Bialek (2016).

[12] See, e.g., Loewer (2020, 22).

> are truths that are mind-independent. On both accounts part of what makes a truth a law is to an extent anthropomorphic since it involves human criteria of simplicity and informativeness and, in the case of the PDA, explanatoriness and "scientific interest". But these may well be *relatively objective* notions. The PDA goes farther in the direction of anthropomorphism—or one might say "physicist-morphism"—in that what counts as a final theory depends on the tradition of fundamental physics. I see this as an advantage of rather than an objection to the PDA. (Emphasis mine)

In short, there is nothing inconsistent for Humean laws to be both objective and relative to us, especially if by 'objective', one only means "relatively objective". Relativism is a feature, not a bug. Loewer is not alone. Recent defenders of Humean accounts have embraced relativism (Bialek 2016, 2) for various reasons.[13]

Is this position tenable? Is being "relatively objective" sufficient to address the *Objectivity Objection*? Although the objection is widely shared by critics of Humean accounts, there hasn't been much discussion on what it amounts to or why it is a genuine concern, other than by appealing to the intuition that laws of nature should be objective.[14] Worse, it is notoriously contentious what objectivity means, and accordingly it is unclear in what sense laws of nature need to be objective. It is thus hard to hold Humeans accountable for thinking their laws are sufficiently objective.

This paper provides a reason why, and in what sense, objectivity matters. Although it may be unclear why, or in what sense, laws should be objective, scientific realism imposes a relatively clear constraint on the objectivity of scientific objects. If relativism of the PDA-laws has the consequence of making scientific objects also relative, it would conflict with scientific realism, which is a rather acute problem. In this way, we can circumvent the difficulties by shifting the target of

[13] See, e.g., Jaag and Loew (2018, 1) who argue that the best system should be *best for us*.

[14] Such appeal is mentioned by, e.g., Bialek (2016, 9).

evaluation from laws to objects. Such a shift is allowed because the PDA treats the fundamental ontology and laws on a par. In short, instead of simply asserting that laws should be objective, the following argument brings out the implication that if the PDA-laws are not objective, the PDA would conflict with scientific realism. Call it the *Core Argument*:

(P1) Scientific realism takes the fundamental ontology of physics to be *objective*.

(P2) If the fundamental laws are *not objective* according to the PDA, then the fundamental ontology is *not objective*.

(P3) The fundamental laws are *not objective* according to the PDA.

(C) The PDA contradicts scientific realism.

(P1) is straightforwardly required by scientific realism, at least according to its standard formulation. By 'objective', I mean: mind-independent, and particularly independent of various (a) scientific languages, (b) goals for scientific investigation, and (c) cognitive capacities. This notion of objectivity is required by scientific realism: Just like any other scientific theories, the fundamental theory of physics (or the final theory of everything) aims to tell us what the world is like. In particular, it tells us what the fundamental ontology of the world is. The fundamental ontology of physics thus does not depend on us—how we think or theorize about it—nor any other creatures. It is not relative to us what the fundamental ontology is or whether it exists. It is what it is out there in the world, even if humans or any conscious beings never existed. Our science does not determine but only tries to know and understand what it is. There is nothing anthropomorphic about whether or not, say, electrons exist or whether electrons or quantum fields are fundamental objects. If Martians discovered a different fundamental ontology from our fundamental theory of physics, then at least one of the two theories is false. If our fundamental theory and Martians' theory are both true, we must discover the same fundamental ontology with the same properties. In

other words, there is a unique fundamental ontology, a single set of fundamental physical objects, that exist in the world. The correct and complete final theory of everything says what it is and how it behaves. Relativism and pluralism (the view that there could be multiple [fundamental] ontology) are usually considered to be incompatible with scientific realism.[15]

(P2) is an implication of the PDA. Since the PDA takes the fundamental ontology and laws both as elements of a package that are metaphysically on a par, they share the same metaphysical status: Either both of them are objective, or neither of them is. That is to say, if laws are not objective, then the fundamental ontology is not objective either.

The key is to establish (P3). Insofar as Humeans think laws of nature are something more than regularities, they need to ground this additional content somewhere: either (i) in us, or (ii) in the world. If they choose (i), it is hard to deny (P3). In this case, laws of nature are *not* fundamental aspects of the world; what makes laws different from mere regularities comes from us: how we categorize facts about the world, how we organize our knowledge. If there were no human (or any conscious) beings, there would be no ground to distinguish laws from mere regularities. Because of this element of 'us', even though Humean laws are "relatively objective", it is not sufficient to match the notion of objectivity defined in (P1).

This element of 'us' is not just a choice but does a lot of heavy lifting for Humean accounts, which drive recent Humeans to embrace relativism and/or pragmatism. First, unless Humeans think it is *a priori* that there can be only one best system, they need to find a way to break the tie between multiple equally good systems. One such way is to accept that the best system is only best relative to us. In addtion, if Lewis's original criteria, simplicity, strength, and their balance, are not sufficient to pick out the best system, introducing pragmatic considerations precisifies standards of lawhood with more fine-grained features. Cohen and Callender (2009, 21), for example, require

[15]The former is argued by, e.g., Psillos and Shaw (2020, 414). The latter is noted by, e.g., Glick (2019, 4146).

treating the measures of strength, simplicity, and their balance flexibly according to *our* needs (and subject to rational revision). Dorst (2019, 877) argues that the Humean standards of lawhood should "generate principles that are predictively useful to creatures like us". Jaag and Loew (2018, 1): "laws need to organize information in a way that maximizes their cognitive usefulness for creature like us".

Moreover, if laws are nothing over above non-modal facts (and science presumably is in the business of investigating those, not what lies behind the scenes), why are laws appropriate and important targets for scientific inquiry (Hall 2015, 268)?[16] In particular, why should it be the goal of science to identify regularities that best balance epistemic virtues like simplicity and strength? Pragmatic considerations are used to answer questions like these. Generally speaking, laws are distinct from mere regularities and targets for scientific inquiry because they are useful *for us*—they make "the world understandable to us" (Loewer 2020, 21), are convenient to use, suit our pragmatic purposes, and/or are a natural result of the limitations of our cognitive capacities. In particular, this pragmatic or relativist understanding of Humean accounts also suggests an explanation for why, specifically, simplicity, informativeness, and their balance are the criteria of lawhood. Consider a metaphorical story that is often used to illustrate the BSA:[17]

> You somehow manage to schedule a last-minute meeting with God. You have so many questions to ask. You are nervous. You finally get one sentence out of your mouth: "Tell me something about the world . . . Please."
>
> God: "Well, there is one particle with spin 1 at such-and-such location at such-and-such time; there is one particle with spin $\frac{1}{2}$ at such-and-such location at such-and-such

[16] In contrast, non-Humeans have a natural answer to this question: laws are also a part of the world, fundamentally different from, and in addition to, non-modal facts.

[17] A similar point is made by Woodward (2014, 117) and Jaag and Loew (2018, 9). For the story, also see, e.g., Albert (2015, 23).

time . . .” This goes on for a while.

You: “Sorry to interrupt. But I actually need to leave for another meeting soon and are not in a position to hear about everything. Can you tell me something about the world that is as informative as possible but can also fit on a T-shirt?”

God says “Fine” and then tells you something a Humean would call the best system.

For creatures like us, with limited capacities for information processing and calculation, a complete specification of everything going on in the world throughout time would be impossible for us to handle and we wouldn’t be able to make use of it anyway. That’s why we need a compressed description that is as informative as possible but simple enough for us to process (i.e., the best system), whereas creatures with unlimited capacities like God don’t. Accordingly, for such creatures, there isn’t anything that makes laws (i.e., regularities that belong to the best system) any special than mere regularities. For creatures with limited but entirely different cognitive capacities from us, they may identify different regularities as laws that suit their way of perceiving the world and processing information (insofar as they need to distinguish laws from accidental regularities at all).

Human beings can, through collective scientific endeavor, eventually agree on what the criteria like simplicity and strength are, since we humans as a whole share the same scientific languages, the same scientific goals, and the same cognitive capacity. Moreover, it is not just up to us what we find useful or what we take to be simple and informative. That’s at least partially a result of human evolution. This may be what Loewer means by “relatively objective”. The way in which Humean laws are mind-dependent seems all benign for the notion of laws. We are humans after all, and science is carried out as a human endeavor. We can’t eliminate all the elements of ‘us’ from science.

However, being “relatively objective” is not sufficient for the sense in which the fundamental ontology is objective, and being mind-dependent in the way Humean laws are does undermine

the sense in which the fundamental ontology is objective. What makes the fundamental ontology belong to the fundamental theory of physics (i.e., the best system) and different from anything else is not due to our limited cognitive capacities. We care about the fundamental ontology and it is appropriate and important target of scientific investigation, not because it is useful for us, but because it really exists out there in the world and we would like to know what the world is like (at least for scientific realists). It is against scientific realism to think of the fundamental ontology in the way Humeans think of laws of nature.

Note that this is a general argument that Humean laws are not objective in the way the fundamental ontology of physics is. It not only applies to Loewer's account according to which laws are relative to us, but also any Humean account that endorses (i), what makes laws different from mere regularities come from us. Relativism or pragmatism is only one specific way in which Humean laws are not sufficiently objective. Insofar as defenders of the PDA hold (i), they cannot avoid the *Core Argument* by simply forfeiting Loewer's relativism.

I now consider three ways that a Humean may respond to the *Core Argument* by revising either Loewer's PDA or standard scientific realism.

2.1 The First Humean Response

Even granted that Humean laws are to some extent mind-dependent, they are not mind-dependent in any problematic way that compromises scientific realism. Our scientific method, for instance, depends on our cognitive capacities. What we consider scientifically significant, how we do experiments, and what we observe in the experiments are all guided and constrained by our cognitive capacities. Nevertheless, a scientific realist would not think science is not objective because of that. Rather, they would think our scientific method, whatever its correct characterization is, somehow leads us to know what the world is really like. Similarly, the Humean standards of lawhood be-

stowed upon us by contingent evolutionary processes, despite being epistemic (especially those arise due to our cognitive limitations), somehow can give the right, objective best system for the world (which includes not just laws, but also the fundamental ontology in the case of the PDA). Different creatures with different cognitive capacities, *prima facie*, may reach different laws with different fundamental ontologies. But if any of their scientists are doing a proper job, there will be a clear winner for *the* best system. And the scientists of other creatures are simply wrong. If they later improve, they will eventually reach the same best system. In short, Humean laws are as objective as science is.

This may be what is behind Lewis's reasoning when he claims:

> I suppose our standards of simplicity and strength and balance are only partly a matter of psychology . . . If nature is kind, the best system will be *robustly* best—so far ahead of its rivals that it will come out first under any standards of simplicity and strength and balance. We have no guarantee that nature is kind in this way, but no evidence that it isn't. It's a reasonable hope. Perhaps we presuppose it in our thinking about law. I can admit that *if* nature were unkind, and *if* disagreeing rival systems were running neck-and-neck, than lawhood might be a psychological matter, and that would be very peculiar. I can even, concede that in that case the theorems of the barely-best system would not very well deserve the name of laws. But I'd blame the trouble on unkind nature, not on the analysis; and I suggest we not cross these bridges unless we come to them.

Critics of the BSA as well as some Humeans find this response unsatisfying:[18] there is no evidence that nature is kind to us either. The problem is: those Humeans who do find it satisfying haven't provided any justification for why nature is kind.

[18] See, e.g., Hall (2015, 277), Bialek (2016, 5), Belot (2022).

I take the real justification for Lewis's optimism comes from scientific realism.[19] The success of science is our evidence that nature is kind. Insofar as our science is successful, as scientific realists we have good reasons to believe that our best scientific theory latches onto what the world is really like, and that there will be a clear winner for the best system "so far ahead of its rivals". Even if Martians have very different, say, cognitive capacities and thus different epistemic standards from us, eventually our sciences will converge and they will have a theory of standard model of particle physics just like ours (or at least their theory will be equivalent or translatable to our theory). That is to say, even if the Humean criteria are not objective, it does not mean that they necessarily lead to a best system that is not objective. *If they exactly track scientific practice*, the best system is as objective as our best scientific theory.

For this justification to work, it requires an implicit assumption: Humean accounts indeed align with scientific practice as close as possible so that their best system is what science actually delivers; in particular, the Humean criteria for identifying laws, i.e., simplicity, strength and their best balance, accurately reflect scientific practice. That is, these are the criteria used in science to evaluate a theory and for theory choice.

Then the necessary questions to ask is: Do the Humean criteria for identifying laws accurately reflect scientific practice? Recall that Loewer's PDA deviates from Lewis's BSA by adding additional criteria like comprehensiveness, explanatoriness, and scientific interest. For Loewer (2020, 17) thinks Lewis's characterizations of simplicity and informativeness are inadequate, and improving them and adding further criteria can plausibly alleviate the worry about multiple tied best systems. Loewer does not commit to simplicity, strength, and their balance as sufficient criteria for the best system for good reasons. It has been argued that they do not correctly reflect actual

[19] In contrast, Massimi (2017, 409, 412) takes natural properties to offer the ground for Lewis's hope that nature is kind to us. Her conclusion is that the standards of simplicity and strength should be reinterpreted along perspectivalist lines. Interestingly, her perspectival realism also differs from standard scientific realism.

scientific practice.[20] Insofar as extra-empirical virtues are used in scientific practice to evaluate empirically equivalent theories (that is, criteria for the best theory to prevent the underdetermination of theory by observational evidence), they do not exactly involve a trade-off between simplicity and strength as described in Lewis's BSA.

If the Humean criteria do not track scientific practice, then there is no good reason to assume that the best system is the same as the one given by science and there will be a clear winner for the best system. One may argue: it doesn't matter; even if the Humean criteria track scientific practice, there is no guarantee of a clear winner anyway—scientific realism already faces the problem of underdetermination; in fact, the possibility of there being multiple competing best systems is just the same problem of underdetermination—it is not a particular problem of Humean accounts but shared by scientific realism, and thus does not cause any trouble for Humeans to be scientific realist. But there is no reason to think that Humeans just have the same problem as the underdetermination of scientific theories, if the Humean criteria don't track scientific practice. The fact that there might be multiple equally good best systems depends on what the Humean criteria for the best system are. It is the Humean criteria that fail to be sufficient to pick out a unique best system, not scientific methods. Thus, Humean accounts face the problem of multiple equally good best systems in a way that scientific realism doesn't. Consequently Humeans cannot appeal to the objectivity of science to argue for the objectivity of their fundamental ontology and laws. Although the criticism that the Humean criteria of lawhood do not track scientific practice is not new, the contribution here is to provide a reason for why a Humean account, which may be said to be only a metaphysical theory, needs to conform to scientific practice: If it doesn't, Humean laws cannot be said to be as objective as science.

A Humean may then respond by emphasizing that their account is meant to be a metaphysical

[20] See, e.g., van Fraassen (1989, 56-58), Roberts (2008), Woodward (2014). Recent Humeans have also made various attempts to improve the Humean standards of lawhood; see, e.g., Hicks (2017).

theory and they are in fact noncommittal to any of those criteria for the best system, which merely serve as a placeholder for whatever criteria used in scientific practice (one may even interpret Lewis and Loewer in this way). Then whatever criteria used in science turn out to be, the best system that such criteria yield will be as objective as science.

The problem is, for one, this modified Humean account consequently does not specify any specific characteristics of what laws are, other than that they belong to our best scientific theory. Recall Lewis's BSA has two components, (I) a metaphysical thesis of reductionism and (II) a guiding principle of identifying laws from non-lawful claims. (II) is central to Humean accounts of laws, not only because it is often used to support (I),[21] but also because it is a substantial proposal that is interesting and significant by itself. It is (II) that makes Humean accounts go beyond just a metaphysical theory but also offers an analysis of what laws are in connection with science. Compared to the original BSA, without (II), this modified account loses a significant part as well as any appeal that comes with it.

Worse. Although the reductionist core of Humean accounts (I) is only a metaphysical thesis, it is not obvious or trivial that (I) does not conflict with any scientific practice that identifies laws from non-laws—whatever it turns out to be. Insofar as Humeans intend to be naturalistic, it is important to ensure that (I) does not conflict with scientific practice. In fact, a significant part of the debate between Humeans and non-Humeans is about whether the reductionist or nonreductionist thesis is better supported by scientific practice. It has been argued that scientific practice in fact conflicts with (I).[22] In particular, the criteria actually used in scientific practice to identify laws and for theory choice may turn out to be irreducibly modal. One may argue, say, predictability or invariance is one of the criteria of lawhood used in science, and it requires modality in a way that

[21] See, e.g., Cohen and Callender (2009, 3), Bhogal (2020, 8).

[22] See, e.g., Maudlin (2007, 105), Hüttemann (2021).

cannot be analyzed away by non-modal terms.[23] Thus, Humeans cannot simply defer to science and claim the criteria of lawfood are whatever used in scientific practice, since not any such criteria will be compatible with (I). Without (II), this modified account, by deferring its criteria of lawhood to whatever is used in scientific practice, runs the risk of being empty.

2.2 The Second Humean Response

To reject the *Core Argument*, a Humean can choose (ii) to refute its third premise (P3: Humean laws are not objective). According to (ii), what distinguishes laws from mere regularities comes from the world, not us; it is an objective, mind-independent matter of fact about which regularity is a law.[24] However, it is unclear whether (ii) is a desirable or even viable option for Humeans, or what *exactly* a Humean account that satisfies (ii) looks like.

Some Humeans, say, may insist that the criteria for the best system, simplicity and strength, are in fact objective in the same sense as mathematical or computational concepts are objective. An obvious problem with this response is: Humeans have not yet developed such mathematical or computational notions of simplicity and strength.[25] Nor have they shown that these notions are indeed objective, other than insisting that it is possible to do so. Worse, their appeal to simplicity, strength, or their balance is often vague and imprecise.[26]

A deeper problem is: Even if one manages to show that there are mathematical or computa-

[23]This point is suggested and inspired by Hildebrand (2022) who argues that Pragmatic Humeanism requires some pragmatic criteria, such as goals or interests, that are modally robust.

[24]Recall Psillos (2002, 154), Earman and Roberts (2005, 256).

[25]One may draw such a notion of simplicity from works in computational complexity; consider, e.g., Levins (1966), Millhouse (2019), Shah et al. (2020).

[26]For more details on this criticism, see Woodward (2014).

tional notions of simplicity and strength that are objective, how do we know these notions are the ones used by scientists for theory choice and identification of laws and thus relevant to lawhood? (Note that this problem is different from the problem of whether scientific practice involves a tradeoff between simplicity and strength mentioned earlier.) There is an appeal for the notion of simplicity to remain vague and imprecise. Then it seems obvious that simplicity plays some role in science, one way or another, across various scientific disciplines ranging from physics to biology. Once we specify what exactly simplicity is, especially in mathematical or computational terms, it becomes questionable whether or not the same notion of simplicity is used across different scientific disciplines. In fact, works on developing a computational notion of simplicity face the exact problem that their notion is not general but only has limited applications as well as the problem that it requires assumptions that are not properly justified.[27]

The flip side of this problem is: If there is indeed an objective best system of the world that identifies laws of nature as required by (ii), how do we know that such a system is picked out by the criteria of simplicity, strength, and their balance? Non-Humean accounts, which take laws to be something out there in the world, are criticized for leaving a gap between what laws are and how we know about them; in contrast, Humean accounts are championed for filling this gap easily: Our epistemic standards are constitutive of lawhood.[28] This claimed advantage requires, again, the Humean criteria of lawhood such as a trade-off between simplicity and strength correctly reflect the epistemic standards used in science, which is in fact questionable (as discussed earlier). More importantly, Humeans can no longer claim this advantage once they choose (ii). In that case, the world has an objective structure such that there exists a best system, but there is no guarantee that our epistemic standards pick out the right best system. To clarify, I'm not suggesting that non-Humean accounts fare better in this regard, but only that Humeans cannot have both ways,

[27] See, e.g., Sober (2002), Norton (2021, Chapter 6-7).

[28] See, e.g., Earman and Roberts (2005), Loew and Jaag (2019, 275).

i.e., objectivity and the epistemic advantage over non-Humeans.

Similarly, Humeans cannot claim both that (i) what makes laws different from mere regularities come from us, how we organize our knowledge in a way that is useful for us, and that (ii) it is an objective, mind-independent fact what the best system is or which regularity is a law. If (ii), laws of nature are not *just* a way of how we organize our knowledge, but a feature of the world by itself. It is ambiguous whether or not some Humeans including Lewis believes in (ii), but they have to make a choice.

2.3 The Third Humean Response

To respond to the *Core Argument*, a Humean may simply bite the bullet and reject its first premise (P1: Scientific realism takes the fundamental ontology to be objective). Either it is not a correct characterization of scientific realism, or even if it is, such an understanding of scientific realism is too demanding anyway and a more reasonable realist position should be compatible with relativism and pluralism. If it turns out that Martians arrive at a different set of fundamental objects, their theories are still true, as well as ours. It's just that there are two distinct sets of fundamental objects in the world, or that there is no matter of fact what objects are fundamental. Such a Humean may counter: why can't there be two, or more, sets of fundamental physical objects?

The problem is: if there are indeed two or more sets of fundamental objects, how are they related to one another? Are they co-located in the same spacetime? Can they interact with another? If the answer to both of the last two questions is "Yes", then it is hard to see why these two sets are not just subsets of the complete set of fundamental objects. In that case, there turns out to be a unique set of fundamental objects after all. It is just that both Martians and we humans only discover a part of *the* fundamental ontology.

A Humean may refine their position and argue instead: similar to the case of laws (where it

is only *what makes a regularity a law* relative, while the truth of a law is still objective), the PDA only entails that what is relative is *what makes certain scientific objects fundamental*, or *which scientific objects count as fundamental*. It is not relative to us what the scientific objects are, what properties they have, or whether they exist or not.[29] Although it is relative to us whether or not, say, electrons are fundamental, it is *not* relative to us that electrons exist and have negative charges.

This response, however, only obscures the tension between the PDA and scientific realism but does not resolve it. Although scientific realism as characterized in Section 1 does not make explicit commitments to the relation between the fundamental and less fundamental objects, it is hard to see why such relations would be relative, given that the objects and their properties are not relative. It is not up to us that, say, molecules are composed of atoms and thus the latter is more fundamental than the former, instead of the other way around. Neither is it up to us that string theory is a candidate for the fundamental theory while nonrelativistic particle quantum mechanics or the theory of evolution by natural selection is not. Suppose, say, electrons are a part of the fundamental ontology of physics, they are fundamental not because we organize our knowledge in certain way, but because the world has an objective structure that makes electrons fundamental. A Humean may further argue that this is not what they mean by 'fundamental'. For them, a theory is fundamental not because it is universal or complete or its ontology is at the lowest length scale, but because, say, it is explanatorily prior to any other scientific theory; and explanation for them is a purely epistemic concept. Then it is up to us which theory is explanatorily prior and thus fundamental. If that's the case, they need to specify and defend such a notion of fundamentality and show that it is indeed the one used in science.

Moreover, it is unclear the PDA only makes *which scientific objects are fundamental* relative. The best system identifies fundamental laws from non-laws. It is unclear how the best system identifies fundamental laws from non-fundamental laws. Similarly, the best system identifies fundamental

[29]Thanks to Barry Loewer for this point.

objects from non-objects. It is unclear how the best system identifies fundamental objects from non-fundamental objects. That is to say, the PDA has not drawn a distinction between fundamental objects and non-fundamental objects, and thus what is relative according to the PDA is not, among all scientific objects, which ones are fundamental, but more generally *what fundamental objects are*. In order to claim that the PDA only makes the idea of fundamentality or which scientific objects count as fundamental relative, defenders of the PDA need to accommodate non-fundamental objects and laws and say more to establish that what is relative is only which scientific objects are fundamental.

In sum, there are significant barriers that Humeans need to jump over in order to ensure a tenable scientific realist position. In this section, I discussed several possible modifications for them to do so. They can show that their criteria for the best system properly align with scientific practice, or modify the Humean criteria to do so. They can also develop mathematical or computational notions of simplicity, strength, and their best balance, and show such notions are objective and indeed used in scientific practice across different scientific disciplines or at least in fundamental physics. Either way, it requires significant modification or improvement on the original PDA or BSA. On the other hand, Humeans can propose a version of scientific realism that does not require the fundamental ontology be objective. They may consider, for example, adopting structural realism, a realist position that does not commit to objects. It is then plausible that the fundamental ontology is anthropomorphic. Another option is to adopt perspectival realism or Putnam's internal realism. (I will leave to the reader to judge whether or not any of these positions is tenable and still counts as scientific realism.)

3 Lewis's BSA and Scientific Practice

To respond to the *Core Argument*, a Humean can also reject its second premise (P2: If the fundamental laws are not objective, neither is the fundamental ontology), which is based on the PDA's

core idea. This leads us back to Lewis's BSA. Since it does not identify the fundamental ontology and laws together as a package deal, the BSA is not at odds with scientific realism in the way as the PDA is. However, exactly because the BSA does not take the fundamental ontology and laws as a package, it faces the problem of failing to conform to scientific practice.

There are many aspects in which the BSA does not conform to scientific practice. Some of them concern the trade-off between simplicity and strength (as discussed Section 2), while others concern the role of perfectly natural properties.[30] Consider an example in the latter case. To prevent trivial generalizations from counting as laws, Lewis's BSA requires a preferred language in which the best system is formulated, that is, a language whose basic non-logical and non-mathematical predicates only refer to perfectly natural properties. Although it is the job of fundamental physics to find out what exactly perfectly natural properties are in the actual world, whether or not a property is perfectly natural is a primitive fact of metaphysics. It is possible for physicists to end up with a set of fundamental laws that do not correspond to perfectly natural properties. In that case, they would not have found the real laws of nature. That is to say, the BSA-laws do not necessarily match the laws identified through scientific practice. The PDA is proposed exactly to fix issues like this.

I want to point out an altogether different aspect in which the BSA does not conform to scientific practice. It concerns the fact that the BSA takes objects (and their categorical properties) to be *metaphysically prior* to laws. In fact, any Humean account that does not identify the fundamental ontology and laws as a package deal faces this problem. Since the PDA is at odds with scientific realism exactly because it identifies the fundamental ontology and laws as a package, either a Humean takes a package deal or not, there will be some issues for them to be scientific realist.

[30] See, e.g., van Fraassen (1989), Loewer (2007, 2020).

How the fundamental ontology and laws of nature are related according to Lewis's account can be illustrated by his thesis of Humean Supervenience (Lewis 1986, ix–x):

> all there is to the world is a vast mosaic of local matters of particular fact, just one little thing and then another . . . We have geometry: a system of external relations of spatiotemporal distance between points. Maybe points of spacetime itself, maybe point-sized bits of matter or aether or fields, maybe both. And at those points we have local qualities: perfectly natural intrinsic properties which need nothing bigger than a point at which to be instantiated. For short: we have an arrangement of qualities. And that is all. There is no difference without difference in the arrangement of qualities. All else supervenes on that.

In this picture, what is taken to be primitive is the Humean mosaic: a mosaic of local facts or distributions of perfectly natural properties of point-sized objects. These are *metaphysically prior* to everything else, including laws of nature. Put another way, the Humean mosaic is taken as given, and laws are inferred as a way to systematically summarize the Humean mosaic.

It is this priority relation that does not conform to scientific practice, both in special sciences and in parts of physics that have been conjectured as fundamental.[31] In scientific practice, it is not always the case that scientists have direct access to certain scientific objects (with their categorical properties) and they just need to find a simple and informative way to summarize the behaviors of those objects in order to figure out what the laws are. Nor do they first discover some novel scientific objects (with their properties) and then infer what the laws are from the regularities or patterns of those objects. Rather, when a scientific object is postulated or predicted by a theory, the object and the laws to which the object is subject are introduced *all together*. The scientific

[31] I focus on the latter in this paper, since Humeans like Lewis and Loewer are only concerned with the fundamental laws. For cases of special sciences, see Woodward (2016).

object and the corresponding laws are accepted as real together.

Consider an example from the history of physics (or at least how it is conceived or understood by modern physicists).[32] In the early nineteenth century, physicists believed that the physical world at a more fundamental level was composed of particles with simple forces acting among them, and they tried to explain as many physical phenomena as possible by only appealing to those fundamental concepts (i.e., particles and forces). However, they later found that certain phenomena could not be explained by those fundamental concepts alone. Eventually, physicists were led to introduce a new concept: electromagnetic field. Initially, the idea of "field" was just a helpful mathematical model used to describe the forces acting between, say, magnetic needles and electric currents. Gradually, it was acknowledged that a magnetic field can be produced by a changing electric field without a magnetic needle and that a changing magnetic field can independently generate an electric field. More importantly, physicists found that what the fields are doing does not logically follow *just* from what the particles are doing, and thus the motions of the particles cannot be predicted from their states alone, that is, without specifying the states of the fields. If we want to know a complete physical state of the world, we need to specify both the state of the particles and the state of the fields. Moreover, electromagnetic fields change and evolve in accordance with Maxwell's equations, even when there is no charged particle present. Maxwell's equations were taken to be a new set of physical laws that are essential to understanding and explaining the electromagnetic phenomena. Because electromagnetic fields are subject to different laws from particles, they are considered as essentially different from particles and thus accepted as a new kind of objects. In this way, physicists came to accept electromagnetic fields as real physical objects—as real as particles—and Maxwell's equations as new physical laws *all together*.

In contrast to what is portrayed in the thesis of Humean Supervenience, in scientific practice the fundamental ontology and its properties are not taken as given and metaphysically prior to laws.

[32] See, e.g., Einstein and Infeld (1938, 125–145).

When theories are proposed or developed, physicists usually do not have access to the Humean mosaic. It is not just that they do not have all the particular instances of the Humean mosaic. Rather, they do not even know what the Humean mosaic could possibly be about. Accordingly, laws are not inferred as a summary of the Humean mosaic. What physicists start with is *the manifest image* with ordinary macroscopic objects like cats, rainbows, and measuring apparatus. They postulate new scientific objects and laws together to account, and make predictions, for the manifest image. Sometimes they may also need to account or make predictions for a particular *scientific image* given by some other theories, but hardly ever for the Humean mosaic itself. If the criteria of simplicity, strength, and their best balance capture anything about scientific practice, it is not laws that best summarize the Humean mosaic in the way that satisfies these criteria; rather, it is the fundamental objects and laws *together as a package* that best summarize *the manifest image* (either directly or indirectly).

Lewis's BSA presupposes that there is an obvious, definite distinction between objects and laws,[33] that the purpose of the best system, given by our best theory, is merely to identify laws, and that theories or systems compete for best balancing simplicity and strength only in terms of their laws. However, a physical theory is more than its laws. As demonstrated in the example above, proposing a new ontology is also central to physics, especially the parts that have been conjectured as fundamental. Moreover, there isn't anything in physical theories or in scientific practice that indicates what the laws are is independent from what the objects are in the way that the objects (with their categorical properties) are primitive whereas the laws are merely secondary or derivative. In fact, a physical object is considered novel and distinct from other kinds of objects often because it obeys a different set of laws from those other objects; and the set of laws is taken to be physical laws (instead of merely mathematical principles) because they contain variables that

[33]Maudlin (2018, 3) argues that a physical theory should clearly specify its ontology and dynamical laws as two distinct categories, even though it is no longer the case in modern physics. But even he does not think there is any requirement that "the elements of each of these categories be definable independently of the rest".

represent the physical object and its properties. The fact that an ontology and its laws are deeply intertwined suggests that there isn't any metaphysical basis to make one prior to the other and they are thus metaphysically on a par: To accept certain scientific objects as physical and real is to accept that there are the corresponding laws. (One may even go further and argue: what it is to be an unobservable physical object is to be a variable in the dynamical laws of motion; that is, the object is identified in terms of the laws.)

In short, Lewis's BSA does not conform to scientific practice by separating the fundamental ontology and laws and treating the former as metaphysically prior to the latter. Since the PDA takes the fundamental ontology and laws as a package deal and thus conforms to scientific practice in this aspect, I argue that it has an advantage over the BSA. This argument for the PDA is distinct from Loewer's original arguments.

A Humean may respond by arguing that failing to conform to scientific practice is not a problem for the BSA. After all the BSA as initially proposed by Lewis is meant to provide a metaphysical account of what laws of nature are, rather than to give a descriptive characterization of how science as a social enterprise works. As long as scientific laws can be accounted for by the BSA or the BSA does not lead to a set of laws that are different from the laws given by our best scientific theories, then the BSA is not at odds with scientific realism even though it might not conform to scientific practice in a particular aspect.

The first thing to say is: many Humeans are in fact motivated to develop their accounts to conform to scientific practice. Smithson (2020) points out: "It is widely agreed that an adequate theory of lawhood ought to align with the roles that scientists assign to the laws";[34] based on this, he defends the Humean accounts by arguing that non-Humean laws fail to align with scientific practice. Smithson is not in the minority. Humeans often appeal to conforming to scientific prac-

[34]Non-Humeans agree that an adequate account of laws should align with scientific practice. What they disagree is which account is better at doing so.

tice as a virtue of their accounts. This is also noted by Bialek (2016),[35] who defends and develops the BSA. He claims:

> Everyone should (and should be willing to) endorse the principle that the consequences of the BSA (or any account of laws) fit, parallel, conform to, answer to, (or, to just pick a word and stick with it) respect scientific practice.

Cohen and Callender (2009) makes explicit efforts to ensure that their version of BSA retains the advertised connection to scientific practice. Loewer (2007) professes that he is very much attracted to the BSA for its part that conforms to scientific practice, and he tries to improve the part that doesn't. It suffices to say: the BSA would lose a significant part of its appeal if it does not conform to scientific practice; thus failing to conform to scientific practice is a problem for Humeans by itself, even without worrying about the tenability of being scientific realist. (Also recall the additional reason for why it is important for the BSA to conform to scientific practice given in Section 2.1.)

The second thing: granting that a metaphysical account of laws does not need to conform to scientific practice *in every single aspect*, the BSA fails to conform in a particularly important aspect. It is not just that the BSA fails to correctly represent the chronological order of scientific discovery (about when laws and objects get "discovered"). Nor is it that the BSA only deviates from scientific practice by considering ideal physicists who just know more (i.e., the complete Humean mosaic) than actual physicists. Rather, the BSA fails to account for the relation between laws and objects as revealed by scientific practice as well as the aim of science. It is essential to scientific practice, especially in physics, that an ontology and its laws are taken as a package deal. There is nothing in physics, either physical theories or physical practice, that indicates objects (with their categorical

[35]He cited several Humean "authors present the close connection between their versions of the BSA and scientific practice as a virtue." For more example, also see Hicks and Schaffer (2017).

properties) are metaphysically prior to laws. If one intends to *be naturalistic* and *read off metaphysics from physics*—as most (if not all) Humeans intend to be—then there is nothing in physics for them to ground the priority relation of objects to laws. It is true that physicists aim to develop a few simple principles or laws that cover as many phenomena as possible, but of the manifest image, not the Humean mosaic. Rarely do they care about making predictions for, say, the trajectories of all elementary particles in the universe.

How is conforming to scientific practice related to scientific realism? In particular, a metaphysical theory of laws may fail to be naturalistic by not conforming to scientific practice, but how can it be at odds with scientific realism? Scientific realism, as presented in Section 1, is only explicit about our epistemic attitudes towards scientific theories and objects. But science is more than just scientific theories by themselves. It includes how the theories are interpreted and connected to observations, tested by experiments, used for explanations and predictions, and so on. It also includes models and simulations. If we take science seriously to inform us about what the world is really like, as scientific realists would do, we should take all those practices seriously as well. The earlier characterization of scientific realism not only takes a very narrow notion of science, but also presupposes that there is a clear, definite boundary between scientific theories and scientific practice. Such a presupposition is worth disputing. One may argue that a physical theory is more than a set of propositions or equations as described in textbooks, but in fact includes how those propositions are interpreted and used by scientists, otherwise the theory by itself would not carry any physical significance. In that case, what has been narrowly considered as scientific practice would be a part of scientific theories. Along these lines, scientific realism goes beyond a number of propositions and equations, and requires one also take scientific practice seriously. Failing to align with scientific practice in a significant way would thus be at odds with scientific realism.

This by no means suggests that we should simply take *any* scientific practice at face value. It is plausible that certain aspects of scientific practice are just contingent or ad hoc about human behaviors (p-value is one such example). It is, nonetheless, plausible that some other aspects of

scientific practice are deeply embedded in the scientific enterprise, are inseparable from scientific theories, and contribute to the goals of science. Accordingly, they may be suggestive about what the world is like. It is us philosophers' job to identify such aspects of scientific practice, and possibly give a general recipe of how it can be done, which would require further investigation. For now, it suffices to say: Given that Humeans often appeal to conforming to scientific practice in certain aspects as a virtue of their accounts and that they haven't explained why those aspects are particularly significant, in order to dismiss my objection they need to at least explain why the aspect of scientific practice that I've been considering is not significant or less significant than the ones to which Humeans do appeal.

Conclusion:

In this paper, I've argued that Humean accounts of laws are at odds with scientific realism. Either a Humean account takes the fundamental ontology and laws as a package deal (such as Loewer's PDA), or it doesn't (such as Lewis's BSA). If it does, then it faces the danger of taking the fundamental ontology to be not objective. This implication is directly at odds with scientific realism. If a Humean account does not take a package deal, although it does not straightforwardly conflict with scientific realism, it faces the problem of not conforming to scientific practice.

The problems that Humean accounts do not take laws to be objective and do not conform to scientific practice may not sound new. But the seriousness of these problems has not been fully appreciated, and in fact underestimated. One goal of this paper is to highlight the significance of these problems by explicating their implications and bringing out their tension with scientific realism. Addressing these problems would make being both a Humean and a scientific realist a more tenable position.

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References

Albert, D. Z. (2015). *After Physics*. Harvard University Press.

Armstrong, D. M. (1983). *What is a Law of Nature?* Cambridge University Press.

Belot, G. (2022). Ratbag idealism. In Y. Ben-Menahem (Ed.), *Rethinking the Concept of Law of Nature: Natural Order in the Light of Contemporary Science*, pp. 1–20. Springer International Publishing.

Berenstain, N. and J. Ladyman (2012). *Ontic Structural Realism and Modality*, Chapter 8, pp. 149–168. The Western Ontario Series in Philosophy of Science 77. Springer.

Bhogal, H. (2020). Humeanism about laws of nature. *Philosophy Compass 15*(8), 1–10.

Bialek, M. (2016). Interest relativism in the best system analysis of laws. *Synthese 194*(12), 4643–4655.

Bourget, D. and D. J. Chalmers (2009). The PhilPapers surveys.

Bourget, D. and D. J. Chalmers (2020). Philosophers on philosophy: The PhilPapers 2020 survey.

Boyd, R. (1983). On the current status of the issue of scientific realism. *Erkenntnis 19*(1-3), 45–90.

Carroll, J. W. (1994). *Laws of Nature*. Cambridge University Press.

Cartwright, N. (1983). *How the Laws of Physics Lie*. Oxford University Press.

Chakravartty, A. (2017). Scientific Realism. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Summer 2017 ed.). Metaphysics Research Lab, Stanford University.

Chibeni, S. S. (2005). A Humean analysis of scientific realism. *Ensaios sobre Hume*, 89–108.

Cohen, J. and C. Callender (2009). A better best system account of lawhood. *Philosophical Studies 145*(1), 1–34.

Dorst, C. (2019). Towards a best predictive system account of laws of nature. *British Journal for the Philosophy of Science 70*(3), 877–900.

Earman, J. and J. T. Roberts (2005). Contact with the nomic: A challenge for deniers of Humean supervenience about laws of nature Part II: The epistemological argument for Humean supervenience. *Philosophy and Phenomenological Research LXXI*(2), 253–286.

Einstein, A. and L. Infeld (1938). *The Evolution of Physics: From Early Concepts to Relativity and Quanta*. New York: Simon and Schuster.

Glick, D. (2019). Pluralist structural realism: The best of both worlds? *Synthese 198*(5), 4145–4166.

Hall, N. (2015). Humean reductionism about laws of nature. *A companion to David Lewis*, 262–277.

Hicks, M. T. (2017). Dynamic humeanism. *British Journal for the Philosophy of Science 69*(4), 983–1007.

Hicks, M. T. and J. Schaffer (2017). Derivative properties in fundamental laws. *British Journal for the Philosophy of Science 68*, 411–450.

Hildebrand, T. (2022). The ideology of pragmatic Humeanism. http://philsci-archive.pitt.edu/21388/.

Hüttemann, A. (2021). *A Minimal Metaphysics for Scientific Practice*. Cambridge: Cambridge University Press.

Jaag, S. and C. Loew (2018). Making best systems best for us. *Synthese*, 1–26.

Levins, R. (1966). The strategy of model building in population biology. *American Scientist 54*(4), 421–431.

Lewis, D. (1973). *Counterfactuals*. Blackwell Publishers.

Lewis, D. (1994). Humean supervenience debugged. *Mind 103*(412), 473–490.

Lewis, D. K. (1986). *Philosophical Papers*, Volume 2. Oxford University Press.

Loew, C. and S. Jaag (2019). What humeans should say about tied best systems. *Analysis 80*(2), 273–282.

Loewer, B. (2007). Laws and natural properties. *Philosophical Topics 35*(1/2), 313–328.

Loewer, B. (2020). The package deal account of laws and properties. *Synthese*, 1–25.

Loewer, B. (2021). What breathes fire into the equations. http://philsci-archive.pitt.edu/19446/.

Massimi, M. (2017, 06). Laws of Nature, Natural Properties, and the Robustly Best System. *The Monist 100*(3), 406–421.

Maudlin, T. (2007). *The Metaphysics Within Physics*. Oxford University Press.

Maudlin, T. (2018). Ontological clarity via canonical presentation: Electromagnetism and the Aharonov–Bohm effect. *Entropy 20*(465).

Millhouse, T. (2019). A simplicity criterion for physical computation. *The British Journal for the Philosophy of Science 70*(1), 153–178.

Nolan, D. (2005). *David Lewis*. Mcgill-Queen's University Press.

Norton, J. D. (2021). *The Material Theory of Induction*. University of Calgary Press.

Psillos, S. (2002). *Causation and Explanation*. Routledge.

Psillos, S. and J. Shaw (2020). Relativism and scientific realism. In M. Kusch (Ed.), *The Routledge Handbook of Philosophy of Relativism*, pp. 407–415. Routledge.

Rescher, N. (1969). Lawfulness as mind-dependent. In N. Rescher (Ed.), *Essays in Honor of Carl G. Hempel*, pp. 178–197. Reidel.

Roberts, J. T. (2008). *The Law-Governed Universe*. Oxford University Press.

Shah, H., K. Tamuly, A. Raghunathan, P. Jain, and P. Netrapalli (2020). The pitfalls of simplicity bias in neural networks. In H. Larochelle, M. Ranzato, R. Hadsell, M. Balcan, and H. Lin (Eds.), *Advances in Neural Information Processing Systems*, Volume 33, pp. 9573–9585. Curran Associates, Inc.

Smithson, R. (2020). Non-Humean laws and scientific practice. *Erkenntnis*, 1–25.

Sober, E. (2002). What is the problem of simplicity? In A. Zellner, H. A. Keuzenkamp, and M. McAleer (Eds.), *Simplicity, Inference, and Modelling*, pp. 13–32. Cambridge: Cambridge University Press.

van Fraassen, B. C. (1980). *The Scientific Image*. Oxford University Press.

van Fraassen, B. C. (1989). *Laws and Symmetry*. Oxford University Press.

Weinberg, S. (1994). *Dreams of a Final theory: The Scientist's Search for the Ultimate Laws of Nature* (Reprint edition ed.). Vintage.

Woodward, J. (1992). Realism about laws. *Erkenntnis 36*(2), 181–218.

Woodward, J. (2014). Simplicity in the best systems account of laws of nature. *British Journal for the Philosophy of Science 65*(1), 91–123.

Woodward, J. (2016). The problem of variable choice. *Synthese 193*(4), 1047–1072.