Are laws of nature consistent with contingency?

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CHESS Working Paper No. 2016-06
[Produced as part of the Knowledge for Use (K4U) Research Project]
Durham University
September 2016

The K4U project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 667526 K4U) The above content reflects only the author's view and that the ERC is not responsible for any use that may be made of the information it contains

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1. Introduction

Are the laws of nature consistent with contingency about what happens in the world? That depends on what the laws of nature actually are, but it also depends on what they are like. This latter is our concern here. Different philosophic views give different accounts of the sort of thing a law of nature is. We shall look at three that are widely endorsed: 'Humean' regularity accounts, laws as relations among universals, and disposition/powers accounts. Our question is, given an account of what laws are, what follows about how much contingency, and of what kinds, laws allow?

Of the three types we shall look at, powers stand out as especially apt for admitting contingency, or so it would appear from conversations we've been engaged in, both with powers advocates and with powers opponents. Our investigation here suggests that this is not so. A powers account of laws may admit contingency but it need not. Conversely, the other accounts may rule out contingency but they need not. In all three cases, we shall argue, the root idea of what laws are does not settle the issue of whether they allow contingency. Advocates of the different accounts may argue for one view or another on the issue, but (at least as we understand the accounts) this will be an add-on rather than a consequence of the basic view about what laws are.

Here we explore the possibility of various kinds of contingency in nature, contingency despite the pockets of rough order we observe in our daily lives and of precise order we report in our modern sciences. But, are contingency and order not obviously in opposition? Yes, we think they are… if a picture of nature dominant since the Scientific Revolution is correct, that order arises from the rule of universal deterministic laws, laws that hold everywhere and everywhen and that cover all aspects of what happens. But, we shall argue, that picture is not dictated by any of the three kinds of accounts of laws we investigate. Contingency and order are not in conflict on a 'Humean' regularity view of laws, as we describe in Section 2. They are also not in conflict if the source of order in nature is relations among universals, as we discuss in Section 3, nor if it is powers and dispositions, neither on Alexander Bird's version nor on that of Nancy Cartwright and John Pemberton. Cartwright and Pemberton argue from how much of modern science works; Bird, by contrast, approaches the issue with the questions and perspectives of metaphysics. We shall briefly review his account in Section 4a; in 4b Cartwright, following consultation with Pemberton, develops various ways in which contingencies are possible on the view of powers (which they call 'capacities') they advance.

We shall assume for this discussion that whatever laws of nature are, they are the kinds of things that our current best science might be representing – not that our current science has it right but that we don't want our philosophic doctrines about what kinds of things laws of nature are to rule out that the world is pretty much as current best science pictures it. In particular, then, we want to admit that candidate accounts of what laws of nature are should allow at least this: whether a radioactive atom decays in some given period of time is contingent, though the probability of this happening is not.

Clarifying the question. Whether contingency is possible given the laws of nature depends not only on what kinds of things laws of nature are but also on what contingency consists in. We distinguish several different questions one might ask in asking 'Do the laws of nature allow for contingencies in nature?'[1] To be as neutral as possible we shall talk of laws *covering* a happening P if they, along perhaps with what the view of laws on offer counts as the 'right' kind of facts (boundary conditions, initial conditions, facts about the past, etc.), say that P will happen (as is typical with common accounts of deterministic laws) or that it is allowed to happen (as with common accounts of probabilistic laws). Using *L* to label the complete set of correct laws and $P_0(L,P)$ for the additional facts that bring L to bear on P, here are the questions we want to keep sorted from one another.

> *Extent.* Is everything that happens covered by L? For instance, there may be happenings, or kinds of happenings, or whole domains about which L is silent.
>
> *Permissiveness.* When L speaks about the outcomes that are to occur, what kind of latitude does it admit? For instance, does it always select a single happening? Does it always lay down at least a probability, or can L admit a set of different outcomes, remaining silent about their probabilities?[2]
>
> *Reliability.* Does what L (plus some relevant $P_0(L,P)$) says is to happen always happen? For instance, can there be exceptions to L and yet L still be the correct and complete set of laws?
>
> *Potency.* Do the things that L speaks about happen on account of L? Or, for instance, merely in accord with L?

[1] We should note that we are not concerned with what the actual laws allow but rather with what laws allow by virtue of the kinds of things they are. It may be, for instance, that a particular account allows that laws may be either deterministic or probabilistic but that the actual laws are all deterministic.

[2] We propose treating laws that say 'anything goes' in some circumstance as not covering that circumstance and thus limited in extent.

> *Free will.* If P, which happens, is an action of a person, is ~P consistent with P_0(L,P) (whatever might be the appropriate P_0(L,P)) obtaining and L being the correct and complete set of laws?

We introduce the last question because it hovers in the background. Indeed it is one of the things that motivated the thinking behind this paper: Merlussi is otherwise writing on the consequence argument in metaphysics (to be discussed in Section 2), which begins with a version of determinism to argue to the conclusion that nobody ever could have done anything to make P false, for any P that describes human actions; and it is often suggested in conversation with Cartwright and Pemberton that a capacities account of laws like theirs leaves more room for free will than other accounts. *Free will* is, we all know, a huge question to which over millennia an enormous amount of intense thought has been dedicated, involving of course debate over the very formulation of the problem. Still, we think there are some simple observations we can make about how some accounts of laws of nature bear on the aspect of the question we formulate here.

We will not always have much to say about every question with respect to each view of laws we survey but rather focus on what might not be altogether obvious or on where interesting differences lie. We will not address *potency* seriously at all. It is generally supposed – though not without objections – that universals and powers accounts allow for *potency*, as well as accounts that involve 'necessary' regularities, whereas 'Humean' regularity accounts do not. We shall not take up this issue because we have nothing useful to add. We list it for completeness and to make clear that it is a separate issue from the others.

There are two guiding ideas we rely on throughout in considering *extent* and *permissiveness*. The idea for *extent* is simple: There may be situations where the laws are silent; they simply do not cover those situations. This is an issue, we claim, that is orthogonal to questions about whether laws are *permissive* when they do speak. For instance, L may be deterministic in the sense that for each appropriate P_0(L,P), L admits one and only one P to occur, yet limited in extent because some real situations are not P_0(L,P)-type situations for any admissible P_0(L,P), i.e. some situations may not fall into any of the categories for the additional facts that bring L to bear.

With respect to extent, a little simple housekeeping is necessary since some of the discussion in both the philosophy of science and the philosophy of religion literature as well as in the related metaphysics literature is confusing (at least to us) because it does not make clear the formulations at

stake to begin with, especially with respect to the quantifiers and what they range over. Consider the claim G': 'Politeness requires giving an expensive gift to one's teacher/mentor', that we suppose is true in some cultures influenced by Confucianism. Shall we say it is limited in extent, or shall we rather consider G: 'In cultures A,B,C, politeness requires giving an expensive gift to one's teacher/mentor', which is, we suppose, true everywhere and in that sense not limited in extent? Similarly Cartwright (1989, 2009, 2010) has suggested that what we think of as the usual laws of physics L' may well be limited in extent in a very specific way: They may be unable to represent all the possible causes of the effects they represent; their truth may then be restricted to just those cases where only causes they can represent are at work. Thus, it should more perspicuously be formulated something like this. L: 'So long as all of the causes of the consequences represented in L' are features represented in the antecedents of L', then L'.' One could think of formulating the issue in terms of domain restrictions: Are these restrictions included in the laws themselves or not? The problem is that it can be difficult to formulate criteria for what counts as a restriction on the domain of a law versus what counts as a feature that it genuinely covers. This is why we formulate the issue as we do: Are there things that happen that the complete and correct set of laws does not cover?

As to *permissiveness*, although we turn to capacities last, it is useful to foreshadow one of the topics discussed there because it will help with understanding our remarks about permissiveness throughout. Cartwright has long urged that some events, even ones in the purview of laws, may just happen - by hap - without even any probabilities assigned by nature. An ear-ring back is stuck in some debris in the crack between the floorboards. You try to lift it with a magnet. The magnet pulls upward on the metal object with a fixed strength and gravity pulls it down with a fixed strength. These activities are both properly treated as sources of forces, where by 'properly' she means that there is a general way to ascribe forces for both. There is a magnet and there is a rule in physics for what forces magnets exert; and there is a large mass – the earth – and there is a rule for what force a mass exerts. There is also debris that inhibits the motion of the ear-ring back. Maybe there is another description of this particular debris for which there is a proper rule in physics that assigns a force. But certainly not under the description 'debris'. And maybe there is no other such description. We may grant that some causes of motion are forces in the proper sense of that concept but that does not imply that all are. To assume there must be because the debris can affect the motion of the ear-ring back is to make a massive metaphysical assumption beyond the empirical evidence, Cartwright (2000, 2010) argues.

If we leave the issue open, then a new possibility for contingency arises. There is a rule for what force is exerted when the magnet and the earth act together in this arrangement, and on this rule only one resultant force is allowed. But what about the motion of the ear-ring back? Is there a rule that says what one motion will happen in this arrangement when the resultant force of the earth and the magnet acts on the ear-ring back simultaneously with the inhibiting power of the debris, or if not a rule dictating one single outcome, is there a rule that dictates a set of outcomes with a probability measure over them?

We have insufficient reason to assume there is, Cartwright has argued, so that assumption should not be forced by our account of what laws are; the account should leave the question open. Yet surely there is some kind of rule since we have what do seem well-warranted beliefs that the ear-ring back will not fly away at near the speed of light, and also, as Keith Ward[3] has pressed, that it will not turn into a pumpkin. This is very underexplored territory. But it seems that here may lie yet another source of contingency; we have labelled this *permissiveness:* When L applies, given a relevant input P_0(L,P), L might admit only one outcome, in which case L is not permissive. On the other hand, L may be permissive in that L admits a set that includes more than one outcome, and in the latter case, L may or may not provide a probability over that set.[4]

2. The 'Humean' regularity account

The central motivating idea behind what we shall call the 'Humean' regularity account of laws is not about laws but about the make-up of the world. The facts that constitute the world involve only qualities, quantities, and relations that are *occurent*, where 'occurent' means different things to different philosophers who call themselves 'Humeans'. What they all have in common is that they want to exclude any kind of 'modal' features. There are no causings, no necessitatings, no doings, no making-things-happen-ings.

In answer to the question 'What is it to be a law of nature?' the naïve 'Humean' account states that laws are regular associations among occurent features. But this is thought to be problematic. There are true accidental regularities that are not laws, it is supposed. To use Hans Reichenbach's memorable example (1947: 368), 'All gold spheres are less than a mile in diameter' is a genuine

[3] Personal conversation with respect to the forthcoming volume *Rethinking Order: After the Laws of Nature*, (eds) N Cartwright & K Ward, London: Bloomsbury.
[4] Clearly this supposes some already given way to individuate outcomes.

regular association, but this does not seem to be a law. So, it is commonly assumed, a satisfactory 'Humean' view of laws should distinguish laws from accidental regularities. This is what David Lewis's best system account (BSA) sets out to do (Lewis, 1973). Since BSA is very well developed and widely adopted, we shall focus on this version of the 'Humean' regularity account. However, the main arguments we put forward should go through for any acceptable 'Humean' account of lawhood, including Craig Callender and Jonathan Cohen's (2009) 'Better Best Systems Account'.

In *Counterfactuals* (1973: 73) and 'Humean Supervenience Debugged' (1994: 478), Lewis takes as a starting point a short note written by Frank Ramsey in 1928. Lewis's restatement of Ramsey's passage asserts that 'a contingent generalization is a *law of nature* if and only if it appears as a theorem (or axiom) in each of the true deductive systems that achieves a best combination of simplicity and strength' (Lewis 1973: 73).[5] [6]

Notice two important features of this view. First, laws supervene on the particular matters of fact. This is so because laws merely summarize facts. So, as to *potency*, laws do not 'govern' the world, they are just special regularities that encompass a good many other regularities. The particular matters of fact determine the laws of nature in the sense that if the laws of nature are different, that's because the facts are different. Because of this, the BSA preserves the alleged intuition that the laws of nature are metaphysically contingent, at least so long as it is metaphysically contingent what the facts are.

Given this brief description we can look at how the BSA deals with questions of whether L is compatible with contingencies.

Extent. Does L cover everything that happens? Following John Earman, one might formulate the question as follows: Do laws have an unrestricted range in space and time? (Earman 1978: 174). As Earman points out, to deny that laws have an unrestricted range in space and time boils down to saying that there is 'a region of space-time R_o such that, as far as L is concerned, "anything goes" in

[5] This looks like a use/mention confusion but it is almost certainly harmless. We shall try to avoid confusing the two but occasionally for ease of expression we will follow Lewis in talking in the formal mode when the claim is really one in the material mode.

[6] Here's what this means: Consider a true deductive system in which the general claims that represent laws of nature appear as a set of true sentences T that is deductively closed and whose non-logical vocabulary contains only predicates that express occurent properties. There are many ways systems can be axiomatized. If the axioms of T preclude more possibilities than T', then T is *stronger* than T'. Likewise, some true deductive systems can be axiomatized more simply than others, in the sense that they have fewer axioms. The general claims representing the laws of nature will belong to all the axiom systems with a best combination of these two virtues, simplicity and strength.

$R_{o.}$' (Earman 1978: 174).[7] More precisely, where $\mathscr{M}$ denotes the set of all models of the putative law sentences, this may be formulated as the question of whether claims representing the complete and correct set of laws L satisfies the following condition:

> (U) There is no non-empty, proper subregion R_0 of space-time such that for any $M \in \mathscr{M}$, there is an $M' \in \mathscr{M}$ where $M' \vDash L$ and $M'|_{Ro} \approx M|_{Ro}$.

This condition states that L is valid on a model that is not restricted to some spatio-temporal region, that is, L is 'universal'. Given the BSA there is motivation for thinking that the laws of nature should be 'universal'. If the range of the axioms (or theorems) of the best deductive systems were limited to some spatio-temporal region, then one would expect more axioms to summarize the whole history of the world. That is, one would need more axioms to cover all spatio-temporal regions. But if the range of the axioms is not limited, then one can naturally expect fewer axioms to summarize all the particular matters of fact. Furthermore, this will not reduce the system's informativeness, since the axioms now are not restricted to some spatio-temporal region. On the other hand, if nature is fairly unruly outside a given range, adding piecemeal information about what happens there to any set of axioms may increase informativeness at too great a cost to simplicity. So the laws may be limited in extent. Despite the fact that the BSA explains why we might expect the laws of nature to be universal, it seems that Earman is right in saying that there is no *a priori* guarantee that the laws of nature according to the BSA will satisfy (U) (Earman 1978: 180).

Permissiveness. Within its domain, under the BSA, does the correct L (plus relevant initial or boundary conditions) always single out a unique outcome? In order to answer this question one needs to bear in mind the main motivation behind Humeanism about laws. The world is void of modalities – no causings, no necessitatings, no probabilifyings; the world is nothing but a mosaic of occurent events. Laws summarize what happens in this mosaic, rather than 'governing' what the particular matters of fact are.

[7] We use this formulation because readers may be familiar with it. But there is no reason to assume that nature thinks in terms of space-time regions rather than, as in Cartwright's view, in terms of what features obtain. For instance, as we noted, her rendering of boundaries on the range of a theory T is roughly this: Those instances of effect E that T covers are the instances for which some or all of the causes of E fall under concepts available in T.

If L is deterministic, given an appropriate P_0(L,P), L admits only one outcome. But there is nothing in the Humean motivation that makes determinism natural. The best summary may be provided by purely probabilistic laws or by laws that constrain outcomes to a given set but do not choose among them nor lay a probability over them. As Helen Beebee points out (Beebee, 2000: 575) whether the world is best axiomatized under deterministic laws depends on how regular the world is. The world can be modality free and still irregular enough to be summarized best by non-deterministic laws.

Reliability. So as not to muddle together issues of *extent*, *permissiveness*, and *reliability*, let's consider the most difficult case for contingency in the *reliability* sense: where the laws have universal extent and are deterministic, allowing only one output for any relevant input. It looks at first sight as if in this case on the BSA, they must be reliable. There can be no exceptions to the correct laws. We think, however, that there is still some wiggle room and will offer two ways that might be thought sympathetic to the 'Humean' viewpoint that might allow for exceptions, one of which is due to Lewis himself. For the sake of this discussion we propose to adapt Earman's definition of determinism in terms of possible worlds to define deterministic laws because it makes for a ready connection to the Lewis wiggle.

Let $\mathscr{L}$ stand for 'L is the correct set of laws', then define 'deterministic' thus:

> Laws L are *deterministic* iff for any P that L covers and any P_0(L,P) that is 'appropriate' input to L for P and any logically possible worlds *w*, *w'* in which $\mathscr{L}$, if *w* and *w'* agree on P_0(L,P), they agree on whether P obtains.

An interesting way to address the question of the reliability of deterministic laws under the BSA is by considering Scott Sehon's objection (2011) to the standard definition of determinism. First, we start by pointing out that

> **D**: If $\mathscr{L}$ and L is deterministic then for any P that occurs and that L covers and any P_0(L,P) that occurs that is an appropriate boundary/initial condition for P with respect to L, $\Box((P_0(L,P) \,\&\, \mathscr{L}) \supset P)$.

To see why, suppose that L is deterministic and P_0(L,P) is an appropriate boundary/initial condition for P with respect to L and P. Let *W* stand for the collection of all possible worlds. Consider an

arbitrary world *w* in *W* where P_0(L,P) and $\mathcal{L}$. Because L is deterministic, if P obtains in any world where $\mathcal{L}$ and P_0(L,P) obtain, it holds in all worlds where P_0(L,P) and $\mathcal{L}$ obtain, including *w*. P obtains in our (the actual) world where L and P_0(L,P) obtain. So P obtains in *w* and thus (P_0(L,P) & $\mathcal{L}$) ⊃ P in *w*. Since *w* is any arbitrary possible world, □((P_0(L,P) & $\mathcal{L}$) ⊃ P) follows.

Sehon, however, thinks that this is problematic. He argues that L and P_0(L,P) should allow exceptions. Even if the correct laws are deterministic, Sehon claims, it should be logically possible that there is, for example, an interventionist God (IG) that could miraculously change water into wine (Sehon, 2011: 31). As Sehon says, 'necessarily, if an IG exists, then it is possible that the same initial state of affairs obtains, along with the same laws of nature, and yet P is false' – i.e it is possible that P_0(L,P)&$\mathcal{L}$&~P (2011:31). His reasoning can be spelled out as follows (using *IG* to stand for 'There is an interventionist God'):

1.	□(IG⊃◊(P_0(L,P)&$\mathcal{L}$&~P))	Premise
2.	◊IG	Premise
3.	◊(P_0(L,P)&$\mathcal{L}$&~P)	From 1&2, assuming S4
4.	~□((P_0(L,P)&$\mathcal{L}$)⊃P)	From 3

And (4), clearly, is the contradictory of □((P_0(L,P) & $\mathcal{L}$) ⊃ P), which follows from the assumption that L is deterministic.

Note that Sehon's main point does not depend on the premise that an IG is logically possible. One might try to cast Sehon's objection as a call for a domain restriction: L holds everywhere that there is no interventionist God (L holds if ~IG). 'Humeans' might not like this because there is no way that the domain restriction could be brought into the antecedents in the laws of nature since laws are supposed to involve only occurent features, and God's intervening does not seem a good candidate for an occurent feature on any 'Humean' account of 'occurent' we know. That aside, the problem is that determinism would be incompatible, say, with the logical possibility of an interventionist demon, in the sense that, necessarily, if an interventionist demon exists, then it is possible that P_0(L,P)&$\mathcal{L}$&~IG&~P. So, Sehon's main worry is not about the logical possibility of an IG, nor about the logical possibility of a demon in particular. It is about the logical possibility of the laws of

nature being violated.[8] Thus, Sehon urges, exceptions to what L (and $P_0(L,P)$) say should happen should be possible even if determinism is true, precisely because it must be logically possible to violate the laws. And if the BSA does not accommodate that, there must be something wrong with the BSA as an account of laws.

In what follows, we will show how a Lewisian might reply to this argument, showing that the BSA may be consistent with assuming that the correct laws are deterministic and yet can be violated, at least in a sense. The task then is to show that these two propositions are consistent:

p: The correct laws L are deterministic.
q: It is possible to violate (the correct laws) L.

The first strategy is to hedge on *p*, using Lewis's own notion of soft determinism, which is supposed to allow a sense in which agents are able to do things such that, if they were to do them, what L says happens does not happen. (Lewis 1981: 114).

Let us assume the truth of *p* and thus of **D**, so that some statement about the distant past, $P_0(L,P)$, and $\mathcal{A}$ logically imply, for instance, P: 'Agent A did not raise her hand'. What if A had raised her hand? There are three options:

1. If A had raised her hand, contradictions would have been true.
2. If A had raised her hand, $P_0(L,P)$ would be false.
3. If A had raised her hand, $\mathcal{A}$ would be false.

Someone like Lewis will naturally reject option 1. Even if the agent had raised her hand, contradictions would not have been true. Lewis also denies 2. Even if the agent had raised her hand, the past would still be the same, so $P_0(L,P)$ would still be true (Lewis 1979). Thus, if we want to say that the correct set of laws L is deterministic and sometimes we are able to act otherwise, the only option remaining consistent with Lewis's viewpoint is 3. Thus, given $P_0(L,P)$ and **D**, ~P implies $\mathcal{A}$ is false. Yet, we are supposed to be arguing that L are the correct laws. How is that possible? Following Lewis the clue is: correct in what worlds?

[8] A domain restriction in this case seems to make law claims tautological, which they should not be for the Humean: 'As are regularly associated with Bs except when they aren't.'

To see how this works we need to draw a distinction between two senses in which one can violate a law:

> *Weak sense*: An agent is able to do something such that, if she were to do it, a law would be violated, either a law of the actual world or a law of nearest possible worlds.
> *Strong sense*: An agent is able to do something such that, if she were to do it, a law would be violated and this law would be of the actual world.

For example, in the weak sense, if the agent were to have raised her hand (i.e. we assume she did indeed raise her hand in the actual world), contrary to what L says, then L would have been violated before the hand raising. To use Lewis's phrase, a 'divergence miracle' would have happened before that, that is, there would be a violation of the laws of nature that hold at our actual world, and this violation would not be caused by A's action. Note that to say that there is a violation of the laws of nature in the weak sense is not to say that the violated laws are the laws of the same world where they are violated. The term 'miracle' is used to express a relation between different possible worlds. As Lewis says, 'a miracle at w_1, relative to w_0, is a violation at w_1 of the laws of w_0, which are at best the almost-laws of w_1'(Lewis 1979: 469). So with a divergent miracle in our actual world, whose laws are the 'almost' laws of a nearest world where L is not violated, we can violate the correct laws of that nearby world. Or vice versa. Now, if by 'violating a law' we mean the weak sense where what we violate is an 'almost law', not a real law, of our world, then it seems agents may be able to violate laws that are deterministic.

But what if by 'violating the laws of nature' Sehon means the strong sense? The *strong sense* is the one in which the laws that are violated in the actual world are the laws of the actual world. This seems what Sehon has in mind when he says that, if IG, then it is possible that we have the same laws, the same past, and yet P is false. However, if by 'violating a law' Sehon means the strong sense, then someone like Lewis will deny that it is logically possible to violate a law in the strong sense. This is so because, as Lewis says, 'any genuine law is at least an absolutely unbroken regularity' (Lewis 1981: 114). Given the BSA, it is clear why we cannot violate laws in the strong sense. Suppose it is a law that no object moves faster than light. If someone were to throw an object that moves faster than light, then that law would not be true. Since Lewis's 'Humean' laws are true regularities, if it is a fact that a certain stone moves faster than light, then it cannot be a true regularity that no objects travel faster than light.

'Humeans' might however, consistent with the commitment that there are only the occurent facts of which laws are summaries, take a more instrumentalist line. The best summaries may not be required to be true, especially if this brings about a big gain in simplicity. They could admit of exceptions but be right most of the time. Or they could be wrong most all the time yet still very nearly right most, even all, the time. This is like William Wimsatt's view (1992) that laws could be templates that fit widely but in many cases not exactly. Whether admitting false claims as the correct laws is a good idea on the 'Humean' view depends on what the world is really like. Cartwright (1983) has argued that high level laws in physics often get fitted to the real details of real situations only by adding *ad hoc* corrections. That could be because we have just missed out on the factors that support those corrections and that bring the situation genuinely under the laws. But it could be that that is just what the world is like. There is no single uniform pattern but only a template which fits widely but not very exactly. If the latter is the case, the BSA can be maintained while allowing contingency in the *reliability* sense, so long as the demand is given up that the best summary of the facts be true.[9]

Potency. Do the things that L speaks about happen on account of L? Or, for instance, merely in accord with L? Perhaps this is the least problematic question to answer according to the BSA. Clearly, the things that L speaks about happen merely *in accord* with L.

Free will. The question whether the 'Humean' account of laws plus assumption **D**, which follows from the hypothesis that the correct laws are deterministic, is compatible with the possibility of agents doing other than what they do, can be introduced in the context of the currently central argument for incompatibilism,[10] namely the *consequence argument*.[11] One of the crucial premises of the consequence argument is that the laws of nature are not up to anyone. The modal formulation makes use of a modal sentential operator '■' in which '■P' abbreviates 'P and no one has or ever had any choice about whether P'. '■' is supposed to satisfy these two inference rules:

(α) $\Box P \vdash \blacksquare P$

(β) $\blacksquare(P \supset Q), \blacksquare P \vdash \blacksquare Q$

[9] Here it is easy to make things look simpler than they are by blurring use/mention distinctions. If laws are 'false' but 'nearly true' then the laws will not be facts as we first claimed for BSA but rather only very similar to facts.
[10] Incompatibilism here understood is the view that if determinism is true, there's no free will.
[11] Cf. Carl Ginet (1983) and Peter van Inwagen (1983). The Consequence Argument is so-called because it relies on the *consequences* of the laws of nature and the past in order to establish incompatibilism.

Here is the consequence argument, supposing that L are the correct laws, the correct laws are true, P is something that happens and P_0(L,P) is the relevant feature to fix P given L:

1. □ ((P_0(L,P) & $\mathcal{L}$) ⊃ *P*) from determinism
2. □ (P_0(L,P) ⊃ ($\mathcal{L}$ ⊃ *P*)) from 1
3. ■ (P_0(L,P) ⊃ ($\mathcal{L}$ ⊃*P*)) from 2 and rule (α)
4. ■P_0(L,P) premise, fixity of past
5. ■($\mathcal{L}$ ⊃ *P*) from 3, 4 and rule (β)
6. ■$\mathcal{L}$ premise, fixity of laws of nature
7. ■*P* from 5, 6, and rule (β)

Is premise (6) true? One might interpret the '■' operator in a more precise way as follows (Pruss, 2013):

(■-*def.*): ■P if and only if P & ~∃ x ∃ α [Can(x, α) & (Does (x, α) □→ ~P)]

where '□→' stands for the counterfactual conditional, x ranges over agents, and α ranges over all past, present and future action types.

The idea is that there is nothing that anyone can do such that if they were to do it P would be false. Now, is '■$\mathcal{L}$' true according to this interpretation? As the interpretation above makes explicit use of a counterfactual conditional, and since we are interested in seeing how the 'Humean' might answer this question, the natural way to proceed is to use an account of counterfactuals that is in line with the BSA. So we will presuppose Lewis's own semantics. At a first approximation, let us say that

(C-L): A □→ B is (non-vacuously) true in a world *w* iff B is true in all the worlds in which A is true that are closest to *w*.

Given ***(***■-*def.***)**, if '■$\mathcal{L}$' is false, then some agent *s* is able to perform an action *a* such that, if *s* were to perform *a*, then $\mathcal{L}$ would be false. To put it in a different way, is $\mathcal{L}$ true in all the closest worlds in which P: Agent *s* does action *a*? Suppose ~P, that *s* does not perform *a* in the actual world w_0. Now, suppose worlds in which *s* performs *a* have the same laws as the actual w_0 and these laws are deterministic. Can we consider these worlds to be the closest relative to w_0 among the worlds where s performs a? Since worlds in which *s* performs *a* do not agree on P they cannot agree on any

P_0(L,P) that with L determines P nor on any R(L,P_0(L,P)) that with L determines P_0(L,P), and so forth. Now L – the set of complete and correct laws of our world – may be very limited in extent. Perhaps they only cover P, in which case the only fact besides P on which these worlds disagree with the actual is P_0(L,P). But this won't work if they are to account in the way we usually expect for the amount of order we see in the world. For instance, what about all the knock-on effects from all the initial or boundary conditions that are related under L to P? And the knock-on effects of the Rs that need to be different when all the laws in L are deterministic to ensure the P_0s are? When so much divergence from the actual world, w_0, occurs in these worlds, can these worlds be the closest worlds relative to w_0 in which *s* does *a*? Following Lewis's own manoeuvres in cases like this, the better option, it seems, is to regard as 'closest' those worlds that are just like w_0 up to about the time that *s* performs *a*, and then diverge by a divergence miracle. Therefore, the closest worlds in which *s* performs *a* are not worlds in which the same laws L obtain. Therefore, the 'Humean' who follows Lewis has motivation for considering '■$\mathcal{L}$' false and, consequently, for rejecting premise 6 of the consequence argument.

3. Laws as relations among universals

Fred Dretske (1977), Michael Tooley (1987), and David Armstrong (1983) developed a rival approach to the BSA. In what follows our presentation will focus on Armstrong's view. Laws of nature, according to Armstrong, are necessary relations among first-order universals. The ontological component of a law according to the BSA is a regularity; on Armstrong's view, it is a second-order relation between first-order universals. Suppose that all F's are G's and that the laws of nature ensure this. F-ness and G-ness are taken to be first-order universals. Armstrong states that a second-order contingent relation holds between these two universals. He labels this relation as 'nomic necessitation' and he uses '*N*' to refer to it. Armstrong symbolizes the relation of necessitation between F and G as '*N*(F,G)'. He also claims that the holding of *N* entails the corresponding generalization. So, the second order-relation *N* between the first order universals F and G, 'N(F,G)', entails 'All F's are G's'.

On the traditional Armstrong/Tooley/Dretske view it seems that laws are *reliable* - what they say goes, goes. At least this is the case under the assumption at the core of the view[12] that the relations that obtain between universals make true the corresponding relations between instantiations of those universals in the real world; what happens in the empirical world depends on and must be in accord with what relations hold among universals. This also ensures that laws are powerful -- things happen because they say so. So *potency* is assured as well.

[12] Though it has frequently been objected that it is hard to see how this assumption could be true (van Fraassen, 1989).

On *extent*, perhaps the issue is more open. Individual advocates may argue that laws govern all that happens. But that seems to be an add-on to the two assumptions that seem central to the account that, first, laws are relations between universals, and second, any instances of universals that figure in the laws must reflect in the appropriate way the relations among those universals. These do not by themselves imply that every feature that occurs in the world instances a universal that has such relations to others and hence the two do not seem to imply that everything that happens is in the purview of laws of nature. Even if one supposes that it makes no sense to think of features that do not fall under universals, there is still the issue of whether the associated universals all participate in the kinds of relations to one another that make for laws of nature.

Permissiveness may also be more open on the laws-as-relations-among-universals view than it seems at first sight. For there may be more relations among universals than just the one – labelled '*N*' – that is the truth maker for the necessitation aspect of law claims. Some universals may be taller or more beautiful than others, which may be irrelevant to what happens in the world when these universals are instantiated. Even among world-guiding relations, necessitation may not be all there is. After all, the view presumably does not want to rule out that a probabilistic theory like quantum mechanics can be correct.

One way to allow for this is to keep only *N* and then suppose that the universal represented by the quantum state is *N*-related to a universal that we represent by a probability measure. Instantiation of this last seems troublesome though; moreover probability itself, as van Fraassen 1980 argues, may best be seen as a modal notion. So, in keeping with the view that modalities reflect facts about universals and their relations, another idea for how to handle probabilistic laws is to assume there is another kind of modality beyond that responsible for necessity: 'probabilifies', with various ways to develop this idea further. Key though is that if the universal corresponding to A probabilifies the universal corresponding to quantity Q in accord with Prob (Q = q), then instances of A will be associated with instances of values of Q in a pattern reflecting Prob (Q = q).

This leads readily to admitting *permissiveness* of the kind we see in the capacities account of laws. Once more world-guiding relations are admitted than *N*, there seems no good reason to suppose that an even weaker modal notion than 'probabilifies' may obtain, one that constrains the values Q may take when A is instantiated to a given set but which dictates no particular pattern to them. One or another in the set must be instantiated but which on any occasion is mere hap, with not even a nice probability-looking pattern to emerge in the long run.

This may, at first sight, seem counter to the universals account of laws. After all, wasn't the point to find some location for necessity? We think not. The point is to find a location for *modality*. Universals are introduced in order to enable laws to do a number of jobs. They are supposed to support counterfactuals, to explain why things happen in the orderly way they do, to justify our inductive practices. All this may require modality but other modalities than necessity can do the jobs required. How is it on this view that the laws of nature *explain* that All Fs are Gs and justify our inductive practice of predicting that the next F we encounter will be G on the basis of past observations that Fs are Gs? It is because the universal associated with F is N-related to that associated with G. But it is not the N-ness of the relation that matters; it is rather the two-fold fact that this relation holds between the universals in Platonic heaven, and whatever world-guiding relations occur in Platonic heaven must be reflected in the behavior of their instances in the empirical world. Other kinds of patterns in the world could then be equally explained and supported by other relations between universals, for instance 'F probabilifies Q=q to degree p', where the p values for Qs satisfy the probability calculus; or 'F φ-necessitates Q', which is reflected in the fact that Fs are always followed by some value or other of Q in φ.

4a. Dispositions, a la Alexander Bird

So far we have mainly focused on Lewis's and Armstrong's accounts. Although they can both be seen as figureheads for rival camps concerning the laws of nature, Alexander Bird (2005, 2007) interestingly notes that the accounts have two theses in common: they both take (i) laws of nature to be metaphysically contingent, and they both take (ii) properties to be categorical. Dispositional essentialism (DE) has emerged as an account of laws that explicitly rejects these two assumptions. First, according DE, the laws of nature are metaphysically necessary, for reasons that we will see soon (though we shall have very little to say about what is supposed to be meant by 'metaphysically necessary'). Second, DE takes at least some – maybe all – natural properties to be essentially dispositional. We will briefly discuss in this Section Alexander Bird's version of DE for a concrete illustration. Similar results with respect to contingency hold for many other versions, making appropriate adjustments.

First, Bird adopts the conditional analysis of dispositions (CA). Where *D* is a dispositional property, *S(D)* is a stimulus property appropriate to it and *M(D)* is its manifestation property, (CA) may be symbolized as follows:

(CA) $Dx \leftrightarrow (S(D)x \; \Box\!\!\rightarrow M(D)x)$.

As Bird points out, (CA) does not merely provide an analysis of the concept *D;* instead, it characterizes the *nature* of the property D. Thus, as Bird says, (CA) is metaphysically necessary:

$(CA_{\Box})$ $\Box_M(Dx \leftrightarrow (S(D)x \ \Box\!\!\rightarrow M(D)x))$.

Second, DE endorses the view that at least some fundamental properties are essentially dispositional. To say that a property *P* is essentially dispositional is to say that, necessarily – in the metaphysical sense – to instantiate *P* is to possess a disposition D(P) to yield the appropriate manifestation in response to an appropriate stimulus:

(DE_P) $\Box_M(Px \rightarrow D(P)x)$

Laws, for Bird, are metaphysically necessary regularities that supervene on dispositions.[13] They are metaphysically necessary in virtue of the conditional analysis of dispositions[14] and the thesis that at least some natural properties have dispositional essences. Here's how to see that:

1. $\Box_M(P(D)x \rightarrow (S(D)x \ \Box\!\!\rightarrow M(D)x))$	from $CA_{\Box}$ and DE_P
2. $P(D)x$ & $S(D)x$	assumption
3. $M(D)x$	from 1 and 2
4. $(P(D)x$ & $S(D)x) \rightarrow Mx$	from 2-3

Since one can generalize over the unbound variable *x*, we get from 4

5. $\forall x\ ((P(D)x\ \&\ S(D)x) \rightarrow M(D)x)$.

Hence, a universal generalization follows from $(CA_{\Box})$ and (DE_P). Furthermore, since both $(CA_{\Box})$ and (DE_P) are metaphysically necessary, this generalization is metaphysically necessary as well. It looks then as if any laws underwritten by dispositional properties will be totally *reliable*, and on Bird's view it seems that these are all the laws there.

The problem with this, though, is that (CA) is often false, Bird notes, because of the existence of *finkish* dispositions and antidotes.[15] However, he argues, rather than being a disadvantage for dispositionalism, this is one of its virtues, since the falsity of (CA) allows the dispositionalist to account for *ceteris paribus* laws. We can just replace the left-to-right implication of (CA) by

[13] Presumably it is not out of keeping with the basic motivations of DE to take them to be rather facts about the dispositions themselves, as in the capacities account described in the next Section.

[14] Bird takes the conditional analysis as a necessary equivalence.

[15] "An object's disposition is finkish when the object loses the disposition after the occurrence of the stimulus but before the manifestation can occur and in such a way that consequently that manifestation does not occur" (Bird, 2007: 25). See also Martin (1994) and Lewis (1997). Bird also points out that one cannot eliminate all counterexamples to (CA→) by excluding finks (Bird, 2007: 27). "Let object *x* possess disposition $D_{(S,M)}$. At a time *t* it receives stimulus S and so in the normal course of things, at some later time *t'*, *x* manifests M" (Bird, 2007: 27). An antidote or mask to $D_{(S,M)}$ is something that "has the effect of breaking the causal chain leading to M, so that M does not in fact occur" (Bird, 2007: 27) when applied before *t'*. See Bird (1998).

(CA→ *) Dx → (S(D)x & *finks and antidotes to D are absent* □→ M(D)x).

Now we deduce the following regularity:

∀x (*finks and antidotes to D are absent* → ((*Dx & S(D)x*) → *M(D)x*)).

This is how the dispositionalist can account for *ceteris paribus* laws – supposing that in all correct *ceteris paribus* laws, the conditions that are referred to in the *ceteris paribus* clause genuinely are either finks or antidotes to the disposition referred to. Conditioning on the absence of finks and antidotes gets built right into the laws themselves. *Reliability*, it seems is thus restored, at least for *ceteris paribus* laws where all that is missing to render the *ceteris paribus* clause explicit is reference to finks or antidotes. Moreover, Bird also argues that there is a fundamental level of laws where no finks occur and where antidotes are very unlikely (Bird, 2007: 63). In that case, as above, *reliability* is assured by (CA), as already noted.

What then about *permissiveness*? It seems that where they speak – which seems to be whenever a dispositional property obtains and there are no finks or antidotes to it – DE laws allow only one outcome, the manifestation associated with that disposition. So DE laws seem impermissive. On the other hand, there seems to be nothing in the basic motivations for this account that implies that the manifestation must be limited to a single choice rather than a set of choices, with or without a probability over them. So impermissivenes seems an add-on for DE laws, just as it is for laws when taken as relations among universals or on the BSA.

Extent too seems to fare just the same as in the other two accounts so far surveyed, except perhaps limitations on extent are to be expected here, at least so far as the basics we have presented go. The issue is whether everything that happens is a manifestation of (some combination of) essentialist dispositions. Two ways they may not be are immediately evident. First, if not all properties are DE properties then DE laws that supervene on DE properties and their associated dispositions will not cover them[16]. Second, DE laws derived above are, as remarked, *ceteris paribus* laws, which cover only situations where no finks and antidotes obtain. What happens when these do? Or – more to the point, will finks and antidotes always be constituted by essentialist dispositional properties so that what happens when they obtain is then covered by the universal generalization that supervenes on the dispositions associated to those? If not, then DE laws won't cover everything that happens. So DE laws may well be limited in extent.

Recall though that Bird maintains that there is a level of fundamental dispositional properties that are not subject to finks and are seldom subject to antidotes. Does this imply that the correct set of laws covers all that happens? Supposing we substitute 'never' for 'seldom', the answer is 'yes', *if* a kind of total reductionism holds in which everything ultimately is covered by laws deriving from fundamental dispositional properties. But this kind of reductionism does not seem to follow from the basic motivating ideas of a DE account of laws. As with many of the other assumptions we have discussed, it is just an add-on.

[16] Some proponents of DE might, however, hold a mixed view according to which some fundamental properties are essentially dispositional and others are categorical, and so a DE law could connect a disposition with a categorical property. As a result, *extent* may be retained since laws won't supervene only on DE properties. Thanks to the editors for pointing this out.

The real issue for extent then depends on two things. First, are all properties, including those that feature in finks and antidotes, essentially dispositional? And second, are all complexes of properties – like: 'P(D) and the properties that characterize antidote A to P(D) and fink F to P(D)' – themselves essentially dispositional properties and hence properties that give rise to laws that can cover every case? Suppose the answer to both is 'yes'. Is that an add-on or rather a central part of the DE view? The answer here seems less clear than in many of the other cases we have considered and we won't take a view. But if the answer is yes and this is not deemed an add-on, then DE laws will be, by their nature, universal in extent.

What about *reliability*? Again let's look at what seems to be the hardest case – where the laws are deterministic, which is where much of the current philosophy of religion and metaphysics literature focuses. As we saw before, if the correct laws L are deterministic, then $\Box((P_0(L,P) \,\&\, \mathit{I}) \rightarrow P)$.

This is true also for Bird's account. But the main difference between Bird's view and the BSA is how they reply to Sehon's objection. If Sehon is right, then determinism should be compatible with 'IG' being logically possible. However, it should be noted that, in Sehon's argument, he reads boxes and diamonds as logical necessity and possibility. Thus, his reasoning is only relevant if the box of $\Box((P_0(L,P) \,\&\, \mathit{I}) \rightarrow P)$ is read as logical necessity. It will be clearer if we present his reasoning again. Let '$\Box_L$' and '$\Diamond_L$' respectively stand for logical necessity and possibility.

1.	$\Box_L(IG \supset \Diamond(P_0(L,P) \,\&\, \mathit{I} \,\&\, \sim P))$	Premise
2.	$\Diamond_L IG$	Premise
3.	$\Diamond_L(P_0(L,P) \,\&\, \mathit{I} \,\&\, \sim P)$	From 1&2, assuming S4
4.	$\sim\Box_L((P_0(L,P) \,\&\, \mathit{I}) \supset P)$	From 3

As we can see, 4 implies the contradictory of $\Box((P_0(L,P) \,\&\, \mathit{I}) \rightarrow P)$ if the box is read as logical necessity.

Now, if we take the initial or boundary conditions that feed into laws to be facts about the past, which is one typical choice for them, then Helen Beebee can help us think about the issue of logical necessity for 'Humean' views:

> For the Humean, the laws and the current facts determine the future facts in a *purely logical* way [our emphasis]: you can *deduce* future facts from current facts plus the laws. And this is just because *laws* are, in part, facts about the future' (Beebee 2000: 578).

So, if the BSA is correct, then it should follow from determinism that $\Box_L((P_0(L,P) \,\&\, \mathit{I}) \rightarrow P)$, as indeed it does under the definition we adopted in Section 2. That is, according to the BSA, determinism is incompatible with 'IG' being logically possible *as possibility is characterized* by Sehon.

On the other hand, if DE is correct, then it seems that determinism could be compatible with 'IG' being logically possible even *as characterized* by Sehon. This is so because the dispositionalist needs only one genuine notion of necessity that applies to issues about what happens in the world, which is metaphysical necessity (Bird 2007: 48). And metaphysical necessity is distinct from logical necessity. As a result, the box of $\Box((P_0(L,P) \,\&\, \measuredangle) \rightarrow P)$ should be read as metaphysical necessity. Let '$\Box_M$' stand for metaphysical necessity. Now it is clear that

(L) $\sim\Box_L((P_0(L,P) \,\&\, \measuredangle) \rightarrow P)$
and
(M) $\Box_M((P_0(L,P) \,\&\, \measuredangle) \rightarrow P)$

are not *explicitly* contradictory. Someone might argue that (L) and (M) are implicitly contradictory. If logical possibility entails metaphysical possibility, then one gets the contradictory of (M); and then (L) and (M) are implicitly contradictory. Nevertheless, the dispositionalist has no motivation for accepting the premise that logical possibility entails metaphysical possibility. One might argue that we should expect a clear explanation of what metaphysical necessity is, since Bird's account relies on it. This might be correct. However, it is not our aim in this paper to defend Bird's view but rather to show the consequences of his view for our discussion.

How though could DE reject the 'logically necessary' reading of the box in $((P_0(L,P) \,\&\, \measuredangle) \rightarrow P)$ since we argued in Section 2 that that reading follows from the definition of determinism we adopt, which is not an unconventional one? It seems the trick would be to revise the definition of determinism so that it doesn't involve logical necessity either but only metaphysical necessity, thus:

> Laws L are *DE-deterministic* iff for any P that L covers and any $P_0(L,P)$ that is 'appropriate' input to L for P and any metaphysically possible worlds w, w' in which L, if w and w' agree on $P_0(L,P)$, they agree on whether P obtains.

This may indeed be a reasonable move for the DE advocate to make given the view that the only modalities that should play a role in these discussions about nature and its laws and possibilities are metaphysical ones.

The second point concerns the question of *free will*. Lewis's view gives motivation for rejecting one of the premises of the consequence argument, namely, the premise that the laws of nature are not up to anyone since laws of nature supervene on the facts and some facts may be up to agents. On the other hand, it seems that those sympathetic to DE should accept this premise because they should, it seems, accept not only rule alpha but the rule α':

(α') $\Box_M P \vdash \blacksquare P$

To see why, for DE, the laws of nature are not up to us then, remember that for the dispositionalist the laws of nature are metaphysically necessary. Consequently, L is also metaphysically necessary. That is,

1. $\Box_M L$

Given rule α', from 1 we can derive

2. ■L.

So, it does not really matter in this case how we interpret '■'. If rule α' is valid, then proponents of DE should accept the premise that the laws of nature are not up to us.

4. Cartwright and Pemberton on capacities and arrangements

Following the language of Cartwright (1989), we call the kinds of powers that Cartwright and Pemberton defend 'capacities'. They do not use the term 'manifestation' since it would be ambiguous in their ontology. Capacities have a canonical way of acting, which is to be distinguished from what happens when they act. For each capacity, there is a prescribed set of ways in which it can act. When the capacity 'gravity' acts, it pulls, no matter what happens to the object on which it pulls. What actually happens depends on what other powers gravity cooperates with in the circumstances and what the arrangements are. When the arrangements are right, the activities of the powers give rise to regular behaviors, as in the orbits of the planets around the sun, or the browning of bread in a toaster, or the expulsion of magnetic fields in a superconductor. These kinds of arrangements are what Cartwright (1989) called 'nomological machines' and more recently are commonly called 'mechanisms'. Whether there are contingencies in nature then depends on whether all arrangements that occur in nature are like nomological machines or mechanisms, where it has been supposed that a single kind of behavior is fixed, or whether the outcomes can sometimes be open, and if so, how this is possible on a capacities account of laws.

To begin with, we must be careful how we think of activities. The conditional account of dispositions and powers has it that for each disposition D there is a (possibly empty) set of stimuli S(D) and an outcome M(D) such that D obtains just in case if some s(D) ϵ S(D) occurs, then M(D), where *s* and *M* represent occurent features. Still in the grip of this account, we can slip into thinking of the activity as an occurent feature like s(D) and M(D). This makes for puzzles when powers act in consort. The outcomes of each power separately then seem to be pictured as 'really there' as outcomes, though it seems they are often invisible. The visible, or occurent, outcome is the result of the powers acting jointly.

The model here is bricks in a wall. Each brick is really there and so too is the wall. Some real cases can be fitted into this model, for instance where the outcomes can be represented with numbers that simply add up. We have the power to put $10 into the piggybank and you do too.

When we all act, the total outcome is $20 sitting there in the piggybank, $20 that is genuinely made up of our $10 and your $10. Perhaps it is not even too much of a stretch to fit forces into this model. When the gravitational capacity associated with mass M acts, it produces a force $GMm/\mathbf{r}^2$ on another mass m located **r** from it; the Coulombic capacity associated with charge Q produces a force $\epsilon Qq/\mathbf{r}^2$ on a charge q located **r** from it. When both act together, they add vectorially. Perhaps we could without too much stretch say that all three forces are really there and in the same sense, as with the bricks and the wall.

But, as Cartwright has argued (2007), this is a poor model for other capacities acting in consort, like the capacities associated with parts of a circuit – conductors, resistors, impedances – producing a total current. Nature may assign each capacity its own role, a role that it has qua the capacity that it is; and nature may fix what happens when capacities act in consort in given circumstances. But nature need not do this via a simple model where each capacity separately produces its own canonical effect and what results overall just is all these separate effects piled up together.

It is because they want to avoid any suggestion of this picture that Cartwright and Pemberton abandoned their former language of capacities, contributions, and rules of combination that determine outcomes in favor of capacities, exercisings or actings, and outcomes, following Peter Machamer, Lindley Darden, and Carl Craver's emphasis on activities (2000). A capacity acts in a canonical way, which is represented in various different ways in scientific theories in different domains, and when capacities act in consort in a particular arrangement, an outcome occurs. For Cartwright-Pemberton capacities, there is indeed a difference between the obtaining of a power and its exercise, as there should be, in defense against Hume who couldn't these two distinct things in his ontology. But that does not make the exercising yet another occurent feature of the same kind as the resultant outcome.

There is a second good reason for avoiding the language of contributions and how they combine. That makes it sound as if the capacity could act outside of any situation and the contribution is just what happens then. But capacities always act in some situation of other. We must not confuse the abstract description we give of a capacity, which allows us to figure out what will happen in various real situations, with a description of what it does in some strange situation-less Platonic heaven. Perhaps we are sometimes led into this conflation by our conceptual model of the ideal experiment in which the capacity acts 'entirely on its own', from which we sometimes

read some canonical expression that we then use in making predictions about other circumstances, in accord with rules we have worked out about how to do this. But it is important to keep in mind that these idealized models picture concrete arrangements located in space and time, albeit ones that might never really occur.

We emphasize this to underline the lesson that Pemberton stresses (2013): Arrangements matter. We may imagine two masses, M and m, located close together, m at **r** away from M, far away from anything else and also devoid of any other features, like charge, that are associated with a capacity to produce forces. Mass m would then experience a force very near to $GMm/\mathbf{r}^2$, which is just the canonical description we give of the capacity of gravitational attraction in order to compute by our rule of vector addition the force exerted on a massive object in more complex arrangements. That however is an arrangement, albeit one very special one that we have discovered gives us a convenient way to represent the capacity of gravity for use in studying other arrangements. It takes a combination of a capacity with its peculiar nature (that in the case of gravitational attraction we represent by $GMm/\mathbf{r}^2$) *and* a given arrangement (like two objects both charged and massive being located close together and far away from all other objects) to fix what happens. This becomes important when we try to identify sources of contingency.

What kinds of general facts are there that might get labelled 'laws of nature' on a capacities account? Three, it seems. First, what the nature of a power is. It is in the nature of the power of gravity to attract with a fixed strength. We represent this with the concept 'the force of gravity' and represent the strength of gravity associated with a body of mass M on m located **r** away by $GM/\mathbf{r}^2$. Second, depending on one's metaphysics of properties, laws should include facts either about what powers co-occur or what properties bring with them what powers. For example, mass brings the power of gravity with it; or, if properties are just to be collections of powers, we could label as a law of nature the general fact that the power to attract gravitationally comes with the power to resist acceleration by a force. Third, laws should include general facts about what happens when powers act, either singly or in consort, in various arrangements. For instance (supposing that resultant forces and not just motions are really there), when the power of gravity vested in M acts in a situation where m is located **r** away and no other sources of force on m are present, then M exerts a force $GMm/\mathbf{r}^2$ on m. Or, in a situation where two powers we represent as forces act together on a body at a given point, then the body experiences at that point a force which is given by the vector sum of the canonical representations of the two powers.

With this in hand, we can look to sources of contingency. Begin with *permissiveness***.** On a capacity account of laws, *permissiveness* can arise along three axes: in the nature of the capacities themselves; in the rules of combination when capacities act together; and in the effects of arrangement on what happens, though the last two will merge except in special cases.

The nature of a capacity. We can think of capacities as having three different possible modes of acting. First, there is one and only one mode of action for the capacity. No *permissiveness* here. Second, there is a set of available ways of acting and a probability over these. The capacity must act in accord with these probabilities. Versions of the propensity theory of quantum probabilities fit here. Third, the capacity may have an available set of modes of acting but no constraints on how often it acts in which ways even in the long run. Both these last two can lead to contingency about what happens when the capacity acts in specific arrangements.

Rules of combination. The familiar rule of vector addition fixes a single force that results in arrangements where two sources of force act together. But we can imagine *permissive* rules that allow a range of outcomes, either with or without a probability over them. Then what results would be contingent in the *permissiveness* sense.

The effects of the arrangement. Of course the effects of the arrangement are already there in the rules of combination. But we hive this off as a different source of contingency to deal with cases where the rules of combination do not cover all aspects of a situation that are relevant to what happens. We are thinking here of cases where experience shows that a given arrangement gives rise to some constraints or other on joint outcomes but there are no known rules of combination to explain this.[17] There is a general tendency in cases like this to think that the description of the situation is not detailed enough; when the details are filled in appropriately, there will be a general rule of combination to cover the case. That may – or may not – be so. The point is that there is nothing in the very notion of laws as facts about capacities and how they act in arrangements that precludes this source of contingency.

Consider *extent* next. One may argue, as some do, that there is nothing but powers and their activities, in which case everything that happens must be the result of this. But just as with the other

[17] One might argue that where outcomes are constrained, there must be a rule of combination, albeit a very local one. That's fine. We include this as a separate category to ensure attention is not focused entirely on well-established general rules of combination.

views of laws, this is an add-on to the basic account of what laws are for a capacities account and probably for most other powers accounts. Nothing about powers in themselves says they must rule everywhere and everything.

As to *reliability*, the situation seems different. There seems no space in the capacity account to allow that things could happen within the domain of laws about capacities and about their joint outcomes that the powers-cum-arrangements do not allow. There seems to be no wiggle room on this account to allow that the laws of nature (which recall are about the natures of powers, what properties correlate with them, and how they are to act in various arrangements) could be as they are and yet for something about which they speak to occur contrary to what they say. Or at least we have not identified any such wiggle room.

Free will. This does not imply however that agents could not have acted otherwise than as they did. After all, the laws could be *permissive*. Or the actions of agents could be outside their domain. If though we insist on the analogue of determinism and universal domain for capacities, then it seems that on a capacities account an agent could not, consistent with those being the correct laws, have done otherwise than what she did do.

There is though an intermediate position even here. The laws for agents could be *permissive* consistent with those for non-agents being *impermissive* so long as only non-agents are involved. In that case, when agents and non-agents act together in certain arrangements, multiple outcomes could be available, including both, for example, that the agent raises her hand and that she does not. There will of course be trouble for this last alternative if it turns out that agents are just special arrangements of non-agents.

5. Conclusion and an observation

The observation is about our discussion of *free will*. For many, what we have discussed under this label is not only very cursory but also has little, even nothing, to do with free will because we have not touched on the 'will' part. Perhaps an agent could do differently from what she does but (and now the very form of this question itself is part of the serious enquiry) something like: 'Can she do so because she wills it?' Or, 'Can she cause it to happen?' After all, establishing that A's actions could have been otherwise is a long way from showing that A is the author of her actions. Conversely, one venerable Christian tradition (Augustine, 1993) along with some modern

libertarian thought (Frankfurt 1969 and Mawson 2011) argues that being the author of one's actions does not imply that one could have done otherwise. Perhaps authorship is where attention should be in the contemporary debate anyway and not, as much seems to be, on the compatibility of free will with determinism since it has been a long time since our best science has supposed that the laws of nature are all deterministic.

At least we hope to have clarified that even if laws govern and in some sense 'make things happen,' there is nothing in the very nature of law in any of the senses surveyed that implies that things couldn't happen other than the way they do consistent with the laws staying the same, nor even that probabilities need be fixed. Laws may be universal in *extent* and yet totally *impermissive*, and one may – or may not – have good independent arguments for these add-ons; but in all senses of 'laws' surveyed that is just what these are: add-ons.

Conclusion: There are two surprises from this work, counter to our starting hypotheses. First, there are a number of different forms of contingency that are worth distinguishing and, contrary to initial expectations, contingency is no more readily admissible in any of these senses on a capacities (i.e. Cartwright and Pemberton powers) account of laws than on those that take laws as strong unifying regularities (BSA), as relations among universals, or as facts about dispositions of the Alexander Bird style (or as the metaphysically necessary facts about regularities that follow from these). All these equally can, but need not, allow laws to be both *permissive* and limited in *extent*.

The second surprise is *reliability*. We use this label to pick out a view easy to say in plain English but hard to make precise, that the laws of nature may remain the laws they are, the correct laws, and yet be 'violated' or broken in their own domain. Violation – *unreliability* in our terms – fares badly on all accounts, except surprisingly, a David-Lewis style best systems account, supposing we are willing to make an adjustment either to the notion of violation or to the BSA itself, where the adjustments rely heavily on a notion of 'almost true'. Under the soft determinism wiggle, though it is dressed up in the possibly impressive-looking quasi-formal language of possible worlds, the final verdict is that the correct laws are never violated in the strong sense. If something seemingly untoward happens (e.g. God intervenes), this can be a violation of some 'almost true' laws that prohibit it but not of the correct laws. The laws-as-templates wiggle gives up on the precise truth of the correct law claims: the regular associations that constitute the laws do not really hold; they only 'almost' hold.

This is surprising in the context of much current discussion of 'compatibilism' in metaphysics– Is an interventionist God/free will compatible with deterministic law? – which seems to suppose the BSA. If we are right that *reliability* is unavoidable on the other accounts but could perhaps fail on the BSA, then this literature is focused on the easiest case for avoiding reliability.

6. References

Armstrong, David, 1983, *What is a Law of Nature?*, Cambridge, Cambridge University Press.

Augustine, 1993, *On the Free Choice of the Will,* tr. Thomas Williams, Indianapolis: Hackett Publishing.

Beebee, Helen, 2000, "The Nongoverning Conception of Laws of Nature," *Philosophy and Phenomenological Research* 61: 571–594.

Bird, Alexander, 1998, "Dispositions and Antidotes," *Philosophical Quarterly* 48: 227-34.

Bird, Alexander, 2005, "The dispositionalist conception of laws," *Foundations of Science* 10: 353-370.

Bird, Alexander. 2007, *Nature's Metaphysics: Laws and Properties,* Oxford: Oxford University Press.

Cartwright, Nancy, 1983, *How the Laws of Physics Lie,* Oxford: Clarendon Press.

Cartwright, Nancy, 1989, *Nature's Capacity and Their Measurement,* Oxford: Clarendon Press.

Cartwright, Nancy, 2000, "Against the Completability of Science" in *The Proper Ambition of Science*. Eds. J. Wolff, M.W.F. Stone. New York: Routledge.

Cartwright, Nancy, 2009, "Causal laws, policy predictions and the need for genuine powers", in *Dispositions and Causes.* Ed T. Handfield. Oxford: Oxford University Press.

Cartwright, Nancy, 2010, "Natural Laws and the Closure of Physics" in *Visions of Discovery. New Light on Physics, Cosmology and Consciousness* ed. Chiao, R.Y., Leggett, A.J., Cohen, M.L., Cohen, M.L. & Harper, C.L. Cambridge: Cambridge University Press: 612-622.

Cartwright, Nancy & Pemberton, John, 2013, "Aristotelian Powers: Without Them, What Would Modern Science Do?," in *Powers and Capacities in Philosophy: The New Aristotelianism,* Greco, J. & Gross, R, New York: Routledge: 93-112.

Cartwright, Nancy & Ward, Keith ed., forthcoming, *Rethinking Order: After the Laws of Nature*, London: Bloomsbury.

Cohen, Jonathan & Callender, Craig, 2009, "A better best system account of lawhood," *Philosophical Studies* 145: 1-34.

Dretske, Fred I., 1977, "Laws of Nature," *Philosophy of Science* 44 (2): 248-268.

Earman, John, 1978, "The universality of laws," *Philosophy of Science* 45 (2): 173-181.

Frankfurt, Harry G, 1969. “Alternate Possibilities and Moral Responsibility,” *Journal of Philosophy* 66: 828–39.

Ginet, Carl, 1983, “In defence of incompatibilism,” *Philosophical Studies* 44: 391-400.

Lewis, David, 1973, *Counterfactuals*, Cambridge: Harvard University Press.

Lewis, David, 1979, “Counterfactual Dependence and Time's Arrow,” *Noûs* 13: 455–76.

Lewis, David, 1981, “Are We Free to Break the Laws?,” *Theoria*, 47: 113–21.

Lewis, David, 1983, “New Work for a Theory of Universals,” *Australasian Journal of Philosophy* 61: 343–377.

Lewis, David, 1997, “Finkish Dispositions,” *Philosophical Quarterly* 47: 143–158.

Machamer, Peter, Darden Lindley and Craver, Carl F., 2000, “Thinking about Mechanisms,” *Philosophy of Science* 67 (1): 1-25.

Martin, Charlie B., 1994, “Dispositions and conditionals,” *Philosophical Quarterly* 44: 1-8.

Mawson, Tim J, 2011, *Free Will: A Guide for the Perplexed*, New York: Continuum Press.

Pruss, Alexander, 2013, “Incompatibilism Proved,” *Canadian Journal of Philosophy* 43 (4): 430-437.

Ramsey, Frank, 1978, *Foundations*, London: Routledge and Kegan Paul.

Reichenbach, Hans, 1947, *Elements of Symbolic Logic*, New York: the Macmillan Company.

Sehon, Scott, 2011, “A flawed conception of determinism in the Consequence Argument,” *Analysis* 71 (1): 30-38.

Tooley, Michael, 1987, *Causation: A Realist Approach*, Oxford: Clarendon Press.

van Fraassen, Bas, 1980, *The Scientific Image*, Oxford: Clarendon Press.

van Fraassen, Bas, 1989, *Laws and Symmetry*, Oxford: Clarendon Press.

van Inwagen, Peter, 1983, *An Essay on Free Will*, Oxford: Clarendon Press.

Wimsatt, William, 1992, "Golden Generalities and Co-opted Anomalies: Haldane vs. Muller and the *Drosophila* Group on the Theory and Practice of Linkage Mapping," in *Fisher, Haldane, Muller, and Wright: Founders of the Modern Mathematical Theory of Evolution*, ed. S. Sarkar. Dordrecht: Martinus Nijhoff: 107-166.