

# Can Humeans be Scientific Realists?

Bixin Guo

University of Pittsburgh, History and Philosophy of Science

## **Abstract**

Many philosophers who defend a Humean account of laws of nature also endorse scientific realism, such as David Lewis and Barry Loewer. It seems as if scientific realism and Humean accounts 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 a way that would require significant changes to the standard formulations of scientific realism or Humean accounts to reconcile the two. I focus on two of the most prominent Humean accounts, Lewis' Best System Account and Loewer's Package Deal Account, as examples and argue: Humean accounts like Loewer's, which take the fundamental ontology and laws as a package deal, conflict with scientific realism, while Humean accounts that do not take a package deal, such as Lewis's, do 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<sup>1</sup> and Loewer. In fact, according to the PhilPapers Surveys (Bourget and Chalmers 2009, 2020), most Humeans believe in scientific realism. *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; scientific realism is about taking a realist attitude towards scientific objects and theories, whereas Humean accounts are intended as metaphysical accounts of laws. 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 closely examines the relation between Humean accounts of laws 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), as examples to demonstrate that Humean accounts are at odds with scientific realism. More specifically, I argue: Humean accounts like Loewer's, which take the fundamental ontology and laws as a package deal, conflict with standard scientific realism, while Humean accounts that do not take a package deal, like Lewis's, do not conform to scientific practice.

The tension between Humean accounts of laws and scientific realism, nonetheless, is not impossible to reconcile. I propose possible modifications that align Humean accounts with scientific realism. The main issue addressed in this paper can be framed in another way: If Humeans aspire to be scientific realists, what kind of scientific realists can they be? And vice versa.

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

## I 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. Moreover, it takes science at “face value” (Putnam 1978, 37), and takes scientific claims literally as informing us about what the world is really like. More specifically, 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 like viruses, atoms, and electromagnetic fields—that exist in the world independent of the human mind. Although 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), the characterization above is more or less the *standard* one. Particularly, it is far less contentious that standard scientific realism is committed to the idea of mind-independence (ibid., Sec. 1.2): objects postulated or predicted by our best scientific theories really exist; their existence and properties are independent of our 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.

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<sup>2</sup> is worth noting because Humean accounts are originally motivated by the empiricist view that we should not commit to the existence of something that goes beyond our sense experience.<sup>3</sup> The accounts are named “Humean” after the leading

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<sup>2</sup>See Boyd (1983) who emphasizes this tension and Chibeni (2005) who tries to accommodate scientific realism within a Humean empiricist tradition.

<sup>3</sup>See, e.g., Bhogal (2020, 7).

empiricist Hume for his renowned rejection of necessary connections between cause and effect that unobservable. 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, its opposed views 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 reject the existence of unobservable scientific objects. It is, nonetheless, 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. Thus, it is natural to question 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. This, of course, is not by itself an argument that Humean accounts are at odds with scientific realism. It nevertheless provides a motivation to examine their relation.

The second motivation arises from considering what scientific realism says about scientific laws. 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. However, scientific theories consist of more than theoretical objects, and laws are also an essential component of scientific theories (at least in physics). Scientific realism thus requires one be *realist about laws* as well.<sup>4</sup> That 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.

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<sup>4</sup>This is challenged by Cartwright (1983). The kind of realism she endorses (entity realism), however, is different from standard scientific realism and not friendly to Humeanism.

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

(RL<sub>1</sub>) The propositions that are laws in our best scientific theories are true (or at least approximately true).

(RL<sub>2</sub>) There is an objective, mind-independent matter of fact about which regularity counts as a law and which doesn't.<sup>5</sup>

(RL<sub>3</sub>) Laws are irreducible to categorical properties of material objects or any non-modal facts.<sup>6</sup>

There has not been much discussion on what realist view on laws is entailed by scientific realism. One exception is Berenstain and Ladyman (2012). They argue that scientific realism (together with its supporting arguments) implies irreducible objective modality and, particularly, primitive natural necessity; hence (RL<sub>3</sub>). Since what it is to be Humean is to deny (RL<sub>3</sub>), Humeanism is deeply at odds with the spirit of scientific realism.

Humeans, nonetheless, can respond by denying such an implication of scientific realism and defend their realist position by adopting (RL<sub>1</sub>). In fact, the Humean Best System Accounts (BSA) associated with Mill, Ramsey, and Lewis do claim (RL<sub>1</sub>). According to 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 effectively has two components:

(I) A metaphysical thesis that laws supervene on, and are reducible to, categorical properties—a thesis that goes against (RL<sub>3</sub>).

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<sup>5</sup>Realism about laws requires (RL<sub>2</sub>), according to Earman and Roberts (2005, 256) who defend a Humean account.

<sup>6</sup>See, e.g., Carroll (1994) and Maudlin (2007). See Dretske (1977), Tooley (1977), and Armstrong (1983) for other variations of non-Humean accounts.

In particular, what makes something a law is the fact that it belongs to a system that best satisfies *certain criteria*, rather than some metaphysical machinery such as necessary connections, relations between universals, or causal powers. Put another way, such criteria are constitutive of lawhood.

- (II) A guiding principle of identifying laws from non-lawful claims (particularly from accidental regularities) that specifies what the criteria for the best system are: simplicity, strength, and their balance.

It is however disputable whether or not (RL<sub>1</sub>) is sufficient for Humean accounts to be scientific realist. Even if scientific realism does not imply (RL<sub>3</sub>), one may argue that scientific realism requires (RL<sub>2</sub>), whereas it is questionable whether Humean accounts can, or should, maintain (RL<sub>2</sub>).

To see why scientific realism arguably requires (RL<sub>2</sub>), let's contrast realist views on laws with subjectivist or conventionalist views. The latter take laws to be at least partially grounded in facts about us, facts about our beliefs and expectations, our preferences to categorize various generalizations in certain ways, or our inclination to organize or systematize our knowledge in certain ways. It is our different *epistemic attitudes* that mark the difference between laws and accidental regularities.<sup>7</sup> That is to say, according to subjectivist or conventionalist views, laws (or at least what makes something 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 scientific realism entails, it at least requires that laws be objective: If the existence of scientific objects and their properties are objective according to scientific realism, the way such objects behave and the laws to which they are subject should be objective as well.<sup>8</sup>

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<sup>7</sup>For a characterization of such views, see Woodward (1992, 182). For specific examples, see Rescher (1969).

<sup>8</sup>One may argue that (RL<sub>2</sub>) is irrelevant to scientific realism, because a scientific theory only includes the content of a law *L*, the first-order statement (e.g., '*F = ma*'), not the second-order statement '*it is a law that L*'. Thus, scientific realism does not say anything about the lawhood of *L*. That is to say, the fact that *L* is a law and distinct from accidental regularities (like 'All spheres of gold are less than one mile in diameter') is not essential to the theory. This is however questionable. Laws play important roles in science in a way that accidental generalizations don't—neither Humeans nor

It is debatable whether or not Humean laws are objective. Insofar as Humeans think of laws as something more than mere regularities, they need to ground this additional content somewhere: either (i) in us, or (ii) in the world. If they choose (i), laws of nature are *not* fundamental aspects of the world; what makes something a law comes from us: how *we* categorize facts about the world, how *we* organize our knowledge. That is to say, the distinction between laws and mere regularities is a human artifact, not a natural category that reflects the structure of the natural world rather than human interests. This makes Humean accounts subjectivist or conventionalist (Woodward 1992, 214).

Particularly, the Humean criteria constitutive of lawhood—what counts as simplicity, strength, and their best balance—arguably depend on “the (possibly idiosyncratic) details of our epistemic practices and interests” (ibid., 182). In fact, Humean accounts are often criticized for not being objective;<sup>9</sup> call this the *Objectivity Objection*. Even Lewis (1994, 479) himself acknowledges:

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.

Recent Humeans, however, take the element of ‘us’ as a feature, not a bug, and embrace relativism (Bialek 2016, 2) and/or pragmatism (Hicks et al. 2023). Cohen and Callender (2009, 21), for example, require 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”. Loewer (2021a, 18) agrees with them that the best system should be “best for us”.

Some Humeans, in contrast, insist that Humean laws are objective: It is an objective fact about the

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non-Humeans debate about this (at least so far). Scientific realism thus requires one not only take *L* seriously, but also take ‘*it is a law that L*’ seriously.

<sup>9</sup>See, e.g., Armstrong (1983, 67) and Belot (2022).

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 (irrespective of whether or not we may ever come to know it). Such Humeans thus choose (ii): what makes something a law comes from the world.

I don’t intend to adjudicate here whether or not Humean laws are objective. Nor do I defend or oppose Berenstain and Ladyman’s argument. My point is to supply the second motivation to examine the relation between Humean accounts of laws and scientific realism: Given that laws play a crucial role in science, it is unsatisfying if scientific realism, which is supposed to provide a systematic view of how we should understand science, leaves open what realist view on laws we should adopt. In particular, it is unclear whether one important realist standard, objectivity, is met by Humean laws.

Having presented two motivations for examining the relation between scientific realism and Humean accounts of laws, I now proceed to argue that Humean accounts are at odds with scientific realism. I consider Loewer’s Package Deal Account (PDA) first, because it is supposed to be an improvement of Lewis’s BSA and its tension with scientific realism comes out more sharply. The main argument in the following section picks up the close connection between scientific objects and laws: they should be treated on an equal footing. Instead of demanding scientific realism imply a particular realist view on laws that might clash with Humean accounts, I propose to approach their relation from the other direction: by examining what Humean accounts of laws say about scientific objects that might contradict scientific realism.

## **2 Package Deal: Loewer’s PDA**

Loewer’s PDA can be seen as a version of BSA in the sense that it also identifies laws as regularities in the best system. The PDA differs from Lewis’s BSA in one aspect that is crucial to our discussion:



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 are specified together as a package deal” (Loewer 2021a, 1080) and are metaphysically on a par (Loewer 2021b).

More specifically, the PDA associates each possible world  $W$  with a pair  $\langle L, T \rangle$ , where  $L$  is a fundamental language and  $T$  is a fundamental theory.<sup>10</sup> 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  $\langle L, T \rangle$ , one *or more* pairs give the theory  $T$  stated in  $L$ ,  $T(L)$ , that best systematizes the fundamental truths of  $W$ .  $T(L)$  is what physicists would call the final theory of everything. 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 2007). In this regard, 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, given together as a result of systematization.

The PDA further departs from Lewis’s BSA in two ways that are relevant to our discussion. First, the PDA expands the criteria for what counts as the best system, going beyond simplicity and strength: The fundamental theory of physics  $T(L)$  is 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). General speaking, the PDA does not use hypothetical or ideal criteria but attends to actual criteria used by physicists.

Second, the PDA explicitly commits to relativism: its best system is best only relative to us (in particular, to our tradition of physics). The PDA admits more than one optimal pair of  $\langle L, T \rangle$  that are equally good for the actual world. That means there can be multiple distinct sets of fundamental

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<sup>10</sup>In a more recent paper, Loewer (2021a) associates  $W$  with a triple  $\langle L, A, T \rangle$ , where  $A$  is a fundamental arena (where fundamental properties are distributed).

laws. But how can that be? What does it mean for there to be more than one set of laws? How are various sets of laws related to one another? Can one set of laws be inconsistent with another set? If not, why not? 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. 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 thinks "if nature is kind to us, the problem needn't arise" (1994, 479). In contrast, Loewer (2021a, 17) thinks it seems "almost inevitable" that different systems are tied for best (since what is basic and simple in one language will be derivative and complicated in another language), and "a better proposal is to accept that being a law is system relative".

The problem of multiple rival systems tied for best 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 one set of fundamental laws, out there in the world, fully independent of how we think or theorize, just waiting for us to discover, wouldn't any alternative sets of laws that are tied for best simply be erroneous? One plausible explanation: Humean laws are not sufficiently objective, but depend on who is doing the systematizing and what criteria they choose to judge what is best; this brings about the possibility for different investigators to arrive at different sets of laws—especially if the chosen criteria depend on the cognitive capacities of the investigators, such as simplicity.

Most, if not all, Humeans deny that the *Objectivity Objection* is a devastating threat.<sup>11</sup> 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, Humeans like Jaag and Loew's (2018, 14) claim, the Humean criteria of lawhood can be

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<sup>11</sup>See, e.g., Bialek (2016).

non-voluntary, robust, shared by all agents we know, and not likely to change over time. Moreover, even if the Humean criteria like 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). The truth values of regularities are untainted and remain mind-independent. It is also mind-independent whether the best system satisfies the Humean criteria. So is whether our world has such a system. Some Humeans (such as Loewer 2021a, 22) believe these features make it sufficient for their laws to be objective. (Other Humeans take their laws to be more objective, which I will address in Section 2.2.)

Importantly, there is nothing inconsistent for Humean laws to be both objective and relative, especially if by ‘objective’, one only means ‘relatively objective’ as specified above. Loewer (2007, 325) claims:

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

Is this position tenable? Is being ‘relatively objective’ sufficient to address the *Objectivity Objection*? Although this 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.<sup>12</sup> Worse, it is notoriously contentious what objectivity means, and accordingly it is unclear in what sense laws need to be objective.

This paper elucidates 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 relative, that would conflict with scientific realism. Given that scientific realism is cogently argued and widely accepted<sup>13</sup>, and, most importantly, endorsed by most Humeans, any conflict with it would pose a clearer and sharper problem. In this way, we circumvent the difficulties by shifting the target of 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.

*The Core Argument:*

(P<sub>1</sub>) Scientific realism takes the fundamental ontology of physics to be objective.

(P<sub>2</sub>) If the (fundamental) laws are *not* objective according to the PDA, then the fundamental ontology is *not* objective.

(P<sub>3</sub>) The (fundamental) laws are *not* objective according to the PDA.

(C) The PDA contradicts scientific realism.

(P<sub>1</sub>) is required by scientific realism, at least according to its standard formulation. By ‘objective’, I mean: mind-independent, and particularly independent of various cognitive capacities, scientific

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<sup>12</sup>Such appeal is mentioned by, e.g., Bialek (2016, 9).

<sup>13</sup>72.35%, according to the 2020 PhilPapers Survey.

languages, and goals for scientific investigation. This notion of objectivity is inferred from scientific realism: The fundamental theory of physics tells us what the world is really like, what its fundamental ontology is, which does not depend on us—how we think or theorize about it—nor any other creatures. Our science does not determine but only tries to know and understand what it is. 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. There is nothing anthropocentric about whether or not, say, electrons exist, or whether electrons or quantum fields are fundamental.

If Martians discovered a different fundamental ontology from our fundamental theory of physics, at least one of the two theories is false. If Martians' theory and ours are both true, we must discover the same fundamental ontology with the same properties. That is to say, 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.<sup>14</sup>

(P<sub>2</sub>) 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, the fundamental ontology is not objective either.

(P<sub>3</sub>): Because the PDA takes laws to be relative to us, its laws are not objective, at least not in the sense that the fundamental ontology of physics is objective to match (P<sub>1</sub>). What makes a regularity a PDA-law is relative to our cognitive capacities, scientific languages, and goals for scientific investigation. More generally, (P<sub>3</sub>) not only applies to Loewer's PDA with relativism, but also any Humean account that endorses (i), what makes laws different from mere regularities come from *us*. Relativism or pragmatism is just a specific way in which Humean laws are not sufficiently objective to match the

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<sup>14</sup>The former is argued by, e.g., Psillos and Shaw (2020, 414). The latter is noted by, e.g., Glick (2019, 4146).

notion of objectivity defined in (P1). Insofar as defenders of the PDA hold (i), they cannot avoid the *Core Argument* by simply forfeiting Loewer's relativism.

The element of 'us' is not simply a choice but does a lot of heavy lifting for Humean accounts that embrace relativism and/or pragmatism. First of all, 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 equally good systems. One such way is to accept that the best system is only best relative to us. Moreover, if Lewis's original criteria (simplicity, strength, and their balance) are not sufficient to pick out a unique best system, introducing pragmatic considerations precisifies criteria of lawhood with more fine-grained features.

Furthermore, 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)?<sup>15</sup> 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 employed to address these questions. 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 2021a, 21), are convenient to use, suit our pragmatic purposes, and/or are a natural result of the limitations of our cognitive capacities. In particular, these pragmatic and/or relativist considerations also explain why specifically simplicity, informativeness, and their balance are the criteria constitutive of lawhood.<sup>16</sup> In the metaphorical story often used to illustrate BSA, God can tell us every single detail about the world but ends up giving us only a short list of true propositions that is as informative as possible (i.e., what Humeans call the best system).<sup>17</sup> For creatures like us, with limited capacities for information processing and calculation, a complete specification of everything going on in the world throughout all time would be impossible for us to handle

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<sup>15</sup>In contrast, non-Humeans have a natural answer: laws are fundamental aspects of the world, in addition to non-modal facts.

<sup>16</sup>Also see Woodward (2014, 117), Jaag and Loew (2018, 9).

<sup>17</sup>See, for example, Albert (2015, 23).

and we wouldn't be able to make use of it anyway. That's why we need the best system, a compressed description that is as informative as possible but simple enough for us to process, whereas creatures with unlimited capacities like God don't. Accordingly, for such creatures, there isn't anything that makes laws any more 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.

It is true that 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 cognitive capacity, the same scientific languages, and the same scientific goals. Thus it is not particularly worrisome that multiple systems may be tied for best according to our standards. Also, 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. The way in which Humean laws are mind-dependent may seem benign for the concept of laws.

However, being 'relatively objective' is not sufficient for the sense in which the fundamental ontology of the world is objective, and being mind-dependent in the way Humean laws are undermines the sense in which the fundamental ontology is objective. What makes something the ontology of the fundamental theory of physics (i.e., belong to the best system) do not come from us. We care about the fundamental ontology and it is appropriate and important target for scientific inquiry, *not* because it is useful for us and/or is a natural result of the limitations of our cognitive capacities, but because it really exists out there in the world and we would like to know what the world is like. It is against scientific realism to think of the fundamental ontology in the way pragmatic and/or relativist Humeans think of laws.

## 2.1 *The First Humean Response*

There is one possible way that allows Humeans to reconcile (i), what makes something a law comes from us, with laws being objective in the way the fundamental ontology is objective. If our needs, our epistemic criteria, and/or the limitations of our cognitive capacities are not simply contingent facts about us, but somehow reflect or lead to the structure of the natural world, then Humean laws are not really mind-dependent. One may say the mind-dependence of Humean laws is just an appearance of how we come to know about laws; the element of ‘us’ does not actually feature into what laws are. Thus, even granted that Humean laws are to some extent mind-dependent, they are not mind-dependent in any problematic way that compromises scientific realism. In fact, Humeans may argue that their laws are as objective as science is.

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. Science is carried out as a human endeavor. We can’t eliminate all the elements of ‘us’ from science. Nevertheless, scientific realists would not think science is not objective because of that. Instead, 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 criteria of lawhood bestowed upon us by contingent evolutionary process somehow can deliver the right, objective best system of the world. In principle, different creatures with different cognitive capacities may initially reach different sets of laws with different fundamental ontologies. But their differences are not irreconcilable—if any of their scientists are doing a proper job, they eventually will realize that there is in fact a clear winner for the best system that captures the structure of the world, and some of them were simply wrong.

This response could be what is behind Lewis’s reasoning for why he (1994, 479) doesn’t think the standards of simplicity, strength, and balance come from us:



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, th[e]n 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 . . .

If nature is kind, then the Humean criteria, despite being mind-dependent, can lead to the objective structure of the natural world, and there will be a clear winner for the best system that characterizes that structure. Critics as well as some Humeans, nonetheless, don't find Lewis's response satisfying:<sup>18</sup> there is no evidence that nature is kind to us either. Do we have any justification for believing nature is kind?

Humeans can appeal to scientific realism to give a justification. Science has been enormously successful, and the best explanation for its success is that scientific theories actually latch onto what the world really is like. The fact that our science succeeds at telling us what the world is (including what laws are) is evidence that nature is kind to us such that our epistemic criteria successfully lead to the objective structure of the natural world, our pragmatic needs or the limitations of our cognitive capacities do not mislead us but actually guide us in knowing what the world really is, and accordingly we don't need to worry about multiple systems tied for best.<sup>19</sup> Insofar as *the Humean criteria track the epistemic criteria actually used by scientists*, there will be a clear winner for the best system that

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<sup>18</sup>See, e.g., Hall (2015, 277), Bialek (2016, 5), and Belot (2022).

<sup>19</sup>Massimi (2017, 409, 412) thinks differently: Lewis's hope that nature is kind is grounded by his metaphysics of natural properties. Interestingly, she doesn't think Lewis's response works unless the standards of simplicity and strength were reinterpreted along perspectivalist lines.

characterizes the structure of the world, as given by science.

This justification requires an important assumption: Humean laws and fundamental ontology do not diverge from science. That means, Humean accounts need to 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 capture the criteria used in science to evaluate a theory and for theory choice.

Then the question is: do the Humean criteria of lawhood actually track scientific practice? Most, if not all, discussions on this question focus on Lewis's original criteria. Loewer (2021a, 17), for one, 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. (That's why Loewer's account includes additional criteria like comprehensiveness and explanatoriness.) In addition to questioning simplicity, strength, and their balance as sufficient criteria, it has been argued that they in fact do not track actual scientific practice (e.g., van Fraassen 1989, 56-58; Roberts 2008; Woodward 2014). Insofar as extra-empirical virtues are employed in scientific practice to evaluate empirically equivalent theories (that is, to prevent underdetermination of theory by observational evidence), they do not exactly involve a trade-off between simplicity and strength as described in Lewis's BSA.

Although the criticism that the Humean criteria of lawhood fail to align with scientific practice is not new, the contribution here is to give a reason for why a Humean account, which may be said to be merely a metaphysical theory, needs to conform to scientific practice: If not, Humeans cannot invoke the objectivity of science to argue for the objectivity of their fundamental ontology and laws. Accordingly, they can't avoid the conflict with scientific realism.

One may argue: even if the Humean criteria do track scientific practice, a unique best system is not guaranteed by scientific realism, which already faces the problem of underdetermination. In fact, the problem of there being multiple tied best systems just *is* the problem of underdetermination. But

I don't think these two problems are the same, if the Humean criteria don't align with scientific practice. It is because the Humean criteria fail to pick out a unique best system that multiple rival systems are tied for best. If the Humean criteria are not actually used in science, this cannot be the reason why theories are underdetermined by observational evidence. Humean accounts face an extra problem of underdetermination that scientific realism doesn't.

A Humean may then respond by emphasizing that their account is only meant to be a metaphysical theory and they are in fact not committed to any of those criteria for the best system, which merely serve as a placeholder for whatever criteria used in scientific practice (one may interpret Lewis and Loewer in this way). Then whatever criteria science turns out to use, the best system satisfying such criteria will be as objective as science.

The problem is, for one, this modified Humean account does not specify any specific characteristics of what laws are, other than that they belong to our best fundamental theory of physics. 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, not only because it is often used to support (I),<sup>20</sup> but also because it is a substantial proposal that is interesting and significant by itself. It is (II) that makes Humean accounts go beyond a metaphysical theory but also offers an analysis of what laws are in connection with science. Compared to the original BSA, this modified account loses a critical component (II), as well as any appeal that comes with it.

Worse. Even though (I) is only a metaphysical thesis, it is not obvious or trivial that (I) is compatible with *any* scientific practice that identifies laws from non-laws. Insofar as Humeans intend to be naturalistic, it is crucial 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: Critics of Humeans argue that (I) conflicts with scientific practice (e.g., Maudlin 2007, 105; Hüttemann 2021). In particular, the criteria

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<sup>20</sup>See, e.g., Cohen and Callender (2009, 3), Bhogal (2020, 8).

employed in science for identifying laws and for theory choice are arguably irreducibly modal; that is, they appeal to facts about how things must, could, or could not have been, not just how things actually are. One may argue, for instance, that predictability or invariance is one of the criteria of lawhood used in science and requires modality in a way that cannot be analyzed away by non-modal terms.<sup>21</sup> By contrast, the advantage of supplying (II) in terms of simplicity, strength, and their balance is that these criteria are *prima facie* non-modal. In sum, Humeans cannot simply defer to science and declare that their criteria of lawhood are whatever is used in scientific practice, since not all such criteria uphold (I). A Humean account without (II) has not completed its task of showing that laws are reducible to non-modal facts.

## 2.2 *The Second Humean Response*

To reject the *Core Argument*, Humeans can choose (ii) to refute its third premise (P<sub>3</sub>: 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 what makes a regularity a law. However, it is unclear whether (ii) is desirable or even viable for Humeans, or what *exactly* a Humean account that satisfies (ii) looks like.

Some Humeans may, say, insist that the criteria for the best system—simplicity, strength and their balance—are in fact objective in the sense that mathematical or computational concepts are objective. Such concepts do not make ineliminable reference to ‘us’. An obvious problem with this response is: Humeans have not shown that their criteria are indeed objective, other than insisting that it is possible to do so. Nor have they systematically developed such mathematical or computational notions of simplicity, strength, and their balance.<sup>22</sup> Rather, their appeal to simplicity, strength, and their balance

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<sup>21</sup>This point is suggested and inspired by Hildebrand (2022) who argues that Pragmatic Humeanism requires criteria, such as goals or interests, that are modally robust.

<sup>22</sup>One may draw such a notion of simplicity from works in computational complexity; consider, e.g., Levins (1966), Millhouse (2019), Shah et al. (2020). There are attempts to make the notion of strength more precise in specific contexts;

is often vague and imprecise (Woodward 2014).

A deeper problem is: Even if one manages to show that there are mathematical or computational notions of simplicity and strength that are objective, it is questionable if they are the ones used in science for theory choice and identifying laws, and thus relevant to lawhood. (This is a different issue from whether scientific practice involves a trade-off between simplicity and strength as described in Lewis's BSA.) There is a certain appeal to leaving the notion of simplicity vague and imprecise. Then it seems obvious that simplicity must play some role in science, one way or another, across various scientific disciplines. 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, attempts to develop a computational notion of simplicity face the exact problem that their notion is not general but has only limited applications; such attempts also require assumptions that are not properly justified.<sup>23</sup> Similarly for the notions of strength and balance.

The flip side of this problem is: if the world indeed has certain natural structure such that there exists an objectively best system as required by (ii), how do we know that such a system is picked out by the Humean criteria like simplicity and strength? 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: our epistemic standards are constitutive of lawhood.<sup>24</sup> This claimed advantage requires, again, the Humean criteria of lawhood correctly reflect the epistemic standards used in science, which is (as discussed earlier) questionable. More importantly, Humeans can no longer claim this advantage once they choose (ii). In this case, the world has an objective structure such that there exists a best system, but there is no guarantee that our epistemic standards will pick out that system. I'm not suggesting that non-

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see, e.g., Callender (2017, Chapter 8).

<sup>23</sup>See, e.g., Sober (2002), Norton (2021, Chapter 6-7).

<sup>24</sup>See, e.g., Earman and Roberts (2005), Loew and Jaag (2019, 275).

Humean accounts fare better in this regard, only that Humeans cannot have it both ways; that is, they cannot claim both objectivity and an epistemic advantage over non-Humeans.

### 2.3 *The Third Humean Response*

To respond to the *Core Argument*, Humeans may simply bite the bullet and reject its first premise (P1: Scientific realism takes the fundamental ontology to be objective). Either it does not correctly characterize scientific realism, or even if it does, 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 fundamental ontology, their theory can still be true, as well as ours. It's just that the world has two distinct fundamental ontologies—it is agent-relative what the fundamental ontology is, or there is no matter of fact which ontology is fundamental. Humeans may counter: why can't there be two or more fundamental ontologies of physics?

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

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* that is relative, whereas the truth value of the law remains objective), the PDA only implies: it is only *which scientific objects are fundamental* or *what makes them fundamental* that is relative. It is not relative to us what scientific objects are, what properties they have, or whether they exist.<sup>25</sup> For instance, although it is relative to us whether or not electrons are fundamental, it is

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<sup>25</sup>Thanks to Barry Loewer for this point.

*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 characterized in Section 1 does not make explicit commitments to how scientific objects are related, particularly which of them are more fundamental, 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, accordingly, atoms are more fundamental than molecules, rather than the other way around. Neither is it up to us that string theory is a candidate for the fundamental theory while nonrelativistic quantum particle mechanics or the theory of evolution by natural selection is not. Suppose, say, electrons are a part of the fundamental ontology, they are fundamental not because we organize our knowledge in certain way, but because the world has an objective structure that makes electrons fundamental.

Humeans may further argue: this is not what they mean by ‘fundamental’. For them, a scientific theory is fundamental not because it is universal or complete, or its ontology is at the smallest length scale, but because it is, say, explanatorily prior to any other theory. If explanation is understood as a purely epistemic concept, then it is up to us which theory is explanatorily prior and thus more fundamental. If that’s the case, Humeans need to specify and defend such a notion of fundamentality and show that it is indeed what physicists mean by fundamental.

Moreover, it is contestable that relativism of laws corresponds to relativism of fundamentality. The best system identifies fundamental laws from non-laws; how it can identify non-fundamental laws (or laws of special sciences) from fundamental laws or non-laws is unclear.<sup>26</sup> Similarly, the best system identifies fundamental objects from non-objects; how it can identify non-fundamental objects from fundamental objects or non-objects is unclear. Thus, what is relative according to the PDA is not, among all scientific objects, which ones are fundamental, but more generally *what fundamental*

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<sup>26</sup>There are attempts to generalize BSA to cover special science laws (e.g., Cohen and Callender 2009). Then the problem is: all scientific objects are relative, not just fundamental ones.

*objects are*. In order to claim that the PDA only makes the idea of fundamentality (or which scientific objects count as fundamental) relative, what is relative in the PDA needs to be what makes a regularity a fundamental law.

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 adjustments for them to do so. (2.1) They can argue: while what makes laws different from mere regularities come from us, how we organize our knowledge in a way that is useful for us, this somehow reflects or leads to the objective structure of the natural world, and Humean laws and fundamental ontology are thus as objective as science. Then the problem is: Humeans need to show that their criteria for the best system properly align with scientific practice, or modify the Humean criteria to do so. (2.2) 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, (2.3) Humeans can propose a version of scientific realism that does not require that the fundamental ontology be objective. They may consider, for example, adopting structural realism, a realist position that does not require the existence of objects. It is then plausible that the fundamental ontology is anthropocentric. Another option is perspectival realism or Putnam's internal realism. (I will leave to the reader to judge whether any of these positions is tenable and still counts as scientific realism.)

### **3 No Package Deal: Lewis's BSA**

To respond to the *Core Argument*, Humeans can reject its second premise (P2: If the laws are not objective, neither is the fundamental ontology), which is based on the PDA's core idea of a package deal. The exemplar of Humean accounts that does not identify the fundamental ontology and laws together as a package deal is Lewis's BSA. Exactly because it does not take a package deal, Lewis's BSA



faces the problem of failing to conform to scientific practice.

There are a few aspects in which Lewis's BSA does not conform to scientific practice. Some of them concern the trade-off between simplicity and strength (see Section 2). Some concern the role of perfectly natural properties:<sup>27</sup> 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 refer to only perfectly natural properties. While it is the job of fundamental physics to find out what exactly perfectly natural properties are in our world, whether or not a property is perfectly natural is a primitive fact of metaphysics. It is possible that physicists deliver 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 physical practice. The PDA is proposed to fix issues like this.

I want to point out a different aspect in which Lewis's BSA does not conform to scientific practice: It takes objects (and their categorical properties) to be primitive and *metaphysically prior* to laws. The thesis of Humean Supervenience illustrates in what sense the fundamental ontology is metaphysically prior to its laws (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.

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<sup>27</sup>See, e.g., van Fraassen (1989), Loewer (2007, 2021a).

Here, 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. They 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.<sup>28</sup> In scientific practice, it is not the case that, *given* what the objects are (how they behave and what properties they have), what the laws are is inferred as a simple and informative way to summarize the behaviors 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 together and accepted as real and physical together. How the object behaves and what properties it has are deeply intertwined with what the laws are—there is no pristine separation between what the object is and what laws it obeys. To some extent, an object is what it is in terms of what laws it obeys.

Consider an example from the history of physics.<sup>29</sup> In the early nineteenth century, physicists believed that the physical world at a fundamental level was composed of particles with simple forces acting among them, and 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 concepts alone, and were led to introduce a new concept: electromagnetic field. Initially, the idea of “field” was just a helpful mathematical tool 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. Physicists found that what the fields are doing does not logically follow *just* from what the particles are doing, and thus the motions

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<sup>28</sup>Following Lewis and Loewer, I focus on the latter. For the case of special sciences, see Woodward (2016).

<sup>29</sup>See, e.g., Einstein and Infeld (1938, 125–145).

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 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 physical 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*.

One might be tempted to read the point of this example as being merely epistemic; that is, it only shows: it is not the case that physicists first discover some novel scientific objects (with their categorical properties) and then infer what the laws are from the regularities or patterns of those objects; rather, they get discovered together. But the problem goes deeper than that. The scientific practice under consideration is not simply about how physicists come to know about laws and objects, but also about what they take laws and objects to be.

More generally, Lewis's BSA presupposes that (1) the purpose of the best system (given by our fundamental theory of physics) is merely to identify laws, (2) systems or theories compete for best balancing simplicity and strength only in terms of their laws, and (3) there is a straightforward, definite demarcation between objects and laws so that objects can be metaphysically prior to laws. These assumptions are problematic.

A physical theory is more than identifying laws. Introducing new ontologies is also central to physics (as demonstrated in the example above), especially the parts that have been conjectured as fundamental. Thus, different best systems not only compete in terms of what the laws are, but also what the fundamental ontology is. 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

prior to laws. When theories are proposed or developed, physicists 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. Thus, laws are not inferred as a summary of the Humean mosaic. What physicists start with is *the manifest image* with ordinary macroscopic objects like tables, cats, and measuring apparatus. They postulate new scientific objects and laws together to account, and make predictions, for the manifest image.<sup>30</sup> Sometimes they 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. It is not the laws that best summarize the Humean mosaic; rather, it is the fundamental objects and laws *together as a package* that best summarize *the manifest image* (either directly or indirectly). If one intends to be naturalistic and read off metaphysics from physics—as most, if not all, Humeans intend to be—there isn’t anything in physics, either in physical theories or physical practice, that grounds the metaphysical priority of objects (with their categorical properties) over laws.

Instead of one being prior to the other, an ontology and its laws are deeply intertwined:<sup>31</sup> A physical object is considered novel and distinct from other kinds of objects because it obeys a different set of laws; the set of laws is taken to be physical laws (instead of merely mathematical principles) because they contain variables that represent the physical object and the associated properties. To accept certain scientific objects as physical and real is to accept that there are the corresponding laws; and vice versa. (One may even go further and argue: what it is to be a physical object is to be a variable in the dynamical laws of motion.) Thus, the fundamental ontology and laws are taken as a package deal and share the same metaphysical status in the way that validates (P<sub>2</sub>) of the *Core Argument*: Either both of them are objective, or neither of them is.

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<sup>30</sup>Loewer (2021b) makes a similar point.

<sup>31</sup>Maudlin (2018, 3) argues that a physical theory should clearly specify its ontology and dynamical laws as two distinct categories, even though this 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”.

A Humean may respond by arguing that failing to conform to scientific practice is not a problem for them. Lewis's BSA is proposed as a metaphysical account of what laws of nature are, rather than a descriptive characterization of how science as a social enterprise works. It does not need to conform to scientific practice in every aspect, so long as scientific laws can be accounted for by the BSA or the BSA does not lead to laws that are different from the laws given by our best scientific theories.

The first thing to note: many Humeans are in fact motivated to develop their accounts to conform to scientific practice. Smithson (2020) claims: "It is widely agreed that an adequate theory of lawhood ought to align with the roles that scientists assign to the laws".<sup>32</sup> Based on this, he defends Humean accounts by arguing that non-Humean laws fail to align with scientific practice. According to Bialek (2016),

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.

He also notes that Humeans often appeal to conforming to scientific practice as a virtue of their accounts. Cohen and Callender (2009) make explicit efforts to ensure their version of BSA retains the advertised connection to scientific practice. Loewer (2007) professes that he is very much attracted to BSA for its aspects that conform to scientific practice, and tries to improve the ones that don't. It suffices to say: BSA would lose a significant part of its appeal if it failed to conform to scientific practice.

Even granting that a metaphysical account of laws does not need to conform to scientific practice in *every single* aspect, Lewis's BSA fails to conform in a particularly important aspect. It is not just that the BSA fails to represent the chronological order of scientific discovery (about when objects and

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<sup>32</sup>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.

laws get discovered). Nor is it that the BSA only deviates from scientific practice by considering ideal physicists who simply 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 indicated by scientific practice.

Since the PDA takes the fundamental ontology and laws as a package deal and thus conforms to scientific practice in this aspect, it has an advantage over Lewis's BSA (this argument for the PDA is distinct from Loewer's original arguments). There is, however, a good reason why Lewis takes the Humean mosaic (or perfectly natural properties) as primitive. As a mosaic of local *categorical* facts at each spacetime point, it is definitionally non-modal. If the Humean supervenience basis can be something else (as the PDA allows), there is no guarantee that such a basis will be non-modal. In that case, Humeans would not have completed their reductionist task: establishing that laws are reducible to non-modal facts.

In addition, if Humean laws are not objective, taking the fundamental ontology and laws as a package deal—both are a result of systematization—implies that the Humean mosaic is not objective either. Although Humeans may be comfortable with their laws being mind-dependent, they probably would not feel the same way if the Humean mosaic is mind-dependent. On the other hand, exactly because Lewis's BSA does not take a package deal, it is not subject to the *Core Argument*.

Does it mean that Lewis's BSA encounters no issue with scientific realism? Not really. Failing to conform to scientific practice could still pose a problem for one's realist position. Scientific realism as presented in Section 1 is only explicit about our epistemic attitudes towards scientific theories and objects. However, 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. Scientific realism is motivated by the success of science—such success involves the success of all these practices as well. Scientific realists can't just ignore the practice. If we take science at "face value" as informing us about what the world is like, as scientific realists would do, we should take at least some of those practices seriously as well.

Characterizing scientific realism solely in terms of theories not only assumes a conception of science that is too narrow, but also presupposes that there is a clear, definite boundary between scientific theories and scientific practice. Such a presupposition is worth disputing. A physical theory is, one may argue, more than a set of propositions or equations stated in textbooks, but includes how those propositions are interpreted and used by scientists, otherwise the theory would not carry much physical significance. That is to say, what is often taken to be scientific practice is in fact a part of scientific theories. Consequently, scientific realism, properly understood in terms of a broader conception of science and of scientific theories, requires one to take scientific practice seriously. Failing to conform to 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. Some aspects of scientific practice are contingent or ad hoc, and do not tell us anything about the world (e.g., *p*-value). There are, nevertheless, some other aspects of scientific practice that contribute to the goals of science, are essential and irreplaceable to the scientific enterprise, and are inseparable from scientific theories. Accordingly, they could be indicative about what the world is like. It is we philosophers' job to identify such aspects of scientific practice, and possibly provide a general recipe for how that 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 justified the significance of those aspects, to address my concern, they need to explain why conforming to scientific practice is a virtue and 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**

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, it faces the danger of treating the fundamental ontology as not objective, especially

so if what makes something a law comes from us. This implication is directly at odds with standard scientific realism. Humeans can possibly avoid this problem by ensuring that their criteria for the best system closely align with scientific practice, or by modifying standard 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 failing to conform to scientific practice in an important way.

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 such 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 the tension with scientific realism. Addressing these problems would make being both Humean and scientific realist a more tenable position.

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