



Metaphysical Grounding

Understanding the Structure of Reality

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CHAPTER 4

Grounding, transitivity, and contrastivity

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Grounding is something like metaphysical causation. Roughly speaking, just as causation links the world across time, grounding links the world across levels. Grounding connects the more fundamental to the less fundamental, and thereby backs a certain form of explanation. Thus the right sort of physical system can support a biological organism such as a cat, and one way to answer the question of *why there is a cat afoot* is to describe the underlying physical system.

Grounding is generally assumed to be transitive. The assumption of transitivity is natural. For instance, if the physical system grounds the chemical arrangement, and the chemical arrangement grounds the biological organism, then it is natural to thereby infer that the physical system must ground the biological organism. Moreover the assumption of transitivity is useful. By treating grounding as transitive (and irreflexive), one generates a strict partial ordering that induces metaphysical structure.

Yet I will offer counterexamples to the transitivity of grounding. Such counterexamples should not be so surprising given that grounding is akin to causation, and that there are known counterexamples to the transitivity of causation. I will conclude by explaining how a contrastive approach can resolve the counterexamples while retaining metaphysical structure.

4.1 BACKGROUND

4.1.1 *Grounding*

Here is a natural picture, with roots tracing back at least to Democritus:

Atomism: Fundamentally there are just atoms in the void. But there are also derivative composites like pebbles, persons, and planets, which are grounded in their fundamental atomic parts.

No sooner is *Atomism* sketched than a relation of grounding comes into view, connecting the fundamental atoms to their derivative composites.

Of course, *Atomism* is hardly mandatory. For instance, one might revise the picture of what is fundamental in various ways. Indeed I myself would prefer to speak of what is fundamental in terms of the whole spatiotemporal manifold and the fields that permeate it, with parts counting as derivative from the whole.¹ But grounding remains integral. Such a revision only affects what grounds what.

One might also revise *Atomism* to excise grounding from the picture altogether. For instance, one might deny that there are any derivative entities at all: no pebbles, persons, or planets, but only the fundamentals (e.g. only atoms in the void).² Or one might allow that there are particles, pebbles, persons, and planets, but refuse any distinction in fundamentality between them.³ But on any sort of picture which is neither radically eliminative nor radically egalitarian – that is, on any sort of picture which distinguishes more from less fundamental entities – grounding relations remain connecting the more fundamental to the less.

Given that grounding is an integral aspect of such a natural sort of picture, it is perhaps unsurprising that there has been a surge of interest in grounding,⁴ though there remains disagreement over the details. Some of these disagreements affect the proper formulation of grounding claims, and thus affect the form in which a transitivity schema must be phrased, and to which the counterexamples must be fitted. For the sake of simplicity and definiteness, I will speak in terms of a singular–singular relation between facts,⁵ with the following schematic form:

The fact that ϕ grounds the fact that ψ

¹ See Schaffer 2009a, 2010a, and 2010b (inter alia) for elaboration of this monistic view, and Sider 2007, 2008, and Morganti 2009 for some critical discussion.

² See Sider 2011 for a defense of such a radically eliminative view. See Horgan and Potrč 2008 for a defense of the radically eliminative monist counterpart view on which only the whole cosmos is real.

³ This is the “flatworlder” view that Bennett (forthcoming) labels “crazy pants.”

⁴ See for instance Fine 2001, Correia 2005, Schaffer 2009b, Rosen 2010, Bennett 2011, Skiles manuscript, and Trogdon forthcoming. For some criticism, see Hofweber 2009, deRosset 2010, and Wilson manuscript.

⁵ This way of speaking is controversial in at least three respects. First, it involves speaking of grounding as a *relation*. Correia (2010) argues that grounding is better regimented via an operator. Second, it involves treating grounding as a relation *between facts*. Rosen (2010) restricts grounding to a relation between facts, while Schaffer (2009b) allows grounding between entities of arbitrary ontological category. Third, it involves treating grounding as singular–singular. Schaffer (2009b) treats grounding as a singular–singular relation, Correia (2010), Fine (2012a), and Rosen (2010) treat grounding as irreducibly plural on the side of the more fundamental, and Dasgupta (manuscript) advocates treating grounding as irreducibly plural on both sides. See Trogdon forthcoming for a useful overview of these and other controversies.

I myself would prefer to speak of grounding as holding between things. (One should distinguish the worldly relation of grounding from the metaphysical explanations between facts that it backs, just as one should distinguish the worldly relation of causation from the causal explanations between facts that it backs.) But I need not quibble over these details. The counterexamples I offer are robust. The reader who would prefer to regiment grounding claims differently should be able to re-phrase the discussion as she prefers.

But one point should be explicitly clarified. It is useful to distinguish between a *partial ground* for the occurrence of a given fact, and its *whole grounds*.⁶ I am here concerned solely with relations of partial ground, and the occurrence of “grounds” in the above schema should be read accordingly. (The reader may substitute “helps ground” for “grounds” if that helps fix the intended meaning for her.)

4.1.2 *Transitivity*

It is natural to assume that grounding is transitive. That is, it is natural to assume the validity of the following inference schema:

The fact that φ grounds the fact that ψ
The fact that ψ grounds the fact that ρ

Thus: the fact that φ grounds the fact that ρ

Indeed, the assumption of transitivity is so natural that it is widely incorporated into accounts of grounding without any further discussion. For instance, Schaffer (2009b, p. 376) baldly asserts that grounding is transitive, Fine (2010, p. 100; also Correia 2010) includes a transitivity axiom as one of his general ground-theoretic assumptions, and Whitcomb (2011, §2) says that transitivity and irreflexivity are both “*obviously* true, in the way that it is obviously true that the *better than* relation is transitive and irreflexive.” The exception proves the rule: Rosen (2010, p. 116) strikes a note of caution with “[t]he grounding relation is not obviously transitive,” but then immediately takes up transitivity as an assumption.

⁶ Indeed, Fine 2012a also distinguishes between a *strict ground* that is prior in the grounding order, and a *weak ground* that is merely not posterior. In the main text I am working with the notion of a strict partial ground.

This assumption is moreover very plausible in many of its instances. Thus the following instance of the transitivity schema looks solid:

1. The fact that there are particles arranged in this way grounds the fact that there are chemicals arranged in that way
2. The fact that there are chemicals arranged in that way grounds the fact that there is a cat afoot
3. Thus the fact that there are particles arranged in this way grounds the fact that there is a cat afoot

Indeed, such a style of inference looks useful in helping to establish the general physicalist claim that everything either is physical or is grounded in the physical, by helping show that the biological is grounded in the physical via the chemical. After all, if this style of inference were invalid then there would arise the worry that, even though the biological is grounded in the chemical and the chemical is grounded in the physical, the biological still might not be grounded in the physical.

The assumption of transitivity is also formally useful. Given transitivity together with the widely accepted principle of irreflexivity,⁷ one gets a relation which induces a strict partial ordering over the set of entities in its range (which I am currently treating as facts). Strict partial orderings provide metaphysical structure. This structure is what allows one to speak of fundamental entities as minimal elements in the ordering, and to apply the resources of directed acyclic graphs needed for structural equation models (cf. Schaffer manuscript). For instance, the style of inference seen in 1–3 is useful in establishing a hierarchy with physics underlying chemistry, and chemistry underlying biology.

That said, the matter of formal utility needs qualification. For one can always define the transitive closure R^* of an intransitive relation R . So one could just define grounding* as the transitive closure of grounding, and then revise physicalism to require only that everything be either physical or grounded* in the physical, while retaining partial ordering structure via the grounding* relation. So the formal utility of transitivity is best understood in terms of preserving simpler and more intuitive accounts of physicalism and of structure.

⁷ Though see Jenkins 2011 for an objection to irreflexivity. See Section 4.3.2 for a brief application of contrastivity to Jenkins's argument.

4.2 COUNTEREXAMPLES

So far I have introduced the notion of grounding and discussed how the assumption of transitivity is widespread, plausible, and useful (Section 4.1). The stage is now set for the counterexamples. I will offer three.

Of course I can only claim to make a reasonable case. With each example, the stalwart defender of transitivity can always reject one of the two linking premises, or “bite the bullet” and accept the chained conclusion. (Likewise with the counterexamples to the transitivity of causation, which I take to have roughly equal force as my counterexamples.⁸) Part of my purpose in providing three counterexamples is to exhibit their diversity, and thereby show just how stalwart a defender of transitivity must be.

4.2.1 *The dented sphere*

Imagine a slightly imperfect sphere, with a minor dent. The thing has a precise maximally determinate shape which English has no ready word for, but which I will dub “shape S.” The thing also falls under a determinable shape which English also has no ready word for, but which I will dub “more-or-less spherical,” understood as covering a range of maximally determinate shapes centered around the perfectly spherical but permitting some minor deviations. Now consider the following grounding claim:

4. The fact that the thing has a dent grounds the fact that the thing has shape S

Claim 4 is plausible since the presence of the dent helps make it the case that the thing has maximally determinate shape S. Were it not for the dent the thing’s shape would have been different. If one wonders why the thing has shape S, the fact that it has a dent is part of the reason.

Now consider:

5. The fact that the thing has shape S grounds the fact that it is more-or-less spherical

Claim 5 is an instance of the generally plausible claim that something’s having a determinate property grounds its having the relevant

⁸ For discussions of the various counterexamples to the transitivity of causation, see for instance McDermott 1995, Hall 2000, Paul 2000, Hitchcock 2001, Sartorio 2006, and Hall and Paul forthcoming, §5. Virtually everyone in the causation literature seems now to accept at least some of these counterexamples as genuine, with the notable exception of Lewis (2000).

determinable (cf. Rosen 2010, p. 126). If one wonders why the thing is more-or-less spherical, the fact that it has precise shape S is part of (indeed perhaps the whole of) the reason.

But given 4 and 5, transitivity would force us to conclude:

6. The fact that the thing has a dent grounds the fact that it is more-or-less spherical

And 6 is implausible, since the presence of the dent makes no difference to the more-or-less sphericity of the thing. The thing would be more-or-less spherical either way. The presence of the dent in no way helps to support the more-or-less sphericity of the thing, but is if anything a *threat* to the more-or-less sphericity of the thing. The thing is more-or-less spherical *despite* the minor dent, not because of it.⁹

4.2.2 *The third member*

Let S be a set with exactly three members, a , b , and c : $S = \{a, b, c\}$. Now consider the following grounding claim:

7. The fact that c is a member of S grounds the fact that S has exactly three members

Claim 7 is plausible since c 's being a member of S helps make it the case that S has exactly three members. Were c not a member of S then S would have had two members and not three. If one wonders why S has exactly three members, the fact that S has c as a member is part of the reason.

Now consider:

8. The fact that S has exactly three members grounds the fact that S has finitely many members

Claim 8 is plausible (along lines similar to claim 5) since *having finitely many members* is a determinable, of which *having three members* is a determinate. If one wonder why S has finitely many members, the fact that it has three members is part of (indeed perhaps the whole of) the reason.

⁹ Trogdon (forthcoming, §4) worries that my example equivocates between partial and whole grounding, since 4 is only a truth of partial grounding but 5 is a truth of whole grounding. But of course any whole ground is also a partial ground, and so 5 is *both* a truth of partial grounding and a truth of whole grounding. The example thus should go through on the intended reading of "grounds" in terms of partial grounding. (Trogdon goes on to offer an "easy fix" to the worry, which is to replace the fact that the thing is more-or-less spherical with the disjunctive fact that the thing is more-or-less spherical or snow is white, in both 5 and 6. This works too.)

But given 7 and 8, transitivity would yield:

9. The fact that c is a member of S grounds the fact that S has finitely many members

And 9 is implausible, since c 's being a member of S in no way helps contribute to the fact that S is finite. S would be finite either way, with or without c as a member. If anything, S remains finite not because of but *despite* taking on c as an additional member.

4.2.3 *The cat's meow*

Imagine that Cadmus the cat is meowing. The fact that Cadmus is meowing is partly grounded in the various facts that make this cat *Cadmus*. Perhaps – given the essentiality of origins (Kripke 1980) – these include origin facts such as the fact that this creature was produced from the meeting of this sperm and that ovum; or perhaps – given the essentiality of species membership – these include wider historical facts that key this creature into the species *felis catus*. So consider:

10. The fact that the creature was produced from the meeting of this sperm and that ovum grounds the fact that Cadmus is meowing

Claim 10 is plausible (given origin essentialism), since being produced from the meeting of this sperm and that ovum helps make the creature Cadmus as opposed to some other cat. If one wonders why *Cadmus* is meowing, the facts that make the meowing creature Cadmus are part of the reason.

The fact that Cadmus is meowing in turn grounds various “higher level” facts that are independent of the “Cadmus aspect” but rather stem from “the meowing aspect,” such as:

11. The fact that Cadmus is meowing grounds the fact that something is meowing

Claim 11 is plausible since the fact that Cadmus is meowing provides a factual witness for the existential generalization that something is meowing, and factual witnesses ground existential generalizations (Fine 2010b, p. 101; Rosen 2010, p. 117). If one wonders why it is the case that something is meowing, then the fact that Cadmus is meowing provides sufficient reason.

But given 10 and 11, transitivity entails:

12. The fact that the creature was produced from the meeting of this sperm and that ovum grounds the fact that something is meowing

And 12 is implausible, since the present extrinsic and historical fact that the creature was produced from the meeting of this sperm and that ovum (as opposed to some other sperm-and-ovum duo) makes no difference to the creature's present intrinsic physical state, which is what is crucial to its ability to witness the existence generalization that something is meowing.¹⁰ Whether the creature counts as Cadmus or some other cat, it is meowing all the same. The fact that the creature was produced from the meeting of this sperm and that ovum helps make it be *Cadmus* meowing, but doesn't help make it be *Cadmus meowing*.

I thus conclude that there are plausible counterexamples to the transitivity of grounding. Such a conclusion befits the idea that grounding is akin to metaphysical causation, since there are known to be plausible counterexamples to the transitivity of causation.

4.3 CONTRASTIVITY

I have offered counterexamples to the transitivity of grounding (Section 4.2). But it would be unsatisfying to leave the matter at that. For given that transitivity is itself a natural, plausible, and useful assumption (Section 4.2), one wants a *replacement* which not only avoids the counterexamples but explains why transitivity seemed plausible, while preserving its use in generating structure.¹¹ Indeed, one might hope for a replacement which is *unified* in at least two respects. First, the replacement might furnish a unified diagnosis of the diverse counterexamples. Secondly, the replacement might cover not just grounding but causation as well, as an analogue notion whose transitivity is equally in doubt. I will thus

¹⁰ Of course, there may well be a *causal* connection from the *past* meeting of sperm and ovum to the *present* meowing. But that must be distinguished from the question of whether there is a *grounding* connection from the *present* extrinsic and historical fact of origin to the *present* intrinsic fact of physical state.

¹¹ As Hall and Paul (forthcoming, Chapter 5) aptly note with regard to the counterexamples to the transitivity of causation: "What's needed is a more subtle story, according to which the inference from "*C* causes *D*" and "*D* causes *E*" to "*C* causes *E*" is safe, *provided* such-and-such conditions obtain – where these conditions can typically be assumed to obtain, except perhaps in odd cases . . . [S]pelling out the needed conditions – or providing some other explanation for why causation can often safely be assumed to be transitive – is a crucial bit of unfinished business."

conclude by sketching a replacement which is unified in both of these two respects, based on *contrastive* treatments of both causation and grounding.

I should clarify that I am only claiming to offer one such unified replacement principle. There may well be other unified replacements to consider. I am also not going to defend a contrastive treatment of causation or the application of contrastive causation to the transitivity of causation (beyond providing one illustrative example), since I have discussed this elsewhere (Schaffer 2005, especially §5). And I am not going to try to defend a full contrastive treatment of grounding. My primary purpose is rather to extend the contrastive treatment of transitivity for causation to the case of transitivity for grounding, and thus exhibit at least one respect in which a contrastive treatment of grounding holds promise.

4.3.1 *Contrastive treatments*

In the causal case, the contrastive treatment involves viewing causation not as a binary relation between two actual distinct events but as a quaternary relation including a non-actual causal contrast and a non-actual effectual contrast, of the form:

C rather than C^* causes E rather than E^*

Here C and E are required to be actual distinct events, but C^* is required to be a non-actual alternative to C , and E^* is required to be a non-actual alternative to E . In the grounding case (continuing to restrict the relata to facts), the contrastive treatment involves viewing grounding as having the form:

The fact that φ rather than φ^* grounds the fact that ψ rather than ψ^*

The fact that φ and fact that ψ are required to be obtaining facts, but the fact that φ^* is required to be a non-obtaining alternative to the fact that φ , and the fact that ψ^* is required to be a non-obtaining alternative to the fact that ψ .¹²

Contrastive treatments might at first seem implausibly radical, but in fact they are now quite orthodox for causation.¹³ Indeed, the leading treatments of causation work within *structural equation models* (cf. Pearl 2000), with events represented via variables each of which is allotted

¹² In both the causal and grounding cases the contrast slots can be expanded to allow for sets of contrasts, but for simplicity I will stick with the case of the single contrast in the main text.

¹³ Contrastive treatments of causation are defended in Hitchcock 1996, Woodward 2003, Maslen 2004, Schaffer 2005, 2010c, and forthcoming, Craver 2007, Menzies 2007 and 2009, and Northcott 2008, inter alia.

a range of permitted values. The range of permitted values constitutes a *contrast space*.¹⁴ What range of values is permitted affects causal outcomes (Schaffer 2010b, §1.3). And so structural equation models are inherently contrastive. Given that grounding is akin to causation, this provides one initial motivation for extending a contrastive treatment to grounding.

A further motivation for a contrastive treatment of both grounding and causation is the idea that both back forms of explanation.¹⁵ Now explanation is widely thought to be contrastive (cf. van Fraassen 1980, Garfinkel 1981). Thus explaining why *Adam* ate the apple is a different matter from explaining why Adam ate the apple, or why Adam ate *the apple*. To explain why *Adam* ate the apple one needs information that distinguishes Adam from other possible apple eaters such as Eve, whereas to explain why Adam ate the apple one needs information that distinguishes the actual eating from other possible actions Adam might have engaged in with the apple such as ignoring it, and to explain why Adam ate *the apple* one needs information that distinguishes the apple from other possible things Adam might have eaten such as the nearby pear. Contrastive treatments of both causation and grounding cast both causation and grounding in an apt form to back explanation.

Some confirmation of the applicability of a contrastive treatment is that focal differences can make for truth-conditional differences. In the case of causation, Achinstein (1975) notes that it may be true to say that Socrates' *drinking hemlock* at dusk caused his death, yet false to say that Socrates' drinking hemlock *at dusk* caused his death. One wants to say: what he drank matters, when he drank it did not. The contrastivist can put this as follows: Socrates' drinking hemlock at dusk rather than wine caused his dying rather than surviving, but Socrates' drinking hemlock at dusk rather than dawn did not cause his dying rather than surviving (Schaffer 2005, p. 308).¹⁶ An analogous point holds with grounding. The grounds for Socrates' *drinking hemlock* at dusk should involve the relevant features of the physical system that make the liquid be

¹⁴ More formally, a causal model may be formalized as a pair $\langle S, F \rangle$ where S (the *signature*) is a triple $\langle U, V, R \rangle$ with U being a set of exogenous variables, V being a set of endogenous variables, and R being a function associating each variable $X \in U \cup V$ with a range of at least two allotted values. R is what encodes the contrasts for a given event $X=x$. (The other element of the model, F , then associates each endogenous variable $X \in V$ with a function f_X mapping values of X 's parent variables to values of X .) See Halpern 2000 for further formal treatment.

¹⁵ Or perhaps better: there is a general notion of explanation which can be backed by causation or by grounding (inter alia), or in some cases by a mixture of the two. After all, to explain a macro-effect from a micro-cause, one needs a "diagonal" explanation that crosses both times and levels.

¹⁶ As Menzies (2009, p. 361) notes, discussing this very example in connection with structural equation models: "The point of the contrastive focus in the event nominals is to indicate the range of values of the relevant variables."

hemlock rather than, say, wine. While the grounds for Socrates' drinking hemlock *at dusk* should involve the relevant features of the physical system that situate it at dusk rather than, say, dawn.

That said, the prospects for contrastive treatments depend on a detailed assessment of fully developed frameworks. In my view the best framework for treating causation is that of structural equation models which incorporate contrastive information. I think that structural equation models can be extended to provide fruitful treatments of grounding relations, but such a claim requires its own full-length discussion (Schaffer manuscript).

4.3.2 *Differential structure*

Grounding – when conceived of as a binary relation – is widely thought to be irreflexive, asymmetric, and transitive. Indeed, such principles impose partial ordering structure (Section 4.2). What happens to all these principles in a contrastive framework?

The simplest and most natural extension of all of these principles into a contrastive framework is to think of them all as holding, not between individual facts, but between *differences*. Continuing to work with a fact-restricted singular–singular relational schema for grounding (Section 4.1.1), think of “The fact that φ rather than φ^* ” as one such difference, grounding the difference “the fact that ψ rather than ψ^* .” Irreflexivity, asymmetry, and transitivity can then be understood as holding between these differences, as per the following schemata:

Differential Irreflexivity: It is not the case that the fact that φ rather than φ^* grounds the fact that φ rather than φ^*

Differential Asymmetry: If the fact that φ rather than φ^* grounds the fact that ψ rather than ψ^* , then it is not the case that the fact that ψ rather than ψ^* grounds the fact that φ rather than φ^*

Differential Transitivity: If the fact that φ rather than φ^* grounds the fact that ψ rather than ψ^* , and the fact that ψ rather than ψ^* grounds the fact that ρ rather than ρ^* , then the fact that φ rather than φ^* grounds the fact that ρ rather than ρ^*

Thus one retains partial ordering structure, albeit not over individual facts but over differences.¹⁷

¹⁷ As mentioned in Section 4.1.2, Jenkins (2011) objects to irreflexivity since she thinks that one could coherently hold both that (a) the fact that neural state n exists grounds the fact that mental state m

One thus recovers the idea of a *fundamental difference* as a minimal element in the ordering over differences:

Differential Fundamentality: The fact that φ rather than φ^* is fundamental =_{df.} there is no difference ψ rather than ψ^* that grounds the fact that φ rather than φ^*

One can moreover speak of a fundamental fact *simpliciter*, as a fact occupying the first slot (“ φ ”) of a fundamental difference:

Absolute Fundamentality: The fact that φ is absolutely fundamental =_{df.} there is a possible fact φ^* such that the fact that φ rather than φ^* is fundamental

The fundamental facts are the obtaining portions of fundamental differences. One can likewise speak of a fundamental entity *simpliciter* as an entity that a fundamental fact concerns. One can thus retain the plausibility of grounding-based formulations of physicalism: all differences are physical differences or grounded in physical differences. Or: all absolutely fundamental facts are physical facts.

One can then consider various structural restrictions on the difference ordering. By way of illustration, one might or might not require differential well-foundedness, now understood as the idea that every difference which is not fundamental is grounded in a difference which is fundamental:

Differential Well-foundedness: If the fact that φ rather than φ^* is not fundamental, then there is a difference ψ rather than ψ^* which is fundamental and which grounds the fact that φ rather than φ^*

In short, a contrastive treatment of grounding augmented with *Differential Transitivity* preserves much of what was promising about transitivity. If transitivity is intuitive, *Differential Transitivity* represents its intuitive extension. If transitivity is plausible in application to physicalist

exists, and that (b) the fact that neural state n exists is identical to the fact that mental state m exists. In response she considers the option of treating grounding as a four-place relation between <fact, aspect> pairs, so as to be able to say that <the fact that the state in question exists, neural aspect> grounds <the fact that the state in question exists, mental aspect>. A contrastive approach outfitted with *Differential Irreflexivity* can equally resolve her objection (while enjoying the motivations of a contrastive treatment: Section 4.3.1, and naturally extending the structural principles used in binary approaches: Section 4.3.2). The contrastive treatment has it that the fact that the state in question exists rather than a state with this other neural feature grounds the fact that the state in question exists rather than a state with that other mental feature.

inferences, and useful (with irreflexivity) in yielding metaphysical structure, *Differential Transitivity* (with *Differential Irreflexivity*) can claim comparable virtues.¹⁸

4.3.3 Counterexamples resolved

A contrastive treatment of grounding augmented with *Differential Transitivity* can resolve the counterexamples to transitivity presented in Section 4.2, just as a contrastive treatment of causation can resolve the counterexamples to the transitivity of causation via the analogous principle:

Differential Transitivity of Causation: If C rather than C^* causes D rather than D^* , and D rather than D^* causes E rather than E^* , then C rather than C^* causes E rather than E^*

With causation the key idea is to show that all the counterexamples to transitivity require illicit shifts in the middle contrast, only fitting the schema: C rather than C^* causes D rather than D^* , and D rather than D^{**} causes E rather than E^* (where $D^* \neq D^{**}$). Cases that only fit such a schema are no counterexamples to *Differential Transitivity of Causation*.¹⁹

I will not discuss the contrastive treatment of the transitivity of causation save to provide an illustrative example (*nudgings*, from Schaffer 2005, pp. 309–10). Thus imagine that when Suzy throws a rock through a window, her rock is ever so slightly deflected in midair (from trajectory₁ to nearby trajectory₂) by a mote of dust. Then it might seem as if the following holds:

13. The dust mote's nudging the rock causes the rock to reach the midpoint of trajectory₂

¹⁸ To the extent that contrastive structure is understood as a concomitant of using structural equation models (where variables are contrast spaces), the structural principles need to force the structure *over the variables* into the structure of a directed acyclic graph (Schaffer manuscript). In the case of binary variables the principles in the main text suffice. But for variables allotted more than two values, the principles need to be extended to take on sets of contrasts. In any case, what bears emphasis is that the relevant structure in structural equation models is not a structure over outcomes (actual values of variables) but a structure over contrast spaces (variables themselves, each with a range of allotted values). Thus from a structural equation modeling perspective the partial ordering needed is not of the form that transitivity might provide but rather of the form that *Differential Transitivity* provides.

¹⁹ If one thinks of the contrasts as supplied by the context when left implicit, this is to say that all the counterexamples to transitivity require illicit *context shifts*. Any statement of the transitivity schema (for either causation or grounding) will be valid *in any fixed context*, given that a fixed context supplies a fixed stock of implicit contrasts.

14. The rock's reaching the midpoint of trajectory₂ causes the window to shatter

Indeed 13 and 14 each seem validated by the simple *counterfactual dependence* test for causation, which is at least an excellent test. But given 13 and 14, the transitivity of causation would entail:

15. The dust mote's nudging the rock causes the window to shatter

But clearly the dust mote's nudging the rock does not cause the window to shatter. At most it makes the tiniest difference in how the window shatters, but the window will shatter either way.

It should be evident how the contrastive treatment holds promise for 13–15. The difference that the dust mote's nudging the rock rather than missing the rock makes is:

- 13*. The dust mote's nudging the rock rather than missing the rock causes the rock to reach the midpoint of trajectory₂ rather than the midpoint of trajectory₁

But the rock's reaching the midpoint of trajectory₂ rather than the midpoint of trajectory₁ does not cause the window to shatter rather than remain intact. The window will shatter either way:

- 14*. The rock's reaching the midpoint of trajectory₂ rather than the midpoint of trajectory₁ does NOT cause the window to shatter rather than remain intact

What does cause the window to shatter rather than remain intact are differences such as the rock's reaching the midpoint of trajectory₂ *rather than dropping directly to the ground*:

- 14**. The rock's reaching the midpoint of trajectory₂ rather than dropping directly to the ground does cause the window to shatter rather than remain intact

But of course the dust mote's nudging the rock does not make the difference as to whether the rock reaches the midpoint of trajectory₂ rather than dropping directly to the ground. There is no differential chain running from the dust mote's nudging the rock to the window's shattering.

Returning to grounding, the key idea is thus to show that the counter-example to transitivity require shifts in the value of the middle contrast, only fitting the following schema (where $\Psi^* \neq \Psi^{**}$):

The fact that φ rather than φ^* grounds the fact that ψ rather than ψ^*
 The fact that ψ rather than ψ^{**} grounds the fact that ρ rather than ρ^*

 X Thus: the fact that φ rather than φ^* grounds the fact that ρ rather than ρ^*

Cases that only fit such a schema are of course no counterexamples to *Differential Transitivity*.

With this idea in mind, return to the case of the dented sphere (Section 4.2.1). Consider the fact that the thing has a dent, as compared to the natural alternative of it being undented. What difference does the presence of the dent make? It makes the difference between the thing having its precise shape S, and its having a slightly different (and more perfectly spherical) shape S*:

4*. The fact that the thing has a dent rather than having no dent grounds the fact that the thing has shape S rather than S*

But the fact that the thing has shape S rather than S* makes *no difference* to whether the thing is more-or-less spherical. The thing will be more-or-less-spherical either way:

5*. The fact that the thing has shape S rather than S* does NOT ground the fact that the thing is more-or-less spherical rather than not

What does make a difference as to whether the thing is more-or-less spherical are differences such as between the thing's having its precise shape S and its having a completely different flat-as-a-pancake shape S**:

5**. The fact that the thing has shape S rather than S** grounds the fact that the thing is more-or-less spherical rather than not

But of course the presence of the dent does not make the difference between the thing's having S or S**. There is no differential chain running from the presence/absence of the dent to the thing's being more-or-less spherical or not.²⁰

One can of course find features of the thing that do make the difference between its having its precise shape S and the flat-as-a-pancake shape S**. But these features *do* make the difference between the thing's being more-or-less spherical rather than not. In general, consider any features of the thing that

²⁰ Indeed it may be natural to think of the case of the dented sphere as the grounding-theoretic analogue to the example of nudgings. One might think of the dent as nudging the location of the sphere in the determination space for shape.

make a difference to its shape. Either these features make a difference to whether the thing is more-or-less spherical, or not. If not then the analogue of 5 will fail (as was seen with 5*). But if so then the analogue of 6 should hold (as was seen with 5**). Either way, *Differential Transitivity* stands.

Similar comments apply to the case of the third member (Section 4.2.2). What difference does having c as a member make to S ?

- 7*. The fact that c is a member of S rather than not a member of S grounds the fact that S has exactly three members rather than exactly two members

But whether or not S has exactly three members or exactly two members, S will remain finite:

- 8*. The fact that S has exactly three members rather than exactly two members does NOT ground the fact that S is finite rather than infinite

What does make the difference as to whether S is finite are differences such as between S 's having exactly three members and its having as many members as there are natural numbers:

- 8**. The fact that S has exactly three members rather than as many members as there are natural numbers grounds the fact that S is finite rather than infinite

But of course the fact that c is a member of S does not make the difference between S 's having exactly three members rather than as many members as there are natural numbers. There is no differential chain running from c 's membership-or-not in S to S 's being finite-or-not.

In general, consider any alternative supposition to S 's having c as a member. That alternative will either preserve S 's finitude or not. If so then the relevant analogue of 8 will fail, and if not then the relevant analogue of 9 will hold. *Differential Transitivity* stands either way.

Similar comments apply equally to the case of the cat's meow (Section 4.2.3). Being produced from the meeting of this sperm and that ovum rather than a different sperm and ovum makes the difference between it being Cadmus who is meowing and it being some other cat (say, Cilix) who is meowing:

- 10*. The fact that the creature was produced from the meeting of this sperm and that ovum rather than a different sperm and ovum grounds the fact that Cadmus is meowing rather than Cilix meowing

But whether it is Cadmus or Cilix who is meowing, there will still be something meowing:

- II*. The fact that Cadmus is meowing rather than Cilix meowing does NOT ground the fact that something is meowing rather than nothing meowing

What does make the difference as to whether something is meowing rather than nothing meowing are differences such as between the creature's intrinsic physical state being this way rather than that:

- II**. The fact that the creature is in this intrinsic physical state rather than that intrinsic physical state grounds the fact that something is meowing rather than nothing meowing

But of course the present historical fact that the creature was produced from the past meeting of this sperm and that ovum does not now help ground the difference between the creature being in this intrinsic physical state rather than that intrinsic physical state. (The meeting of this sperm and that ovum may have had various causal repercussions across time, but at the present moment it makes no difference to the intrinsic physical state of the system.) There is no differential grounding chain running from the present historical fact of production from this sperm and that ovum, to the present fact of being in this intrinsic physical state rather than that.

In general, consider any alternative supposition to the creature's having been produced from the meeting of this sperm and that ovum. The alternative will either preserve the fact that something is meowing or not. If so then the analogue of II will fail; if not then the analogue of II will hold; either way *Differential Transitivity* stands.

Putting all this together, I have argued that a contrastive treatment of grounding not only comes with strong initial motivations (Section 4.3.1), but also provides a natural unified replacement principle of *Differential Transitivity* which can help generate metaphysical structure (Section 4.3.2), while resolving the plausible counterexamples to transitivity (Section 4.3.3). For these reasons I think that a contrastive treatment of grounding holds promise. But whatever one may think of contrastivity as a corrective, I would contend that the assumption of transitivity was a mistake.²¹

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