The Problem of Disjunctive Explanations[*]

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Abstract

I present a problem for theories of explanation, concerning explanations involving disjunctive properties. The problem is particular acute for the explanatory non-fundamentalist, according to whom non-fundamental scientific explanations are sometimes superior to fundamental physical explanations. I criticise solutions to the problem due to Woodward, Strevens and Sober, and Lewis, and then defend a solution inspired by an account of non-fundamental laws recently defended by Callender and Cohen.

Contents

If I build a gadget that's just a red filter and a buzzer, what the buzzer buzzes for is the redness of the input, not its redness or blueness. And if I have two such gadgets, one that's just a red filter and a buzzer and the other that's just a blue filter and a buzzer, then the whole thing buzzes for red and it buzzes for blue, but it doesn't—at least by my lights—buzz for red-or-blue.
—Fodor (1987).

1 Introduction

In this paper I present a problem for theories of explanation, concerning explanations involving disjunctive properties. The problem is particular acute for the explanatory non-fundamentalist, according to whom non-fundamental scientific explanations are sometimes superior to fundamental physical explanations.

To my knowledge, the problem was first presented by Kitcher (1981). It is also discussed by Woodward (2003) and Woodward and Hitchcock (2003b)[1], and by Strevens (2004; 2008)[2]. However—perhaps because it is often treated as arising in the context of a particular theory of explanation, rather than as a puzzle about explanation in general—it has not yet received the attention it deserves. My main goal is to isolate and identify the problem, and to argue that the attempts to solve it have so far been unsuccessful. However, at the end of the paper I offer a sketch of a solution that I regard as promising.

I will make a number of simplifying assumptions about explanation. First, I restrict myself to explanation of events. Second, I assume that explanations of events have two components: a *particular* component, which consists in the specification of an initial condition; and a *general* component, which consists in the specification of a set of generalisations (I will refer to the explanandum as the *target* of an explanation). Third, I assume that explanations permit the explanandum to be derived from the explanans. However, I will not assume any particular account of what it is in virtue of which such derivations are explanatory. In particular, everything I say below is compatible with the *deductive-nomological* theory of explanation, on which it is in virtue of providing derivations that essentially involve natural laws (Hempel and Oppenheim 1948); with the *unificationist* theory of explanation, on which it is in virtue of involving unifying arguments (Kitcher 1981; 1989; 1999); with the *interventionist* theory of explanation, on which it is in virtue of representing a certain class of counterfactuals (Woodward 2003, Woodward and Hitchcock 2003a; 2003b); and with the *kairetic* theory of explanation, on which it is in virtue of representing the difference makers (Strevens 2004; 2008)[3].

The structure of the paper is as follows. In §2 I introduce the question of whether

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[1]For discussion, see Franklin-Hall (forthcoming).

[2]For discussion, see Weatherson (2012), Hall (2012), Lange (2012) and Strevens (2012).

[3]The interventionist and kairetic theories can be thought of as causal theories of explanation. The relationship of what I say to the causal theory of explanation defended by Lewis (1986), on which the derivations are explanatory in virtue of providing information about causal history, is more complex. For on the Lewis theory not all explanations involve such derivations, nor feature such generalisations.

explanatory fundamentalism is true, present an account of explanatory value on which it is false, and introduce the problem of disjunctive explanations. In §3 I describe and criticise some candidate solutions to the problem before sketching my preferred solution. I conclude in §4.

2   Abstraction

Explanations can be good or bad *qua* explanation. There may be multiple dimensions of explanatory value, these dimensions may trade off with one another, and there may be explanations whose value cannot be compared. Even so, explanations can sometimes be compared to one another with respect to their explanatory value. A particularly interesting question concerns the relationship between the explanatory value of what I will call *fundamental* and *non-fundamental* explanations.

By a *fundamental* explanation, I mean an explanation that consists in the derivation of an explanandum from some maximally precise specification of initial conditions and a specification of a set of fundamental laws. By a *non-fundamental* explanation, I mean an explanation that consists in the derivation of an explanandum from, *inter alia*, a set of generalisations that does not include a fundamental law. By a fundamental law, I mean a law that does not obtain (even in part) in virtue of any others.

According to a position I will call *explanatory fundamentalism*, it is never the case that a non-fundamental explanation is superior to a fundamental explanation in any respect. It is a popular view that explanatory fundamentalism is false—but it is hard to say why. In the remainder of this section, I present some examples to motivate non-fundamentalism, present an account of explanatory value which entails non-fundamentalism, and introduce the problem of disjunctive explanations.

2.1   Motivating Non-Fundamentalism

Consider a gas at constant temperature in a cylinder with a movable piston, in which the piston is withdrawn and the pressure changes (Woodward 2003, pp. 231–233). Now consider two candidate explanations for the final pressure. In the first, we conjoin an initial condition stating the maximally precise initial state of the system in terms of a fundamental physical theory, with a set of fundamental laws of that physical theory, in order to derive (perhaps in conjunction with appropriate bridge laws) the final pressure. Call this explanation GAS_L. In the second, we conjoin the initial temperature and volume of the gas with the ideal gas law $PV = nRT$ in order to derive the final pressure. Call this explanation GAS_H.

Next consider a sexually reproducing biological population which starts with an uneven ratio of males to females and ends with an even ratio of males to females. Now consider two candidate explanations for the final ratio. In the first, we conjoin an initial condition stating the maximally precise initial state of the system in terms of a fundamental physical theory, with a set of fundamental laws of that physical theory, in order to derive (perhaps in conjunction with appropriate bridge laws) the final ratio. Call this explanation SEX_L. In the second, we conjoin an initial condition specifying

some general biological constraints (but *not* the initial sex ratio), with a frequency-dependent fitness function, in order to derive the final ratio[4]. Call this explanation SEX_H.

Examples of this type have led many philosophers to the conclusion that there is a dimension of explanatory value along which GAS_H is better than GAS_L and SEX_H better than SEX_L. That is, these examples strongly suggest that explanatory fundamentalism is false[5]. This conclusion is also endorsed by many scientists (Weisberg 2004). One way to motivate non-fundamentalism is by focussing on our particular judgements about these and similar examples: it seems that there is something of explanatory value about GAS_H and SEX_H that is lacked by GAS_L and SEX_L respectively. An alternative way to motivate non-fundamentalism is to focus on the connection between explanation and understanding: it seems that even if we were in an ideal epistemic situation and capable of formulating explanations such as GAS_L and SEX_L, still we would fail to *understand* something about these systems if we did not grasp GAS_H and SEX_H. Non-fundamentalism offers an explanation for, and is therefore motivated by, these judgements.

2.2 Motivating Abstraction

More controversial than the question *whether* explanatory fundamentalism is false is the question *why* it is false. In Weslake (2010), I argue that it is false because what I call the *abstractive account* of explanatory value entails that it is false. The *abstraction* of an explanation is a measure of the degree to which the explanation applies to a range of metaphysically possible situations. The more possible situations to which an explanation applies, the more abstract it is, and so the better it is along the dimension of abstraction.

Note that the abstraction of an explanation is not determined by the range of possible situations to which the general component of the explanation applies, but rather by the range of possible situations to which the whole explanation applies. Consider for example the relationship between GAS_L and GAS_H. Since GAS_H applies to all possible situations in which GAS_L applies, but not *vice versa*, GAS_H is more abstract than GAS_L and so better along the dimension of abstraction. Likewise, *mutatis mutandis*, for the relationship between SEX_L and SEX_H. Indeed, it is plausible that GAS_H and SEX_H apply to possible situations in which the fundamental laws are different from what they actually are[6]. If so, then GAS_H and SEX_H are more abstract not merely than GAS_L and SEX_L respectively, but than any explanation with a general component consisting of the fundamental laws.

Notice that the abstractive account of explanatory value is independent of any particular account of the nature of explanation. In particular, the account is compati-

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[4]For a survey of explanations of this type, see Charnov (1982). For an argument that they raise problems for the causal theory of explanation, see Sober (1983).

[5]Those who endorse this conclusion include Putnam (1973), Jackson and Pettit (1992), Kitcher (2001), Woodward (2003) and Strevens (2008).

[6]See Lange (2000, CH 8; 2002; 2005).

ble with the deductive nomological theory of explanation, the unificationist theory of explanation, the interventionist theory of explanation, and the kairetic theory of explanation. I regard this independence as a virtue of the account, and draw a methodological lesson for the theorist of explanation: it is one thing to specify the nature of explanation, and another to specify the nature of explanatory value.

In my view, the central reason we should believe that abstraction is a genuine dimension of explanatory value is that it provides the best explanation for our judgements concerning the value of non-fundamental explanations. It also provides an elegant account of why we sometimes value less accurate over more accurate explanations, and for the value of idealisations and mathematical explanations (Weslake 2010, §3.2.4). It is also plausible that abstraction plays a role in our ordinary explanatory judgements (Weslake forthcoming).

2.3 A Problem for Abstraction

The attraction of the abstractive account notwithstanding, it faces a problem concerning explanations in which abstraction is bought with disjunctive predicates. To set up the problem I will describe a number of (candidate) explanations in schematic form. In these explanations, (P) denotes the particular component, (G) denotes the general component, and (E) denotes the explanandum. Let T stand for the temperature, V' for the final volume, and P' for the final pressure. Then GAS_H can be represented as follows:

GAS_H

(P) T & V'

(G) $PV = nRT$

(E) $\therefore P'$

Next consider a classical explanation for the configuration of planets in the solar system at a time. Let C stand for the initial planetary configuration, C' stand for the final planetary configuration, and L stand for Newton's laws. Then an explanation PLANET_H for the final configuration can be represented as follows:

PLANET_H

(P) C

(G) L

(E) $\therefore C'$

Now consider two explanations for why it is that the gas instantiates the property $P' \vee C'$:[7]

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[7]Note that I am stipulating that this is a property instantiated by the gas. I discuss worries about the legitimacy of such properties below.

GAS$_\vee$

(P) T & V′

(G) PV = nRT

(E₁) ∴ P′

(E₂) ∴ P′ ∨ C′

GAS$_\vee$PLANET

(P) (T & V′) ∨ C

(G) (PV = nRT) & L

(E) ∴ P′ ∨ C′

GAS$_\vee$ is constructed by simply adding an additional conclusion to GAS$_H$, involving the inference of a disjunctive property from one of the disjuncts. GAS$_\vee$PLANET on the other hand is constructed by taking the disjunction of the particular components, and the conjunction of the general components, of GAS$_H$ and PLANET$_H$.

What is the relationship between GAS$_\vee$ and GAS$_\vee$PLANET? Both ground sound deductive arguments: all the premises are true, and entail their conclusions. However, GAS$_\vee$PLANET is at best explanatorily inferior to GAS$_\vee$, and at worst no explanation at all. What I will call the *problem of disjunctive explanations* is to specify why this is so.

There are a number of forms a solution might take. First, we might bite the bullet and accept that GAS$_\vee$PLANET is better than GAS$_\vee$ after all. I regard this as unacceptable, and will not discuss it further. Second, we might argue that GAS$_\vee$PLANET is not an explanation at all. This would require articulating a necessary condition on explanation that it fails to satisfy. Third, we might argue that there is no dimension of explanatory value on which GAS$_\vee$PLANET is better than GAS$_\vee$. This would require articulating the dimensions of explanatory value, and demonstrating that they have this consequence. Fourth, we might argue that while there is a dimension (or dimensions) of explanatory value on which GAS$_\vee$PLANET is better than GAS$_\vee$, it is counterbalanced by a loss of explanatory value along another dimension (or dimensions). Again, this would require articulating the dimensions of explanatory value, and demonstrating that they have this consequence.

Stated in this form, we have a perfectly general problem for theories of explanation. However, the problem of disjunctive explanations is particularly acute for the abstractive account of explanatory value. For notice that GAS$_\vee$PLANET applies to all possible situations in which GAS$_\vee$ applies, but not *vice versa*. In particular, it applies to planetary systems that instantiate P′ ∨ C′. So it is more abstract and hence better along the dimension of abstraction. The problem is to specify why this does not constitute a *reductio* of the abstractive account. More generally, the problem is acute for all those who wish to reject explanatory fundamentalism. For the challenge is then to explain why it is that GAS$_H$ is superior to GAS$_L$, and yet GAS$_\vee$PLANET inferior to GAS$_\vee$. In what follows, I assume that explanatory fundamentalism is false, and therefore that it is a defect of a solution if it entails that GAS$_H$ is inferior to GAS$_L$.

Before turning to some candidate solutions, I wish to ward off an initial worry concerning the explanandum in question, the event consisting in the gas instantiating the property $P' \vee C'$. One might worry that events involving "disjunctive" properties such as this are not suitable targets of explanation in the first place[8]. Perhaps there is something problematic about such properties, a possibility I consider below. But the problem with these explanations cannot be simply that they are aimed at events involving such properties, for the problem also arises for explanations aimed at events involving properties about which no-one should have qualms. Suppose that there exists some possible planetary configuration, radically different from the actual initial configuration, but that leads to the same result—one for example in which the planets come flying in from infinity, with momenta delicately arranged so as to lead to the final configuration[9]. Call this radically different initial configuration C_z. Then we can construct an explanation PLANET$_Z$ as follows:

PLANET$_Z$

(P) $C \vee C_z$

(G) L

(E) C'

The explanandum here is the same as in PLANET$_H$. But PLANET$_Z$ is problematic with respect to PLANET$_H$ in just the same way as GAS$_\vee$PLANET is with respect to GAS$_\vee$[10]. So the problem cannot simply be that events involving disjunctive properties are not legitimate targets of explanation. While I will focus on the question of the relationship between GAS$_\vee$ and GAS$_\vee$PLANET in what follows, everything I say should also be taken to apply to the relationship between PLANET$_H$ and PLANET$_Z$. Nevertheless, I will continue to refer to the class of problematic explanations of this sort as *disjunctive explanations*.

3   Constraining Abstraction

In this section I criticise a number of candidate solutions to the problem of disjunctive explanations, before turning to a solution I regard as promising[11].

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[8]I say "disjunctive" because strictly speaking it is *predicates* that are disjunctive, not *properties*. For discussion, see Clapp (2001, §III), who offers a definition of disjunctive properties in terms of disjunctive predicates. For the remainder of the paper I will drop the scare quotes, on the assumption that an account of what makes for a disjunctive property can be provided.

[9]See Norton (2003, §3) for an illustration of this possibility, in which distinct initial conditions converge to the same final condition.

[10]There is a difference: perhaps there is an explanation for C' that covers a range of different initial planetary configurations, including C and C_z; however, it is implausible that there is an explanation for $P' \vee C'$ that covers C. Even so, PLANET$_Z$ would remain defective, occupying a halfway house between PLANET$_H$ and this more general explanation.

[11]In Weslake (2010, p. 287) I claimed that the solution was "straightforward". I was wrong.

3.1 Invariance

A first candidate solution is provided by the interventionist account of explanation defended by Woodward (2003) and Woodward and Hitchcock (2003a; 2003b). According to this theory, to explain is to exhibit patterns of counterfactual dependence relating *explanans* to *explanandum*, by describing generalisations that are *invariant* in the sense that they would continue to hold under various possible changes to the system in question. The account of explanatory value preferred by Woodward and Hitchcock ties explanatory value together with degree of invariance, with greater degrees of invariance making for greater degrees of explanatory value. There are a number of varieties of invariance, but all involve different ways in which a generalisation describes a greater range of true counterfactuals concerning possible changes to the system in question—or equivalently, answers to more *w-questions*, in the sense of Woodward (2003, CH 5). This has the consequence that if an explanation does not answer more *w-questions* than another, it does not improve upon it. Note that unlike abstraction, invariance is a property of the general component of an explanation rather than the explanation as a whole.

Woodward and Hitchcock (Woodward 2003, pp. 261–262, Woodward and Hitchcock 2003b, pp. 190–191) do not directly address the problem of disjunctive explanations as I have formulated it, but their treatment of very similar issues suggests a solution. The solution is to rule that $GAS_\vee PLANET$ is no better than $GAS_\vee$ on grounds that it does not answer any additional *w-questions*. For example, $GAS_\vee$ tells us that a change to T would result in a change to whether $P' \vee C'$ is instantiated, but $GAS_\vee PLANET$ provides no further dependency information of this kind, for the situation to which the explanation applies.

The problem with this suggestion is that it would also rule that GAS_H is inferior to GAS_L, a conclusion that Woodward himself wishes to resist (see Woodward 2003, pp. 232–233; 355–356). Just as $GAS_\vee PLANET$ answers no *w-questions* not answered by $GAS_\vee$, so GAS_H answers no *w-questions* not answered by GAS_L. Indeed, it answers *less*[12]. Degree of invariance cannot provide the solution to the problem of disjunctive explanations, for it does not provide a dimension of explanatory value that can discriminate between GAS_H and $GAS_\vee PLANET$[13].

3.2 Cohesion

A second candidate solution is provided by the idea that disjunctive explanations are not *cohesive*. This solution can take a number of different forms, depending on what makes for cohesion. In this section I argue that no existing account of cohesion solves the problem.

Here is a first attempt at solving the problem this way, suggested by Strevens (2004, pp. 170–172). According to this proposal, the problem arises from the fact

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[12]I defend this claim in Weslake (2010).

[13]For criticism of some other solutions to our problem that might be formulated from within the interventionist theory, see Franklin-Hall (forthcoming).

that a disjunctive explanation covers a range of possible situations that can be divided into two classes, with a distinct single type of explanation applying to each class at the exclusion of the other. So for instance, in our example we can exclusively and exhaustively divide the situations in which $\text{GAS}_\vee\text{PLANET}$ applies into one class to each member of which $\text{GAS}_\vee$ applies, and another class to each member of which $\text{PLANET}_\vee$ applies (where $\text{PLANET}_\vee$ is PLANET_H plus the additional inference to $\text{P}' \vee \text{C}'$).

This proposal is a non-starter. Consider the class of situations to which GAS_H applies. This class can be divided into two mutually exclusive and exhaustive subclasses in any number of arbitrary ways. One such division divides the class in two, with one subclass covering instances where the number of particles of the gas is odd, and the other subclass covering instances where the number of particles of the gas is even. We can then, trivially, construct explanations that apply only to each subclass by explicitly restricting the scope of the ideal gas law. Clearly, the existence of these subclasses and correspondingly restricted explanations does not undermine the explanatory power of the ideal gas law in the slightest.

Here is a second attempt, suggested by Sober (1983) and Strevens (2004, pp. 164–165). According to this proposal, the problem arises from the fact that a disjunctive explanation does not pick out a single type of causal process. The idea is that all of the possible systems to which GAS_H applies involve the same type of causal process, while the possible systems to which $\text{GAS}_\vee\text{PLANET}$ applies involve different types of causal processes. After all, it is one thing for a gas to expand and quite another for a solar system to revolve.

This proposal is also unacceptable. To begin, notice that this cannot be the problem with PLANET_Z, which is explicitly constructed to cover situations that only involve a single type of causal process. The basic issue with the proposal, however, is that the problem of specifying what counts as a single type of causal process is just as pressing as specifying the problem with disjunctive explanations. To see this, consider SEX_H. This is an explanation that covers populations of sexually reproducing creatures of myriad different types: populations of fish, giraffes, birds and so on. The causal mechanisms responsible for the evolution of these populations are enormously heterogenous. In what sense, then, do they all count as implementing the same type of causal process? In order for the proposal to succeed, we need an answer to this question that does not simply consist in the observation that the populations are all such that SEX_H applies to them. For it is also true, trivially, that all situations to which $\text{GAS}_\vee\text{PLANET}$ applies involve a single type of causal process in this sense. The problem then is not so much that the proposal is false, but that it leads to the same problem all over again, under the guise of specifying what counts as a single type of causal process.

A third attempt is made by Strevens (2008), who suggests that explanations should satisfy a requirement of what he calls *causal contiguity*. Strevens postulates a continuous similarity space over all possible fundamental causal processes, and proposes that we call an explanation *contiguous iff* all possible realisers of the explanation constitute a contiguous set in that space, in the sense that for every possible realiser, there exist paths through the space to every other realiser that do not pass through any non-realisers. The idea is that the regions in this space that realise $\text{GAS}_\vee\text{PLANET}$ are

not contiguous, while the regions that realise GAS$_H$ are contiguous. The proposal also promises to identify what is wrong with PLANET$_Z$, since this too is plausibly not contiguous.

Nevertheless, contiguity cannot be the solution to the problem of disjunctive explanations. The problem is that it is enormously implausible that SEX$_H$ is contiguous[14]. There is every reason to believe that in the similarity space of fundamental causal processes, there are regions between fish populations and giraffe populations which do not involve sexually reproducing entities at all, and hence do not fall within the scope of SEX$_H$. So the requirement that explanations satisfy contiguity is too strict[15].

I conclude that cohesion cannot solve the problem of disjunctive explanations.

3.3 Naturalness

A third candidate solution to the problem of disjunctive explanations is to appeal to the metaphysics of properties. In particular, the idea is to suggest that the problem with disjunctive explanations is that the properties they involve are metaphysically problematic. There are three different strategies here, but I will discuss them together. First, we might say that there are no such properties as $(T \& V') \vee C$ and $C \vee C_z$. Second, we might say that these properties are unnatural, and take degree of naturalness to trade off with abstraction[16]. Third, we might say that these properties are unnatural, and take naturalness to be a necessary condition on explanation[17].

There is clearly something correct about this idea. $(T \& V') \vee C$ and $C \vee C_z$ seem unfit for *any* metaphysical work, not merely explanatory work. Moreover, it might be thought that the notion of naturalness is already needed to play a wide range of roles in metaphysics, and hence is legitimately taken as a primitive (Lewis 1983). Nevertheless, leaving naturalness as a primitive should be a position of last resort, since it leaves us with an epistemic quandary concerning which properties are natural, and hence whether our explanatory judgements are correct[18]. As Loewer (1996, p. 109) puts the point, the problem with the idea that naturalness is primitive is that even if we knew every true sentence about the world in every language (except the sentences specifying the natural properties) there would remain a further question, utterly unconstrained by these truths, concerning which predicates express natural properties. An alternative solution to the problem of disjunctive explanations would be preferable to the pious hope that we know what the natural properties are.

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[14]See Potochnik (2011), Weatherson (2012) and Lange (2012) for similar remarks.

[15]I should note both that Strevens himself expresses reservations concerning the requirement that explanations be contiguous, and that he provides a sophisticated account of explanations that are not contiguous (for a synopsis, see Strevens 2012, §1). The problem of disjunctive explanations, I suggest, simply arises again for this account.

[16]This strategy is pursued by Yablo (2003; 2005) in a similar context.

[17]This strategy is pursued by Owens (1989).

[18]This line of argument against the notion of natural properties is developed by van Fraassen (1989), Loewer (1996), and Callender and Cohen (2009).

3.4 Unification

In this section I outline an alternative approach to the problem of disjunctive explanations. It is inspired by the work of Craig Callender and Jonathan Cohen (2009; 2010) on the best-system theory of laws[19].

First an epistemological point. Properties such as temperatures, pressures and the configurations of massive bodies all feature in systematic, autonomous theorising about the world in a domain of scientific inquiry. That is, these are properties in terms of which we have been able to formulate *unifying* scientific theories. Obviously, properties such as $(T \& V') \vee C$ and $C \vee C_z$ have not featured in such theories.

Second a metaphysical claim. It is no accident that we have been able to formulate unifying scientific theories in terms of some properties rather than others, for there are genuine explanatory connections between some properties but not others. This is not to say that our best theories are all true, of course. Rather, the point is that our confidence in the truth of our theories should amount to a confidence that they reflect such explanatory connections.

What is required is an account of what it is for there to be genuine explanatory connections of this sort between properties, and how it is possible for us to be justified in believing that we have identified these connections. And a natural move is to achieve both goals at once by simply *identifying* these explanatory connections with the metaphysical shadows of the ideal best theories of the relevant properties.

A move of just this type is famously made by Lewis (1973, pp. 73–75; 1983, pp. 366–368; 1994, pp. 478–482), who developed the so-called *best-system* theory of laws[20]. Now Lewis thought that the best-system theory of laws itself required an appeal to natural properties. In particular, he imposed the constraint that best-systems must only contain basic predicates that refer to natural properties. But this is a feature of the theory that is optional, for instead of constraining best-systems to be formulated in terms of predicates that refer to natural properties, we may constrain them in other ways. So for example, Loewer (1996, pp. 109–110) has proposed that one of the criteria that determines the strength of a best-system is the extent to which it permits the derivation of sentences with predicates referring to the positions and motions of ordinary objects. More recently Craig Callender and Jonathan Cohen (2009; 2010) have proposed to relativise the best-system view to the properties of the special sciences more generally. Their proposal is that we measure both the simplicity and strength of best-systems relative to a selection of special-science properties[21]. I will follow them in referring to this proposal as the *better best-system* account of laws.

In fact, Callender and Cohen (2009) dispense with the appeal to a privileged class of properties altogether. They claim that there is no metaphysically basic difference between properties we regard as natural and properties we regard as unnatural. Rather,

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[19]Hall (2012) proposes a similar approach, though he does not make the connection with the best-system theory of laws.

[20]Of course, Lewis himself did not accept a theory of explanation on which laws were required for explanations (see Lewis 1986).

[21]A similar view is defended by Markus Schrenk (2008), though Schrenk is more sympathetic to natural properties. See also Halpin (1999; 2003) and Roberts (2008, CH 10).

for any arbitrary set of properties, there exists a best system for the actual distribution of those properties. Moreover, the axioms and theorems in that system are genuine laws. As it happens, however, we only care about the laws that relate properties we care about. This relativisation of lawhood to a selection of properties raises a worry about gruesome properties[22]. The worry takes two forms. First, there is a worry that, relative to a gruesome set of properties, the better best-system account countenances gruesome laws. This is a consequence of the account that Callender and Cohen explicitly accept. Second, there is a worry that, relative to a non-gruesome set of properties, the better best-system account will generate gruesome laws. As noted by both Loewer (1996, p. 110) and Callender and Cohen (2009, §4.3) however, this worry is groundless: if strength is determined by a non-gruesome set of properties, there is every reason to believe that gruesome laws will not enter the corresponding best-system.

The idea that I take from Callender and Cohen is that it is an objective matter which generalisations feature in the best system for an arbitrary set of properties. So we can consider which properties will feature in the axioms of the best systems for the properties that are the targets of the disjunctive explanations GAS$\lor$PLANET and PLANET$_Z$ respectively. My claim is that the disjunctive properties that appear in GAS$\lor$PLANET and PLANET$_Z$, $(T \& V') \lor C$ and $C \lor C_z$, will not feature in these axioms. And this, I claim, is the basis on which we can rule out explanations GAS$\lor$PLANET and PLANET$_Z$.

Care is required to formulate this proposal so that it gives us the result we want. It will not do to impose a necessary condition on which an explanation may only cite properties that appear in the axioms of the best-system for the distribution of the properties that are the target of the explanation. This threatens to rule out GAS$_L$, since it is plausible that the ideal gas law, but not the fundamental laws, will feature in the best-system for the distribution of pressure properties. I suggest rather that it is a necessary condition on explanation that an explanation may only cite properties that appear in the axioms of the best-system for the distribution of the properties in both the initial component and target of the explanation. For this proposal to succeed in our leading example, the following claims must be true:

- The best-system for the set containing the fundamental properties and the pressure properties contains the fundamental laws (and perhaps relevant bridge laws) as an axiom.

- The best-system for the set containing the temperature, pressure and volume properties contains the ideal gas law as an axiom.

- The best-system for the set containing the disjunctive properties $(T \& V) \lor C$ and $P \lor C$ contains the ideal gas law and Newton's laws as axioms (and no law that quantifies over these disjunctive properties).

The central piece of evidence for this last claim is simply the existence of classical thermodynamics and mechanics on the one hand and the non-existence of an autonomous

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[22]I thank a referee for raising this concern.

theory of $P \lor C$ on the other. The reasons we have to disbelieve in the existence of such a theory, I claim, are also reasons to reject the disjunctive explanation GAS$_\lor$PLANET[23]. On the other hand, we may explain $P' \lor C'$ with GAS$_\lor$, since it is plausible that the best-system for the set containing T, V and $P \lor C$ contains the ideal gas law as an axiom.

What reason is there to believe that this should count as a constraint on explanation? First, it captures the idea that explanations should trace genuinely explanatory relations between properties. Second, it captures the idea that explanations should involve laws. Third, it captures the idea that explanations involve unification[24]. This helps to relieve the suspicion that the solution I have sketched is arbitrarily manufactured to deliver the desired result. For these considerations suggest that it is a natural constraint to impose on explanations, that they involve derivations of their targets from their initial components using just those generalisations that appear in the best-system for those properties.

4   Conclusion

My main aim in this paper has been to formulate the problem of disjunctive explanations, and to argue that it has not yet been satisfactorily solved. If explanatory fundamentalism were true, we would have a simple solution to the problem. For then we could argue that the problem with disjunctive explanations is simply that they are not fundamental. But explanatory non-fundamentalism is a more popular because more plausible position, and I argued that it is true because the abstractive account of explanatory value is true. If this is right, the problem of disjunctive explanations is particularly acute, for what is required is an account of how it can be that non-fundamental explanations are distinctively valuable in a way that disjunctive explanations are not.

I suggested a solution to the problem that, I argued, is more promising than the alternatives. The solution I sketched obviously requires a more sustained defence than I am able to provide here. In particular, it is hostage to the viability of the best-system view of laws, which is by no means without critics[25]. Regardless of the viability of my proposed solution, however, the problem itself offers a nice illustration of the way in which issues in metaphysics and philosophy of science are mutually relevant. For it is hard to escape the conclusion that a solution to the problem of disjunctive explanations will require appeal to a metaphysical theory of either causal processes, natural properties, or laws of nature.

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[23]Likewise for PLANET$_Z$, since it is implausible that the best-system for $C \lor C_z$ and C' has axioms that quantify over $C \lor C_z$.

[24]That the best-system conception of laws fits nicely with the idea that explanation involves unification is also noted by Loewer (1996).

[25]An excellent overview can be found in Hall (2009).

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