

LAWS IN METAPHYSICS

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ABSTRACT OF THE DISSERTATION

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The first two chapters of this dissertation defend the Deductive-Nomological Account of metaphysical explanation. Chapter 1 develops the Nomological Account of ground, – p_1, \dots, p_n ground q if and only if the laws of metaphysics determine q on the basis of p_1, \dots, p_n , – and the *constructional theory* of the metaphysical laws, – the laws are general principles that characterize construction-operations.

Chapter 2 offers an analysis of the notion of determination involved in the Nomological Account: the laws determine q based on p_1, \dots, p_n if and only if q follows from p_1, \dots, p_n and the laws in the *grounding-calculus*. The grounding-calculus is characterized in terms of two inference rules and a suitable notion of ‘proof’. The rules are designed to analyze the input- and output notions that are intuitively associated with laws: the laws take some facts as *input* and deliver some other facts as *output*.

Chapters 1 and 2 also go beyond the development of the positive view. Chapter 1 shows how the Nomological Account explains general patterns among grounding-truths, the modal force of ground, and certain connections between ground and construction. Chapter 2 shows why the Deductive-Nomological Account of metaphysical explanation escapes the objections to the traditional DN-account of scientific explanation, and it also outlines two views on logical explanation that are available to the proponent of the Nomological Account.

Chapter 3 focuses on laws of nature and presents the Circularity Puzzle, which is a generalized version of a familiar circularity-based objection to Humeanism about the laws of nature. The three solutions to the Circularity Puzzle correspond to three different general views on the laws, one Anti-Humean and two Humean views. I argue that for the Anti-Humean, the Circularity Puzzle collapses into the familiar inference-problem, and for the Standard Humean, the solution to circularity-related worries lies in the rejection of the governing-conception of laws. I explain what I take to be the strongest response to the inference-problem.

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Table of Contents

Abstract.....	ii
Acknowledgements.....	iv
Chapter 1. The Nomological Account of Ground.....	1
1.1 Introduction.....	1
1.2 Desiderata for a Theory of Ground: Necessitation, Generalization, Inheritance	3
1.3 The Nomological Account: Ground is Lawful Determination among Truths	7
1.4 The Nomological Account meets the Desiderata	23
1.5 Conclusion	28
Chapter 2. The Deductive-Nomological Account of Metaphysical Explanation.....	30
2.1. Introduction.....	30
2.2 The Content of the Metaphysical Laws.....	33
2.3 The Deductive-Nomological Analysis of Determination	40
2.4 The Objection from the Historic Failure of DN-Accounts.....	49
2.5 The Objection from Logical Ground	54
2.6 Conclusion	60
Chapter 3. The Circularity Puzzle in the Metaphysics of the Laws of Nature.....	63
3.1 The Realist Metaphysics of the Laws of Nature	63
3.2 Two Circularity-Objections to Humeanism.....	66
3.3 The Circularity Puzzle	71
3.4 The Anti-Humean Choice: Rejecting Regularity.....	76
3.5 The Standard Humean Choice: Rejecting Priority	82
3.6 The Non-Standard Humean Choice: Rejecting Generality	85
3.7 Conclusion	90
Bibliography	93

Chapter 1. The Nomological Account of Ground

1.1 Introduction

Common sense recognizes a wide range of entities including tables and chairs, mental processes, social and moral institutions, and works of art, to only name a few. Science suggests that there are further entities, including atoms and molecules, sets and numbers, or organisms and species. Fundamental reality, on the other hand, contains only a few kinds of objects which correspond to the terms of the ideal fundamental scientific theory. So, if common sense and science provide accurate views of the world, the following question naturally arises: How does some austere fundamental reality give rise to a dazzling variety of entities? How does the fundamental connect to the derivative?

It has recently been suggested that there is a univocal notion of metaphysical explanation, or *ground*, which connects the fundamental to the derivative (Correia 2005, Fine 2001 and 2012, Rosen 2010, Schaffer 2009, and Trogon forthcoming). We can thus restate our initial question as, “How does the fundamental ground the derivative?” And we can replace this general question with more specific ones: How does the physical ground the mental (if it does)? How does the descriptive ground the normative (if it does)? How does the concrete ground the abstract (if it does)? And how is it that the location or mass of a complex object is grounded in the locations or masses of its constituents (if it is)?

According to the common response to questions of this sort, there simply is no comprehensive answer. For, ground is usually taken to be a primitive notion that is not explicable in different terms (Rosen 2010, Schaffer 2009). Instead of explaining how it is that the derivative arises from the fundamental, the *primitivist* accepts this as an unexplained given. I propose a more ambitious alternative to the primitivist response. In this paper, I develop

and defend a theory of ground that explains what it takes for some truths to ground others. This theory will not remove the mystery altogether, but it will help to reduce it.

The theory I defend relies on the notion of a *law of metaphysics*. Laws of metaphysics are akin to laws of nature in the sense that they guide the development of the world along a dimension. Whereas the natural laws work along the temporal dimension, the metaphysical laws work along the axis of fundamentality: from the truths of fundamental physics via the truths of chemistry, biology, and so on, all the way up. According to the specific conception I develop in this paper, the metaphysical laws characterize ‘construction-relations,’ which include composition, set-formation, and property-determination, among many others. The job of the laws is to determine the construction of derivative entities and facts via these relations. With this novel and independently motivated conception in hand, I will argue that the metaphysical laws support metaphysical explanations and thus allow for a *Nomological Account* of ground: some truths $p_1 \dots p_n$ ground q just in case $p_1 \dots p_n$ together with the laws of metaphysics determine q .

My defense of the Nomological Account takes the following three steps: Section 1.2 identifies three substantive desiderata that a theory of ground needs to meet. Section 1.3 presents the Nomological Account; it explains the notion of a metaphysical law in detail and elucidates the crucial notion of lawful determination. Section 1.4 states my case in favor of the Nomological Account; it shows that the account satisfies the three desiderata from section 1.2. The defense of the Nomological Account is ultimately a defense of the metaphysical laws. Since the laws of metaphysics play a key role in the theory of ground, they earn their keep in metaphysical theorizing.

1.2 Desiderata for a Theory of Ground: Necessitation, Generalization, Inheritance

In this section, I introduce three substantive features of ground. These features are *deep* in the sense that they are necessary and yet go beyond the purely logical properties of ground. They are of the sort that requires an explanation in terms of an underlying theory. I will articulate three principles which capture these substantive features. Each of the three principles corresponds to a desideratum for a theory of ground: the successful theory will explain why each of the three principles holds. The desiderata will be of use in assessing the Nomological Account of ground that I develop in the next section. In section 1.4, I will show that the Nomological Account meets the three desiderata and therefore receives significant *pro tanto* justification.

The first substantive feature of ground is captured by the Necessitation-principle (\Box_M stands for ‘it is metaphysically necessary that’):

(Necessitation) p grounds $q \rightarrow \Box_M(p \supset q)$

The Necessitation-principle says that p grounds q only if p metaphysically necessitates q . To be clear, modal entailment is not sufficient for ground: for example, your existence necessitates, but does not ground that $2+2=4$. But I take it that modal entailment is necessary for ground: if Socrates’ existence grounds that {Socrates} exists, then it is necessary that if Socrates exists, so does {Socrates}. The key motivation for Necessitation is conceptual. The concepts of ground and necessitation overlap on the intuitive notion of ‘metaphysical sufficiency’: grounds are metaphysically sufficient conditions for what they ground and metaphysical sufficiency in turn suffices for necessitation.¹

¹ See deRosset (2010), Rosen (2010), Trogon (2013) for additional support for Necessitation.

I call the second substantive principle about the nature of ground the “Generalization-principle.” For all qualitative properties, F and G:

(Generalization) $F(a) \text{ grounds } G(a) \rightarrow \forall x(F(x) \supset G(x))^2$

The Generalization-principle says that if an object has some property in virtue of having some other property, then the former property is in general sufficient for the latter. For instance, if the fact that you are human is grounded in the fact that you are a rational animal, then being a rational animal is in general sufficient for being human. And hence, everything that is a rational animal is also human. In short, ground is not sensitive to the specific individuals that enter into grounding-facts.

Generalization arguably underlies the method of counter-examples in various areas of philosophy. If, for instance, a subject knows that p in virtue of standing in the ‘justified true belief’-relation to p, then Generalization entails that everyone who stands in the JTB-relation to p knows that p. And thus, if we can find a subject who stands in that relation to p without knowing p, the initial grounding-claim fails.³

Finally, the third principle, in slogan form, says that properties trickle up along mereological pathways:

(Inheritance) Properties of constructed entities are determined by properties of their constituents

‘Construction’ and ‘constituency’ are broadly mereological notions that I will explain more thoroughly in the next section. I intend them to apply to sets, states of affairs, complex

² The restriction to qualitative properties rules out counterexamples of the following sort: The fact that Peter has the relational property ‘loves-Peter’ grounds the fact that Peter is narcissistic. But Carla may have the property ‘loves-Peter’ and fail to be narcissistic. Thanks to Shamik Dasgupta here.

³ deRosset (2010) presents other versions of Generalization and the motivation in the text.

(Ground to Constituent) $\varphi(a_1 \dots a_n)$ fully grounds $F(b) \rightarrow$ Some of $a_1 \dots a_n$ construct b ⁵

The Ground-to-Constituent principle says that if some truth involving b is fully grounded in a truth involving distinct objects, then some of these distinct objects construct b . This is again clear in the case of the grounds of the intrinsic properties of an object: if b 's mass, weight, and location are grounded in properties of $a_1 \dots a_n$, then $a_1 \dots a_n$ construct b . However, the principle is also plausible for relational properties, because every ground for b 's possession of some property needs to comprise a ground for b 's existence. And b 's existence is always at least in part grounded by truths involving the entities that construct b .

Ground to Constituent faces potential counterexamples. For instance, the fact that castling through check is illegal in chess is grounded in facts about people. And yet the abstract object chess is not constructed from people. Similarly, while the existence of *The Magic Mountain* is fully grounded in facts about Thomas Mann, the novel is not constructed from the man.⁶ Since the account I develop below is committed to Ground to Constituent, I will argue in the final section that these counterexamples are inconclusive. But even if examples of this sort are convincing, a version of Ground to Constituent that is restricted to concrete objects remains plausible and can be used to characterize the Inheritance principle.

The Construction to Ground and the Ground to Construction principles clarify the meaning of the Inheritance principle. I will return in section 1.4 to the more precise principles in order to explain Inheritance. More important for current purposes, however, is the bottom

⁵ 'F' is a *genuine property term*, where this notion is partly characterized by the following necessary condition: if 'F' is the result of lambda-abstraction as applied to a logically molecular sentence, then 'F' is not a genuine property term. In particular, $\lambda x(G_1(a) \vee G_2(x))$ is not a genuine property term. Consequently, $G_1(a)$ grounds $\lambda x(G_1(a) \vee G_2(x))(b)$ is not a counterexample to Ground to Constituent. Thanks to an anonymous referee for raising the issue.

⁶ Thanks to an anonymous referee for these examples.

line of Inheritance: ground is entangled with broadly mereological relations. Since this entanglement is robust and pervasive it cries out for explanation.

Necessitation, Generalization, and Inheritance characterize key features of ground that invite explanation. This should be especially clear in the case of Necessitation and Inheritance, which encode intimate connections between ground and a different central metaphysical notion: metaphysical necessity in the case of Necessitation and mereology in the case of Inheritance. These connections are modally robust and hence require a philosophical treatment. We could simply treat these connections as brute facts, or as holding in virtue of the nature of ground. But it would be preferable to have a more explanatory account of why they hold, if possible. Generalization is also not a good contender for bruteness. For, Generalization says that grounding-truths exhibit general patterns; and these patterns cry out for explanation just as much as the fact that similar causes have similar effects.

The resulting challenge is to design a plausible theory of ground that explains these three principles. I develop the Nomological Account of ground in the next section, and I show in section 1.4 that it meets these desiderata. The fact that the Nomological Account explains the three principles provides us with strong *prima facie* reasons in its favor.

1.3 The Nomological Account: Ground is Lawful Determination among Truths

I will next develop an account of ground that is based on the notion of a law. The basic idea of the account is that some truths, $p_1 \dots p_n$, metaphysically explain q just in case there are certain laws that determine q on the basis of $p_1 \dots p_n$. The laws in question are *metaphysical laws*. The aim of the current section is to explain the notion of a metaphysical law and to develop the Nomological Account of ground, which understands ground as determination via the metaphysical laws.

I will introduce the notion of a metaphysical law in two steps. In the first step, I characterize the general features of the laws independently of their specific content, and I show that these features can help us to explain Necessitation and Generalization. I will then develop a specific conception of the metaphysical laws, the *Constructional Conception*, and I will argue that it provides us with sufficient resources to account for Inheritance. This conception is a novel approach to the important but initially elusive notion of a metaphysical law. Once the Constructional Conception is on the table, I will introduce the Nomological Account of ground.

Whatever the laws of metaphysics say, they satisfy at least the following three constraints which partly characterize the general nature of lawhood: the *strength-constraint*, the *generality-constraint*, and the *modality-constraint*. By way of intuitive gloss, we can understand the strength of the laws of nature as the number of truths that they determine at any given time. This intuitive idea cannot be easily converted into a definition of the strength of laws, since there are infinitely many truths that laws may or may not determine. However, we can usefully think of the maximum strength of laws this way: laws are maximally strong if they determine a unique future at every point in time. Laws of nature fall short of this maximum to the extent that they are probabilistic. Since there is no analog to probabilistic mechanisms in the case of metaphysical explanations, the metaphysical laws are maximally strong: they take the truths at any level of fundamentality to all the truths at higher levels.

To count as a system of laws, the metaphysical laws arguably have to be relatively simple.⁷ To ensure simplicity, the generality-constraint requires that the laws are generalizations that mention only a few select properties and objects. The generality-constraint poses a challenge

⁷ Lewis (1983) takes simplicity to be constitutive of the nature of law-hood. But even if we disagree with this, relative simplicity is required to uphold the analogy between the metaphysical laws and the laws of nature.

for the proponent of metaphysical laws: the laws ‘capture’ every object and property and yet they only feature a special minority of them ‘by name’. To state the laws we thus need some properties that can be used to pick out every object and property; and these select properties need to have an appropriately special status that makes them eligible for entering into the laws directly. I will show that the Constructional Conception of the laws that I develop below meets this challenge from the generality of the laws.

Finally, the laws of nature hold with natural necessity: if it’s a natural law that p , then it is naturally necessary that p . It would also seem attractive to hold that metaphysical laws are metaphysically necessary: if it’s a metaphysical law that p , then it is metaphysically necessary that p . This is the modality-constraint on the laws. The necessity of the laws can be explained either by the nature of law-hood or the nature of necessity. On the first view, metaphysical necessity is the force that accompanies and arises from the laws.⁸ On the second view, metaphysical necessity is a restriction on logical necessity: the space of metaphysically possible worlds is defined (in part) as the space in which all the actual metaphysical laws hold.⁹ I remain neutral between these two accounts.

With the three constraints on the nature of law-hood in mind, we can begin to see that a law-based account of ground is well-equipped to meet at least two of the three desiderata. For,

⁸ This idea can be developed further as follows: certain axioms of metaphysical necessity hold in virtue of the nature of metaphysical law-hood. These axioms include the ‘detachment-principle’ $\Box_M(L_M(p) \supset p)$ and the ‘uniformity-principle’ $L_M(p) \supset \Box_M(L_M(p))$, where ‘ \Box_M ’ means ‘it is metaphysically necessary that’. Since the notion of metaphysical necessity enters the essence of metaphysical law-hood, the laws are the source of metaphysical necessity. Similarly, detachment- and uniformity-principles of natural necessity may be encoded in the essence of the laws of nature. I argue in chapter 3 that the Anti-Humean about laws of nature should use this maneuver to solve the inference problem articulated in Lewis (1983).

⁹ This view faces the challenge of distinguishing arbitrary restrictors from genuine kinds of necessity (cf. Rosen (2006, p. 33) and Fine (2002, p. 265-6)). A common response to this problem which, to my knowledge, has not been discussed adequately in print (although see Sider 2012, ch. 12), relies on the context-sensitivity of modals: Speakers determine different restrictors on the space of possibilities in different contexts; what counts as necessary in each context is a purely conventional matter. According to this response, the feeling that certain restrictors are ‘genuine necessities’ is misleading.

assume that p grounds q because the metaphysical laws determine q on the basis of p . If the laws are necessary, then they determine the same truths on the basis of p in every possible world in which p obtains. And hence, it is metaphysically necessary that if p obtains, then q obtains. So, if ground is lawful determination, then ground entails necessitation, and hence satisfies the Necessitation principle. Secondly, the generality of the laws may help to explain Generalization. Since it is plausible that the laws do not name individual objects, they don't discriminate between facts that only differ in the particular object that features in them. Thus, if $F(a)$ lawfully determines $G(a)$, then $F(b)$ lawfully determines $G(b)$. I provide the details of these explanations in section 1.4.

But how does a law-based account meet the Inheritance-desideratum, which roughly says that the properties of entities are grounded in the properties of the entities' constituents? Before answering this question I will first develop the content of the laws. Metaphysical laws take the form $L_M(p)$ (read: it is a metaphysical law that p). In order to explain Inheritance we need to think of the propositions in the scope of the law-operator as building a bridge between ground and broadly mereological notions. I will next introduce a conception of the laws that does just this, and I will show that the conception is independently motivated by the generality-constraint of the laws.

The conception of the metaphysical laws I advocate rests on the view that each derivative entity can be ultimately traced back to the fundamental, or *basic*, entities via broadly mereological relations. Kit Fine (1991) has captured this view with the notion of a constructional ontology. I will use the term *construction-relation* to cover the relevant mereological relations. Fine has developed a more specific conception of construction-relations in recent work (Fine 2010). But the general idea has been developed independently in slightly different ways by Karen Bennett (2011) and Jonathan Schaffer (2009) under the

labels ‘building-relations’ and ‘grounding’.¹⁰ The conceptions of these authors come apart in various ways. For instance, while Fine does not take the truth-maker relation to be a construction-relation, Schaffer uses truth-making as one of his go-to examples. While Schaffer uses ‘grounding’ on the same level of generality as I use the term ‘construction’, Bennett regards grounding as one building-relation among many. And Bennett even toys with the idea of treating cross-temporal causal relations as building-relations.

It does not matter for my purposes which of these authors characterizes construction-relations correctly. My account is independent from any specific proposal. I will use the following minimal characterization of construction-relations: the constructing entities are more basic than the constructed entity, and the constructed entities exist in virtue of the constructing entities.¹¹ To this bare-bones characterization we can add the following observations. First, Construction-relations often correspond to ontological categories or kinds. There may be, for instance, one relation for constructing facts, one for events, one for conjunctive properties, one for hunks of matter, and so on. Secondly, I assume that every derivative entity is related to the fundamental entities via a chain of construction-relations. I also assume, thirdly, that the constructed reality contains all sorts of complex objects, properties, facts, events, processes, and so on. This last assumption is not essential to the account, but it is a natural view, since constructed entities arguably do not fall prey to Occam’s razor.¹²

¹⁰ Note that my notion of ‘ground’ differs from Schaffer’s notion of ‘grounding,’ which Sider (2012) refers to as ‘entity-grounding.’

¹¹ This characterization of construction is not a definition. Relative fundamentality among individual entities is to be defined in terms of construction. And the claim that constructed entities exist in virtue of the constructing entities is just a gloss of the notion of construction, which I am treating as conceptually and metaphysically primitive. However, there is an interesting view on which construction is defined in terms of ground. On that view, constructional relationships between entities can somehow be read off from the grounding-structure defined over truths. This view would render the Nomological Account presented below non-reductive. A non-reductive proposal might still provide illuminating interconnections between important notions. Thanks to an anonymous referee for suggesting this option.

¹² See Schaffer (2012) for discussion of the ontological innocence of derivative entities.

Let us consider a number of potential examples of construction-relations to fix ideas (although I do not wish to commit myself to any of them).

Some Object-Object Relations

- The Lump of Clay constitutes the Statue
- Socrates forms the set {Socrates}
- The H₂O-molecules compose the body of water

Some Property-Property Relations

- The individual colors determine the property 'being colored'
- The properties F and G form the property 'being F & G'
- Individual heights form the internal relation 'being taller than'

Some Cross-Categorical Relations

- Peter and the property 'being human' form the state of affairs that Peter is human
- Facts construct events
- Properties form objects as 'property-bundles'

Which construction-relations there are is a substantive issue that I won't need to settle here. What matters to the view defended in this paper is that there is a univocal notion of construction and that our ontology is structured by a multitude of construction-relations.

Finally, every construction-relation corresponds to a *construction-operation*. Consider, for instance, material parthood and composition. If some complex object, A, has B_i as a part, then there are some things, B₁, ..., B_n, including B_i that together compose A. Instead of the parthood-relation, we can thus speak of the composition-operation (COM). And we can

express the relationship between A and B_1, \dots, B_n using a term for the operation. The following formula, for instance, says that A is the object composed from B_1, \dots, B_n :

$$\text{(Operation)} \quad A = \text{COM}(B_1, \dots, B_n)^{13}$$

Thus, if Wall is composed from $\text{Brick}_1, \dots, \text{Brick}_n$, we can express this with “Wall = COM(Brick₁, ..., Brick_n).” Similarly, we can express that Goliath the statue is constituted by Lump₁ the lump with “Goliath = CON(Lump₁).” I will use the language of operations to simplify the presentation of the Constructional Conception of the metaphysical laws below.¹⁴

We are now in a position to develop the Constructional Conception. On this conception, the laws of metaphysics are general principles that characterize the individual construction-operations. I distinguish between two kinds of principles that feature in the generation of derivative reality in a two-step process. *Ontological principles* determine which collections of entities give rise to constructed entities by means of particular construction operations. *Linking-principles* determine which of the constructed objects and properties ‘go together’ to form facts. The two kinds of principles thus work as a team: ontological principles determine the derivative ontology, and linking-principles determine the derivative facts.

Ontological principles specify the *application-condition* of a given construction-operation. C is an application-condition of the operation O just in case the fact that some entities, $A_1 \dots A_n$, satisfy C explains that some entity, B , is constructed from $A_1 \dots A_n$ via O . Thus, Peter van Inwagen’s *special composition question*, “Under which circumstances do some things compose

¹³ Operation assumes that construction-operations are ‘functional’ in the sense that an expression of the form ‘ $O(A_1, \dots, A_n)$ ’ picks out a unique referent. I think that functionality is plausible if we accept ‘ $O(\dots)$ ’ as a context that is both order-sensitive and repetition-sensitive. Thus, $O(A, B)$ need not be identical with $O(B, A)$, and $O(A)$ need not be identical with $O(A, A)$. See Bader (2013) for some discussion of this extended notion of functionality. However, if functionality is rejected, the formulation ‘ $A = O(B_1, \dots, B_n)$ ’ can be consistently replaced with the relational expression ‘ $O(B_1, \dots, B_n; A)$ ’. I’ll stick to the formulation that assumes functionality for simplicity.

¹⁴ Fine (2010) argues that construction-operations are more fundamental than construction-relations. I am neutral on this issue.

another thing?” asks for the application-condition of the composition-operation (van Inwagen 1995). Every construction-operation, O , is associated with at least one application-condition, C_o , and hence is characterized by a least one ontological principle of the following form (the variables range over both objects and properties):¹⁵

(Ontological Principle) $\forall xx(C_o(xx) \supset \exists y(y = O(xx)))$ ¹⁶

The ontological principles determine facts of the form ‘ $a = O(bb)$ ’ on the basis of facts pertaining to the satisfaction of an associated application-condition. The facts determined through ontological principles encode both the existence of the constructed entity as well as its *constructional profile*: the entities from which it is constructed and the specific operation involved in the construction.

The form of linking-principles is more complex. A linking-principle determines whether two entities form a fact on the basis of their common *constructional history*. This means that whether an object, a , and a property F , form the fact that a is F depends on three factors:

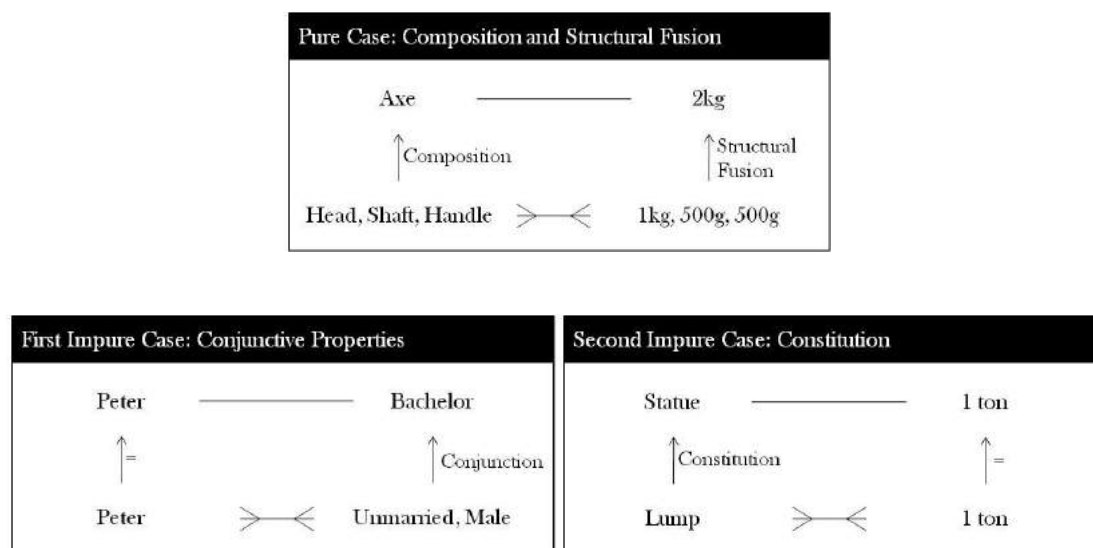
- (i) The entities constructing a and F respectively
- (ii) The operations by which a and F are constructed
- (iii) The patterns of instantiation holding among the constructing entities

There are two kinds of cases involving the application of linking-principles. In one case, the fact that a is F is determined on the basis of patterns of instantiation between the entities that construct a and the entities that construct F . Call this a *pure* application of linking-principles.

¹⁵ There may be exceptions. If some operation has no application-condition, then the existence of the entity constructed in this way has no sufficient ground. These entities would be *emergent* in a sense similar to the one captured by Barnes (2012).

¹⁶ We can also use O in Ontological Principle as a relational expression: $\forall xx(C_o(xx) \supset \exists y(O(xx; y)))$. Analogous substitutions are possible in the principles below.

In the second case, the fact that a is F is determined on the basis of patterns of instantiation holding between one of a and F on the one hand and the entities that construct the other one of a and F on the other. Call this an *impure* application of linking-principles. Let me present one pure and two impure applications to illustrate the role of the linking-principles.



In the pure case, the weight of the axe is determined by the weights of the axe's parts. I assume that the magnitude 2kg is the structural fusion of the magnitudes 1kg, 500g, and 500g.¹⁷ In the first impure case, Peter's bachelorhood is established by the fact that Peter instantiates each of the two conjunct-properties 'being unmarried' and 'being male'. For the sake of the case I assume that bachelorhood is a simple conjunctive property that consists only of just the two conjuncts. And in the second impure case, the fact that the statue weighs 1ton is determined by the fact that the constituting lump weighs 1ton. Note that in each of the impure cases, the constructional profile of only one of the two entities involved in the explained facts matters for the application of the relevant linking-principle.

¹⁷ See Armstrong (1997) for an account of quantities along these lines.

I will next specify some plausible linking-principles that capture these cases. The proposed principles are mere candidates whose purpose is to familiarize the reader with the notion of a linking-principle. What specific linking-principles we should ultimately endorse is a hard question that we don't need to answer here. (In what follows, read unbound variables as bound by universal quantifiers taking widest scope. Lowercase variables range over objects; uppercase variables range over properties. 'SF' stands for structural fusion, 'CP' for composition, 'C&' stands for conjunctive-property construction and 'CT' for constitution.)

(Structural Fusion) $[X = SF(Y_1 \dots Y_n) \ \& \ x = CP(y_1 \dots y_n) \ \& \ Y_1(y_1) \ \& \ \dots \ \& \ Y_n(y_n)] \supset X(x)$

(Conjunction) $[X = C\&(Y_1 \dots Y_n) \ \& \ Y_1(y_1) \ \& \ \dots \ \& \ Y_n(y_n)] \supset X(x)$

(Constitution) $[x = CT(y) \ \& \ X(y)] \supset X(x)$

The Structural Fusion principle says that a composed object, o , has a structural-fusion property, F , if the objects composing o instantiate the properties fusing into F . The conjunction-principle says that an object has a conjunctive property if it has all the conjunct-properties. And the constitution-principle says that a constituted object inherits the properties from its constitution-base. This last principle will of course be plausible only if the property-quantifier is restricted, since constituted objects do not inherit *all* of the properties of the constituting objects. I will not decide the first-order question of what this restriction is exactly. Let us also look at additional linking-principles for determinable-property formation and internal-relation formation. ('DC' stands for 'determinable-construction'; 'IRC' stands for 'internal-relation construction'):

(Determinables) $[\exists ZZ(X = DC(Y, ZZ)) \ \& \ Y(x)] \supset X(x)$

(Internal Relations) $[\exists ZZ(R = IRC(<X, Y>; ZZ)) \ \& \ X(x) \ \& \ Y(y)] \supset R(x, y)$

The principle Determinables says that an object instantiates a determinable property if it has one of its determinate properties. And the Internal Relations principle says that two objects, A and B, stand in the internal relation R, if A and B each have a property from a property-pair that is involved in the construction of R. Internal Relations covers, for instance, the internal relation ‘taller than’ which is constructed from property pairs including <6”, 5”>.

From the examples we have considered we can abstract a canonical form of linking-principles. Where O_1 and O_2 refer disjunctively to either a construction-operation or to the relation of identity, we can state the canonical form as follows: (‘yy ARE YY’ stands for the presence of patterns of instantiation between the objects yy and the properties YY; variables are bound by universal quantifiers taking widest scope.)

(Linking-Principle) $[x = O_1(yy) \ \& \ X = O_2(YY) \ \& \ yy \text{ ARE } YY] \supset X(x)$

This canonical form is not fully general as it does not accommodate the case of relations. And it is also only a form, which needs to be ‘filled in’ to generate individual candidates for linking-principles. But it captures the role of the linking-principles: they determine whether an object and a property form a fact on the basis of their common constructional history.

Let me re-emphasize the interplay between ontological principles and linking-principles. The ontological principles determine that some collections of entities construct ‘new’ entities via specific operations, and the linking-principles determine which constructed entities ‘go together’ to form facts. This division of labor allows the principles to determine derivative facts involving derivative entities on the basis of more fundamental facts involving more basic entities. The Constructional Conception of the metaphysical laws says that all ontological principles and linking-principles are laws: for every such principle, p, $L_M(p)$. The division of

labor among the metaphysical laws, therefore, allows the laws to determine derivative facts on the basis of more fundamental facts.

We can now see how the Constructional Conception satisfies both the strength-constraint and the generality-constraint on the laws. What linking-principles we should endorse depends on the construction-operations we acknowledge and the systematic connection between entities constructed in these ways and their constructional bases. We need to posit sufficiently many operations to account for every member of the ontology; and we need to posit enough linking-principles in order to account for the derivative facts on the basis of more fundamental facts. Since the ontological principles and linking-principles are strong enough to determine the derivative facts on the basis of the fundamental facts, the Constructional Conception of the laws satisfies the strength-constraint on the laws.

The Constructional Conception also satisfies the generality-constraint on the laws. To see this, note that the ontological principles and linking-principles make almost no reference to individual derivative objects and properties. They talk in general terms about construction-operations and those properties that feature in the application-conditions of individual construction-operations. Since the laws only refer to construction-operations and application-conditions, they avoid naming a wide range of derivative entities. And yet, since every derivative entity is constructed, the laws ‘capture’ every object and property there is. Hence, the metaphysical laws as specified by the Constructional Conception satisfy the generality-constraint laid out at the beginning of this section.

I will not argue in favor of any specific construction-relations and associated ontological principles and linking-principles. Determining these metaphysical laws is an important part of every metaphysical project involving the explanation of derivative phenomena. A catalog of all construction-relations and the principles governing them would be a large part of the

complete final metaphysical theory. The Nomological Account of ground that I develop next does not rely on the acceptance of any specific laws.

The unification of ontological principles and linking-principles under the category of metaphysical law allows us to carve out a distinctive notion of metaphysical explanation. I define the *Nomological Account* of ground as follows:

(Nomological Account) $p_1 \dots p_n \text{ ground } q \iff_{\text{def}} \begin{array}{l} \text{(i) } p_1 \dots p_n \text{ lawfully determine } q \\ \text{(ii) } p_1 \dots p_n \text{ obtain} \end{array}$

To see the account at work, consider a simple example. Assume that some tomato, t , is both red and round. The ontological principles determine the existence of the conjunctive property ‘being red and round’ on the basis of the properties ‘being red’ and ‘being round’. The linking-principle for conjunctive-property formation, determines that t has the conjunctive property on the basis of the fact that t has each of the conjunct-properties. It thus follows from the Nomological Account that ‘ t is red’ and ‘ t is round’ together ground ‘ t is red-and-round’.

This example illustrates that the Nomological Account provides a straightforward conversion from truths about the work of the laws to truths involving ground. The combination of the Constructional Conception of the laws of metaphysics and the Nomological Account of ground thus ties the notions of ground and construction closely together. I will show in section 1.4 that this close connection suffices to explain the Inheritance-principle from section 1.2.

The Nomological Account analyzes ground in terms of *determination via the laws*. This analysis invites question about the nature of both laws and determination: What is the metaphysical status of laws, are they fundamental or reducible to underlying phenomena? And is the notion of determination further analyzable or do we need to treat it as a primitive notion?

While a comprehensive answer to these questions would take us beyond the scope of this paper, I will briefly lay out my views on them. Whatever the answer to these questions, however, the explanatory potential of the combination of the Constructional Conception of the metaphysical laws together with the Nomological Account of ground constitutes significant progress.

We could attempt to analyze the idiom ‘ $L_M(p)$ ’ along the lines of a Humean regularity theory. On the most developed version of this theory, the *best system analysis*, the fundamental laws of nature are those general truths that best summarize the *mosaic* consisting of instantiations of fundamental properties and relations by fundamental objects. A system of truths is ‘best’ in the relevant sense if it strikes the best balance between simplicity and strength (cf. Lewis 1983). A best system approach to the laws of metaphysics would take the mosaic to cover the entirety of the facts, as the metaphysical laws concern the behavior of all entities at every level of fundamentality. The regularity theorist would then have to define a notion of *best-ness* for systems of general truths that summarize this enlarged mosaic.

I think, however, that any regularity theory of the metaphysical laws faces a serious difficulty and ultimately should be rejected. Regularity theories of laws of nature face the following familiar circularity-worry. Each element of the mosaic is an instance of some generalization in the best system. Since instances of general truths partly explain the generalities that they are instances of, every element of the mosaic partly explains the laws. But the laws in turn feature in the explanation of the elements in the mosaic. Explanation therefore runs in a circle. In the case of the laws of nature, this circularity may be benign as the kinds of explanations involved in the circle are distinct: the goings-on in the mosaic *metaphysically* explain the laws, whereas the laws *causally* explain the mosaic.¹⁸ In the case of metaphysical laws,

¹⁸ See Loewer (2012) for a version of this reasoning.

however, this defensive move is not available, since the elements of the mosaic metaphysically explain the laws and the laws in turn are involved in the metaphysical explanation of the elements of the mosaic. This explanatory circularity seems irresolvable and thus vicious. Other reductions of the laws may be available. But I am tempted to accept truths of the form $L_M(p)$ as fundamental: the laws are the independent dynamic postulates that God would have to decree in addition to the instantiations of fundamental properties and relations.

The notion of determination, on the other hand, invites further analysis. For, what a certain law determines on the basis of some truth, p , should depend on both the content of the law and the specific truth, p . It is tempting to understand determination as some form of entailment: the laws determine q on the basis of p just in case p and the (contents of) the laws entail q . There are a number of different notions of entailment that may be used in the analysis, including modal entailment, a priori entailment, and logical entailment. I prefer an analysis of determination in terms of logical entailment. If determination is understood in terms of modal entailment, we cannot use ‘determination via the laws’ in the analysis of metaphysical modality on pain of circularity. I think, however, that such a partial analysis of modality in terms of lawful determination is desirable. A priori entailment is an interesting resource in this context that would render ground in part an epistemic phenomenon. The analysis in terms of logical entailment is the purest that allows the laws to feature in the analysis of modality and that also renders metaphysical explanations independent of the reasoning-capacities of agents. I develop and defend the analysis of ‘determination via the laws of metaphysics’ in terms of a non-classical notion of logical entailment elsewhere (Wilsch (forthcoming)).

I will next sketch very briefly how this analysis of determination proceeds. Classical entailment is unsuitable for the analysis of determination for a variety of reasons. The most obvious reason is perhaps the difference in general logical features of these relations. Classical

entailment is reflexive and monotonic: every truth classically entails itself, and if some set of truths, Δ , entails q , then any superset of Δ also entails q . The notion of determination, however, does not share these features, as no truth determines itself, and while the existence of {Socrates} may be determined by the existence of Socrates, it is not determined by, say, the existence of Socrates together with the fact that $2 + 2 = 4$.

We can see that the unsuitability of classical entailment runs even deeper if we consider certain classical inference rules. For instance, take the schematic ontological principle of the form $\forall xx(C_o(xx) \supset \exists y(y = O(xx)))$. Using contraposition and modus ponens we can derive $\sim C_o(aa)$ from $\sim \exists y(y = O(aa))$. Thus, if determination was classical entailment with the laws, it would follow that $\sim \exists y(y = O(aa))$ determines $\sim C_o(aa)$. Intuitively, however, this gets things backwards: the fact that some entities do not satisfy the application condition of some operation explains the fact that the operation does not apply to them.¹⁹

To respond to these challenges, we can refine the notion of entailment by restricting both the admissible inference rules and the notion of proof. In particular, I prefer an approach that uses only the inference-rules of universal instantiation and modus ponens. The first rule analyzes the idea that general laws *apply to* individual truths, and the second rule analyzes the thought that the laws *output* truths on the basis of those they apply to. The relevant notion of proof requires that each premise is (non-vacuously) made use of by one of the admissible inference-rules. The mere addition of premises to a proof, therefore, does not preserve its status as a proof, thus ruling the resulting notion of entailment non-monotonic. Obviously,

¹⁹ How does the Nomological Account handle the fact that $\sim C_o(aa)$ grounds $\sim \exists y(y = O(aa))$? We could appeal to negative ontological principles of the form $\forall xx(\sim C_o(xx) \supset \sim \exists y(y = O(xx)))$. I prefer an approach on which some negative truths are explained by the absence of possible grounds. Assuming, for instance, that $C_o(xx)$ is the only possible ground for $\exists y(y = O(xx))$, the absence of the former counts as (absence-)ground of the latter. Possible ground is the non-factive version of the notion of ground as defined by the Nomological Account.

much more needs to be said to convince the reader of the feasibility of the analysis of determination in terms of a non-classical notion of entailment. I hope, however, that these all too cursory remarks show that the analysis of determination is far from hopeless.

Whatever the prospects of the various reductive approaches to metaphysical laws and determination, the Nomological Account of ground constitutes explanatory progress. In the next section, I show how we can use the account to explain the three desiderata from the first section: Necessitation, Generalization, and Inheritance. The success of these explanations provides us with *pro tanto* reasons to accept the Nomological Account of ground and the associated idea that there are laws of metaphysics that develop the facts along the axis of fundamentality.

1.4 The Nomological Account meets the Desiderata

In this section, I show that the Nomological Account meets the three desiderata for a successful theory of ground. The account is well-equipped to explain the three substantive principles Necessitation, Generalization, and Inheritance. I will discuss each of these explanations in turn.

(Necessitation) p grounds $q \rightarrow \Box_M(p \supset q)$

The Necessitation-principle says that necessitation is required for ground. It captures the idea that a ground is sufficient for the grounded. If the notion of determination can be analyzed in terms of some kind of entailment, then the modal force of ground would be explained by the modal status of the entailment together with the modal status of the laws. If, for instance, determination is analyzed in terms of a specific kind of logical entailment, the modal force of ground is a product of the necessity of the laws and the necessity of logic. Since I have not

developed this analysis here, I will instead use a more general strategy to show how Necessitation can be explained.

Deterministic laws of nature determine the same output on the basis of the same input in every nomologically possible scenario. The laws of metaphysics are associated with metaphysical possibility. And so the deterministic laws of metaphysics determine the same output on the basis of the same input in every metaphysically possible world, assuming that they hold in all metaphysically possible worlds.²⁰ If therefore the laws determine q on the basis of p , then they determine q on the basis of p in every metaphysically possible world. But this is to say, according to the Nomological Account, that if p grounds q , then the laws determine q on the basis of p in every possible world. Consequently, every possible world in which p obtains, q obtains as well. And so Necessitation follows from the Nomological Account.

(Generalization) $F(a) \text{ grounds } G(a) \rightarrow \forall x(F(x) \supset G(x))$

According to Generalization, the identity of an object is irrelevant to the question of in virtue of what it has its properties. The Nomological Account predicts that Generalization holds. To see this, assume first that $F(a)$ grounds $G(a)$. From the Nomological Account it follows that the laws determine $G(a)$ on the basis of $F(a)$. But since the laws do not mention a in particular, they determine any truth of the form $G(\alpha)$ on the basis of the corresponding truth $F(\alpha)$. Consequently, $\forall x(F(x) \supset G(x))$ holds. The general insight is that laws are inherently general and are thus not sensitive to the identity of particulars. Whether an object has a given property

²⁰ As mentioned in the previous section, the necessity of the laws can be explained by the nature of laws or the nature of metaphysical necessity. An anonymous referee suggests that the metaphysical laws might be necessary because they hold in virtue of the nature of the construction-operations. For instance, it might lie in the nature of set-formation that each suitable plurality of entities forms a set. I do not take a stance on this proposal here. But note that these essences would then be *generative* in the sense that they entail the existence of additional derivative entities on the basis of more fundamental entities. For discussions of such ‘Anselmian’ Essences, see Dasgupta (2014) and Rosen (2006).

depends on the constructional profile of that property. For instance, an object has a determinable property if it has one of its determinate properties; and it has a conjunctive property if it has all of the conjunct-properties. This is the information encoded in the linking-principles. And these principles apply to all objects regardless of their identity.

(Inheritance) Properties of constructed entities are determined by properties of their constituents

The explanation of Inheritance relies on the form of the metaphysical laws. Linking-principles determine which derivative entities ‘go together’ to form facts on the basis of their common constructional history. It is therefore in general the case that the properties of a derivative object are determined by the properties of the entities from which it is constructed.

To explain the Inheritance principle in more detail, we need to turn to the two more precise principles that characterize its content:

(Constituent to Ground) $a_1 \dots a_n$ construct b & $F(b)$ & $F(b)$ is not subject-fundamental
 \rightarrow Some fact $\varphi(a_1 \dots a_n)$ partly grounds $F(b)$

(Ground to Constituent) $\varphi(a_1 \dots a_n)$ fully grounds $F(b) \rightarrow$ Some of $a_1 \dots a_n$ construct b

The Constituent-to-Ground principle says that the constituents of an object are involved in the grounds for each non-emergent property of the object. The Ground-to-Constituent principle says that if some fact involving b is fully grounded in a fact involving distinct objects, then some of these distinct objects construct b .

To explain the Constituent-to-Ground principle, assume that $a_1 \dots a_n$ construct b and that $F(b)$ is a truth that is not subject-fundamental. $F(b)$ is thus grounded in truths that involve objects other than b . The Nomological Account entails that there are some truths which

involve these other objects and which lawfully determine $F(b)$. The relevant laws are ontological principles that underlie the construction of b , as well as linking-principles which determine that F and b ‘go together’ to form a fact. Linking-principles determine a truth, p , on the basis of the constructional profiles of the entities involved in p . Since $a_1 \dots a_n$ construct b , linking-principles therefore determine $F(b)$ on the basis of some truth involving $a_1 \dots a_n$.

To explain the Ground-to-Constituent principle, assume that $\varphi(a_1 \dots a_n)$ fully grounds $F(b)$. The Nomological Account entails that $\varphi(a_1 \dots a_n)$ lawfully determines $F(b)$ and thus that $\varphi(a_1 \dots a_n)$ together with ontological principles and linking-principles determines $F(b)$. But linking-principles determine whether F and b ‘go together’ based on information about the constituents of F and b . So $\varphi(a_1 \dots a_n)$ lawfully determines $F(b)$ only if at least some of $a_1 \dots a_n$ construct b . Since the Nomological Account explains both the Constituent-to-Ground Principle and the Ground-to-Constituent principle, it explains Inheritance.

In sum, the Nomological Account meets three key desiderata for a theory of ground: It explains Necessitation, Generalization, and Inheritance. I take this not only to show that the account passes a reasonable test for adequacy with flying colors, it also suggests that the Nomological Account captures the very essence of ground. Before concluding, I will discuss one objection to the Nomological Account.

We saw in the first section that the Ground-to-Constituent principle faces potential counterexamples. This is problematic for the Nomological Account, which entails that $\varphi(a_1 \dots a_n)$ grounds $F(b)$ only if b is constructed from some of $a_1 \dots a_n$. Recall the examples. The fact that castling through check is illegal in chess is grounded in facts about peoples. And yet the abstract object chess is not constructed from people. Similarly, although the existence of The Magic Mountain is fully grounded in facts about Thomas Mann, the novel is not constructed from the man.

In response to these examples, we can either reject the grounding-claims or insist that certain constructional relationships hold contrary to initial appearance. I am tempted to deny the grounding-claim involving the game of chess: the fact that it's illegal to castle through check is not grounded in the fact that people are disposed to act in certain ways, but instead is the very same fact. More specifically, the word 'chess' does not commit us to an item in the ontology; it is a short-hand device to talk about more complex facts involving the behavior of humans.²¹

Assume, on the other hand, that the game of chess was an item in our ontology. Is this entity a basic building block of reality or is it constructed from more basic entities? If it is constructed from concrete entities, perhaps from individual occurrences of chess-games across space and time via some operation of abstraction, then the sufficient grounds for truths involving chess would feature these concrete entities. And if (somewhat incredibly) chess was a basic building block of reality, chess-truths would arguably only be grounded in other chess-truths (if at all). Either way, sufficient grounds for the illegality of castling through check would only involve chess or entities from which chess is constructed.

The case of *The Magic Mountain* is similar. It seems especially tempting to regard the novel as an abstraction from individual copies of the book. The existence of the novel would then plausibly be grounded in truths to the effect that Thomas Mann created the first copy. This truth involves constituents of the entity that features in the *explanandum* truth 'The Magic Mountain exists', and is thus in conformity with Ground to Constituent.²²

²¹ Note that this claim about the word "chess" is not linguistic but metaphysical. Claims such as 'The game of chess exists' and "'chess' is a referring expression in English' are true. The strategy I suggest, however, denies that chess is 'in the ontology' or that chess really exists. This can perhaps be understood in terms of fact-identifications: every chess-fact is identical to some fact that doesn't feature chess. The notion of fact-identity used here is akin to 'grounding-theoretic equivalence' in Fine (2012).

²² I realize that the appeal to an unfamiliar construction-operation of abstraction is somewhat unsatisfying. But the characterization of the logic and nature of the various construction-operations goes beyond the scope of this paper.

The general upshot is that the Nomological Account entails a methodological principle: To sustain a grounding-claim, we have to argue in favor of constructional relationships among the constituents of the truths involved in that claim. If no such relationships can be found, we can attempt to collapse the intended explanation into an identity, or else we have to reject the grounding-claim. I believe that this is a fruitful guide to the grounding structure of reality.

1.5 Conclusion

We began with the question of how a sparse fundamental layer of facts could give rise to an enormous variety of derivative entities. The Nomological Account answers this question as follows: the fundamental objects and properties give rise to derivative objects and properties in complex constructional ways. This constructional unfolding of the world along the axis of fundamentality is governed by the metaphysical laws, which determine the derivative ontology and the derivative facts. Therefore, to understand how the fundamental gives rise to the derivative, we need to understand the content and the workings of the metaphysical laws.

I have suggested that ontological principles and linking-principles constitute the core of the metaphysical laws. Future research will need to uncover the precise content of these principles. For, it is neither obvious which construction-operations there are, nor is it obvious which rules they are governed by. There are, moreover, many important questions about construction-operations that have been widely ignored. For instance, there seem to be a number of different property- and fact-construction operations whose workings are very unclear. Is there an operation of disjunctive or negative property construction? Are there fact-constructions operations via which general, disjunctive, or negative facts can be constructed? If so, which ontological principles and linking-principles govern these operations? Many of these and related questions are still wide-open.

If the Nomological Account is correct, these questions need to be answered in order to fully uncover the grounding structure of the world and to explain why it is the way it is. I have argued that a successful theory of ground should explain the three principles Necessitation, Generalization, and Inheritance. The Nomological Account explains all three. The necessity of the laws accounts for Necessitation, the generality of the laws accounts for Generalization, and the constructional content of the laws accounts for Inheritance. The fact that the Nomological Account is the only developed theory which meets all three desiderata is a significant reason in its favor.

Chapter 2. The Deductive-Nomological Account of Metaphysical Explanation

2.1. Introduction

Metaphysical ground is the relation of metaphysical explanation that orders the truths into a tree-like structure of fundamentality: derivative truths about molecules, organisms, artefacts, and so on, rest atop the fundamental (i.e. ungrounded) truths of the fundamental sciences.²³ Every truth, q , is either fundamental or else grounded in other truths, p_1, \dots, p_n . The goal of metaphysics is not just to determine the truths, but also to sort them into an explanatory structure. In Jonathan Schaffer's words, metaphysics is about what grounds what.

The notion of ground deserves discussion because it's *important*, *productive*, and *connected*. Ground is important since metaphysical explanations are ubiquitous in philosophy: almost every philosophical discussion includes metaphysical explanations. Ground is productive as it turns a potentially sparse layer of fundamental truths into the incredibly rich and abundant reality we live in. And ground is connected because it is intimately tied to other central metaphysical notions, including the notions of necessity, part, and essence. The importance of ground provides ample motivation for exploring its nature. And the fact that ground is productive and connected offers theoretical targets: explain how ground mediates the transition from the austere fundamental truths to the rich derivative truths, and explain the connections to other notions.

I will return to these targets later in the paper. My initial focus, however, lies on two other striking features, which suggest that ground is associated with the notion of a *metaphysical law*. Ground exhibits general patterns and comes equipped with a modal force. To illustrate the

²³ For introductions to ground, see Fine (2001), Correia (2005: ch. 3), Schaffer (2009), Rosen (2010), Audi (2012a), and Fine (2012a). Some authors use 'ground' to refer to the relations that underlie metaphysical explanations.

first feature, consider the grounding-truth expressed by the following sentence: ‘That the tomato *t* is red grounds that *t* is coloured.’ It follows from this grounding-truth that any truth expressed by a sentence of the form ‘*o* is red’ grounds the corresponding truth expressed by ‘*o* is coloured’. Since Ground is not sensitive to the identities of the individuals that enter into the grounding-truths, grounding-truths exhibit general patterns.²⁴ To illustrate, secondly, the modal force of ground, assume again that *t is red* grounds *t is coloured*. It follows from this grounding-truth that *t*’s redness entails the fact that *t* is coloured with the force of metaphysical necessity. In general, if p_1, \dots, p_n is a sufficient ground for q , then p_1, \dots, p_n metaphysically necessitate q .²⁵

The generality and the necessity of ground suggest the existence of general laws that underlie the grounding-truths. Humour me for a moment. Laws of nature underlie scientific explanations, and thereby account for the natural necessity and the generality of scientific explanations: similar causes have similar effects because of the laws of nature. Analogously, if the metaphysical laws underlie metaphysical explanations, they account for the metaphysical necessities and the generality of ground: similar truths ground similar more derivative truths because of the laws of metaphysics. A theory of ground that relies on metaphysical laws, therefore, promises to explain the modal force and the generality of ground. While this is not a decisive reason in favour of metaphysical laws, it gives us plenty of motivation to explore a *nomological account of ground*.

This paper explores a theory that takes the connection between ground and laws seriously. I will present the most straightforward implementation of this idea, on which ground just is a

²⁴ Identities of individuals appear to matter sometimes. Consider, for instance, *Dido loves Aeneas* grounds *Dido loves a human being*, but *Dido loves Zeus* does not ground *Dido loves a human*. I reject this counterexample as incomplete. It should read: *Dido loves Aeneas, Aeneas is human* ground *Dido loves a human*. Thanks to an anonymous referee.

²⁵ Audi (2012b: 697-8) and Rosen (2010: 130ff) defend the generality and Fine (2012a: 37ff) and Trogon (2013) the necessity of ground.

matter of lawful determination among truths, i.e. true propositions. And I will show that the resulting view is surprisingly resilient in the face of objections.

(Nomological Account) p_1, \dots, p_n ground $q \leftrightarrow_{\text{def}}$ metaphysical laws determine q on the basis of p_1, \dots, p_n

The Nomological Account relies on metaphysical laws and the notion of *determination*. I will develop a specific conception of metaphysical laws and explore an analysis of ‘determination’ in terms of logical entailment.²⁶ The analysis roughly says that the metaphysical laws determine q on the basis of p_1, \dots, p_n just in case the laws and p_1, \dots, p_n logically entail q . The account I will explore, therefore, is a *deductive-nomological account of metaphysical explanation*.

It is widely assumed that the traditional deductive-nomological account of scientific explanation was little more than an instructive failure. I will argue below, however, that the form of metaphysical laws is more conducive to a deductive-nomological account of metaphysical explanation. There are two features of metaphysical laws, in particular, that set them apart from laws of nature. First, they have a direction built into them which runs from the more fundamental to the less fundamental. And secondly, metaphysical laws apply more locally than laws of nature, which apply to huge closed systems at a time. I will explain these differences in some detail below, after clarifying the Nomological Account.

Here is how I will proceed. The next two sections introduce the Deductive-Nomological Account of Ground and the following two sections discuss objections. Section 2.2 introduces a particular theory of the metaphysical laws, and section 2.3 develops the deductive machinery

²⁶ Why not modal or epistemic entailment? Metaphysical modality should be partly understood in terms of ground, and it is also not sufficiently fine-grained to capture metaphysical explanation (Fine 1994). I also find it implausible that metaphysical explanation is epistemic. See, however, Chalmers (2012: 16th Excursus) for such a view.

required for the DN-Account. Section 2.4 presents the standard objections to the traditional deductive-nomological account of scientific explanation, and explains why the DN-Account of metaphysical explanation escapes these objections. Section 2.5 discusses the objection that the DN-Account cannot handle cases of ‘logical ground’. I will conclude with an elaboration of the big-picture view suggested by the account.

Before we get started, one disclaimer is in order. A thorough defence of the DN-Account of Ground requires more space than I have available in this paper. In particular, to properly motivate the account, I would need to show in detail how it captures the necessity and generality of metaphysical explanations (see Chapter 1 for an attempt). And a conclusive defence of the account against the objection in section 2.5 raises fundamental questions that I don’t have the space to answer. For these reasons, my conclusion will be modest: the deductive-nomological account of ground is an attractive proposal that holds up against scrutiny. Further work needs to be done, however, to properly defend it against alternatives.²⁷

2.2 The Content of the Metaphysical Laws

According to the Nomological Account of Ground, p grounds q just in case the laws of metaphysics determine q on the basis of p . To understand this proposal, we need to understand the two notions of a metaphysical law and of determination. I will turn to the latter notion in the next section. In this section, I present the *constructional theory* of the laws of metaphysics. This particular theory is somewhat inessential to the DN-Account, which is neutral about the content of the laws. Having a specific theory on the table, however, will allow for a much more concrete presentation of the DN-Account in section 3. And the laws

²⁷ Alternatives include *primitivism* (i.e. grounding-truths are fundamental) and *essentialism about ground* (i.e. grounding-truths reduce to essence-truths). We could also accept the Nomological Account but reject the DN-Analysis.

delivered by the constructional theory also play an important role in the discussion of the objections in sections 2.4 and 2.5.

According to the constructional theory, the laws are general principles that govern *construction-operations*. I will briefly explain what construction-operations are and will then explain the form of the metaphysical laws that characterize them. At the end of the section, I will briefly outline the benefits of the constructional theory.

Derivative entities are constructed from more basic entities. Some construction-operations are quite familiar. Composition, constitution, and set-formation are well-known operations that take more basic objects to ‘new’, less basic objects. But there are also construction-operations that apply to different ontological categories. ‘Conjunctive-property construction’, for instance, takes a collection of properties to a conjunctive property, and the ‘determinable-property formation-operation’ takes collections of mutually exclusive properties to determinable properties. Some construction-operations also cross the boundaries of ontological categories. Fact-construction, for instance, takes objects and properties to facts, and event-construction may take facts to events. There are many candidate operations. Ontologists get paid to determine which operations account for all derivative entities in the ontology, including the objects and properties of the natural sciences, psychology, morality, theology, mathematics, and so on.

I will use both of the following formulas to express that the entity y is constructed from the entities x_1, \dots, x_n , where O designates the operation involved in the construction:

$$\text{‘}O(x_1, \dots, x_n; y)\text{’ and ‘}y = O(x_1, \dots, x_n)\text{’}$$

How unified is the notion of construction? Unified enough, I think, to establish a fundamentality- hierarchy over all the entities. Construction-operations are united in their task

to generate the entire hierarchy of derivative entities on the basis of the most fundamental, *basic* entities. If we judge that an elephant is less fundamental than an H₂O molecule, we track the fact that the elephant has a more complicated constructional profile than the molecule. Kit Fine (1991) was first (in recent times) to suggest that a single notion of construction covers a wide range of operations by which derivative elements of the ontology are obtained from the basic entities. I follow Fine's example.²⁸

On the constructional theory, the contents of the laws of metaphysics are general truths that characterize individual construction-operations. Thus, where 'p' refers to a suitable general truth about some construction-operation, O, 'L_M(p)' expresses that p is a law of metaphysics. I distinguish between two kinds of laws. The *ontological principles* specify the circumstances in which a particular construction-operation applies to a given collection of entities; they determine which collections give rise to constructed entities. The *linking-principles* determine which constructed objects and properties 'go together' to form truths. I will next explain these two kinds of metaphysical laws in detail.

Ontological principles specify the *application-conditions* of a given construction-operation. C is an application-condition of the operation O just in case the fact that some entities, A₁, ..., A_n, satisfy C explains that some entity, B, is constructed from A₁, ..., A_n via O. Thus, Peter van Inwagen's *special composition question*, 'Under which circumstances do some things compose another thing?' asks for the application-condition of the composition-operation (van Inwagen 1990: 82). Any standard construction-operation, O, is associated with at least one application-condition, C_O, and hence is characterized by at least one ontological principle of the following form (the variables range over both objects and properties):

²⁸ For a more thorough discussion of construction-operations see Fine (2010).

(Ontological Principle) $\forall xx(C_o(xx) \supset \exists y(y = O(xx)))$ ²⁹

The ontological principles determine truths expressed by sentences of the form ‘ $\exists x(x = O(bb))$ ’ on the basis of truths about the satisfaction of an associated application-condition. The truths determined by ontological principles encode both the existence of the constructed entity and its *constructional profile*: the entities from which it is constructed and the specific operation involved in the construction.³⁰

The form of linking-principles is more complex. A linking-principle determines whether two entities ‘go together’ on the basis of their common *constructional history*. This means that whether an object, a , has a property F depends on three factors:

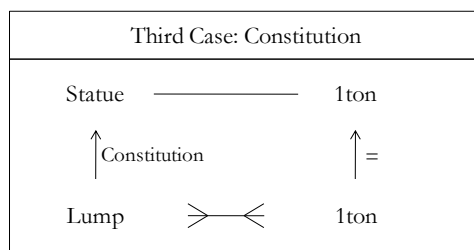
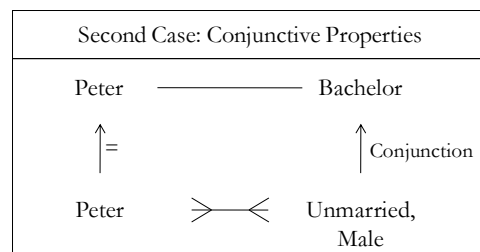
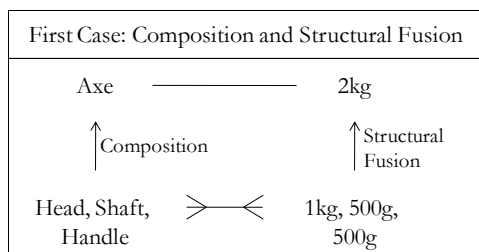
- (i) The entities constructing a and F
- (ii) The operations by which a and F are constructed
- (iii) The patterns of instantiation holding among the constructing entities

In general, if either one of a and F are constructed, then whether ‘ a has F ’ holds is determined by patterns of instantiation among the entities that construct a and F , as well as a and F themselves. I will next present three examples illustrating the mechanics of the linking-principles.

²⁹ If an operation has no application-condition, nothing fully explains the existence of entities constructed via this operation. Such entities would be *emergent* in roughly the sense explored by Barnes (2012).

³⁰ I am setting aside another kind of ontological principle that is less central to our purposes. *Identity principles* encode sufficient conditions for identity. For instance, the ‘extensional’ identity principle for set-formation says $\forall xx \forall yy (xx=yy \supset \{xx\} = \{yy\})$. For order- and repetition-sensitive identity principles, see Fine [2010] and Bader (2013). Identity principles underlie explanations of identity and distinctness truths.

Moreover, according to the proponents of so-called ‘abstraction-principles’, some identity principles also underlie the grounds of the existence of derivative entities. Hume’s Principle, $\forall F \forall G (F \approx G \supset \#(F) = \#(G))$ (read ‘ \approx ’ as equinumerous and ‘ $\#$ ’ as ‘the number of’), is such a candidate principle. The feasibility of abstraction-principles and the question of whether the constructional theory covers them successfully is a topic for further research.



The weight of the axe in the first case is determined by the weights of the axe's parts. I assume here that the magnitude 2kg is the 'structural fusion' of the magnitudes 1kg, 500g, and 500g. Structural fusions are properties whose constituent-structure mirrors the constituent-structure of their instances (see Armstrong [1997: 31ff] for details). They are in part defined by the metaphysical laws that characterize the structural-fusion operation. In the second case, Peter's bachelorhood is established by the fact that Peter has each of the two conjunct-properties 'being unmarried' and 'being male'. I assume for simplicity that bachelorhood is a simple conjunctive property with only two conjunct-properties. And in the third case, the fact that the constituting lump weighs 1ton determines that Statue weighs 1ton.

I will next specify some linking-principles that capture these cases. These principles are merely plausible candidates whose purpose is to familiarize the reader with the notion of a linking-principle. Which specific linking-principles we should ultimately endorse is a hard question that we don't need to answer here. In what follows, read unbound variables as bound by universal quantifiers taking widest scope; the principles are sentences, not schemas. Lowercase variables range over objects; uppercase variables range over properties. 'X(x)'

abbreviates ‘x instantiates X’. (‘SF’ stands for structural fusion, ‘CP’ for composition, ‘C&’ for conjunctive-property construction, and ‘CT’ for constitution.)

(Structural Fusion) $[x = CP(y_1, \dots, y_n) \ \& \ X = SF(Y_1, \dots, Y_n) \ \& \ Y_1(y_1) \ \& \ \dots \ \& \ Y_n(y_n)] \supset X(x)$

(Conjunction) $[X = C\&(Y_1, \dots, Y_n) \ \& \ Y_1(x) \ \& \ \dots \ \& \ Y_n(x)] \supset X(x)$

(Constitution) $[x = CT(y) \ \& \ X(y)] \supset X(x)$

Structural Fusion says that a composed object, o , has a structural property, F , if the objects composing o instantiate the properties fusing into F . Conjunction says that an object has a conjunctive property if it has all the conjunct-properties. And Constitution has it that a constituted object inherits the properties from its constitution-base. This last principle is plausible only if the property-quantifier is restricted, since constituted objects do not inherit all of the properties of the constituting objects. I will not decide the first-order question of what this restriction is exactly.³¹

These examples suggest a canonical form of linking-principles. Let O_1 and O_2 refer disjunctively to a construction-operation or the identity-function, and let ‘ $ARE(y_1, \dots, y_n; Y_1, \dots, Y_m)$ ’ stand for patterns of instantiation between y_1, \dots, y_n and Y_1, \dots, Y_m .

(Linking-Principle) $[x = O_1(y_1, \dots, y_n) \ \& \ X = O_2(Y_1, \dots, Y_m) \ \& \ ARE(y_1, \dots, y_n; Y_1, \dots, Y_m)] \supset X(x)$ ³²

³¹ Are there also corresponding linking-principles for negative truths, such as $[X = C\&(Y_1, \dots, Y_n) \ \& \ \sim Y_1(x)] \supset \sim X(x)$? I suggest instead that some negative truths are explained by the absence of grounds. For instance, $\sim(Susan \text{ is male})$ explains $\sim(Susan \text{ is a bachelor})$ because $Susan \text{ is male}$ is among all possible grounds for $Susan \text{ is a bachelor}$.

Alternatively, we could appeal to a bi-conditional principle of the form ‘ $X = C\&(Y_1, \dots, Y_n) \supset (X(x) \leftrightarrow Y_1(x) \ \& \ \dots \ \& \ Y_n(x))$ ’. To avoid the problem from directionality (section 2.4), I construe linking-principles as universally quantified material conditionals ‘running from’ more fundamental to less fundamental truths. Thanks to two anonymous referees here.

³² The identity-function, I , maps every entity to itself. For instance, the principle (Conjunction) can be brought into the canonical form as follows: $[x = I(x) \ \& \ X = C\&(Y_1, \dots, Y_n) \ \& \ Y_1(x) \ \& \ \dots \ \& \ Y_n(x)] \supset X(x)$.

This canonical form encodes that linking-principles determine whether an object has a property on the basis of their common constructional history.³³

The above examples are only a fraction of the metaphysical laws. For, every construction-operation is characterized by ontological principles and linking-principles. And since every derivative entity is constructed from basic entities, there are operations that generate relational properties, dispositions, realized properties, and a range of different objects, among others. The more kinds of entities we consider derivative, the more operations we need. The naturalist about mentality and morality, for instance, must explain by what operations mental and moral properties are constructed, and she needs to specify ontological principles and linking-principles for these operations.

This concludes my presentation of the constructional theory of the metaphysical laws. Let me briefly explain why this theory is plausible. First of all, the laws are relatively simple, as they mention only construction-operations and properties that enter into application-conditions. And they are also fully general, as they characterize every constructed entity. Since simplicity and generality are central features of systems of laws, the metaphysical principles singled out by the constructional theory are rightly called ‘laws’. Secondly, since the laws govern construction-operations, the Nomological Account of Ground establishes a tight connection between ground and construction. Oversimplifying a bit, the account explains why there are grounding-connections between facts just in case there are constructional connections among the constituents of the facts. The ability to explain this tight connection between ground and

³³ Linking-Principle ignores the case of constructed relations. To illustrate, assume that internal relations such as ‘taller than’ are constructed from properties, such as individual heights. The following linking-principle for the operation IR says that if two objects have the properties in a pair partly constructing an internal relation, Z, then they are related by Z: $[Z = \text{IR}(\langle X_1, Y_1 \rangle, \dots, \langle X_n, Y_n \rangle) \ \& \ F_i(x) \ \& \ G_i(y)] \supset Z(x, y)$.

construction, I believe, is an important advantage of the constructional theory of the laws (see Chapter 1 for details).

According to the Nomological Account of Ground, every grounding-truth is backed by some metaphysical law: ground just is lawful determination among truths. With the constructional theory of metaphysical laws on the table, we are now in a position to develop the deductive analysis of the notion of lawful determination. I will introduce the analysis in the next section and will then continue with a discussion of two major objections to the resulting view.

2.3 The Deductive-Nomological Analysis of Determination

The Nomological Account of Ground says that p_1, \dots, p_n ground q just in case some metaphysical laws determine q on the basis of p_1, \dots, p_n . This section explains what it takes for laws of metaphysics to determine a truth on the basis of others. For the purposes of this section, I ask the reader to bracket cases of ground that correspond to logical entailments, such as ‘ p, q ground $p \& q$ ’ or ‘ p grounds $p \vee q$ ’. I discuss the topic of ‘logical ground’ in section 2.5.

The deductive-nomological proposal says that lawful determination reduces to logical entailment with the laws of metaphysics as auxiliary premises. Let L be the set of the contents of metaphysical laws ($L = \{p \mid L_M(p)\}$). Let ‘ $\Delta \vdash_L p$ ’ stand for ‘ $\Delta, L \vdash p$ ’: Δ and the laws together entail p . The proposal can then be expressed as follows:

$$(DN_1) \quad p_1, \dots, p_n \text{ lawfully determine } q \leftrightarrow_{\text{def}} p_1, \dots, p_n \vdash_L q$$

Without an interpretation of the entailment-symbol ‘ \vdash ’, however, the definition in DN_1 is underspecified. The obvious interpretation takes ‘ \vdash ’ to mean classical logical entailment. But

the logical features of classical entailment are different from the logical features of ground and thus of lawful determination. In particular, entailment is reflexive, non-symmetric, and monotonic: every proposition entails itself, some entailments run both ways, and if ‘ $p \vdash q$ ’ then ‘ $p, r \vdash q$ ’ (for any r). Since lawful determination is plausibly asymmetric and non-monotonic, classical entailment seems unapt to analyze the notion. Hence, if we understand ‘ \vdash ’ as classical entailment, DN_1 fails.

Even setting worries about general formal features aside, classical entailment it is too weak for our purposes. To see this, consider an ontological principle characterizing some construction-operation, O , together with its contrapositive (C_O is an application-condition of O):

(Ontological Principle) $\forall xx(C_O(xx) \supset \exists y(y=O(xx)))$

(Contraposited Principle) $\forall xx(\sim\exists y(y=O(xx)) \supset \sim C_O(xx))$

The contraposited law together with the fact $\sim\exists y(y=O(aa))$ entails $\sim C_O(aa)$ via *modus ponens*. According to DN_1 , therefore, $\sim\exists y(y=O(aa))$ lawfully determines $\sim C_O(aa)$. But this is the wrong result: objects fail to construct another object in the O -way because they do not satisfy the application-condition C_O . One of *modus ponens* and contraposition are therefore not among the inference-rules that characterize lawful determination. We thus need a stronger notion of entailment to support DN_1 .

Which inference-rules should we use to characterize lawful determination? Instead of aiming directly for an analysis of ‘lawful determination’, the deductive-nomological analysis should target the specific mechanisms by which the laws act on the facts. Let me explain. Intuitively, the laws *apply* to some truths and *take* them to some other truths. Thus, laws of nature apply to some closed system S and take the state of S at time t_1 to a different state at

the subsequent time t_2 . Similarly, metaphysical laws apply to some truths, p_1, \dots, p_n , and take them to a truth, q , at a less fundamental level. I suggest that the DN-approach to lawful determination should provide an entailment-based analysis specifically of the notions of *applying to* and *taking to*.

Logic offers us pretty natural stand-ins for these metaphysically loaded notions. I will say that a law expressed by a sentence of the form ‘ $\forall x(\varphi(x) \supset \psi(x))$ ’ applies to a truth, p , just in case p witnesses the antecedent of $\forall x(\varphi(x) \supset \psi(x))$. And p witnesses the antecedent of $\forall x(\varphi(x) \supset \psi(x))$, if p is expressed by the antecedent of a conditional that can be derived from $\forall x(\varphi(x) \supset \psi(x))$ via \forall -elimination. Thus, $\varphi(a)$ witnesses the antecedent of (1), because it is expressed by the antecedent in (2).

$$(1) \quad \forall x(\varphi(x) \supset \psi(x))$$

$$(2) \quad \varphi(a) \supset \psi(a) \quad [1, \forall\text{-elimination}]$$

It is then a natural next step to identify the ‘output-notion’ *taking to* as the result of applying *modus ponens* to a witnessing instance of the antecedent of the law and the result of \forall -elimination applied to the law. Thus (2) and (3) together entail (4).

$$(3) \quad \varphi(a) \quad [\text{Assumption}]$$

$$(4) \quad \psi(a) \quad [2, 3, \textit{modus ponens}]$$

The derivation in (1) – (4) represents schematically in purely logical terms how the metaphysical laws operate on the facts.

Since lawful determination reduces to the relation between a law’s input and its output, we can define a notion of logical entailment, \vdash_G , in terms of the inference-rules \forall -elimination and *modus ponens*, and use this notion of entailment to analyze lawful determination. I don’t believe

that we need any additional justification for using these inference-rules in the analysis of the input/output-operations of the laws. Given that the laws are universally quantified conditionals, the two rules simply constitute the best fit. Characterizing lawful determination in terms of \forall -elimination and *modus ponens* is, therefore, not inadmissibly *ad hoc*.

Since lawful determination can be broken down exhaustively into the combination of input and output, and since \forall -elimination and *modus ponens* fully capture the input- and output-operations of the laws, we should not appeal to any additional inference-rules to characterize lawful determination. And since we wish to use the two inference-rules exclusively to analyse how metaphysical laws operate on the facts, we need to restrict their scope to laws:

\forall -Elimination* ($\forall E^*$)

$\frac{\forall x_1 \dots \forall x_n \varphi(x_1, \dots, x_n)}{\varphi(a_1/x_1, \dots, a_n/x_n)}$ – If $L_M(\forall x_1 \dots \forall x_n \varphi(x_1, \dots, x_n))$

Modus Ponens* (MP*)

$\frac{s_1 \& \dots \& s_n \supset t}{t}$ – If ‘ $s_1 \wp \dots \wp s_n \supset t$ ’ is derived via $\forall E^*$
 $\frac{s_1, \dots, s_n}{t}$

A few clarifying remarks are in order. First, $\varphi(a_1/x_1, \dots, a_n/x_n)$ in $\forall E^*$ represents the result of substituting individual constants for each of the variable expressions in φ . Secondly, a multi-premise version of *modus ponens* is required to capture that laws act on pluralities of truths. Third, s is derived via $\forall E^*$ iff s appears on a line whose derivation cites $\forall E^*$. Finally, the one line s_1, \dots, s_n in MP* abbreviates n separate lines.

We can define the notion of entailment \vdash_G in terms of the inference-rules $\forall E^*$ and MP*. Since ‘ \vdash_G ’ is defined as a relation between sentences, however, and lawful determination is a relation among propositions, I stipulate: $p_1, \dots, p_n \vdash_G q \leftrightarrow_{\text{def}}$ for some sentences s_1, \dots, s_n , t such that s_1 expresses p_1 , ..., s_n expresses p_n , and t expresses q , $s_1, \dots, s_n \vdash_G t$. The updated account

of lawful determination then takes the following form (recall that ‘ $p \vdash_L q$ ’ stands for ‘ $p, L \vdash q$ ’):

(DN₂) p_1, \dots, p_n lawfully determine $q \leftrightarrow_{\text{def}} p_1, \dots, p_n \vdash_{G, L} q$

To fully understand DN₂, however, we need to go beyond the inference-rules that characterize \vdash_G . We also need to specify the notion of a proof in the system relative to which \vdash_G is defined. A very natural rendering of the notion of a proof secures the correct formal features of lawful determination. To this end, I make the following stipulations.

First of all, ‘ $s_1, \dots, s_n \vdash_{G, L} t$ ’ holds only if each of s_1, \dots, s_n is actually used in the derivation of t .³⁴ This secures the non-monotonicity of lawful determination. For, assuming that t can be proven from s_1, \dots, s_n , there is no guarantee that t can be proven from s_1, \dots, s_n and r in such a way that r is actually used in the proof. Secondly, we are not allowed to introduce a logical truth at any line of the proof unless it is considered a premise or derived via one of the inference-rules of the calculus. The two inference-rules \forall -Elimination* and *modus ponens** together with this characterization of a proof define a calculus, which I will call the *grounding-calculus*. We can read the formula ‘ $p \vdash_{G, L} q$ ’ as ‘ q is derivable from p and some laws in the grounding-calculus’.

Lastly, the grounding-calculus needs to be augmented with a device for introducing names of derivative entities. For, due to the general nature of the metaphysical laws, they only allow the derivation of truths that quantify over derivative entities without referring to them ‘by name’. For instance, the ontological principle for set-formation together with Socrates’

³⁴ Line n is a *parent* of line m in proof P iff n is cited in the derivation of m . n_1 is an *ancestor* of m iff there is a sequence of lines n_1, n_2, \dots, m in P , s.t. each line is the parent of the line adjacent in the sequence. A sentence, s , is *used* in the derivation of P ’s conclusion iff s appears on a line that is an ancestor of P ’s concluding line.

existence does not determine the existence of $\{Socrates\}$, but only the general fact that there is something that is set-constructed from Socrates:

- | | | |
|----|--|-------------------------|
| 1. | Socrates exists | [Assumption] |
| 2. | $\forall x(x \text{ exists} \supset \exists y(y = \{ \}(x)))$ | [Ontological Principle] |
| 3. | $\text{Socrates exists} \supset \exists y(y = \{ \}(\text{Socrates}))$ | [2, $\forall E^*$] |
| 4. | $\exists y(y = \{ \}(\text{Socrates}))$ | [1, 3, MP*] |

To derive the singular truth $\{Socrates\} \text{ exists}$ from line 4 we need a device which names entities whose existence is already granted. There are a number of formal tools for deriving truths that involve names for derivative entities. I will introduce one such tool and I will then briefly explain that the added formalism is neutral on substantive philosophical interpretations. The formal implementation I develop relies on *Auxiliary Locating-Identities*:

(ALI) $\text{Aux}(A = \iota x(Fx))$

Read ALI as ‘If there is a unique F, this unique F is identical to A’. The identity in the scope of ‘Aux’ is flanked by a name on the left, which marks the *bearer* of the identity, and a definite description on the right.³⁵ The context ‘ $\text{Aux}(_ = \iota x(Fx))$ ’ allows for substitution of co-referring names in the bearer-position *salva veritate*: if $\text{Aux}(A = \text{the } F)$ and $A = B$, then $\text{Aux}(B = \iota x(Fx))$. The intuitive job of the ALI associated with an entity, A, is to locate A in a world that is specified in A-free terms. I will use the following two inference-rules to characterize the mechanics of the auxiliary identities in the grounding-calculus:

³⁵ $\iota x(Fx)$ in the scope of an ALI is not an ordinary definite description, since $\text{Aux}(A = \iota x(Fx))$ does not entail the existence of A.

$$\begin{array}{ll}
 \text{(ALI-Elimination)} & \text{a) } \text{Aux}(A = \iota x(Fx)) \qquad \qquad \qquad \text{b) } \text{Aux}(A = \iota x(Fx)) \\
 & \frac{\exists xFx}{A \text{ exists}} \qquad \qquad \qquad \frac{\exists xFx}{A \text{ is } F}
 \end{array}$$

The above derivation can then be continued:

...

4. $\exists y(y = \{\}(Socrates))$ [1, 3, MP*]
5. $\text{Aux}(\{Socrates\} = \iota x(x = \{\}(Socrates)))$ [ALI]
6. $\{Socrates\}$ exists [4, 5, ALI-Elim a]

Hence, ALIs allow the derivation of singular truths involving derivative entities.

ALIs are technical devices that admit of at least three philosophical interpretations: they express fundamental facts (*Haecceitism*), the individual essences of entities (*Essentialism*), or they are purely representational devices that underlie translations of quantificational language into a language with names (*Deflationism*). On all three interpretations, it is a substantive question which ALIs hold. The essentialist makes a substantive claim about the content of individual essences, and the haecceitist needs to say which fundamental truths introduce individuals into a qualitative reality. The deflationist could hold that ALIs are contextually determined: $\text{Aux}(A = \text{the } F)$ holds just in case ‘the F ’ is a contextually salient definite description of A (akin to contextually determined counterpart-relations). The DN-approach to lawful determination is compatible with all these views on the nature of derivative entities.³⁶

Lawful determination is entailment with the laws and the ALIs in the grounding-calculus. Thus, if \mathcal{A} is the set of all true ALIs, and if ‘ $p \vdash_{LA} q$ ’ stands for ‘ $p, L, \mathcal{A} \vdash q$ ’, we can replace DN_2 as follows:

³⁶ Plantinga (1983) defends a view in the spirit of haecceitism and Russell (2013: section 7) presents a broadly deflationist view. Mackie (2006) discusses individual essences.

(DN₃) p_1, \dots, p_n lawfully determine $q \leftrightarrow_{\text{def}} p_1, \dots, p_n \vdash_{G, LA} q$

This concludes my presentation of the deductive-nomological approach to lawful determination. I have argued that the most fruitful application of a deductive account of determination focuses on the analysis of the input/output-operations of the laws. My analysis uses the grounding-calculus, which is characterized by specific inference-rules and a well-defined notion of proof. The Nomological Account of Ground combined with the deductive-nomological account of lawful determination entails the DN-Account of Ground:

(DNA) p_1, \dots, p_n ground $q \leftrightarrow_{\text{def}} \begin{array}{l} \text{(i) } p_1, \dots, p_n \vdash_{G, LA} q \\ \text{(ii) } p_1, \dots, p_n, q \text{ obtain} \end{array}$

I will next present an example to illustrate how the different parts of the account work together. I assume for simplicity that bachelorhood is a simple conjunctive property that is constructed from the two properties Male and Unmarried. (I use capitalized adjectives as proper names for properties.) ‘Peter has Bachelor’ follows from the two premises ‘Peter has Unmarried’ and ‘Peter has Male’ together with the existence of Male and Unmarried in the grounding-calculus:

- | | | |
|-----|---|-------------------------|
| (1) | Peter has Unmarried, Peter has Male | [Assumptions] |
| (2) | Unmarried exists, Male exists | [Assumptions] |
| (3) | $\forall X \forall Y (X \text{ exists} \ \& \ Y \text{ exists} \supset \exists Z (Z = C_{\&}(X, Y)))$ | [Ontological Principle] |
| (4) | Unmarried exists & Male exists \supset
$\exists Z (Z = C_{\&}(\text{Unmarried}, \text{Male}))$ | [3, $\forall E^*$] |
| (5) | $\exists Z (Z = C_{\&}(\text{Unmarried}, \text{Male}))$ | [2, 4, MP*] |
| (6) | Aux(Bachelor = $\iota X (X = C_{\&}(\text{Unmarried}, \text{Male}))$) | [ALI] |

- (7) Bachelor = $C_{\&}(\text{Unmarried}, \text{Male})$ [5, 6, ALI-Elim b]
- (8) $\forall x \forall X, Y, Z ((X(x) \& Y(x) \& (Z = C_{\&}(X, Y))) \supset Z(x))$ [Linking-Principle]
- (9) (Peter has Unmarried & Peter has Male &
Bachelor = $C_{\&}(\text{Unmarried}, \text{Male})$) \supset Peter has Bachelor [8, $\forall E^*$]
- (10) Peter has Bachelor [1, 7, 9, MP*]

The derivation mirrors in logical terms how laws operate on the truths ‘Peter has Unmarried’ and ‘Peter has Male’ and the existence of the two properties Unmarried and Male. The ontological principle for conjunctive-property-formation determines the existence of the property $C_{\&}(\text{Unmarried}, \text{Male})$ based on the properties Unmarried and Male (line 5). The auxiliary identity for bachelorhood determines that this conjunctive property is identical to the property bachelorhood (line 7). Once bachelorhood is constructed from its conjuncts, the linking-principle for conjunctive properties determines that Peter has Bachelor based on Peter’s possession of the conjunct-properties (line 10). DNA therefore predicts that *Peter has Bachelor* is grounded in *Peter has Male*, *Peter has Unmarried* together with the existence of Unmarried and Male.³⁷

This concludes the introduction of the DN-Account of Ground. I have given a precise account of laws of metaphysics that ties together metaphysical explanation and the notion of construction. Although I am open to alternative conceptions of the laws, the constructional theory has allowed for a vivid presentation of the DN-Account. I have also developed a formal system, the grounding-calculus, to define the notion of lawful determination. If ground just is lawful determination among truths, the DN-Account of Ground captures the nature of

³⁷ It may surprise the reader to find the existence of Unmarried and Male among the grounds for *Peter has Bachelor* (see, e.g., Trogdon (2013: 479) for discussion). This addition is motivated since existence is the application-condition for conjunctive-property formation.

metaphysical explanation. In the rest of the paper, I will defend DNA against two central objections. Section 2.4 provides a summary of the arguments against the traditional DN-approach to scientific explanation, and it shows that these arguments gain no traction on the DN-Account of Ground. Section 2.5 responds to the charge that the account fails to deal with metaphysical explanations that correspond to logical entailments.

2.4 The Objection from the Historic Failure of DN-Accounts

Carl Hempel and Paul Oppenheim [1948] introduced the original DN-account of scientific explanation in the 1940s. On their view, every scientific explanation of particular facts subsumes facts under a general law-like regularity: a complete scientific explanation takes the form of an inference from a law-like statement together with premises concerning individual matters of fact to a conclusion that also concerns individual matters of fact. If we refer to inferences of this form as *deductive-nomological inferences*, we can restate Hempel and Oppenheim's claim as follows: a deductive-nomological inference is both necessary and sufficient for scientific explanation. Both the necessity and the sufficiency of deductive-nomological inferences have been questioned. The aim of this section is to show that attacks on the DN-account of scientific explanation do not generalize to the DN-Account of Ground. I will begin with objections to the necessity of a deductive-nomological inference for explanation. Many explanations we actually give do not make explicit reference to regularities. Thus, we explain that the fire occurred because of a short circuit, without mentioning (or even knowing) the relevant lawful regularity that connects short-circuits and fires. But we don't need to think of the laws as included in the *explanans*; we can think of them instead as underlying the explanation. And since when we give explanations we don't go beyond the *explanans*, we do not mention the laws. Moreover, we should distinguish between an

explanation in the abstract and an explanation as something that can be possessed or communicated.³⁸ Even if abstract explanations consisted of deductive-nomological inferences, the possession and communication of an explanation would not require complete grasp of the premises involved in the inference. The same considerations also apply to the DN-Account of Ground. We don't need to know the metaphysical laws in order to successfully give metaphysical explanations. And the metaphysical laws are not part of metaphysical explanations, but underlie them.

A more pressing objection against the necessity of deductive-nomological inferences for explanation arises from statistical or probabilistic explanations. Future events cannot be deduced from present events via statistical laws. Hempel and Oppenheim argued that there are certain inductive inferences that allow us to regard statistical explanations as subsuming individual events under regularities. But this extension of the deductive-nomological project is widely considered unsuccessful [Salmon 1989: ch. 1]. This particular objection, however, influential as it has been, does not concern metaphysical explanations. Since there is no metaphysical analogue to statistical explanations, the laws of metaphysics are deterministic.

Let us next look at the question of whether deductive-nomological inferences are sufficient for scientific explanations. There are two influential kinds of examples that suggest a negative answer. The first kind of example concerns bogus laws. Hempel and Oppenheim accepted a crude regularity-view about laws of nature: law-like generalizations are general statements that are not restricted to particular regions of space or time and that do not make reference to individual objects [Ibid: ch. 2].

³⁸ Lewis (1986a) draws a similar distinction between the explanations as speech-acts and explanations as “chunk of explanatory information.” (Ibid.)

This crude definition of ‘law-likeness’ invites counterexamples to sufficiency. Consider, for instance, the following well-known case. According to Hempel and Oppenheim’s criteria, ‘Every bit of salt that has been pointed at with a wand by a man with a funny hat dissolves in water’ is a law-like regularity. For, it is a true general statement that does not make reference to any individual objects. Now assume that a man with a funny hat points a wand at a specific bit of salt that is then submerged in water. It follows deductively from the regularity and this assumption that the bit of salt dissolves in water. Consequently, the DN-account entails that the dissolving of the salt is explained by the pointing of the wand. But this is of course absurd. This is only one of the difficulties for the traditional DN-Account that arises not from the deductive approach to explanation, but from an implausible approach to the nature of laws. I take it that the right response to this case denies that any regularity involving hexed salt is a law. Suffice it to say that the DN-Account of Ground does not rely on an implausible analysis of metaphysical laws. For all I have said, law-truths of the form $L_M(p)$ may be fundamental. There is, therefore, no analogous ‘hexed-salt problem’ for the DN-Account of Ground.

Perhaps the most influential objection to the deductive-nomological approach to scientific explanation concerns the direction of explanation. The laws of Newtonian Mechanics, for instance, entail facts about the past on the basis of facts about the present. But present facts do not explain the past. The most prominent version of this *problem from directionality* involves deductive symmetries. For instance, the laws of the propagation of light allow us to derive the length of a shadow cast by a flagpole on the basis of the height of the flagpole. But the reverse derivation is also possible: the height of the flagpole can be derived from the length of the shadow [Bromberger 1966]. The explanation, however, only runs one way and not the other. It is widely accepted that the problem from directionality shows that the traditional DN-approach to scientific explanation fails.

But the problem from directionality does not arise for the DN-Account of Ground, because of the form of the metaphysical laws. While laws of nature are symmetric mathematical equations, metaphysical laws are quantified material conditionals. These material conditionals in combination with the inference-rules that define the grounding-calculus are clearly directional. Since *modus ponens*, but not *modus tollens*, is an admissible inference-rule in the grounding-calculus, derivations from metaphysical laws always take us from the antecedent of the law to its consequent. And this means that the derivations only take us from the more fundamental to the less fundamental facts. One important difference between the metaphysical laws and the laws of nature, therefore, is that the directionality of the metaphysical laws, but not of the natural laws, can be captured by means of logic alone.³⁹

This response faces the question of motivation: ‘Why choose material conditionals in the scope of the laws? And why choose specific inference-rules to characterize the notion of lawful determination?’ I think that material conditionals (in the scope of the L_M -operator) provide natural formulations of the ontological principles and linking-principles. After all, ontological principles express sufficient conditions for the application of construction-operations. And linking-principles encode sufficient conditions for the instantiation of constructed properties by constructed objects. Moreover, as I have argued in section 2.3, the inference-rules that define the grounding-calculus are natural logical stand-ins for the input- and output-notions that we intuitively associate with governing laws. But the formalism should ultimately be assessed on the basis of the extensional adequacy and explanatory merit of the resulting account.

³⁹ Perhaps the laws of nature can be re-interpreted as quantified conditionals. The problem of directionality could then be solved without appealing to the direction of time as suggested below.

The objections to the traditional DN-account of explanation don't get traction on the DN-Account of Ground. The resulting package of views, however, may suffer from a lack of unity. If the DN-approach captures only metaphysical explanations, the generic notion of explanation is surprisingly disjunctive. But I am not convinced that this lack of unity among different kinds of explanation would constitute a significant reason to reject the view I am advocating. There are a number of different kinds of explanation, including metaphysical, scientific, mathematical, conceptual, logical, teleological, practical, and normative explanations. We should investigate which of these kinds of explanations are more basic than others, and how each kind can be analyzed in more basic terms. We have little reason to prejudge the substantive issue of whether all kinds of explanation have the same general nature.

I am also not convinced that deductive-nomological inferences should be excluded from the theory of scientific explanation. I have argued above that DN-analyses should target the notion of determination. There is a useful notion of *natural determination* that can be analysed in terms of nomological deductions: p -at- t_1 naturally determines q -at- t_2 just in case (i) p -at- t_1 and the laws of nature logically entail q -at- t_2 , (ii) t_1 is earlier than t_2 and (iii) p -at- t_1 characterizes the entire state of the world at t_1 . Since laws are temporally symmetric, we need (ii): the direction of time fixes the direction of determination. And since laws fundamentally apply holistically to the entire state of the world at a time, we need (iii): only entire world-states naturally determine.⁴⁰

The deductive-nomological approach captures metaphysical as well as natural determination. Since metaphysical explanation just is metaphysical determination, a deductive-nomological account of metaphysical explanation is possible. But it is less clear whether natural

⁴⁰ Schaffer (2013) explains why the laws of nature fundamentally apply to entire world-states.

determination is a notion of scientific explanation. Since the laws of nature work holistically, only entire world-states naturally determine future states. Ordinarily, however, we accept complete scientific explanations that are local: the 8-ball went into the corner pocket because the cue ball hit it with a certain momentum at a particular angle. The state of, say, the Milky Way at the time of the collision does not enter into the explanation. There is, therefore, a gap between the ordinary notion of scientific explanation and the notion of natural determination. An account of scientific explanation in the ordinary sense, thus, requires additional resources: natural determination only supplies necessary conditions for scientific explanation. But if both metaphysical and scientific explanations rely on underlying notions of determination, the DN-Account of Ground does not compromise the unity of explanation.⁴¹

To take stock, the DN-Account of Ground does not fall prey to any of the objections to the deductive-nomological account of scientific explanation. And so even if we reject the deductive-nomological approach to scientific explanation, we can embrace it in the case of metaphysical explanation. Moreover, I remain unconvinced that nomological deductions play no role in the correct treatment of scientific explanation; the DN-Account does not entail a disjunctive view on explanation. I therefore suggest that the historical failure of the traditional DN-account of scientific explanation poses no threat to the DN-Account of Ground.

2.5 The Objection from Logical Ground

Some of the standard-examples of ground in the literature concern logical ground: metaphysical explanations corresponding to valid entailments [Correia 2010; Fine 2012b].

⁴¹ Leading approaches to scientific explanation, such as Woodward [2003], don't use 'natural determination' because they don't have reductive ambitions; 'natural determination' features in the reduction-base of scientific explanation.

- (Logic 1) That people exist grounds that people exist or life is not worth living
- (Logic 2) That people exist, that life is beautiful ground that people exist and life is beautiful
- (Logic 3) That Peter is a sophist grounds that something is a sophist

The DN-Account does not handle these cases, as \vdash_G does not support the relevant inferences. For instance, the disjunction in Logic 1, ‘People exist or Life is not worth living’, cannot be derived from the disjunct ‘People exist’ in the grounding-calculus, since disjunction-introduction is not among the admissible rules. The *objection from logical ground* is that since DNA does not handle cases of logical ground it is not sufficiently general.

This section presents two strategies in response. The first strategy claims that DNA can be extended to logical ground, and the second one argues instead that metaphysical ground and logical ground should receive separate treatments. A thorough defence of either strategy would take us beyond the scope of this paper. However, their availability shows that the objection from logical ground does not refute the Deductive-Nomological Account.

According to the first strategy, it is possible to extend the DN-Account to logical ground. This would require additional inference-rules or additional laws. Additional inference-rules, however, would not actually apply the core idea of the Nomological Account to logical ground. To see this, consider the case of disjunctions. The introduction-rule for ‘or’ licenses the derivation of ‘p or q’ from ‘p’ even without the metaphysical laws. Explanations of disjunctions would, therefore, not be a matter of lawful determination. This manoeuvre is, thus, an instance of the second strategy: metaphysical ground and logical ground receive separate treatments.

Additional metaphysical laws would have to play the role of the missing inference-rules. The best approach, I believe, is suggested by the constructional theory of the laws. I will outline

the approach here, but will leave a thorough discussion for another occasion.⁴² The key idea is to posit construction-operations which correspond to some of the logical connectives. One such operation takes collections of facts to conjunctive facts. The ontological principle characterizing this operation would in effect take any list of truths to their conjunction. Instead of relying on the rule conjunction-introduction, we would then use a metaphysical law, which says that every collection of facts constructs a conjunctive fact. The mechanics of this law can be characterized with the inference-rules $\forall E^*$ and MP^* .

We can derive the existence of conjunctive facts from the existence of their conjunct-facts ('CS' stands for 'conjunctive-fact construction', $[p]$ for 'the fact that p ')

- | | | |
|----|---|-------------------------|
| 1. | $[p]$ exists, $[q]$ exists | [Assumptions] |
| 2. | $\forall f_1 \forall f_2 (f_1 \text{ exists} \ \& \ f_2 \text{ exists} \supset \exists g (g = CS(f_1, f_2)))$ | [Ontological Principle] |
| 3. | $[p]$ exists & $[q]$ exists $\supset \exists g (g = CS([p], [q]))$ | [2, $\forall E^*$] |
| 4. | $\exists g (g = CS([p], [q]))$ | [1, 3, MP^*] |
| 5. | $Aux([p \ \& \ q] = CS([p], [q]))$ | [ALI] ⁴³ |
| 6. | $[p \ \& \ q]$ exists | [4, 5, ALI-Elim a] |

This derivation, however, doesn't yield the result that p, q ground $p \ \& \ q$. To close the gap between facts and propositions, I suggest that a truth is *metaphysically equivalent* to the existence of the corresponding fact:

(Fact-Equivalence) p is metaphysically equivalent to $[p]$ exists

⁴² We could go beyond the constructional conception here. But I'm not sure which 'non-constructional' laws would help. Perhaps quantification into sentence-position could work, such as $\forall p \forall q (p \supset p \vee q)$. Irreducible propositional quantification, however, borders on unintelligibility.

⁴³ To simplify the presentation, I abbreviate 'Aux($A = \text{tx}(x = O(\dots))$)' as 'Aux($A = O(\dots)$)' here and below.

The notion of metaphysical equivalence can be illustrated in grounding-theoretic terms: p is equivalent to q if every possible ground for p would also be a ground for q and *vice versa*, and if p and q would also ground the same truths. Metaphysical equivalence is ground-theoretic equivalence (see Correia [2010]). More intuitively, two metaphysically equivalent propositions capture exactly the same ‘portion of reality’: p is metaphysically equivalent to q iff $[p] = [q]$. My conception of facts is akin to Armstrong’s [2004: 48ff] conception of states of affairs. I do not distinguish obtaining and existing. Facts are constructed from their constituents, and they are individuated by their constructional profiles. That is, two facts are identical if they are the same with respect to their constituents, the order of their constituents, and the number of times that each constituent appears in the facts.⁴⁴

Thus understood, Fact-Equivalence is pretty plausible. Assuming that there are facts, there simply seems to be no real difference between ‘ a and F form a fact’ and ‘ a is F ’: to say that a is F just is to say that $[a \text{ is } F]$ exists. Since DNA delivers that $[p] \text{ exists}, [q] \text{ exists}$ ground $[p \& q]$ exists, Fact-Equivalence entails that p, q ground $p \& q$.⁴⁵ DNA can thus be extended to conjunctions.

To capture existential generalizations, I posit a construction-operation for general existential facts. I prefer an operation that takes collections of properties, F_1, \dots, F_n , to corresponding facts, $[\exists x(F_1(x) \& \dots \& F_n(x))]$. Let ‘GE’ stand for the ‘general-existential-fact construction-operation’. The Ontological Principle for GE says that all collections of instantiated properties construct an existential general fact:

⁴⁴ It follows from Fact-Equivalence that $[p] = [[p] \text{ exists}]$. I therefore deny that $[p]$ is a constituent of $[[p] \text{ exists}]$; “[p] exists” does not accurately represent the structure of its referent. Thanks to an anonymous referee here.

⁴⁵ We can add a meta-rule to the grounding-calculus that allows the substitution of equivalent sentences:
 (Equivalence-Rule) If P is a proof that consists of lines l_1, \dots, l_n and s is metaphysically equivalent to l_i ($1 \leq i \leq n$), then P^* is a proof, where P^* is generated from P by substituting s for l_i .

(GE) $\forall F_1 \dots \forall F_n \forall x (F_1(x) \& \dots \& F_n(x) \supset \exists f (f = GE(F_1, \dots, F_n)))$ ^{46, 47}

Generalizations can then be derived from their instances in the grounding-calculus:

- | | | |
|----|--|-------------------------|
| 1. | $F(a)$ | [Assumption] |
| 2. | $\forall F \forall x (F(x) \supset \exists f (f = GE(F_1, \dots, F_n)))$ | [Ontological Principle] |
| 3. | $F(a) \supset \exists f (f = GE(F))$ | [2, $\forall E^*$] |
| 4. | $\exists f (f = GE(F))$ | [1, 3, MP*] |
| 5. | $\text{Aux}([\exists x F(x)] = GE(F))$ | [ALI] |
| 6. | $[\exists x F(x)]$ exists | [4, 5, ALI-Elim a] |

Assuming again Fact-Equivalence, it follows that *a* is *F* grounds $\exists x F(x)$.

The cases of conjunction and existential generalization illustrate how the Deductive-Nomological Account can in principle be extended to logical ground. But I have chosen these two cases partly because they admit of brief presentations. The explanations of disjunctions and negative truths are more complicated and I don't have the space to present my account of them here. The general strategy, however, is this: we posit fact-construction operations and associated ontological principles that allow us to derive the derivative complex facts from simpler facts. In this vein, we posit operations to construct (specific and general) negative facts, and we appeal to incompatibilities and totality-truths in the application-conditions for

⁴⁶ To avoid circles of ground, the second-order quantifiers in GE are restricted to properties that don't feature in the ALIs of objects: that *a* is *F* grounds that $\exists x Fx$, only if *F* doesn't feature in *a*'s ALI.

⁴⁷ GE can be extended to the polyadic case:

$$(GE^i) \quad \forall R_1 \dots \forall R_n \forall x_1 \dots \forall x_n (R_1(x_1, \dots, x_n) \& \dots \& R_n(x_1, \dots, x_n) \supset \exists f (f = GE(R_1, \dots, R_n)))$$

A more complex operation, however, is required to account for truths such as $\exists x (R(x, a))$.

these operations.⁴⁸ Since disjunctions are metaphysically equivalent to negated conjunctions, a full treatment of the explanation of negative truths therefore also captures disjunctive truths.⁴⁹ There is also a second promising response to the objection from logical ground: logical and metaphysical grounds are two distinct phenomena that require different treatments. According to a widespread belief (rooted perhaps in logical atomism), logical complexity is not a feature of reality, but of representations. Conjunctions, quantifiers, and so on, can be used to characterize a world that does not itself contain conjunctive or quantificational complexity. On this view, there are no logically complex facts and hence no metaphysical laws governing their construction.

It is compatible with this attitude about logic that various complex objects and properties are part of reality. So, whereas, say, compositional complexity is a feature of the world, logical complexity is merely a feature of representations. This divide would be naturally captured in the distinction between two kinds of explanations: metaphysical explanations arise through substantive metaphysical laws, and logical explanations arise through the rules that govern the meaning of logical expressions.⁵⁰

There is a *prima facie* reason in favour of this manoeuvre. Logical explanations are more certain than metaphysical explanations: in some epistemically possible scenarios objects fail to form sets or fusions, but there is no epistemic possibility in which p holds but ' $p \vee q$ ' does not. This epistemic difference can be explained by the claim that metaphysical explanations but not logical explanations require the world to co-operate: metaphysical explanations rely on

⁴⁸ See Armstrong [2004: ch. 6] for explanations of negative truths in terms of incompatibilities and totality-facts.

⁴⁹ Some negative truths are explained by the *absence of possible grounds*: if p_1, \dots, p_n is the only possible ground for q , then the absence of p_1, \dots, p_n explains $\sim q$. If disjunctions are metaphysically equivalent to negated conjunctions, this strategy applies: $\sim p \text{ } \mathcal{E} \text{ } \sim q$ has only one possible ground, ' $\sim p, \sim q$ '. There are two ways in which this ground could be absent: p and q . Thus, both p and q sufficiently explain $\sim(\sim p \text{ } \mathcal{E} \text{ } \sim q)$ and hence also explain $p \vee q$.

⁵⁰ Logical ground could, for instance, be analyzed via truth-maker inclusion as discussed in Fine's [2012a] semantic for 'ground'.

substantive metaphysical principles, but logical explanations rely on the rules that govern the meaning of logical terms. We could deny that the DN-Account of Ground needs to capture logical ground based on this observation.

I have presented two responses to the objection from logical grounds. The first response has it that the DN-Account can in fact be extended to logical ground. The second response denies that the DN-Account of Ground should be extended, since the nature of logical ground differs from the nature of metaphysical ground. I prefer the first response for its ability to unify explanation, but regard the second response as a respectable fall-back position if the first one fails. Although I have lacked the space to present a thorough defence of either response, I have shown that they are both plausible. The objection from logical grounds, therefore, does not provide a compelling reason to reject the DN-Account of Ground.

2.6 Conclusion

I began this paper with the Nomological Account of Ground, which explains the important notion of Ground in more basic terms. The account promises to explain the connections between ground, modality, and mereology, and it also accounts for certain general patterns within the grounding-facts. Assuming a specific theory of the metaphysical laws, the Nomological Account also provides us with an understanding of the productive feature of ground: ground takes an austere layer of fundamental facts to the dazzling derivative reality around us. The Nomological Account explains this in constructional terms: complex derivative entities are constructed ultimately from the sparse basic entities, and the metaphysical laws govern these constructions along the axis of fundamentality – from the most fundamental truths to extremely derivative ones.

But the Nomological Account, promising as it seemed, was resting on the unanalyzed notion of lawful determination. The DN-Account of Ground analyzes lawful determination in terms of logical entailment. The notion of logical entailment that features in the analysis is heavily constrained, but I think that the constraints are well-motivated. This analysis does not only help us to better understand the notion of ground, but it also yields an attractive big-picture view of the fundamental facts. I will conclude by drawing out the big picture resulting from the Deductive-Nomological Account of Ground.

The fundamental truths are divided, on this view, into two kinds. The contingent fundamental truths involve the entities of the fundamental sciences; and the metaphysical laws (together with locating-identities) develop the contingent fundamental truths into a complete derivative superstructure.⁵¹ The driving force of this development is the force of logic which underlies lawful determination. This resulting view has two important advantages over a non-reductive view of ground that accepts grounding-truths as fundamental. The first advantage is that the grounding-truths ultimately reduce to ordinary contingent fundamental truths together with the laws of metaphysics. And since the laws form a simple system, they do not compromise the economy of our theory. The second advantage concerns the minimality of the fundamental truths. A fundamental truth of the form ‘p grounds q’ is awkward if p is itself fundamental. Since ‘p grounds q’ entails p, fundamental grounding-truths of this kind render other fundamental truths redundant; they undermine the minimality of the fundamental. Since the metaphysical laws do not entail any other fundamental truths they are a non-redundant addition to reality.

The DN-Account of Ground weds the Nomological Account of Ground with a plausible big-picture view on the fundamental truths. We have seen that the Nomological Account is

⁵¹ This is in the spirit of the view that deRosset [2013: section 5] calls ‘trialism’.

promising and that the DN-Account can be defended against important objections. In particular, the account does not fall prey to the objections against traditional deductive-nomological accounts of scientific explanation. And we have seen that it can in principle be extended to the case of logical ground. I conclude that we should regard it as a strong contender among the theories of fundamentality.⁵²

⁵² Thanks are due to Shamik Dasgupta, Marco Dees, Raul Saucedo, Erica Shumener, Alex Skiles, Dean Zimmerman, and especially Jonathan Schaffer for discussions and comments on previous drafts. Two anonymous referees from AJP have also provided very helpful comments.

Chapter 3. The Circularity Puzzle in the Metaphysics of the Laws of Nature

3.1 The Realist Metaphysics of the Laws of Nature

Everything that happens in nature falls under the regime of some general law. Pick any single event and ask why it occurred. Most likely, there is some scientific explanation that is based solely on the properties of the entities involved in the situation: any similar arrangement of similar objects in a similar situation would have resulted in a similar event. Scientific experiments are repeatable because explanations generalize in this way. Some generalizations are, therefore, at the heart of scientific practice. Among these generalizations are the laws of nature.

I write “L(p)” to express that it is a law of nature that p. I use the term *law-truth* to refer to truths of the form L(p), and I use *law* to refer to propositions in the scope of the law-operator (not to the truth-makers of “L(p)” if there are any). Thus, if L(p) is a law-truth, then p is a law. Laws are generalizations about properties of scientific importance. Throughout this paper, I will restrict my attention to *fundamental laws* that are characterized by the fundamental sciences. Every *realist about laws* accepts some truths of the form L(p). The *realist metaphysics of laws* concerns the question of what *grounds* L(p)? I follow Kit Fine (2001) and Gideon Rosen (2010) in treating ‘ground’ as a sentential connective that is synonymous with ‘metaphysical explanation’ and ‘in virtue of’. Thus, ‘p₁, ..., p_n ground q’ says the same as ‘p₁, ..., p_n metaphysically explain q’ and ‘q holds in virtue of p₁, ..., p_n’. I will distinguish sufficient from partial ground in the obvious way, and I will introduce the additional notion of a ‘required ground’ below. Ground has only recently entered the literature on the laws of nature; I hope that it will become clear that this is a fruitful addition.

Every realist view can be classified either as *Humean* or as *Anti-Humean*. Humeanism holds

that $L(p)$ is grounded in purely ‘non-modal’, or ‘categorical’, truths that don’t introduce ‘necessary connections’. Since these notions have never been successfully defined, Humeanism is perhaps best understood in contrast to specific Anti-Humean accounts of laws, which rely on ‘non-categorical’ or ‘modal’ ideology: David Armstrong (1983) appeals to a relation between universals he calls ‘nomic necessitation’, Tim Maudlin (2007) introduces a primitive ‘it’s a law that’ operator, Marc Lange (2009) posits irreducible counterfactuals, Herbert Hochberg (1981) suggests that general states of affairs exemplify the property of ‘being a causal necessity’, and others appeal to fundamental dispositions (Bird 2007).

The Humean, in contrast, does without any primitive modal ideology. On most Humean views, some regularities count as laws because they summarize the facts most effectively, where ‘most effectively’ is understood in categorical terms. According to David Lewis’ (1983) influential *best system theory*, for instance, the laws are the axioms of the theory that strikes the best balance between informativeness and simplicity. Much could be said about these criteria, but we can ignore the details here. Intuitively, the laws are those sentences in the language of fundamental science that summarize as many facts as possible as simply as possible.

All Humean theories are *regularity theories* about laws, according to which $L(p)$ holds because p is a regularity in nature that ‘stands out’. Different regularity theories differ on what makes a regularity stand out, but all have in common that a law-truth is partly explained by the regularity in its scope:

(Regularity) $L(p)$ is partly grounded in p

Hochberg’s (1981) proposal is an Anti-Humean regularity-theory which includes both the regularity p and the ‘modal’ property of ‘being a causal necessity’ among the grounds of law-truths. The other, more popular, Anti-Humean accounts, however, reject Regularity.

(Consider, for instance, Armstrong's view on which $L(p)$ holds in virtue of certain relations among universals. The regularity p does not ground the fact that the universals are so related, and hence does not ground the law-truth.) In the next section, I will present a familiar attack on Humeanism that targets Regularity.

Humeans use strictly less ideological resources than Anti-Humeans. The debate between them, thus, depends on whether the Humean can get away with her comparatively simple view. A number of arguments against Humeanism rely on modal intuitions, which raise complicated methodological questions.⁵³ I will instead focus on two more principled *circularity-objections*, and I will argue that a new version of these objections, the *circularity puzzle*, sheds important light on the realist metaphysics of laws of nature.

Here is the plan for the paper. I will explain two familiar circularity-objections to Humeanism in section 3.2, and I will argue that these objections can easily be avoided. I will then present the novel *circularity puzzle* in section 3.3, which takes the form of a general paradox. Sections 3.4–3.6 discuss one Anti-Humean and two Humean responses to the puzzle. I argue in sections 3.4 and 3.5 that both parties can solve the circularity puzzle on pain of certain theoretical costs. In section 3.6, I show that the circularity puzzle can be used to motivate a widely overlooked version of Humeanism, and I will argue that this version deserves additional scrutiny. To be clear, I will not adjudicate between Anti-Humeanism and Humeanism. Instead I attempt to give a precise account of the costs that they incur through the threat of circularity. Weighing these and other costs against one another in order to settle the debate, however, is a much larger project that cannot be pursued in this paper.

⁵³ See Beebe (2000) and Schneider (2007) for an overview of the modal arguments and the role of modal intuitions.

3.2 Two Circularity-Objections to Humeanism

In this section, I explain two familiar circularity-objections to Humeanism, and I will show how the Humean can easily sidestep them. This will prepare us for the novel circularity puzzle that I will introduce in the next section. I believe that to advance the debate we should set the traditional objections to the side and focus on the circularity puzzle instead.

The first circularity-objection traces back to Armstrong's (1983) complaint that regularities do not explain their instances. Regularities, so Armstrong, *contain* their instances; and, therefore, if a regularity explained one of its instances, then the instance would partly explain itself. Suppose, for instance, that, as a matter of law, short circuits in circumstances C precede fires. Call this *the short circuit law*. Circumstances C include the presence of oxygen, flammable material, and so on. Assume further that a particular short circuit, Circuit, precedes a particular fire, Fire. Since the occurrence of Fire (succeeding the occurrence of Circuit) is an instance of the short circuit law, it is 'contained' in it. And hence if the short circuit law explained the Fire, the Fire would partly explain itself.

This argument is notoriously difficult to understand, as the notion of *containment* in 'regularities contain their instances' requires clarification. Moreover, the argument rests on a controversial principle to the effect that if q is 'contained' in p, then p does not partly explain q. Armstrong's own explication of the containment-relation uses his controversial theory of states of affairs. Erica Shumener (manuscript) provides an alternative analysis of the relation in terms of the semantic notion of 'partial content'. She also makes a convincing case for the principle that bridges containment and explanation: "If the content of a sentence E is part of the content of a set of sentences Γ , then an explanation of E in terms of Γ is unsuccessful."

(*ibid.*: 10)

Whatever the chances of spelling out the notion of containment, however, I believe that the Humean can sidestep the objection by denying Laws Explain:

(Laws Explain) Laws enter into scientific explanations

I see no reason to accept, for instance, that the short circuit law is part of the scientific explanation of the occurrence of Fire. Armstrong-style considerations may show that we should instead treat the law-truth *it's a law that short circuits precede fires*⁵⁴ as entering into the explanation. Schematically, we can deny “p, f explain g” in favor of “L(p), f explain g”. Laws Explain then gets replaced by Law-Truths Explain:

(LTs Explain) Law-truths enter into scientific explanations

The remaining question is then whether Humeanism is committed to Laws Explain. If Humeanism entailed that law-truths and laws were inter-substitutable in the context of explanations, LTs Explain would entail Laws Explain. But I don't think that Humeanism carries this commitment. As I have introduced the view above, Humeanism is a regularity theory of laws that considers p a partial ground of L(p). Since Humeanism thus understood admits of a clear distinction between the law-truth L(p) and the law in its scope, Humeans are free to hold that law-truths enter into explanations while laws do not. If Humeans are free to reject Laws Explain, then Armstrong's circularity-objection fails.⁵⁵

The recommended solution, however, runs into a related objection raised by Maudlin (2007: 172) and further developed by Lange (2013). This second circularity-objection should

⁵⁴ The reference to circumstances C is left implicit here and in what follows.

⁵⁵ I suggest that the apparent plausibility of Laws Explain is owed to a hangover from the deductive-nomological account of explanation, on which explanations are deductively valid arguments (cf. Hempel & Oppenheim 1948). Since laws feature among the premises of such arguments, they count as part of the *explanans*. But the deductive-nomological account is compatible with the rejection of Laws Explain if we reinterpret the view: ‘p₁, ..., p_n explain q iff p₁, ..., p_n deductively entail q together with the laws.’

be understood not as attacking Humeanism directly, but as targeting regularity theories. Since the more competitive Anti-Humean proposals aren't regularity-theories (Hochberg's (1981) view being perhaps the only exception), the circularity-objection to regularity theories attempts to adjudicate between Humean and Anti-Humean accounts of laws. My reconstruction of this second circularity-objection to Humeanism is based on the following principles:

(LTs Explain)	Law-truths enter into scientific explanations
(Regularity)	$L(p)$ is partly grounded in p
(Transitivity)	Explanation is generally transitive
(Generality)	Generalizations are partly grounded in their instances ⁵⁶

The four principles entail the unpalatable conclusion that explained facts explain themselves. To see this, assume again that Circuit's occurrence explains the occurrence of Fire. Since the occurrence of Fire is an instance of the short circuit law, we can run the following derivation:⁵⁷

1. $L(\text{short circuits precede fires})$ partly explains Fire's occurrence [LTs Explain]
2. That short circuits precede fires partly explains $L(\text{short circuits precede fires})$ [Regularity]
3. Fire's occurrence partly explains that short circuits precede fires [Generality]
4. Fire's occurrence partly explains Fire's occurrence [1-3, Transitivity]

The lines 1 – 3 are instances of the principles LTs Explain, Regularity, and Generality. Transitivity supports the inference to 4. Since 4 is untenable, one of the four principles has to be given up. The Humean is committed to Regularity, and LTs Explain was recommended to

⁵⁶ Hicks and van Elswyk (forthcoming: 3) offer a different reconstruction. Since they rely on Laws Explain ("The natural laws explain their instances" *ibid.*), my own reconstruction is more suitable for the current discussion.

⁵⁷ I use 'instances' here to include witnessing instances of the consequent of universally quantified conditionals. Thus, 'G(a)' counts as instances of the generalization 'All Fs are G'.

avoid Armstrong's objection. Generality rests on both systematic considerations and obvious plausibility. Logically complex truths are systematically grounded in less complex truths: conjunctions are grounded in their conjuncts, disjunctions in their true disjuncts, and existential generalizations in their witnessing instances.⁵⁸ It would be surprising if universal generalizations marked an exception. Moreover, the fact that all very tall mountains have been climbed is obviously intimately related to the fact that K2 has been climbed. The latter fact intuitively 'goes towards' the generalization, and thus seems to partly explain that all very tall mountains have been climbed. I will discuss Generality in section 3.6 below. For now, however, I will conclude that if Transitivity is accepted, Regularity and thus Humeanism should be given up.

Barry Loewer (2012) rejects Transitivity. He points out that the objection equivocates between two different notions of explanation. LT's Explain involves scientific explanation, while Generalization and Regularity involve metaphysical explanation: the law-truths scientifically explain individual facts, and the individual facts metaphysically explain the laws. Since there is no reason to expect transitivity to hold across different kinds of explanation, Loewer argues, the conclusion in 4 can be avoided. Loewer's response has inspired an important debate about the connection between metaphysical and scientific explanation. Marc Lange (2013) argues that *grounds of scientific explainers are also scientific explainers*. And since the occurrence of Fire is a partial ground of L(short circuits precede fires), and since L(short circuits precede fires) helps to scientifically explain the occurrence of Fire, Fire's occurrence partly scientifically explains itself. If Lange's principle is correct, therefore, the second circularity-objection stands strong even in light of Loewer's response.⁵⁹

⁵⁸ See Fine (2012) for discussion of these cases of 'logical ground'.

⁵⁹ For a critical discussion of Lange's arguments see Hicks and van Elswyk (forthcoming).

But whatever the verdict on Lange's principle, Humeans can sidestep the objection by rejecting LTs Explain. That is, Humeans can insist that while law-truths partly ground scientific explanations, they are not part of scientific explanations. In slogan form, laws *underlie* but do not *enter into* scientific explanations. To illustrate, L(short circuits precede fires) does not scientifically explain the fire, but instead partly grounds the truth 'Circuit's occurrence explains Fire's occurrence'. The short circuit by itself sufficiently explains the fire. The laws, however, are an indispensable ground of the explanation: Circuit's occurrence would not explain the occurrence of Fire if the laws were not in place. If this view is plausible, Humeans can reject LTs Explain and thereby avoid the second circularity objection as it stands.

Since LTs Explain seems quite plausible, I will defuse one argument in its favor. LTs Explain receives support from the principle that sufficient explanations necessitate: if p_1, \dots, p_n sufficiently explain q , then it is necessary that if p_1, \dots, p_n obtain then q obtains. Since the law-truths are contingent, they must, therefore, be included in the *explanans* to render explanations sufficient. For instance, since the short circuit law considered above is contingent, it is possible for the short circuit to occur (in C) without the fire. The law-truth, therefore, must be included in the explanation of the fire. In response, however, Humeans can insist on understanding the necessitation-principle in terms of *natural necessity*: if p_1, \dots, p_n sufficiently explain q , then it is *naturally* necessary that if p_1, \dots, p_n obtain then q obtains. The laws of nature are metaphysically contingent, but naturally necessary. Consequently, the presence of the short circuit (in C) naturally necessitates the fire, and hence constitutes a necessitation-base in the relevant sense. From a modal point of view, therefore, there is no need to consider the law-truths parts of scientific explanations.⁶⁰

⁶⁰ Natural necessity is whatever necessity is associated with the laws of nature, and is plausibly weaker than metaphysical necessity. I will say more about this notion in section 3.4.

To conclude this section, I suggest that Humeans can resist both Laws Explain and LTs Explain and, thus, escape both traditional circularity-objections. Moreover, the two escape-routes are parallel: the objections seemed forceful only because the role of the laws in scientific explanations was misunderstood. Neither laws nor law-truths enter into scientific explanations; they underlie them. Explanation, therefore, does not run in a circle. Hence, for all that's been said, even if transitivity held across different kinds of explanation, no harmful circularity would follow.

In what follows, I will discuss the issue of circularity in the metaphysics of laws in a fresh light. To that end, I will present the novel *circularity puzzle* in section 3.3. Since the puzzle does not rely on the view that laws or law-truths enter into explanations, it cannot be as easily avoided as the traditional circularity-objections. However, the circularity puzzle is not an objection to any particular view, but instead takes the form of a paradox: every party to the debate has to reject at least one of three plausible premises. I will present the three views that emerge from rejecting the premises of the puzzle in sections 3.4–3.6, and I will discuss their respective costs. I will argue that the circularity puzzle teaches us important lessons about the realist metaphysics of laws.

3.3 The Circularity Puzzle

For the purposes of presenting the circularity puzzle, I use 'ground' and 'explanation' to mean 'partial metaphysical explanation' and 'partial scientific explanation' respectively. The circularity puzzle relies on the following assumptions:

- (Law-Role) Law-truths ground explanations of their instances
- (Generality) Generalizations are grounded in their instances

- (Priority) p grounds (q explains r) & $p \neq r \rightarrow p$ is *explanatorily prior* to r
- (Regularity) $L(p)$ is grounded in p

The assumptions are in tension and one of them has to be given up. To see this, assume that f explains g , and that g is an instance of p . The assumptions support the following derivation:

- | | | |
|-----|--------------------------------------|------------------------------------|
| (1) | $L(p)$ grounds ' f explains g ' | [Law-Role] |
| (2) | $L(p)$ is explanatorily prior to g | [(1), Priority] |
| (3) | g grounds p | [Generality] |
| (4) | p grounds $L(p)$ | [Regularity] |
| (5) | g grounds $L(p)$ | [(3), (4), transitivity of ground] |

The lines in (2) and (5) are incompatible: no fact grounds another fact that is explanatorily prior to it. Hence, one of the assumptions must go. This is the *circularity puzzle*.

Law-Role replaces the principles Laws Explain and LTs Explain of the traditional circularity objections presented in the previous section, but it should also be accepted by supporters of LTs Explain. For, laws and explanations are constitutively related. And the direction of dependence clearly goes from the laws to the explanations. Since Law-Role is true, we are left with three negotiable assumptions. I will devote a section to each of them (3.4–3.6). I will first, however, briefly explain the initial plausibility of Priority and Regularity to show the puzzle's *prima facie* force. The case for Generality was presented in the previous section.

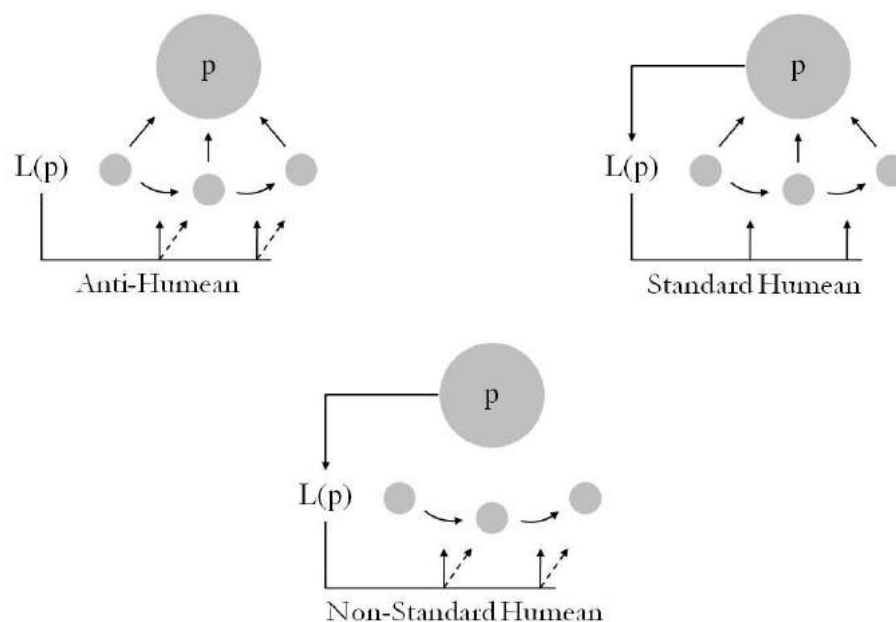
Priority says that any partial ground of a scientific explanation, ' f explains g ', is explanatorily prior to the explained truth, g . The only exception is the *explanandum*-truth g , which may be

required to ground ' f explains g '.⁶¹ 'Explanatory priority' is a *sui generis* notion. Intuitively, a truth, p , is explanatorily prior to q if p 'metaphysically contributes' to q , or if p 'comes before' q in the logical order of things. Ground entails explanatory priority: if p grounds q , then p contributes to q , and p comes before q . According to the Priority-principle, however, ground is not the only source of explanatory priority: anything underlying an explanation, ' f explains g ', is explanatorily prior to g .

Priority has intuitive appeal. Laws are involved in the generation of new facts. If it weren't for the laws, the new facts would not arise. The laws, therefore, 'come before' the new facts; they are explanatorily prior to them. This thought can also be captured in temporal language: facts at an earlier time, t , together with the laws holding at t give rise to facts at later times. And so the laws were in place even though the later facts had not yet obtained. And therefore, the laws metaphysically precede the later facts, and are thus explanatorily prior to them. I will further discuss Priority in section 3.5. For now, I just note that it has some initial plausibility. It is harder to motivate *Regularity* (the claim that $L(p)$ is partly grounded in p) on purely intuitive grounds, but there is considerable theoretical pressure in its favor. It is widely accepted that the material conditional $L(p) \supset p$ is metaphysically necessary. This modal claim is equivalent to these two formulations: only a truth can be the content of a law, and laws are necessarily exceptionless. Regularity provides an explanation for this necessity: since p is a required ground for $L(p)$, if $L(p)$ holds so does p . Since it is unclear how this metaphysical necessity could be explained without appeal to Regularity, the necessity of $L(p) \supset p$ provides a strong reason to accept the principle.

⁶¹ f and the laws may be naturally but not metaphysically sufficient for ' f explains g ' (see section 3.4 for discussion). The laws and f are then insufficient to ground ' f explains g ' and g has to be considered a partial ground of the explanation.

We can also conveniently preview the three possible solutions to the circularity puzzle in the form of diagrams.



Anti-Humeans should reject Regularity: laws are not grounded in their contents. Standard Humeans should reject Priority: laws are not explanatorily prior to their instances. And a Non-Standard Humean view emerges from rejecting Generality: some general truths are not grounded in their instances. I will discuss these solutions in sections 3.4 – 3.6.

Before we get started, let me preview the results of my discussion. Both the Anti-Humean and the Humean have characteristic responses to the circularity puzzle. I will show that for the Anti-Humean, the puzzle collapses into a version of the *inference-problem*: “How can ‘it is a law that p’ necessitate p, if laws are not mere regularities?” I will argue that the most promising response involves a primitive notion of ‘natural necessity’. My second goal is to argue that the Humean avoids the circularity puzzle through their rejection of the so-called *governing-conception* of the laws of nature. And finally, I will discuss a Non-Standard Humean view that emerges from the rejection of the claim that all generalizations are explained by their instances. I will

argue that the Non-Standard view promises a Humean governing-account of laws. I will point to some of the problems of the view, but will recommend it for further discussion.

3.4 The Anti-Humean Choice: Rejecting Regularity

Since Humeans are committed regularity theorists, they accept that $L(p)$ is partly grounded in the regularity p . Anti-Humeans, however, can reject Regularity to avoid the circularity puzzle. The current section discusses the costs associated with this strategy.

The case for Regularity rests on the claim that no other principle can explain the following metaphysical necessity:

(M-Detachment) $\Box_M(L(p) \supset p)$ ⁶²

M-Detachment is widely accepted. It says that, necessarily, the laws of nature are true. Alternative formulations are ‘The law-truths necessitate the laws’ and ‘Laws are necessarily exceptionless’. Regularity helps to explain M-Detachment. If p is a ground of $L(p)$, it is plausibly a *required ground* of $L(p)$. That is to say that no collection of truths, q_1, \dots, q_n , could sufficiently ground $L(p)$, unless p is among q_1, \dots, q_n . If p is a required ground of $L(p)$, M-Detachment is fully accounted for. We can thus formulate the following argument for Regularity:

- (1) If M-Detachment holds it needs to be explained
- (2) Regularity provides the only available explanation of M-Detachment
- (3) M-Detachment holds
- (4) Hence, Regularity holds

⁶² The label “M-Detachment” reflects that the law ‘detaches’ from the law-truth with metaphysical necessity.

Since the argument bears important similarities to the *inference-problem*, introduced by Bas van Fraassen (1989, Ch. 5) and famously employed by Lewis (1983) against Armstrong's theory of laws, I call it *the new inference-problem*. Anti-Humeans who reject Regularity have to deny a premise of the new inference-problem. I will recommend that Anti-Humeans deny premise (3).

If we reject (1), we can consider M-Detachment an unexplained necessity. However, I am skeptical of all unexplained necessities. Many metaphysical necessities arise from connections of ground or from the essences of entities. For instance, the presence of H₂O necessitates the presence of water, because the former is a sufficient ground for the latter. And the presence of water necessitates the presence of H₂O, because the latter is also a required ground for the former.⁶³ And Peter's existence necessitates that Peter is human, because it lies in Peter's essence to be human. There are also other sources of metaphysical necessity, including logical entailments, identities and incompatibilities. For instance, having 1kg mass might necessitate the absence of having 2kg mass because of an incompatibility-relation holding among the two properties (Wang 2013). These cases give support to a general principle about metaphysical necessities: accept a necessity only if there is an explanation available in terms of some plausible source. Since this principle is attractive, premise (1) is plausible.⁶⁴

Rejecting premise (2) is more ambitious: an alternative explanation of M-Detachment that doesn't appeal to Regularity would solve the new inference-problem directly.⁶⁵ An important

⁶³ You won't like this example if you think that water and H₂O are identical (which I believe they are not since one is a liquid and one is a molecule). Another example is this: *Socrates exists* necessitates *{Socrates} exists*, because the former is a sufficient ground for the latter. And *{Socrates} exists* necessitates *Socrates exists*, because the latter is also a required ground for the former.

⁶⁴ If you still want to reject (1) be my guest. Note, however, that this would incur certain costs – for unexplained necessities at the very least add to the costs of a theory. These costs would then come to bear in the debate with the Humean. I will set this rather implausible response to the side.

⁶⁵ It's worth noting in this context that Hochberg (1981) develops an Anti-Humean theory that accepts Regularity precisely to avoid both Humeanism and a version of the inference-problem that he traces back to Gustav Bergmann (1949).

alternative attempt to explain M-Detachment relies on the essence of lawhood. To make this attempt precise, I use Kit Fine's notion $E_x(p)$ which says that it lies in the essence of x that p (Fine 1995). Every essence-truth explains both the truth in its scope as well as the metaphysical necessity of that truth. Schematically, $E_x(p)$ explains both p and $\Box_M(p)$. There are, therefore, two essence-claims that, if true, could explain M-Detachment.

(Conditional-Essence) $E_{LAW}(L(p) \supset p)$

(Necessitation-Essence) $E_{LAW}(\Box_M(L(p) \supset p))$

Conditional-Essence says that it lies in the nature of lawhood that $L(p)$ only if p . It would explain M-Detachment by conferring necessity to the encoded material conditional $L(p) \supset p$. Necessitation-Essence says that M-Detachment holds in virtue of the nature of lawhood and would, therefore, explain the principle directly.

If one of these two essence-claims is true, the Anti-Humean can explain M-Detachment and, hence, avoid the new inference-problem. But I am skeptical of both essence-claims. I will argue next that Conditional-Essence entails Regularity and should therefore be rejected by the Anti-Humean. And I will argue that Necessitation-Essence is implausible. If these claims are correct, then premise (2) of the new inference-problem stands strong.

Consider Conditional-Essence first: it lies in the nature of lawhood that $L(p)$ only if p . My objection to Conditional-Essence is that it entails Regularity. The intuitive idea is that if the regularity, p , enters into the essence of a law-truth, $L(p)$, then p is a 'metaphysical precondition' for $L(p)$: the regularity needs to be in place to (partly) explain that the law-truth obtains. But there are also more formal considerations that support the inference from Conditional-Essence to Regularity. Note first that material conditionals in the scope of the essence-operator, $E_x(_)$, systematically correspond to sufficient and required grounds. In particular, if

$E_x(p \supset q)$ holds, then p is either a sufficient ground for q , or q is a required ground for p .

Consider the following examples to illustrate this point.

- $E_{\text{Water}}(\text{Water exists} \supset \text{H}_2\text{O exists})$ $\text{H}_2\text{O exists}$ is a required ground of *Water exists*
- $E_{\text{Water}}(\text{H}_2\text{O exists} \supset \text{Water exists})$ $\text{H}_2\text{O exists}$ is a sufficient ground of *Water exists*
- $E_{\text{Bachelor}}(\forall x(\text{Bachelor}(x) \supset \text{Unmarried}(x)))$ $\forall x(x \text{ is unmarried req. ground of } x \text{ is a bachelor})$
- $E_{\text{Bachelor}}(\forall x(\text{Unmarried}(x) \ \& \ \text{Male}(x) \ \& \ \dots \ \forall x(x \text{ is unmarried} \ \& \ x \text{ is male} \ \& \ \dots \text{ is a} \\ \supset \text{Bachelor}(x)))$ sufficient ground of *x is a bachelor*)

Hence, if the material conditional $L(p) \supset p$ is encoded in some essence, then $L(p)$ is a sufficient ground for p or p is a required ground for $L(p)$. And since $L(p)$ does not sufficiently ground p , p is a required ground for $L(p)$. This entails Regularity. Since the Anti-Humean rejects Regularity to avoid the circularity puzzle, she should also reject Conditional-Essence.

The second essence-claim that could explain M-Detachment is Necessitation-Essence, $E_{\text{LAW}}(\Box_M(L(p) \supset p))$. This claim may appear plausible at first. For, it is a defining feature of laws that they necessitate, or ‘enforce’, their content; as John Roberts (2009) says, laws “confer inevitability”. Thus, if some law says that electrons repel each other, the law ‘makes it inevitable’ or ‘necessitates’ that electrons repel each other. If necessitating their content is a defining feature of laws, then it is plausibly encoded in the essence of lawhood. Hence, Necessitation-Essence appears plausible.

But this reasoning rests on a mistake. Although it does lie in the nature of laws to necessitate their contents, the correct notion of necessitation is natural and not metaphysical necessitation. To see this, note that laws are involved in a number of different ‘modal platitudes’, including at least the following three:

(MP1)	Laws necessitate their contents	$\Box(L(p) \supset p)$
(MP2)	The contents of laws are necessary	$L(p) \supset \Box(p)$
(MP3)	Laws are necessary	$L(p) \supset \Box(L(p))$

You might even use these truths to explain what laws are, and it is therefore not implausible that they are encoded in the essence of lawhood. But note that MP2 and MP3 arguably concern natural necessity and not metaphysical necessity.⁶⁶ It is therefore plausible that if MP1–MP3 characterize the essence of laws, they all concern natural necessity. Thus, M-Detachment is not encoded in the nature of laws, but a similar principle involving natural necessity is:

(N-Detachment) $\Box_N(L(p) \supset p)$

The same result is suggested by a slightly different thought: laws of nature are associated with a distinctive modal force, the force of natural necessity. Insofar as any necessity enters into the nature of lawhood, therefore, it is natural necessity and not metaphysical necessity. But Necessitation-Essence characterizes the nature of laws with metaphysical necessity. It should thus be rejected.

To sum up, Conditional-Essence is unavailable to the Anti-Humean as it entails Regularity, and Necessitation-Essence should be rejected. I therefore think that premise (2) of the new inference-problem stands strong. Since both (1) and (2) are plausible, I recommend that the Anti-Humean rejects (3), the M-Detachment principle. I will argue that this solution is feasible, but that it also gives rise to a distinctive cost.

⁶⁶ Some ‘necessitarian’ views as the one defended in Shoemaker (1998) accept MP2 and MP3 even if ‘ \Box ’ is taken to mean metaphysical necessity. But it is implausible that these claims would hold in virtue of the nature of natural law-hood.

Rejecting M-Detachment is to recognize the metaphysical possibility of worlds in which a law-truth, $L(p)$, holds, while the corresponding law, p , fails to hold. In these worlds, laws are *genuinely violated*: although a law-truth holds, it is not always ‘in effect’. Genuine violations of law are not obviously incoherent. They have played an important role in various religious belief systems and folklore. Since these beliefs were not obviously irrational or inconsistent, I see no reason to deny the metaphysical possibility of genuine violations of law.

To capture the platitude that law-truths ‘enforce’ or ‘guarantee’ the laws in their scope the Anti-Humean should endorse the weaker N-Detachment principle, $\Box_N(L(p) \supset p)$.⁶⁷ According to this principle, genuine violations of laws are naturally impossible: only law-abiding worlds are naturally possible.⁶⁸ The important difference between N-Detachment and M-Detachment is that the former principle can plausibly be taken to hold in virtue of the nature of lawhood, as it concerns natural and not metaphysical necessity. It lies in the essence of law-hood that there is an associated modal force, natural necessity, with which $L(p)$ entails the law in its scope. More generally, all modal axioms that characterize the notion of natural necessity hold in virtue of the nature of (natural) lawhood. Laws of nature are thus the *source* of natural necessity.

This is then how the Anti-Humean can solve the new inference-problem: she can reject M-Detachment in favor of N-Detachment, and she can insist that the latter principle is explained by the nature of laws. The cost associated with this move is that natural necessity remains a primitive notion. Since the axioms characterizing natural necessity hold in virtue of the nature of lawhood, natural necessity cannot in turn be defined in terms of the laws. ‘Natural

⁶⁷ Are there any platitudes about law-truths? I believe so, since the word ‘law’ refers to law-truths in phrases such as ‘laws necessitate’ and ‘laws underlie explanations’.

⁶⁸ A world w can thus fail to be naturally possible, relative to our world, in two ways: (i) the laws of our world are false in w , and (ii) the laws at w are false at w .

necessity', therefore, is a primitive form of necessity, which constitutes an ideological cost for Anti-Humeans. This is the price they pay for their solution to the circularity puzzle. The next section presents the price paid by the rival Humean view.

3.5 The Standard Humean Choice: Rejecting Priority

I will next turn to the Humean responses to the circularity puzzle. Since Humeanism is committed to Regularity, Humeans avoid the circularity puzzle by rejecting Priority or Generality. This section discusses the rejection of Priority, and the next section introduces a Non-Standard version of Humeanism that rejects Generality.

Priority says that any truth which grounds an explanation, *f explains g*, is explanatorily prior to the explained truth *g*. The notion of explanatory priority may appear somewhat mysterious. I will offer three clarifications. First, explanatory priority bears the following connection to ground:

(Entailment) p is explanatorily prior to $q \rightarrow \sim(q \text{ grounds } p)$

Since Entailment holds, Priority entails that a truth, q , does not ground any truth which grounds the scientific explanation of q . In particular, Priority entails that q does not ground the law that ground the explanation of q . Secondly, ground is sufficient for explanatory priority. If, for instance, the existence of Socrates grounds the existence of {Socrates}, then Socrates' existence is explanatorily prior to the existence of {Socrates}. Thirdly, ground is not necessary for priority. For instance, even assuming that *o is F* is a fundamental, i.e. ungrounded, truth, *o's* existence is explanatorily prior to *o is F*. The existence of *o* is a metaphysical prerequisite that precedes *o is F* in the logical order of things.

Priority has strong intuitive appeal. Assume that p scientifically explains q and that this explanation is partly grounded in some law, L . Intuitively, L produces q on the basis of p in the sense that q owes its reality to the law (and p): the law is a metaphysical precondition for, and thus explanatorily prior to q . The Humean, however, rejects Priority in order to avoid the circularity puzzle. She denies that the laws are explanatorily prior to the explained facts. On her view, the laws give rise to explanatory structure among facts that are ‘already there’. The laws do not take ‘old’ facts to ‘new’ facts, but they establish connections within the mosaic, which is, in its entirety, prior to the laws and the explanatory connections within it. The resulting view is certainly coherent. Without additional support for Priority, therefore, Humeans are at liberty to reject it.

Support for Priority comes from the so-called *governing-conception* of the laws. I understand the notion of *governing laws* in terms of the idea that the laws determine new facts on the basis of old facts. Helen Beebe describes this idea in contrast to laws that necessitate but do not govern:

For the Anti-Humean, the notion of determination is a metaphysically meaty one. It isn’t just that the laws plus current facts *entail* future facts; rather *the laws "make" the future facts be the way they will be*: the laws are the ontological ground of the future facts.” (Beebe 2000, p. 578. Second italics are mine.)

Governing laws act on earlier facts to *make* or *generate* later facts. This does not mean (as Beebe suggests), however, that earlier events and the laws are ontologically prior to future facts. Earlier facts and later facts are ontologically on a par: they are equally fundamental.⁶⁹ Thus, I submit that the “metaphysically meaty” sense in which the laws help to *make* or *determine* the

⁶⁹ Bennett (2011) suggests that causal relations may establish differences in relative fundamentality. I find this suggestion deeply counterintuitive.

future facts has to be understood in terms of explanatory priority: Priority is at least a necessary (if not sufficient) condition for governing laws.

Since Priority is a hallmark of the governing-conception, it is unsurprising that Humeans reject it. But what are the costs associated with this rejection? The governing-conception is arguably part of our intuitive understanding of how things work. It is part of the pre-theoretical role of laws that they generate future facts on the basis of the world's history. Governing also promises to explain the 'oomph' of causation: if c causes e , c is not just earlier than e , or counterfactually tied to e , or subsumable with e under some interesting regularity. Rather, e is generated from c via the laws, where the explanatory priority of the laws over e is an essential ingredient in e 's genuine generation. Finally, governing promises to explain the flow of time: if t_1 precedes t_2 , the two times are not just ordered along a dimension, like beads on a rosary. The flow of time may consist in the generation of later events from former events through the laws.

It is difficult to assess the case for the governing-conception for at least three reasons. First, the question of whether governing-theories of laws can analyze causation and the flow of time is underexplored. Secondly, the gain in elegance and parsimony promised by Humean accounts of laws may justify sacrificing some of our more elusive intuitions about laws, causation, and time. And thirdly, Humeans have developed a wealth of explanations of why we would have the governing-intuitions even if Humeanism was true.⁷⁰

Some of these issues concern deep methodological disagreements about the importance of our pre-theoretical conception of reality as well as questions about the proper targets of metaphysical analysis: should we, for instance, regard the subjective fact that time appears to flow as evidence, or should we instead treat the objective fact that time flows as evidence? In

⁷⁰ See Loewer (2012) and Paul (2010) for examples of these Humean explanations.

any case, many Anti-Humeans are drawn to their view, because it allows for a governing-conception of the laws, and hence they agree that the rejection of governing laws incurs a significant cost.

To sum up, if we have reasons to embrace the governing-conception of laws and if we accept that Priority is a necessary condition for governing, then we have reasons to accept Priority. But the Humean, I suggest, needs to reject Priority to solve the circularity puzzle and so must either deny that we have reasons to believe the governing-conception or else must provide comparatively stronger reasons in favor of the Humean package. Since Humeans have always rejected the governing-conception, however, the circularity puzzle does not raise any additional problems. Since I have argued (in section 3.2) that Humeans can also avoid the other circularity-objections, circularity-based arguments against Humeanism appear to be unconvincing.

3.6 The Non-Standard Humean Choice: Rejecting Generality

I have presented two standard solutions to the circularity puzzle: Anti-Humeans can give up Regularity and Humeans can reject Priority. In this final section, I discuss Non-Standard Humeanism, a view that arises from the rejection of Generality. I will argue that the non-standard view is compatible with the governing-conception, and thus avoids the major cost paid by the Standard Humean in response to the circularity puzzle. Although I will point to some of the problems the view faces, my goal is not to refute Non-Standard Humeanism but to encourage further discussion.

Generality says that universal generalizations are partly grounded in their instances. I will next present a view that can exploit the rejection of Generality to solve the circularity puzzle. Laurie Paul describes the view as follows:

[...] we can reject the implicit assumption that the arrangements of the individuals of the [manifold] determine its overall qualitative structure, which then frees us to accept a fundamental, nonlocal distributional property of the manifold. For example, instead of taking the property of the manifold R that *all Fs are Gs* to be grounded by the fact that when a subregion of R instantiates F, a subregion of R instantiates G, we take the property of *all Fs are Gs* to be a primitive, fundamental distributional property of R. (Paul 2013, p. 102)

Paul suggests that some general truths are grounded in ‘fundamental, nonlocal distributional properties of the manifold’. These properties are nonlocal insofar as they are instantiated by the entire four-dimensional manifold, or *cosmos*. They are fundamental since their instantiation by the cosmos is not metaphysically explained by anything else. And the properties are distributional insofar as they determine the properties of the cosmos’s parts.⁷¹ The distributional properties of the cosmos ground the contents of the fundamental laws. Thus, assuming that $L(p)$ holds, there is some global H, such that the fact that the cosmos is H grounds p.

Paul’s suggestion can be used to reject Generality. For, the content of the fundamental laws are generalizations about the properties of quarks, electrons, and so on. If we consider these generalizations to be grounded in global properties of the cosmos, we are free to reject that they are also grounded in their local instances. The proposal thus avoids the circularity puzzle by rejecting Generality: the laws ground explanations of facts about quarks, electrons, and so on, and these facts do not in turn ground the laws.

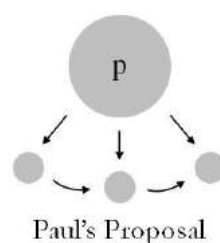
What are the merits of the proposal? The rejection of Generality renders the view compatible with both Regularity and Priority. Since it is compatible with Regularity, it allows for a regularity-theory that avoids the new inference-problem without invoking a primitive notion of natural necessity. The proposal is even compatible with a best-system theory of

⁷¹ For more on distributional properties see Parsons (2004) and Schaffer (2010).

laws.⁷² And since it is compatible with Priority, it might allow for a governing-conception of the laws. There is, therefore, a Humean view which promises to avoid the costs incurred by its rivals. I call this view *Non-Standard Humeanism*.⁷³

The Non-Standard view faces some important questions. Since it allows for properties that the cosmos has fundamentally, it raises the question of whether the manifold considered as a whole is a fundamental object.⁷⁴ It also rejects the initially very plausible claim that all generalizations are partly grounded in their instances. But I will leave these vexing issues for a different occasion. I will focus instead on the question of whether Non-Standard Humeanism, if defensible, could provide us with a feasible Humean governing-conception of the laws. I will answer with a somewhat pessimistic “Maybe!”

Although Non-Standard Humeanism is compatible with Priority, it does not support the governing-conception of the laws in its current form. To see this, note that if the distributional properties of the cosmos determine all the facts, then each individual fact that receives a scientific explanation is also grounded in the distributional properties of the cosmos:



⁷² There is a potential incompatibility between Paul's proposal and Lewis' best-system account. Since laws concern local matters, and since local matters are grounded in global properties of the cosmos, Lewis' requirement that laws are stated in perfectly natural terms may be violated. But we can tweak the naturalness-requirement: the 'best system' is the one that achieves the best balance between informativeness, simplicity, and naturalness. Since the local properties featuring in the laws are highly natural, they may well make it into the best system.

⁷³ Fundamental distributional properties are incompatible with Lewis' doctrine of *Humean Supervenience*, "the doctrine that all there is to the world is a vast mosaic of local matters of particular fact." (Lewis 1986b: ix) But the Non-Standard View is still Humean as the analysis of lawhood it offers does not involve 'modal' or 'non-categorical' notions.

⁷⁴ See Schaffer (2010) for a discussion of this view.

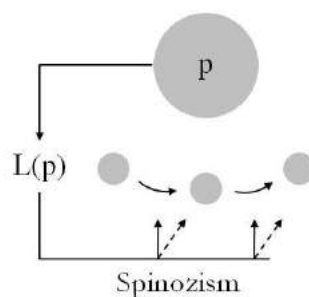
The local facts are, therefore, over-determined by the presence of both metaphysical and scientific explanations. To see this, consider any local fact, g . If there is a scientific explanation of g in terms of an earlier truth, f , then there is also a metaphysical explanation of g in terms of the distributional properties of the cosmos. Consequently, if the laws generate a ‘new’ fact on the basis of some history, this fact was also guaranteed to obtain by the distributional properties of the mosaic. The work of the laws, therefore, appears systematically idle; their ‘governance’ reminds us of the British Shadow Cabinet.

This shows, I believe, that the governing-conception does not only require explanatory priority, but *explanatory dependence*. Thus, from the point of view of the governing-conception, Priority should be replaced with the stronger Dependence-principle:

(Dependence) p grounds (q explains r) & $p \neq r \rightarrow r$ explanatorily depends on p

On Paul’s proposal, no individual fact depends (in the intended sense) on the law-truths, as the distributional properties of the cosmos over-determine the laws’ work. If the laws broke, the cosmos would still determine the future facts.

But Paul’s proposal can be modified to accommodate Dependence, if the grounding-connection between the nonlocal properties of the cosmos and the local facts is severed. I call the resulting view *Spinozism*:



According to Spinozism, the cosmos has certain global properties that determine the the laws. But these properties do not also determine the fundamental properties of the smallest parts of the cosmos. For instance, the global properties of the cosmos might ground the general truth ‘all electrons repel each other’, without grounding, for any two particular electrons, that they repel each other. On this view, both facts involving global properties of the cosmos and certain facts involving its smallest parts are fundamental.⁷⁵

Spinozism allows for Dependence, since it rejects any direct pathways from the properties of the mosaic to the local matters of fact. Individual facts depend explanatorily on the laws: had the laws not done their job, there would not have been a backup mechanism to fix the future facts. On this version of Non-Standard Humeanism, therefore, the laws truly govern the development of the facts through time. The non-standard view, thus, succeeds in avoiding the costs its rivals incur to solve the circularity puzzle. Before I close, I present one objection to Spinozism.

Let F and G be fundamental physical properties, let H be a fundamental property of the cosmos, and assume that ‘The cosmos is H’ grounds ‘All Fs are G’. It is metaphysically impossible that the cosmos has the property H, while it is also the case that *a is F & a is not G*. For, if this scenario were possible, then it would be possible that (i) all Fs are Gs and (ii) *a is F & a is not G*. The problem for Spinozism is that the scenario in question *should* be metaphysically possible, since H, F, and G are fundamental properties, and nothing stands in the way of their recombability. Spinozists thus have to embrace embarrassing necessary connections between fundamental properties. Whether this result is unpalatable will need further discussion elsewhere.

⁷⁵ The label ‘Spinozism’ reflects that Spinoza (2000) holds that individual events (‘finite modes’) are not grounded in the properties of the cosmos (‘infinite modes’). It should be taken with a grain of salt.

Let's take stock. Paul's proposal supports Non-Standard Humeanism, which avoids the circularity puzzle by rejecting Generality. The view has a potential advantage over its standard Humean rival if it allows for the governing-conception of laws. I have suggested that our intuitive understanding of the governing-conception requires explanatory dependence of scientifically explained truths on the laws. And I have argued that Spinozism, a modified version of Paul's proposal, secures this explanatory dependence. I have also presented a problem for this view. Whether Non-Standard Humeanism provides a convincing solution to the circularity puzzle, therefore, depends on the nature of the governing-conception and on the feasibility of Spinozism. Both of these issues deserve further exploration.

3.7 Conclusion

I began this paper with a brief discussion of two familiar circularity-objections to Humeanism about the laws of nature. I have argued that these traditional objections can be easily sidestepped and that we should focus instead on the novel circularity puzzle that takes the form of a general paradox. I tried to show that the circularity puzzle provides an illuminating background for a systematic discussion of major challenges for Humean and Anti-Humean accounts of the laws of nature. Our discussion has reached four main conclusions.

First, both Humeans and Anti-Humeans can solve the circularity puzzle on their own terms. The main cost paid by the Anti-Humean is a primitive notion of natural necessity, and the main cost paid by the Humean is the rejection of the governing-conception of the laws. How these costs should be weighed against one another is a difficult question that depends on the role of governing in the apparent 'oomph' of causation and the flow of time.

Secondly, I have suggested that Anti-Humeans should reject that laws are necessarily exceptionless in order to solve the new inference problem. I have argued that this is coherent,

theoretically viable, and even independently motivated: since the laws are essentially associated with natural necessity, we should expect the laws to necessitate their contents with the force of natural and not metaphysical necessity.

Thirdly, I have provided Priority and Dependence as characteristic conditions for governing laws. The availability of these 'hallmark'-criteria bolsters the intelligibility of the notion governing laws. I have not, however, provided an analysis of governing in terms of both necessary and sufficient conditions; this strikes me as an important project for future research.

Finally, our discussion of the circularity puzzle has shown that there is a Non-Standard Humean view that might deserve the label of a governing-account of laws. I lacked the space to discuss the view in detail, but it seems to me to warrant additional attention, even in spite of the objection I have presented against it.

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I acknowledge that the first two chapters of this dissertation are currently in print (see Wilsch forthcoming a and Wilsch forthcoming b for references).

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