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Classifying Dependencies

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This is a draft of a chapter published in “The Foundation of Reality: Fundamentality, Space, and Time”, eds. David Glick, George Darby and Anna Marmodoro, Oxford University Press, 2020.

Abstract: Metaphysicians typically distinguish sharply between grounding and causation, and philosophers of science typically distinguish sharply between causal and non-causal explanation, but there has been surprisingly little discussion of how exactly to draw these distinctions. In this paper I argue that six of the most obvious criteria fail to capture the intended distinction between causation and grounding. I propose and defend an alternative criterion in terms of the principles mediating the dependency, and I explore some of the implications of this criterion for the possibility of simultaneous causation in physics.

1. Introduction

It is no surprise that the literature on causation is primarily concerned with the kinds of causal relationships that are discovered and exploited in mainstream empirical science and in ordinary planning and decision-making. Philosophers of causation usually focus on paradigm cases of practical relevance such as the dependence of a window’s shattering on an incoming missile, the dependence of climatic trends on carbon dioxide emissions, and the dependence of an industrial injury on an employer’s negligence. In comparison, the outer limits of causation are not often explored, and in particular the precise relation between causation and temporal priority is rarely questioned. Do causes always precede their effects? Is causation across a temporal gap possible? Is simultaneous causation possible? The neglect of such questions means that we still lack a clear view of the underlying nature of causation. In this paper I will probe the limits of causation by first investigating the surprisingly slippery distinction between causing and grounding, then arguing that we should draw this distinction in terms of the status of the principles that mediate the dependency, and finally exploring some initial implications for the possibility of simultaneous causation in physics.

These days, metaphysical questions are frequently cast in terms of the ideology of grounding. This notion is usually introduced by explicit contrast to causation: ground is supposed to be a non-causal dependency relation that supports metaphysical explanations, just as causal relations support causal explanations. But the distinction between causation and grounding has never been very clear-cut, and recent work (Schaffer 2016; A. Wilson 2018) has highlighted how deep the structural similarities between the notions run. Schaffer concludes that causation and grounding are merely closely analogous. My paper defends the more radical view that grounding is a specific type of causation; however, I set that heterodox view aside for the purposes of this chapter and proceed on the assumption that there is a coherent distinction to be drawn between the two notions. In any case, the structural similarities between them show that we cannot afford to take the distinction between grounding and causation for granted; those who would wield both notions owe us a substantive account of the way in which they differ. Tracing the contours of the distinction between grounding and causation accordingly promises to cast valuable light on both notions. In this paper I will consider and reject six natural-seeming demarcation criteria, and endorse a seventh.

First, section 2 provides some relevant background on causation and grounding. Then in sections 3-8 I examine six obvious criteria by which to distinguish these two notions. I argue that each of the criteria is problematic in some way or other, which motivates the search for a better criterion. In section 9 I offer my own account of the distinction between grounding and causation in terms of how the dependency is mediated. This *mediation criterion* can explain the appeal of the next best candidate criteria – the temporal criterion and the modal criterion – without suffering from their problems. Section 10 provides further support for the mediation criterion by arguing that it makes the classification of dependencies in physics appropriately sensitive to the interpretation of the physical theories involved. Section 11 is a conclusion.

2. Causation and Grounding

So, back to the guiding question: what is the difference between grounding and causation? Numerous possible ways of drawing the distinction spring to mind, but (surprisingly enough) few of these have received much explicit defence. Grounding is often simply introduced as a non-causal form of explanatory connection (see e.g. Fine 2012, p.37) without much attention to exactly what might prevent it from being causal. If this way of introducing grounding is not to be badly misleading, no single dependency relation can count both as grounding and as causation (although of course two relata may be related both by a grounding relation and by a causal relation). And if this way of introducing the relation is to be informative, there must be more to be said about how the two relations differ.

In informal fieldwork, I have encountered the following six criteria most frequently:

- Perhaps causation relates distinct entities, while grounding relates not fully distinct entities? (Call this the distinctness criterion.)
- Perhaps causation has no connection to fundamentality, while the ground fact is always more fundamental than the grounded fact? (Call this the fundamentality criterion.)
- Perhaps causation relates events, while grounding relates facts? (Call this the categorial criterion.)
- Perhaps causation holds diachronically, while grounding holds synchronically? (Call this the temporal criterion.)
- Perhaps causal connections are those which can in principle be exploited for purposes of manipulation and control? (Call this the intervention criterion.)
- Perhaps causal connections hold contingently, while grounding connections hold non-contingently? (Call this the modal criterion.)

The next six sections will argue against these criteria in turn.

Before diving in, we should note that it remains controversial whether there is any clear or univocal notion of ground. Outright sceptics about ground, including Chris Daly (2012) and Thomas Hofweber (2009) argue that the notion is ‘unintelligible’ or ‘esoteric’. More qualified sceptics, such as Naomi Thompson (2018, forthcoming), have suggested we should understand grounding talk in a deflationary way, perhaps by appeal to fictionalist or expressivist machinery. If there is no coherent notion of ground, then there is no coherent grounding-causation distinction either. A different sort of objection to the project of this paper doesn’t deny that the grounding/causation distinction is coherent, but instead questions whether it is exhaustive. For example, Bennett (2017) acknowledges numerous different ‘building relations’ alongside and akin to grounding and causation; these include set formation, composition, and property realization. Other pluralists about dependence, including Kathrin Koslicki (2012, 2015), Jessica Wilson (2014), and David Kovacs (2017) have argued, in different ways, that grounding fails to capture a theoretically interesting category of dependence relations. Empiricist philosophers of science including Lewis (1986), Skow (2015) and Strevens (2008) have in various ways attempted to give deflationary accounts of all non-causal explanation in science, typically treating apparent non-causal explanations as highly abstract causal explanations. If causation is the only kind of objective dependence relation we need, my target distinction fails to correspond to any real difference.

Both grounding sceptics and dependence pluralists, however, typically still agree that causation itself is a clear and theoretically interesting category of dependence relation. Dependence pluralists can therefore still contrast causation in a useful way with non-causal dependence relations, whatever such there be. Eliminativists about non-causal dependence can similarly ask what features characterize causation. If you have misgivings about how clean the grounding/causation distinction is, then you can still think of this paper as potentially casting light on the limits of causation taken by itself. While I will assume that causation is at least a relatively unified phenomenon, I will not presuppose that there is any unified notion on the non-causal side of the target distinction.

I will aim to remain neutral on a number of theoretical controversies concerning grounding. For example, some grounding theorists take ground itself to be a form of explanation, while others think of it as a kind of worldly relation that can back or support explanation (for further discussion, see Raven 2015). And, some grounding theorists deny that (full) grounding entails necessitation, while others maintain that a genuine full ground must necessitate the grounded fact (for further discussion, see Skiles 2015). I aim for my arguments to remain neutral on all such controversies; however, the question of necessitation will inevitably come into play in section 8 when I evaluate the modal criterion. And, I will aim to remain neutral on whether ground is best expressed by a relational predicate or a sentential connective (for further discussion, see Raven 2015).

I have needed to pick a particular conception of the relata of grounding relations in order to frame my arguments throughout. In an attempt to be as neutral as possible on the metaphysics of individuals, I treat both grounding and causation in full generality as relating facts, in the sense of states of affairs: real, worldly, *ways things are*. Facts in the intended sense are not representational entities: they do not depend in any way on us or on our linguistic practices, and they are not in any interesting sense abstracted from reality. While there is certainly a fact that I am human, and this fact is as concrete as can be, I don't assume anything about its underlying metaphysics, for example about how it is composed out of me and of humanity. I will presuppose, however, that facts have an algebraic structure sufficient to define basic logical operations: facts can be negated, conjoined, and disjoined to generate new facts. My preferred theoretical model for facts, as developed by Lewis (1988a, 1988b), links them to cells of partitions over possible worlds. Lewis' notion is intensional, but Yablo (2014) generalizes it to a hyperintensional framework of facts which can be modelled by cells of partitions over impossible worlds in the sense of Priest (2005) and Nolan (1997). An advantage of all of these approaches is that facts are treated as fundamentally answers to questions, and so picking out a fact picks out a relevant contrast class of alternative answers. (Structural-equations treatments of causation also have this advantage.)

With preliminaries out of the way, we now can focus on the demarcation question: what exactly is the difference between grounding and causation? What we would ideally want from our account of this distinction is a decision procedure which would allow us to determine, for each particular instance of dependence, whether it is a case of grounding or causation. No such decision procedure may be forthcoming – perhaps not every concept can be given necessary and sufficient conditions – but before we conclude that no such procedure is available in this case we should explore and assess all the plausible candidates. That is the purpose of the next six sections of this paper.

3. Against the Distinctness Criterion

The first of the criteria that I will be criticizing is the distinctness criterion. Fine hints at this criterion in the following passage: “It will not do, for example, to say that the physical is *causally* determinative of the mental, since that leaves open the possibility that the mental has a distinct reality over and above¹ that of the physical” (Fine 2012 p.41). Depending on how ‘distinct reality’ is to be understood, the distinctness criterion may converge with one of the criteria to be discussed below: perhaps with the categorical criterion, the concreteness criterion, or the modal criterion. However, I’m sure that Fine would resist any such ways of understanding ‘distinct reality’, and I understand he would prefer to take distinctness of realities to be a basic and unanalysable notion. This would fit with his general approach to our question of taking the distinction between grounding and causation to be basic and unanalysable (Fine, p.c.). Still, we might reasonably flesh out Fine’s suggestion into an account of the grounding-causation distinction as follows:

Distinctness Criterion: causation relates facts corresponding to fully distinct realities, while grounding relates facts not corresponding to fully distinct realities.

¹ It is possible that Fine intends the work to be done by a notion of ‘over-and-aboveness’ rather than by a notion of distinct reality. I assume that the former is to be explained in terms of the latter, but I think that my arguments would still go through if we assumed the contrary.

My primary objection to the distinctness criterion is that we lack an independent grip on the notion of ‘distinct reality’. Indeed, there is a strong suspicion that any notion which bears the appropriate relation to grounding will have to be tailored specifically for the purpose. The best way to cash out the notion of distinctness involved will then itself appeal to the notion of grounding: two facts having distinct realities will coincide with lack of any chains of grounding (including connections of common ground) linking the two facts. We accordingly face the question of whether to explain distinct reality in terms of ground, or to explain ground in terms of distinct reality. Ideological parsimony dictates that we do one or the other; and grounding seems to be much more apt as a theoretical primitive than distinctness of realities.

Perhaps there is another way to explain what it is for two realities to be distinct, but Fine gives us no hint as to what it might be and the terms in which such an explanation might be given remain unclear. Some such explanations (for example, a modal explanation in terms of the possibility of one reality existing without the other) would make the criterion coincide with criteria discussed later in this chapter (in our example, the modal criterion.) I shall consider one example of this phenomenon: Lewis’s account of distinctness, which is only informative insofar as it collapses the distinctness criterion into the modal criterion.

Lewis makes it a necessary condition of one event standing in a causal relation to another that the two events must be distinct, contrasting causation here with *implication*: “We may take it as a general principle that when one event implies another, then they are not distinct and their counterfactual dependence is not causal.” (Lewis 1986a p.256).² Lewis provides a modal gloss on implication as necessitation: but to characterize distinctness in this way would be simply to adopt a disguised version of the modal

² This doesn’t cover cases where events fail to be distinct despite neither implying the other, as with two partially overlapping events such as my childhood and my teenage years. Presumably Lewis would want to distinguish between partial implication and full implication, but still to account for each of them in modal terms.

criterion and I think it is not what he intended. Later, in Postscript F to “Causation”, Lewis provides a gloss on distinctness in terms of identity and parthood: “two events are distinct if they have nothing in common: they are not identical, neither is a proper part of the other, nor do they have any common part” (Lewis 1986b, p.212).

The problem now is that the notion of parthood is unspecified, if we are not to understand it in modal terms. Lewis points out that mere spatiotemporal overlap for events doesn’t exclude distinctness – two distinct events (a conference and a goblin battle) can occur at the same spacetime region. And once we move beyond events to include dependencies between facts including negative facts (as I shall argue in section 5 we need to do), the parthood relations involved become more obscure still. Absent a general theory of parthood for facts, the Lewisian account of distinctness fails to give it an independently graspable content.

While I cannot canvass all conceivable accounts of distinctness here, the most natural way to account for (the relevant kind of)³ distinctness of facts seems to be to characterize distinct facts as facts with non-overlapping grounds. This account, while very plausible, renders the Distinctness criterion uninformative for the broader purposes of this chapter. What I am searching for is a criterion that allows us to distinguish between grounding and causation in terms on which we have an independent grip, and (at least absent further explication) the Distinctness criterion fails to deliver this. This type of difficulty – lack of independent graspability – will also affect the criterion that I shall consider in the next section.

³ A referee has pointed out (correctly, I think) that my theorizing in terms of facts in the first place requires some grip on how facts are individuated. But fact individuation by itself is not enough to account for fact distinctness: as Lewis emphasizes, distinctness goes beyond mere non-identity to non-identity of any parts, and so we plausibly can get a grip on fact individuation while still lacking any grip on fact parthood.

4. Against the Fundamentality Criterion

The fundamentality criterion in its most plausible form relies on the thought that causation has no special relation to relative fundamentality, while grounding does have a distinctive relation to relative fundamentality.

Fundamentality Criterion: Causation has no connection to fundamentality, while the ground fact is always more fundamental than the grounded fact.

A variety of fundamentality-based criteria are conceivable, of which this particular one is amongst the strongest in the sense of being the most specific concerning the connection between grounding and fundamentality. Weaker criteria which are less specific about the grounding-fundamentality connection are also viable, but they are subject to the same line of criticism that I shall develop in this section against the stronger version, and so I set them aside here. The strong version of the criterion is the most plausible-looking, and it is the one which has been recently advocated by Alex Skiles:

“[W]hat contingentists should point to [when characterizing grounding] are the different implications of grounding and causation for relative metaphysical fundamentality. If a fact is grounded, then it must also be metaphysically less fundamental than each of the facts that partially ground it; yet an effect may be more, less, or equal in relative fundamentality with respect to its causes.” – Skiles (2015) p. 739

My reason for rejecting the fundamentality criterion has the same structure as my reason for rejecting the distinctness criterion: both criteria explain the obscure in terms of the even more obscure. One of the main benefits of the notion of ground is for characterizing a variety of notions in metaphysics, especially the notion of *relative fundamentality*. By using relative fundamentality itself to characterize the nature of ground,

we give up on the prospect of a reductive account of relative fundamentality in terms of ground. That is bad news⁴.

Proponents of grounding should, I suggest, endorse a reduction of fundamentality (both relative and absolute) to grounding. The case for employing grounding (whether as a unified theoretical category or merely as a useful catch-all term) rests on it being able to do theoretical work in a variety of areas; a reductive account of fundamentality in terms of grounding is a key component of this explanatory work. If we endorse such an account, then we should not presuppose fundamentality when demarcating grounding from causation.

Bennett (2017, ch.6) devotes an extensive discussion to accounts of relative fundamentality, defending what she calls the ‘deflationist’ view that ‘relative fundamentality facts just are complex patterns of building’ (p.140). Her project is not to reduce relative fundamentality to grounding, but to reduce relative fundamentality to relations from her larger category of building relations which includes causation and grounding. She thus accepts that causes are (at least in some sense) more fundamental than their effects, a conclusion that most will be unwilling to swallow⁵. Stripping that unpalatable consequence from Bennett’s account yields what I think is the most plausible reduction of relative fundamentality to grounding. I will not here dwell on the details of the resulting reduction, but since we want to be able to make comparisons of relative fundamentality between isolated individuals it will need to be more complex than simply ‘A is more fundamental than B iff A grounds B’. Bennett (ibid.) has argued – convincingly, in my view – that such a reduction is viable, and has explored a number of potential ways of developing it.

⁴ A different perspective (e.g. Turner 2016) sees this instead as good news, since it opens up logical space for heterodox views on the relation between fundamentality and dependence such as that of Barnes (2012). I’m not convinced that the explanatory benefits of these heterodox views is worth the costs of the more complex ideology required to get such views onto the table, but can’t address the question properly here.

⁵ A. Wilson (2019) and Schaffer (forthcoming) criticize Bennett’s assimilation of causation to her other building relations.

In summary, since the best way to understand relative fundamentality is itself in terms of chains of grounds, the fundamentality criterion should be rejected as uninformative. What we would like is a criterion that allows us to distinguish between grounding and causation in terms on which we have some independent grip. In the next section I will consider one such criterion: a criterion that appeals to the difference between facts and events.

5. Against the Categorical Criterion

According to the categorical criterion grounding and causation differ with respect to the categories of their relata: grounding is always a relation between facts, whereas causation is always a relation between events.

Categorical Criterion: Causation relates events, whereas grounding relates facts.

My first objection is that this combination of views about the relata of dependence relations is unstable. The arguments that motivate a conception of grounding as relating facts also motivate a conception of causation as relating facts, and the arguments that motivate events as causal relata also motivate events as grounding relata. However, the real problem with the categorical criterion is more basic. A criterion that gets to the bottom of the difference between grounding and causation ought to specify something distinctive not merely about the relata but about the connection between the relata.

To simplify the discussion. I will set aside more exotic views of the causal relata, such as those envisaged by proponents of agent causation. Some have proposed views of the causal relata that, while event-like, are more fine-grained than events. Examples are L.A. Paul's *aspect causation* (Paul 2000) or Jonathan Schaffer's *contrastivism* (Schaffer 2005). Most of these views can be fitted into the fact-causation framework on which I will settle.

My first line of argument against the categorical criterion – call it the *parity argument* – is that the asymmetry it relies on does not in fact obtain. The main arguments that motivate facts as grounding relata also motivate facts as causal relata, and the main arguments that motivate events as causal relata also motivate events as grounding relata. As I will now argue, consideration of dependence upon absences motivate treating both causation and grounding as relating facts, while considerations of preserving the grammatical form of dependence attributions motivate treating both of them as relating objects, including events. There seems to be no principled basis for accepting either argument in the causal case but not in the grounding case, or *vice versa*.

A central argument for facts as causal relata, heavily relied upon for example by Mellor (1995), is the argument from absence causation. Absences can cause and be causes. The absence of beer causes dismay, the absence of a hat causes sunburn, and the absence of air causes suffocation. As Schaffer (2000) has pointed out, even such a paradigmatic causal process as the execution of a prisoner by firing squad presupposes absence causation, since there are steps in the operation of typical gun mechanisms that rely on an absence. But absence causation, treated as event causation, is a most peculiar phenomenon. It requires negative events—*not-happenings*—which are metaphysically problematic. In contrast, fact causation has no problem with absences: the fact that something does not occur is no more mysterious than the fact that it does, and it can be unproblematically captured by the partition-based framework for facts (see section 2)⁶. Since facts already have an algebraic structure, it is natural to negate them; events, lacking any algebraic structure, cannot be naturally negated.

The argument from absences for facts as relata applies equally just as strongly to grounding as it does to causation. The absence of any unicorns grounds the emptiness of the set of unicorns; the absence of any sodium ions grounds the water's zero salinity; the

⁶ Some accounts of the nature of facts do not give them this sort of algebraic structure. I take this to be a reason to prefer the partition-based account of facts, rather than a problem for the overall argument of this section. The reader's mileage may vary.

absence of any brain activity in the comatose patient grounds the absence of any conscious states. In each of these cases, grounding between facts is preferable to grounding between events, and for an analogous reason to the causal case: facts can be naturally negated, while events cannot be. So there is a fact of absence, which is available to do causal work or grounding work, but there is no absent event to do that work: it isn't around to stand in any relation at all. Grounding and causation are thus on a par when it comes to the argument from absences for facts as relata.

When combined with the observation that every case of apparent causation between events can be captured in terms of causation between facts, this case for fact causation becomes rather strong. For every event that could be a cause or an effect, there is a corresponding fact: the fact that that event occurs. So the view that facts are causal relata is more flexible than the view that events are causal relata. Everything event causation can do, fact causation can do also. Once again, the same goes for grounding: for any putative case of grounding between events or grounding between objects, we can understand that case in terms of grounding between facts about events' occurrences or about objects' existences.

Of course, the argument from absence causation to causation as relating facts remains very controversial. Cases of apparent absence causation can be explained away, perhaps by locating suitable surrogates for negative facts amongst the events, or by attributing them some non-obvious logical form. While I am myself convinced by the above arguments and accordingly prefer to think of both causation and grounding as relating facts in full generality⁷, not all are convinced; for example, Noordhof (1998) criticizes Mellor's case for fact causation. Faced with this sort of resistance, for the purposes of the parity argument we can concede the point and instead rest the case for parity on the idea that objects – including events – can ground and be grounded.

⁷ It is also worth observing at this point that it is quite orthodox to treat grounding as always relating facts; see Rosen (2010) and Audi (2012). It's also mandated by the approach to ground which represents ground by a sentential operator (see e.g. Fine 2012); thanks to Nicholas Jones for pointing this out.

Schaffer (2009) claims that entities of arbitrary ontological category can stand in the grounding relation, motivating his claim through examples such as the grounding of modes by the substances they modify, of singleton sets by their members, of abundant properties by sparse properties, and of truths by their truthmakers. Consider the singleton set containing this workshop, and the truth that this workshop occurred. Each of these, according to Schaffer, is grounded in an event: the workshop itself. Furthermore, Schaffer would say that events can ground other events, for example when individual talks ground a conference. I think of this line of thought as an argument from the grammatical form of grounding claims. In each case the grounding relation could be reformulated as connecting facts (the fact that a singleton set exists, the fact that a truth is true, and so on); however, such reformulations require a positive motivation, which appears not to be forthcoming. Hence we should accept at face value our intuitive judgments of ground between events.

Putting all this together, we are left with no principled basis for distinguishing grounding from causation via the nature of their relata. There are good arguments for treating causation as relating facts in at least some instances, and the best reasons for rejecting these arguments tend to motivate treating grounding as relating events in at least some instances. While we could insist on taking the logical form of the dependency claims at face value in the one case but not in the other, unless we can find some independent motivation for doing this then such a move looks *ad hoc*.

The parity argument might be resisted by rejecting Mellor's arguments, endorsing Schaffer's arguments, and locating the difference between grounding and causation in a modified categorical criterion: grounding can relate things of any ontological category, while causation always relates events. Here is the first instance of an approach that I will call occasionalism, and which we will encounter again in later sections. Occasionalist approaches characterize the difference between two relations by specifying that all instances of one relation have some property, while only some instances of the other

relation have that property. I will reject occasionalist approaches throughout, since they do not always allow for an answer to the basic diagnostic question I ask: is this particular instance of dependence a case of grounding or causation? Suppose we are presented with a case of grounding between events: the present approach gives us no way to say what makes it grounding and not causation.

I have a second line of argument against the categorical criterion, which I think runs deeper; call it the perspicuity objection. There is an underlying problem with the strategy of characterizing relations by their relata. Even if instances of the relations of grounding and causation do take different relata, this is something that ought to be explained in terms of the kinds of relations of which they are instances, rather than vice versa. We ought to explain why instances of grounding and causation have the relata that they do in terms of the kind of relation of which they are instances, rather than vice versa.

My discussion in this section has presupposed a view of both grounding and causation as relational. How do things look if we instead treat grounding as a sentential connective? The view that ground is best expressed by a sentential connective rather than by a relation will tend to undermine the categorical criterion as stated, but the criterion can easily be revived by contrasting the sentences on either side of the connective. However, this improved version of the categorical criterion does not escape the problems I raised in this section. The case for a sentential connective is just as strong in the causal case as in the grounding case – indeed, Mellor has explicitly argued that causation should be thought of as a connective – so the parity argument still tends to undermine the categorical criterion⁸. And the perspicuity argument applies in just the same way as in the relational approach: we shouldn't classify dependencies expressed by a connective in terms of the type of sentences that they connect, but in terms of the type of connection that is imposed between these sentences. It is time to move on.

⁸ It will also tend to undermine any attempt to build a demarcation criterion on the idea that grounding is best expressed by a connective while causation is best expressed by a relational predicate.

6. Against the Temporal Criterion

According to the temporal criterion, causes are temporally prior to their effects, while grounds are not temporally prior to the facts they ground:

Temporal Criterion: Causation holds diachronically, while grounding holds non-diachronically.

The temporal criterion seems more initially promising than the criteria I have discussed up to this point. Indeed, if there is any orthodoxy in this domain then the temporal criterion probably constitutes that orthodoxy. It has been explicitly defended by Stephan Leuenberger (Leuenberger 2013), and is apparently lurking in the background of many informal discussions including that of Schaffer (2009). Something very like the temporal criterion is endorsed as an account of causation by Bader (this volume), who recognizes classes of ‘generative operations’ corresponding to kinds of dependence – causal, grounding, and compositional – such that causation is “a trans-temporal operation that has inputs and outputs that exist at different times”⁹. Paradigm cases accord with the temporal criterion; the throwing of a rock is temporally prior to the breaking of a window, but Socrates is not temporally prior to Singleton Socrates. However, once we move beyond paradigm cases, the criterion begins to look more doubtful.

A preliminary line of argument against the temporal criterion appeals directly to the possibility of particular cases of simultaneous causation. Examples might be drawn from mechanics: perhaps the net applied force on an object causes its instantaneous acceleration within Newtonian mechanics, even though the application of the force and the acceleration are simultaneous (see section 10 for further discussion of this case). Or, examples might come from various kinds of mental causation: perhaps an interactionist dualism, where mind can act instantaneously on matter.

⁹ Bader combines the temporal criterion as an account of causation with the fundamentality criterion as an account of grounding, seeing both as distinct from causation and maybe from other forms of dependence.

There is a ready response to this kind of argument: modal epistemology is hazy, and our judgments about particular cases at the borderline are not fully reliable. If a compelling theoretical principle demands it, revision to our intuitions about a reasonable proportion of borderline cases is to be expected. So appeal to the possibility of these sorts of cases may be unpersuasive against the denier of simultaneous causation, who will either seek to reinterpret Newtonian mechanics in a way that doesn't require simultaneous causation, or will deny that this theory corresponds to a genuine metaphysical possibility. I would prefer to have an argument against the temporal criterion that does not rely on controversial judgments about the possibility of particular cases at the limits of our modal knowledge; but I advise readers who are convinced of the intuitive possibility of simultaneous causation to skip the remainder of this section.

A more interesting-looking line of argument for simultaneous causation is indirect, going via the possibility of time travel loops. If a contemporary time-traveller goes back in time to hand over the blueprints for their time machine to their earlier self, who goes on to construct the machine and complete the loop, the activation of the time machine is caused (at least in part) by the activation of the time machine. Indeed, if time is cyclical (in the sense of having the topology of a circle, not in the sense of including an endless sequence of distinct indiscernible epochs) then every event is both temporally prior and temporally posterior to its effect, and so causation of events by themselves might turn out to be endemic. Perhaps these are esoteric scenarios, whose metaphysical possibility a defender of the temporal criterion may deny, but importantly for present purposes they don't seem to be ruled out by the nature of causation. If they are metaphysically impossible at all, presumably they are rendered impossible by metaphysical necessities concerning the temporal structure of reality rather than by metaphysical necessities concerning the nature of causation.

Although the argument against the temporal criterion from time travel has some *prima facie* force, I don't think it's ultimately decisive. This is because a defender of the

temporal criterion can legitimately respond by distinguishing between immediate simultaneous causation and simultaneous causation with diachronic intermediaries. This move appeals to a distinction between local time and global time¹⁰. Local time is elapsed time along a worldline, time from the perspective of an object undergoing change, while global time is time from the perspective of the universe. Armed with this distinction, we can sharpen the temporal criterion to say that causation is always diachronic with respect to local time, even if they're not diachronic with respect to global time. Causation, on this picture, is always directed forwards along a worldline even if that worldline ends up reversing direction or coming full circle with respect to the global temporal ordering. The temporal loop argument against the temporal criterion is therefore inconclusive.

A better argument against the temporal criterion takes a different tack. Rather than arguing that causation is sometimes non-diachronic, we can approach the problem from the opposite direction and argue that grounding is sometimes diachronic¹¹. As far as I know, cases of this sort were first discussed by Allen Hazlett (2006, 2011).

An initial class of cross-temporal grounding relations are those that relate entities to the causal histories that are responsible for their kind-membership. On some plausible views of what it takes to be human, for example, humans must be descended from the ancestral *homo sapiens*; a swampman (a perfect duplicate of a human formed by pure chance) would not qualify as a human. So the fact that I am a human is grounded in the fact that some past events occurred: those constituting my ancestral lineage. Cases of this general sort can be proliferated. We might think that to be a church is (in part) to have been consecrated at some prior time; so the fact that this building is a church is partly grounded in a particular past event of consecration¹². Perhaps the fact that I'm in the mental state of believing that Montana is beautiful has to be partly grounded in the fact

¹⁰ This distinction is more commonly referred to as personal time vs. external time, but the cases under consideration here need involve no persons.

¹¹ This way of putting things assumes a broadly B-theoretic approach to time. Presentists and other A-theorists can substitute 'facts obtaining at different times' for 'facts about different times' as necessary.

¹² It is also relevant in this case that the church was not deconsecrated at some later time. I defer discussion of these delicate issues to the next section, where cases of contingent grounding take centre stage.

that I've had some prior causal interaction with Montana. And perhaps anyone's holding of a PhD degree is grounded in some prior event of degree conferral. More generally, being an ex-convict – or an ex-anything – requires having been some way in the past, and being a future president – or a future anything – requires being some way in the future. Being 'the once and future king', like T.H. White's King Arthur, is grounded in both past and future.

Could the opponent of cross-temporal grounding find some principled reason to reject these cases? Perhaps they could maintain that the cases all appeal to abundant properties rather than to sparse properties, or that the cases all appeal to extrinsic properties rather than intrinsic properties, and then go on to argue that when the facts involved are appropriately restricted then the ban on cross-temporal grounding remains in force. However, I'm not sure what motivation there would be for imposing such restrictions. And in addition, some of the examples – being human, having beliefs about objects – certainly seem at least relatively sparse, while some of them – being human, being a church – seem plausibly intrinsic. I won't pursue these details here, since I don't want to put much weight on these cases. Instead I want to draw attention to a more systematic motivation for rejecting the temporal criterion: the coherence of metaphysical views that posit systematic cross-temporal grounding.

The claim that cross-temporal grounding is ubiquitous has been defended in multiple ways in the recent literature on the metaphysics of time. Sam Baron (2015) argues that the best form of presentism – a view that he calls *priority presentism* – should not deny that past entities exist but instead should maintain that past entities are grounded in the present. And Ross Cameron can be construed as arguing that presentists (Cameron 2010) and moving spotlight theorists (Cameron 2015) should each say that facts that either are or purport to be about the past are grounded in distributional properties of the world as it presently is.

Now, these views about time are obviously controversial. Tim Williamson has written dismissively that such views are “obviously false: what I was yesterday is not grounded in what I am today, in any useful sense” (Williamson 2015 p.13). Still, I think such views give us reason to look for an alternative to the temporal criterion if any is available. Three alternative demarcation criteria remain to be addressed.

7. Against the Intervention Criterion

According to the intervention demarcation criterion, what is essential to causation is its connection to the possibility of intervention, manipulation or control. It is of course a platitude that some causal relations can be exploited for practical purposes. The intervention criterion makes this into the defining feature of causation: all causal relations can (at least in principle) be exploited, whereas grounding relations cannot be.

Intervention Criterion: Causation in principle permits manipulating the dependent fact by intervening on the fact on which it depends; grounding does not.

A clear example of the intervention criterion is the view of Price and Menzies (1993), who defend the view that “the ordinary notions of cause and effect have a direct and essential connection with our ability to intervene in the world as agents” (p.187). Something very like the intervention criterion has played a prominent role in recent work on causal explanation within philosophy of science. In particular, interventionist accounts of causal explanation characterize causation (albeit in a non-reductive manner, since interventions themselves are counted as causings) in terms of the counterfactual consequences of interventions. The *locus classicus* of this approach is Woodward (2003), who traces a number of historical anticipations of his interventionist approach (p.25) and whose eventual “manipulability theory” of the notion of direct cause (p.59) is given in terms of possible interventions on the cause variable, holding fixed suitable other variables, which changes (the probability distribution over) the effect variable.

Interventionist accounts of causal explanation are enlightening and fruitful. However, they are not well suited for characterizing my target in this chapter, the distinction between causation and grounding. It is difficult to make sense of interventions on some apparent causal relata, such as the dimensionality of spacetime (Woodward 2003, p.220), but I shall set that concern aside here. My primary objection to the intervention criterion is that relations of ground also support manipulation, in the sense that we may intervene on the grounding fact and thereby manipulate the grounded fact. Consider intervening on the colour of a red house, by painting it emerald green. Since (we may grant for the sake of argument) the fact that the house is emerald green grounds the fact that the house is green, by intervening to paint it emerald green we have thereby manipulated whether it is green. Without further restrictions on the relevant interventions, then, manipulability accounts of causation fail to distinguish causation from grounding.

Woodward is aware of the problem. In the specific context of mental causation and the causal exclusion argument, Woodward imposes a condition he calls Independent Fixability on the variables that can be included in causal models.

“for each value it is possible for a variable to take individually, it is possible (that is, “possible” in terms of their assumed definitional, logical, mathematical, or mereological relations or “metaphysically possible”) to set the variable to that value via an intervention, concurrently with each of the other variables in V also being set to any of its individually possible values by independent interventions.” – Woodward (2015), p. 316

While Independent Fixability does prevent relations of ground from counting as causal (at least on the conventional view according to which full grounds necessitate what they ground), it collapses the intervention demarcation criterion into (some form of) the modal criterion that is the focus of the next section. It is not manipulability *per se*, but the possibility of independent fixing of variables, that is now bearing the theoretical load. So it is time to set aside the intervention criterion, and consider the modal criterion directly.

8. Against the Modal Criterion

According to the modal criterion, the difference between grounding and causation concerns their modal force. Causation, so this line of thought runs, holds contingently in that it is possible for the cause and the effect both to occur without the causal relation holding between them. Grounding on the other hand holds non-contingently: necessarily, if the ground fact and the grounded fact both obtain, then the former grounds the latter. This view about grounding is often called ‘grounding internalism’. We can distill grounding internalism into the following demarcation criterion:

Modal Criterion: The causal relation between cause and effect holds contingently; the grounding relation between ground and grounded holds necessarily.

The modal criterion seems reasonably popular. Gideon Rosen identifies the modal status of the dependency as a respect of difference between grounding and causation:

“[That grounds necessitate] is one respect in which the grounding relation, which is a relation of metaphysical determination, differs from causal and other merely nomic forms of determination. There is a difference between the materialist who holds that facts about phenomenal consciousness are grounded in (hence necessitated by) the neurophysiological facts directly, and the dualist who think that facts about the brain cause or generate conscious states according to contingent causal laws.” – Rosen (2010) p.118.

The modal criterion relies on orthodox views about the modal status of laws of nature and of grounding. For those who accept nomic necessitarianism – the view that the laws of nature are necessary – the modal criterion seems unsuitable. Likewise, the modal criterion presupposes grounding internalism in order to work as intended. Here I am disagreeing with Alex Skiles, who has argued that the modal approach to demarcation is compatible with the rejection of grounding internalism:

“For the distinction between the two might simply be that in at least some cases a fact is necessitated by its ground, while an effect is never necessitated by its causes, given that the metaphysically contingent laws of nature governing causal interaction could have differed.” – Skiles (2015) p.739

I have already argued that this kind of occasionalist approach to distinguishing causation from ground is unsatisfactory. What we are after is a criterion that allows us to classify any given case of dependence as causation or as grounding. If it is to correctly classify all cases, the modal criterion does require grounding internalism.

Still, the modal criterion is intuitively quite appealing. Causation is a connection that can be interfered with and re-routed; there are various different possible causal pathways, we might think, between two events. Grounding, on the other hand, looks to be harder to interfere with; no external contingencies seem capable of disrupting the dependency between a thing and its grounds. The criterion also gets paradigm cases right. It is possible for a brick to be thrown at the window, and for the window to break, without the former causing the latter (for example, suppose some other missile breaks the window first.) But it is impossible for Socrates to exist, and for Singleton Socrates to exist, without the former grounding the latter. So far, so good.

Unfortunately, I think that the modal criterion is untenable because it appeals to a false view of ground. The problem is that the modal criterion builds in grounding internalism, the view that grounding connections hold necessarily when their relata do. This view has been the target of a number of recent critiques, including those of Skiles (2015) and Leuenberger (2013)¹³; a related line of argument in the context of truthmaking dates back to Parsons (1999) and has been defended by Briggs (2012). I think that the counterexamples provided by these authors – while one might quibble here and there – are collectively compelling. But in addition, I think there are important further cases of

¹³ These authors primarily target the related principle of grounding necessitarianism: that full grounds necessitate the facts they ground. Grounding necessitarianism obviously entails grounding internalism.

failures of grounding internalism that have not attracted as much attention; they involve grounding connections that are mediated by contingent principles of ground.

For an example of a contingent grounding connection, consider first legal grounding; the illegality of a particular act is at least partly grounded in whichever particular features of that act are forbidden by law. Or consider grounding as it figures in rule-governed activities such as sports; the location of the ball relative to the goalposts partly grounds the fact that a goal has been scored. To work through a particular example, consider my current status as an EU citizen. Given the actual legal framework of the EU, my citizenship of the EU is grounded in my citizenship of a member country. However, the EU legal framework could at some point be changed to introduce birthright citizenship, in which case my citizenship of the EU might become grounded instead in my having been born in the UK. I would still be a UK citizen, and still be an EU citizen, but the latter would no longer ground the former. Still, the EU would persist through the change: altering membership regulations does not replace an institution with a different institution. Similar counterexamples can be generated for any cases grounding mediated by contingent grounding principles, including all kinds of conventional principles.

An obvious line of response for the grounding internalist is to build the apparently contingent grounding principles into the full grounds in all such cases. Then, we might say, the full ground of my EU membership includes both my UK citizenship and the rules of the EU connecting member-state citizenship with EU citizenship. Along the same lines, the fact that a goal has been scored might depend partly on the position of the ball and partly on the laws. However, this move should be resisted, since recourse to it tends to undermine the modal criterion.

If we can build the supposed grounding principles into the grounds of social facts, then we can likewise build the laws of nature into the causes of particular effects – unless of course some relevant disanalogy between grounding and causation rules this out, but as yet we have found no such disanalogy. So if the laws of football may legitimately be

counted among the grounds of the goalscoring, it looks like the law of gravity may legitimately be counted among the causes of the apple's falling. But this manoeuvre, at least in the case of deterministic laws, means that dependency governed by laws of nature would be judged as grounding rather than causation by the modal criterion. The connection between the conjunction of the initial conditions and the deterministic laws on the one hand, and the later state of the universe on the other, becomes non-contingent: if the laws are deterministic, then all later states of the universe are logically entailed by the conjunction of the laws and the initial conditions. This conception of causation as involving necessitation may have been popular in the Early Modern period, but few have any truck with it today.

Again, in arguing that grounding and causation should be treated in the same way unless we can identify a non-question-begging reason to do otherwise I am drawing on the closeness of the grounding-causation analogy. Just as the same arguments concerning *relata* apply in each case (section 5), so here the same arguments concerning the inclusion of general principles in the dependence base apply in both cases. I have defended the use of this grounding-causation analogy to draw substantive conclusions about the relations involved elsewhere (A. Wilson 2018b), and it has also been emphasised by Jonathan Schaffer (Schaffer 2016). Essentially the only place where Schaffer thinks the grounding-causation analogy breaks down is with respect to indeterministic causation. He maintains that grounding cannot be indeterministic, but causation can. We need not adjudicate for now on whether this is correct, since even if correct it cannot provide the kind of demarcation criterion we are seeking. At most, the appeal to indeterminism can provide an occasionalist criterion unable to distinguish instances of deterministic causation from instances of grounding. We must continue our search for a more general criterion.

There are of course ways in which my line of argument against the modal criterion can be resisted. Perhaps there is after all some non-question-begging reason why we should build contingent grounding principles into the grounds in the case of social grounding, but resist building contingent laws into the causes in the case of causal

dependency. Or perhaps deterministic laws of nature are not metaphysically possible (maybe because the actual laws are indeterministic, and a modal necessitarian account of the laws is correct.) However, I take it that the arguments of this section at least provide us with some reason to continue our search. In the next section I shall present my own preferred demarcation criterion, which accounts for the intuitive appeal of the temporal and modal criteria while avoiding the counterexamples to them that I have discussed.

9. A Mediation Demarcation Criterion

In many cases, the temporal criterion seemed to produce the right results. Most causal relations are diachronic and most grounding relations are synchronic. Similarly, the modal criterion got things largely correct: causal connections do seem to be contingent, and the paradigm cases of grounding connection do seem to be non-contingent. Perhaps this is because of some deep conceptual connection between causation and time, or between grounding and modality? I have an alternative diagnosis. Perhaps what distinguishes causation from grounding is whether or not the holding of dependency itself partly depends on the laws of nature.

To help formulate the mediation criterion, it is useful to introduce the notion of a *mediating principle*. In the case of causation, the mediating principles are laws of nature; in the case of grounding, the mediating principles are something like laws of metaphysics¹⁴. Either way, the mediating principles are the principles responsible for the substantive connection between ground and grounded, those general facts that explain the holding of more specific explanatory connections. In Wilson (2018a) I explain the notion of a mediating principle in terms of the structural-equations modelling framework that is there used to unify both grounding and causation. Schaffer also makes appeal to

¹⁴ In this category I would intend to include synthetic principles such as principles of mathematics as well as principles with an obviously metaphysical subject-matter. There is a substantive further debate to be had about the unity or diversity amongst the principles in this category, and it will feed directly into what we say about the unity of grounding. This doesn't matter for present purposes; what matters is the contrast with laws of nature.

mediating principles in his treatment of the analogy, using the term *formative principles* (Schaffer 2016, p.57). Here I will rest content with the intuitive notion of a principle that explains the holding of the dependency connection.

With the notion of a mediating principle in hand, we can set up our contrast between causation and grounding as a contrast between two different ways in which a dependence relation can hold. We have clear cases where the dependence is mediated by the laws of nature and cases where it is not. That the throwing of the stone is sufficient for the breaking of the window is to be explained by reference by the laws of nature that mediate the process; that the existence of Socrates is sufficient for the existence of Singleton Socrates is not to be explained by reference to any laws of nature. (Presumably the connection is mediated instead by principles of set theory.)

Mediation Criterion: Causation is mediated by laws of nature; grounding is not.

The mediation criterion gives correct results in paradigm cases, and it avoids the objections to the criteria described in previous sections. Facts about dependencies between facts, including facts about dependencies involving absences, can be properly assessed for what they themselves depend on; so can facts about dependencies between events. Some dependency relations between both facts about concreta and facts about abstracta depend on the laws of nature, while others do not. There are at least some dependency connections between facts about different times that do not depend on the laws of nature: it's not because of any law of nature that it's impossible to be an ex-president without having been president at some earlier time.

The mediation criterion can account for the apparent plausibility of some of the other criteria we have considered. In particular, the mediation criterion can explain why the temporal criterion gets paradigm cases right. According to the mediation criterion, causal relations, but not grounding relations, are mediated by laws of nature. So, we can

explain our intuitions about the different temporal properties of grounding and causation by relying on the widespread conception of laws of nature as diachronic constraints that relate events at a later time out of events at an earlier time. Since the laws of nature typically (but not always) entail diachronic connections between facts, while principles of logic or metaphysics typically (but not always) entail non-diachronic connections between facts, the mediation criterion supports the corresponding intuitions about the temporal properties of grounding and causation.

A recurring theme in recent interlevel metaphysics has been to emphasize the dynamic and interactive aspects of the dependence between phenomena at different levels¹⁵. Material objects may initially look static and unchanging, but zoom in on the smaller-scale structure of their matter and we find a complex and active interplay of intermolecular, interatomic, and nuclear forces. Complex systems with many degrees of freedom may be in overall equilibrium, yet at all but the lowest energies this equilibrium is a dynamic one maintained through constant causal interactions between and within subsystems. We must accordingly take care in the application of the mediation criterion to interlevel connections. For example, where some property (say, magnetization) of a macroscopic object (say, an iron girder) is grounded in the configuration of the microscopic parts of the girder (atoms of iron in a lattice arrangement), a full story about the dependence of overall magnetization on the individual iron atoms will cite causal relations between adjacent atoms in the cubic lattice. So the laws of nature that mediate the causal connections between atoms are at least complicit in the grounding of the overall magnetization. However, that is no threat to the mediation criterion, since a systematic treatment of these cases of ‘dynamic composition’ is available: distinguish between the causal processes operating at some lower level and the grounding relation which connects the operation of those causal processes with the higher-level phenomenon. The causal relations at the lower level are mediated by the causal laws of

¹⁵ This point is emphasized for example by Bennett (2017), who refers to the phenomenon as ‘causal taint’ in various other building relations.

electromagnetism, while it is not dynamical laws but some kind of level-connection principles that mediate the grounding relations between the lower-level pattern of causal relations (atomic electromagnetic interactions) and the higher-level phenomenon (overall magnetization). What the level connection principles actually are is typically a hard question, and one that is answered by work on specific reductive programs from the philosophy of the special sciences¹⁶. But proponents of the mediation criterion may point to a systematic division of labour between level connection principles and the laws of nature, such that the former take as input patterns of instances of the latter.

Importantly, the proposed distinction between grounding and causation is conceptually conservative. It relies primarily on the notion of a law of nature, a notion to which most metaphysicians and philosophers of science are independently committed and which can be, if desired, given a deflationary Humean analysis¹⁷. What the mediation proposal achieves, then, is to bring our understanding of the distinction between causation and grounding up to the same level of our understanding of the distinction between laws of nature and other synthetic principles that characterise reality. This does not, of course, by itself provide a full account of the nature of grounding and of what grounding facts there are: for that, we still need to better understand the range of metaphysical laws. But my intention here has been only to cast light on the difference between causation and grounding by connecting that distinction to the well-understood notion of laws of nature, and that much does seem to have been successfully achieved. We are now in a position to classify arbitrary putative dependencies as causal or grounding, even if we are not yet in a position to know which grounding dependencies there in fact are.

¹⁶ I make some remarks about how we might begin to identify these principles in the specific context of emergent spacetime in A. Wilson (forthcoming). In general, the way in which individual theoretical principles are classified will be sensitive to the details of interpretation of the physical theory involved, as I argue below.

¹⁷ If (as contemporary Humeans maintain) the notion of a law of nature does not run metaphysically deep, then the distinction between causation and grounding will likewise fail to run deep. I take it that this is a feature rather than a bug.

Perhaps the notion of a law of nature is not after all as clear and unproblematic as I have been supposing. We could imagine borderline cases, where it is clear that some dependence is mediated by a particular principle, but not clear whether that status has the status of a law of nature. This situation might arise in the face of disagreement about what it is to be a law of nature, but it might also arise within the context of a specific theory of laws if that theory does not support a thoroughgoing demarcation into laws and non-laws. While this would be bad news for our ability to distinguish causation from grounding according to the mediation criterion, it would not necessarily be bad news for the criterion itself. If the distinction between law and non-law is unclear in just the same cases in which the distinction between causation and grounding, then the mediation criterion in fact delivers the correct results in those cases. And consider a potential interpretation of quantum theory according to which the principle mediating the dependency between the measurements is a hybrid, halfway between a metaphysical principle and a law of nature. The mediation criterion quite reasonably predicts that the dependency involved is likewise a hybrid between grounding and causation¹⁸.

Beyond the notion of a law of nature, the proposal makes use of the notion of a mediating principle. In this paper I have characterized mediating principles as neutrally as possible in order not to make unnecessary assumptions about the controversial question of how grounding itself is grounded. But I take it that any plausible account of grounding will include some link between general metaphysical truths and particular instances of metaphysical dependence. Grounding facts are not scattered randomly and arbitrarily around reality – their pattern should reflect underlying general metaphysical principles. Any approach to grounding capable of doing justice to this thought will give us suitable candidates for mediating principles. For an extended discussion of what principles mediating grounding connections might be like, see Wilsch (2015).

¹⁸ Thanks to Suzy Kilmister for pressing me on this point.

In making this appeal to mediating principles, the mediation criterion reuses the notion of dependence. The explanatory connection between the mediating principle and the instance of dependence that it mediates is itself an instance of dependence of the sort that that is already presupposed in the very terms of the debate. This is benign, and does not give rise to any circularity. If we can make sense of one fact depending on another in order to pose the question of whether that dependence is causal or grounding, then we can make sense of the second-order dependence of that first-order dependence fact on some further fact. (The mediation criterion will plausibly count this second-order dependence as grounding, since it is plausible that laws of nature do not tell us anything about what dependence facts depend on. But this is not our present concern¹⁹.)

It should be noted that the mediation criterion does not automatically render all dependence involving laws of nature as causation. For example, the set of all laws of nature is presumably grounded in the laws, but still this connection is not itself mediated by laws. (Again, it is likely mediated by principles of set theory.) A worry raised by Jessica Wilson may be addressed along similar lines. Functionalist physicalists typically suppose that when a mental state *M* is grounded in a physical state *P* that plays the role *R* associated with *M*, *whether P plays the role R* will depend on laws of nature. This may look like it risks making functional realization into a causal relation. But these laws of nature are mediating a different connection, the connection between *P* and *R*; they are not mediating the connection between *M* and *P*. So the mediation criterion does after all give the desired conclusion: *M* is grounded in *P* rather than caused by *P*.

It will be helpful to see how the mediation criterion plays out in applications. To that end, the next section considers its implications for some cases of dependence in physics. The mediation criterion makes the type of dependence involved sensitive to details of the interpretation of the physical theory, which I think is exactly the right result.

¹⁹ See A. Wilson (MS) for discussion, within the current general framework, of what dependencies depend on.

10. Implications for Simultaneous Causation

Some cases of simultaneous dependence are assessed as clear cases of grounding by the mediation criterion: for example, the EU membership and goal-scoring cases from section 8, as well as the relation between Socrates and his singleton set. But does the criterion allow for cases of simultaneous causal dependence? If simultaneous dependence is to count as causation according to the mediation criterion, then the holding of the dependency between two facts about simultaneous events must be able itself to depend on the laws. Whether this is possible turns in part on what laws are.

On the conception of laws as generative, producing later states of the world out of earlier states (described forcefully, for instance, by Maudlin 2007), then laws do not directly support dependencies between distinct facts about any single time. Such facts may be common effects of some earlier cause, but there will be no direct causal dependency between them. (The dependence counterfactuals are then analogous to back-trackers; see Lewis 1973.) On alternative conceptions of laws, for example the Humean view of laws as efficient summaries of the occurrent facts (Lewis 1973), there is no obvious barrier to the laws directly entailing relations between simultaneous events. Absent barriers of this sort, we need to look at particular physical theories and their interpretations to establish whether they really do involve simultaneous causation.

The demarcation criterion makes the status of physical dependencies, as grounding or causation, dependent on the interpretation of the physical theories involved. A simple example comes from Newtonian mechanics. Newton's so-called second law, expressible by the familiar equation $F=ma$, relates the resultant force vector applied to a body to the mass and acceleration vector of that body. It is highly plausible to think that accelerations depend on the applied force, rather than vice versa; and, if $F=ma$ expresses a law of nature according to Newtonian mechanics, then this dependency will be classified as a case of causation according to the mediation criterion. However, the fact that F is the

resultant force applied to the body and the fact that a is the instantaneous acceleration of the body seem to be facts about the same instant. So, as I suggested above, this case apparently involves simultaneous causation.²⁰

The relation between matter distribution and gravitation presents another example. In general relativity, gravitation is interpreted as a manifestation of curved spacetime; according to Wheeler's memorable description of general relativity, "spacetime tells matter how to move; matter tells spacetime how to curve" (Wheeler 1999). In contrast, in Newtonian theory gravitation is interpreted as a manifestation of a force law acting at a distance. However, these interpretations are not forced on us by the bare mathematics. Gravitation can be understood as a manifestation of curved spacetime even in classical physics, which gives us Newton-Cartan theory. Conversely, the theory of teleparallel gravity is mathematically closely related to general relativity but it involves interpreting gravitation as resulting from the operation of forces²¹. It is natural to expect that these interpretive differences are relevant to how we classify the dependencies involved, and the mediation criterion ratifies this expectation.

In classical mechanics the dependency of gravitational motion on the distribution of matter can be interpreted nomically (yielding Newtonian mechanics) or geometrically (yielding Newton-Cartan theory). In relativistic mechanics the dependency of gravitational motion on mass-energy distribution can be interpreted nomically (yielding teleparallel gravity) or geometrically (yielding general relativity). The mediation criterion parlays these interpretive differences into differences in the status of the dependence between matter distributions and gravitational motions. If a geometric formulation of the physics involved is correct, then it is incompatible with the nature of space (in the

²⁰ There may be legitimate reasons for doubting the existence of instantaneous accelerations in classical mechanics, but these considerations seem to be completely orthogonal to current concerns.

²¹ For detailed discussion of both cases, see Knox (2011). While in the relativistic cases the relationship between matter and gravitation is not simultaneous in the sense that it holds at a specific instant, it is still simultaneous in the sense relevant to this discussion, since there is no temporal priority between mass distribution and spacetime curvature.

classical case) or of spacetime (in the relativistic case) to pull apart the curvature of space(time) from the motion of matter. Since facts about the nature of space(time) are not usually regarded as laws of nature, the mediation criterion will classify the relation between matter distribution and gravitational motion as one of grounding. But if a nomic (force-law) understanding of gravitation is correct, then the mediation criterion will classify the link between matter distribution and gravitational motion as causal. So, if Newtonian mechanics and/or teleparallel gravity describe ways the world could have been, then the mediation criterion will give us possible cases of simultaneous causation.

Limitations of space prevent me from considering further examples in any detail, but two additional cases are worth mentioning briefly: the dependence in some quantum gravity theories between spacetime and a more fundamental non-spatiotemporal reality, and the relationship between entangled systems in quantum theory.

The emergent spacetime example I discuss in a companion chapter to this one (A. Wilson forthcoming); my preliminary conclusion in that chapter is that a promising way to understand emergent spacetime is as being grounded in the operation of causal (although non-spatiotemporal) processes at the fundamental level. The mediation criterion enables this plausible conclusion through its focus on mediating principles rather than on any relationship with time. The invocation of mediating principles permits both grounding and causation to be *achronic*, or timeless, rather than having to be (respectively) synchronic and diachronic as per the temporal criterion.

The quantum example I hope to address in future work. A preliminary conjecture is that the status of entanglement dependencies as causation or as grounding will turn out to be highly sensitive to the chosen interpretation of quantum theory, particularly to questions concerning the metaphysical status of the quantum state.

11. Conclusion

I have proposed a criterion for determining whether particular cases of dependence are causation or grounding. Causal dependencies are those dependencies the holding of which partly depends on a law of nature, while grounding dependencies are those dependencies the holding of which does not depend on any law. I have argued that this criterion avoids various difficulties facing other criteria, that it classifies core cases correctly, that it explains the initial appeal of the more plausible alternative criteria, and – aptly – that applying it within physics typically requires adopting a specific interpretation of the physical theory that describes the dependence of interest²².

²² I am grateful to audiences at the Philosophy Mountain Workshop, Leeds, Gothenburg, Birmingham, and Monash for feedback. Particular thanks to Antony Eagle, Shamik Dasgupta, Nina Emery, Dana Goswick, Nick Jones, David Kovacs, Dan Marshall, Kristie Miller, Martin Pickup, Mike Raven, Gonzalo Rodriguez-Pereyra, and two OUP referees for extensive and helpful comments on previous drafts, and to David Glick for both extensive and helpful comments and extensive and helpful patience. This work forms part of the project A Framework for Metaphysical Explanation in Physics (FraMEPhys), which received funding from the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation programme (grant agreement no. 757295). Funding was also provided by the Australian Research Council (grant agreement no. DP180100105).

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