

Structural Universals

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Abstract

Structural universals are a kind of complex universal. They have been put to work in a variety of philosophical theories, but are plagued with problems concerning their compositional nature. In this article we will discuss the following questions. What are structural universals? Why believe in them? Can we give a consistent account of their compositional nature? What are the costs of doing so?

1. Introduction

Structural universals are a kind of complex universal. Like other universals they can be multiply instantiated and are wholly present in their instances. They are complex because they are composed of other, simpler universals, although the meaning of ‘composed’ is left open at this stage. In being complex such universals have other (simpler) universals as parts or constituents, where the notion of part or constituent is similarly left open for interpretation. (Simple universals are not complex; they lack proper parts or constituents.) Structural universals have been put to work in a variety of philosophical theories by realists about universals, most notably D.M. Armstrong (1978a, 1978b) who introduced the concept of a structural universal to contemporary metaphysics.¹ The explanatory power that structural universals afford realists about universals is attractive. However, as David Lewis famously argued, structural universals are plagued with problems concerning their compositional nature (Lewis 1986a). Since then many attempts have been made to give a consistent account of the compositional nature of structural universals.

In what follows, we will discuss the following questions. What are structural universals? Why believe in them? Can we give a consistent account of their compositional nature? What are the costs of doing so?

2. What are Structural Universals?

There are two kinds of complex universals: conjunctive and structural. Each kind can be multiply instantiated and has other universals as parts or constituents. The distinctive character of each kind is exhibited by the differing behavior of their instantiations. Any conjunctive universal E must satisfy:

(CONJ) If E is instantiated by x and E has F and G as parts or constituents, F and G are instantiated by x .²

Take this ornament from my Christmas tree. It is red and round. According to realism about universals, it instantiates *being red & round*. This universal has *being red* and *being round* as parts or constituents. The ornament also instantiates *being red* and *be-*

ing round. Thus *being red&round* satisfies (CONJ). Structural universals do not satisfy (CONJ). Consider a methane molecule (CH_4). It is composed of four hydrogen atoms and one carbon atom in such a way that each hydrogen atom is bonded to the carbon atom. It instantiates *being a methane molecule*, or *methane*, for short.³ The universal *methane* is complex because it is composed (somehow) of simpler universals such as *hydrogen*, *carbon*, and the *bonding* relation. However, *hydrogen*, *carbon*, and the *bonding* relation – the parts or constituents of *methane* – are not instantiated by the molecule. Hereafter we will focus on structural universals and ignore conjunctive universals, unless they are relevant to the discussion.⁴

Instantiations of structural universals have further peculiarities. The parts or constituents of *methane* (say, *hydrogen*) are instantiated by certain proper parts of the molecule. The universal *hydrogen* is instantiated by the four hydrogen atoms. If *methane* is instantiated by the molecule, the proper parts of the molecule that are relevant to the instantiation of *methane*, namely, the four hydrogen atoms and the carbon atom, do not instantiate *methane*. The carbon atom, for instance, does not instantiate *methane*.⁵ If *methane* is instantiated, the molecule that instantiates it has five spatio-temporal parts. These parts must instantiate certain universals: four of the five parts instantiate *hydrogen*, and the remaining part instantiates *carbon*.⁶ In general, any structural universal E must satisfy:

- (1) If E is instantiated by x , the parts or constituents of E are not instantiated by x .
- (2) If E is instantiated by x , the parts or constituents of E are instantiated by certain proper parts of x (those parts that are relevant to the instantiation of E by x).
- (3) If E is instantiated by x , the proper parts of x that are relevant to the instantiation of E by x do not instantiate E .
- (4) If E is instantiated by x , E is instantiated by some particular x such that x is complex (i.e., x has proper parts).

Proponents of structural universals should explain these principles. In the literature, this explanatory challenge has boiled down to explaining necessary connections like necessarily if *methane* is instantiated by x , some part of x instantiates *carbon*. More schematically:

(CO-INT) \square (every instance of F contains an instance of G as a part).

An account of the compositional nature of structural universals can be used to explain (CO-INT). This involves either a story about how some universals are parts or constituents of others or a story about some other relation that relates structural universals with other (simpler) universals. But it is controversial whether any sense can be made of the thesis that one universal is a part or constituent of another. It is also controversial whether some other relation that relates universals can in fact explain (CO-

INT). Before we look at these issues let us consider the main reasons to posit structural universals.

3. *Structural Universals at Work*

Realism about universals is the view that there are universals. The view as such does not entail the existence of structural universals. We could quite easily believe in universals and posit only simple universals. If there are universals, why believe in structural universals? Why not posit only simple universals? Structural universals allow us to unify and systematize a wider variety of philosophical theories. Armstrong employs structural universals in a number of ways in his Aristotelian brand of realism. Roughly, he uses structural universals:

- (i) To explain resemblances among certain universals. Series of determinates united by one determinable, if identified with structural universals, resemble each other because each determinate universal is part of (and so partially identical with) other determinate universals (Armstrong 1978b, 122; Lewis 1986a, 29-30).⁷
- (ii) To be the relata of certain complex laws of nature, according to his theory of laws as relations between universals. If we posit only simple universals, all laws of nature are simple. To capture complexity of lawhood, we need complex universals, some of which are structural (Lewis 1986a, 29); (cf. Armstrong 1989a, 113).⁸
- (iii) To serve as relata for proportion relations, which he identifies with numbers. Numbers are proportion relations that hold between a (possible) structural universal and a (possible) unit-property (Armstrong 1989a, 126-33; Forrest & Armstrong 1987).⁹
- (iv) To be one subset of natural kinds. If natural kinds such as *gold*, *tiger*, and *water* are reduced to complex universals, structural universals would be the natural kinds that cannot be identified with conjunctive universals (Armstrong 1978b, 62-65; 1997, 67). For a recent defense, see (Hawley & Bird 2011, 209-10).

After Armstrong other metaphysicians have used structural universals:

- (v) To play the role of possible worlds in ersatz modal realism. An ersatz world is a certain type of uninstantiated structural universal – a world-nature. The actual world instantiates one of these world-natures. The rest are ways worlds could be (Forrest 1986a, 19).¹⁰
- (vi) To play the role of ersatz times in presentism. This is the temporal analogue of Peter Forrest's ersatzism. The present is ontically privileged. The past and future are ersatz times that are identified with uninstantiated structural universals (for non-committal discussion, see Parsons 2005, 173-74).
- (vii) To serve as the subvening base of emergent properties. An emergent property supervenes on the properties of the parts of the complex particular and any rel-

evant relations between those parts. Hence ‘the continuing instantiation of the emergent property depends on the continuing presence of the structural universal that generated it’ (O'Connor & Wong 2005, 665).

This list could be extended. However, while it shows the explanatory utility of structural universals, we – as realists about universals – only have a reason to believe in them if we accept the specific theory that uses them. If there are universals, a more compelling motivation for structural universals is to find genuine possibilities that can only be accounted for by structural universals and not by universals of any other kind (say, simple universals). To this end consider *methane*. It is composed (somehow) of *hydrogen*, *carbon*, and the *bonding* relation. Science has shown that hydrogen and carbon atoms are supposedly composed of protons, neutrons, electrons, etc. According to realism about universals, this translates into the hypothesis that the universals *hydrogen* and *carbon* are composed of simpler universals like *proton*, *neutron*, and *electron*. Some of those simpler universals are composed of yet simpler universals such as *up-quark*. For all we know these quark-universals might be composed of simpler universals, and so on ad infinitum. For all we know every universal is like this, not just *methane*. For all we know every universal is structural. If there are universals, we should posit structural universals because without them we cannot account for the possibility of infinite complexity (Armstrong 1978b, 67-68; 1989a, 113; 1997, 33).¹¹ This is Armstrong’s initial and main argument for structural universals. Lewis thinks the possibility of infinite complexity is the strongest reason (for realists about universals) to believe in structural universals (Lewis 1986a, 30; see also Lewis 2009, 218-19, n. 3).¹²

J. Robert G. Williams (2007) argues that this argument is invalid. Consider emergent universals such as (putatively) *being alive* and *being conscious*. Emergent universals are non-complex and emerge from lower-level universals. Assuming they exist, whether they exist is a matter of nomological necessity between an emergent universal and its lower-level universals (Williams 2007, 199). Now consider a world with infinite complexity. If emergent universals are possible, it is possible that at each level the subvening base gives rise to an emergent universal and that the subvening base itself consists of emergent universals. In such a world there are only emergent universals, emerging from each layer that descends to a deeper layer of emergent universals without end (Williams 2007, 200). So, Williams concludes, we need not posit structural universals to account for infinite complexity. Realists about universals must rest their case for structural universals on the explanatory utility of structural universals, which hinges on the plausibility of the theories that use structural universals, or respond to Williams’s objection.

4. David Lewis’s Critique of Structural Universals

Lewis argues that we cannot give a consistent account of the compositional nature of structural universals. He recognizes three conceptions of structural universals: linguistic, pictorial, and magical. According to the linguistic conception, structural universals

are set-theoretic constructions of simple universals. Lewis dismisses this conception because it presupposes simple universals and so fails to account for infinite complexity (Lewis 1986a, 32). According to the pictorial conception, structural universals are mereological wholes represented pictorially via their instances, which requires us to take a structural universal as isomorphic to its instances. Take an instance of *methane*: *f*'s being a methane molecule. *f* has parts, say, *a*, *b*, *c*, *d*, and *e*. *a*, *b*, *c*, and *d* instantiate *hydrogen*, and *e* instantiates *carbon*. Also, *a*, *b*, *c*, and *d* each stand in the *bonding* relation to *e* (*a* is bonded to *e*, *b* is bonded to *e*, etc). In isomorphic fashion *methane* has as parts these properties of *a*, *b*, *c*, *d*, and *e* as well as this relation that *a*, *b*, *c*, *d*, and *e* stand in to each other (Lewis 1986a, 33). Call this the isomorphic variant of pictorialism.

Lewis raises the following objection against the isomorphic variant. *f* has four hydrogen atoms. If a structural universal is isomorphic to its instances, *methane* has *hydrogen* four times over. But this makes no sense. First, there is only one universal called 'hydrogen', not four. Second, it is unintelligible for a complex to have the same part multiple times over. The notion of composition concerns the combination of many things into one. The same thing cannot be combined with other things into a whole more than once – the many things remain present in the combination, just like the leg of a chair remains present in the chair after it becomes a part of the chair (Lewis 1986a, 34). Even if talk of having parts multiple times over is intelligible there are cases of distinct structural universals that are composed of the same universals the same number of times over. E.g., *butane* and *isobutane* have *hydrogen* ten times over, *carbon* four times over, and the *bonding* relation thirteen times over (Lewis 1986a, 38). They are identical when they and their instances are clearly distinct.

At this point in his critique Lewis considers several ways around this objection on behalf of pictorialism. One thing we could do is avoid talk of having parts multiple times over and drop the thesis that a structural universal is isomorphic to its instances. If *methane* is not isomorphic to its instances, it can have *hydrogen*, *carbon*, and the *bonding* relation as parts just once. Call this the non-isomorphic variant of pictorialism. Lewis argues that the non-isomorphic variant problematically implies that *methane* and *butane* are composed of the same parts (Lewis 1986a, 36). This violates the principle of uniqueness of mereological composition (hereafter uniqueness): no two entities can be composed of the same parts. Uniqueness is also known as the principle of extensionality and is a core doctrine of classical mereology.

Another thing we could do is supplement pictorialism with a sui generis mode of composition that is neither mereological nor set-theoretic. This mode of composition would deny uniqueness and allow distinct entities to be composed of the same parts (or constituents). Following Forrest, we can further describe this mode of composition by breaking it down into three (non-mereological) operations: product, contraction, and projection, which can be performed on each other and in iterative fashion to build up structural universals (Forrest 1986a, 17-19). If a combining operation is called a mode of composition, it must deserve this label by filling a specified composition-role – *calling* it a mode of composition does not make it a mode of composition. The prob-

lem, Lewis says, is that no mode of composition can fill such a role except the mereological relation of part-whole. Only it deserves the label ‘combining operation’. Any talk of composition falls under mereology. Were we to posit a non-mereological mode of composition, we could only grasp it by magic (Lewis 1986a, 38-39).¹³

In a last ditch attempt to save pictorialism Lewis considers an isomorphic variant according to which the universals that compose a structural universal are ‘amphibians’. An amphibian is halfway between a universal and a particular. It is repeatable yet it can be duplicated. Hence *methane* has four ‘hydrogen-amphibians’ as parts. This view gets around the problem of having a part multiple times over, but, as Lewis notes, it is too weird to be taken seriously (Lewis 1986a, 39-40).¹⁴ This completes his criticism of pictorialism.

According to the magical conception, a structural universal does not have parts or constituents. It is simple or mereologically atomic. Nonetheless it is involved with other (simpler) universals that are wholly distinct from it. The involvement of *methane* with *carbon* rests on a certain necessary connection between instances of *methane* and instances of *carbon*. This necessary connection is an instance of:

(CO-INT) \Box (every instance of *F* contains an instance of *G* as a part).

Proponents of structural universals must explain (CO-INT). Pictorialists do so as follows:

(P1) \Box (*F* has *G* as a part).

(P2) \Box (*F* has *G* as a part \supset every instance of *F* contains an instance of *G* as a part).

(C) Thus, \Box (every instance of *F* contains an instance of *G* as a part).

According to the magical conception, (CO-INT) is a brute modal fact.¹⁵ It is by magic that *G* is dragged along, of metaphysical necessity, with *F* and not some other universal (Lewis 1986a, 41). Without an explanation of *how* these necessary connections obtain we have no notion of *why* they obtain. The magical conception is really no conception at all (Lewis 1986a, 42).

5. Non-mereological Accounts of Structural Universals

Can we give a consistent account of the compositional nature of structural universals? In this section we will examine two non-mereological accounts of structural universals, the first by Armstrong and the second by John Bigelow and Robert Pargetter.

In 1978, Armstrong claimed that complex universals are mereological wholes. From 1988 onwards, due to Lewis’s critique, Armstrong abandoned this position and analyzed structural universals in terms of states of affairs.¹⁶ A state of affairs, on Armstrong’s view, is a particular-having-certain-properties or two-or-more-particulars-standing-in-a-relation. For Armstrong, the certain properties instantiated by a particu-

lar are immanent universals. The state of affairs of *a's being F* contains (somehow) the universal *being F*, while the state of affairs itself is particular. The 'thin' particular is *a* abstracted from all its properties and relations (Armstrong 1978a, 114). The 'thick' particular is the state of affairs of *a's being F*. The universal/particular distinction can be applied to *a's being F* such that *something's being F* is a universal state of affairs or state of affairs-type. In Armstrong's later work, he brings this notion to the fore with the hypothesis that universals *are* state of affairs-types (Armstrong 1997, 28-29). *Being F* is *_ 's being F* with the thin particular excised.

With this notion of state of affairs-types in view, he identifies structural universals with conjunctions of state of affairs-types (Armstrong 1993, 431-32; 1997, 34-38). For convenience, let us write *a's being F* as [Fa] and *a's bearing R to b* as [aRb]. Consider *f's being a methane molecule*, where *f* is the mereological sum of *a*, *b*, *c*, *d*, and *e*. Suppose *methane* is M. Hence *f's being a methane molecule* is [Mf]. *a's being a hydrogen atom* is [Ha], etc. *e's being a carbon atom* is [Ce]. *a's being bonded to e* is [aBe], etc. If [Mf] exists, so do [Ha], [Hb], [Hc], [Hd], [Ce], [aBe], [bBe], [cBe], [dBe]. [Mf] is the conjunction of [Ha], [Hb], [Hc], [Hd], [Ce], [aBe], [bBe], [cBe], [dBe]. The universal *methane* is the corresponding conjunction of state of affairs-types.¹⁷ We explain the idea of a universal being a part multiple times over with reference to the number of instances of the state of affairs-type. E.g., there are four tokens of the state of affairs-type: *hydrogen*.

Armstrong's account of structural universals is non-mereological because structural universals are reduced to states of affairs and states of affairs are subject to a non-mereological mode of composition. States of affairs are subject to a non-mereological mode of composition for two reasons. First, *a's being F* cannot be the mereological sum of *a* and *F*, nor can it be the set of *a* and *F*, because there are worlds where *a* and *F* exist along with their sum or set but *a* does not instantiate *F*. Something non-mereological and non-set-theoretic is required to get *a's being F*. Second, uniqueness is a formal property of the mereological relation of part-whole. States of affairs do not obey uniqueness. So the relation that holds between first-order states of affairs like *a's being F* and their 'constituents' (formerly called 'parts') is not mereological (Armstrong 1988, 312; 1989b, 92; 1991, 190; 1993, 433). This marks a change of doctrine for Armstrong: complex universals and states of affairs are no longer mereological wholes; they now have constituents, not parts (Armstrong 1989a, xi, 70-71).

As Lewis sees it, this plays right into his hands. Talk of numbered tokens of the same state of affairs-type is no replacement for an analysis of whether and how one universal is a part or constituent of another. As Lewis writes, 'I should like to know what [Armstrong] thinks we *can* say, not about notions and not about instances, but about the universals themselves' (Lewis 1986a, 35, his italics).¹⁸ Even if we grant that Armstrong has explained the compositional nature of structural universals *themselves*, he does so at the cost of admitting a non-mereological mode of composition, a mode of composition that Lewis has argued can only be grasped by magic.¹⁹ For Armstrong's account to be successful the mystery surrounding this non-mereological mode of composition must be dealt with.

Kris McDaniel notes that Armstrong is committed to compositional pluralism, the view that there is more than one fundamental parthood relation (McDaniel 2009, 255-56; see also McDaniel 2014). After all, although Armstrong revised his position such that first-order states of affairs and complex universals have constituents, he maintained that constituents are ‘a sort of part’ (Armstrong 1993, 433). If then he admits two primitive modes of composition, he is in effect positing two fundamental *parthood* relations. One that obeys every core principle of classical mereology and another that does not. Despite the latter’s disobedience, it can be systematized and rendered intelligible. As McDaniel argues, it satisfies five conceptually necessary conditions for being a genuine parthood relation, namely, transitivity, a version of supplementation (i.e., a remainder principle), irreflexivity (in the case of proper parthood), inheritance of intrinsic properties of parts/constituents, and inheritance of location of parts/constituents (McDaniel 2009, 264-71). McDaniel’s treatment of Armstrong’s compositional pluralism goes some way in dealing with the charge that this non-mereological mode of composition can only be grasped by magic.

Bigelow and Pargetter construct their theory of structural universals by dividing entities into three levels. At level 1 there are particulars. At level 2 there are universals instantiated by those particulars. At level 3 there are relations that hold between the universals of level 2. The relevant third-level relations are proportion relations. To use our methane molecule: the proportion relation *having four times as many instances as* holds between (the following conjunctive universals) *being a hydrogen atom & part of this methane molecule* and *being a carbon atom & part of this methane molecule*. This explains the four-fold repetition of hydrogen in this molecule structure (Bigelow & Pargetter 1989, 6-7).

Now consider *methane*. It stands in a pattern of proportion relations to *hydrogen*, *carbon*, and the *bonding* relation. These proportion relations are essential to the universal *methane*; it could not exist without *hydrogen*. To be clear, it is the proportion relations that are doing the work: ‘the relation explains the essences not the other way around’ (Bigelow & Pargetter 1989, 7). Moreover, these third-level essential relations hold between mereologically atomic universals because, according to Bigelow and Pargetter, structural universals lack mereological structure. Therefore, their account of structural universals is non-mereological.

Bigelow and Pargetter use proportion relations to explain (CO-INT) in a similar way to pictorialism:

(P1*) $\Box(F \text{ stands in } R \text{ to } G)$.

(P2*) $\Box(F \text{ stands in } R \text{ to } G \supset \text{every instance of } F \text{ contains an instance of } G \text{ as a part})$.

(C*) Thus, $\Box(\text{every instance of } F \text{ contains an instance of } G \text{ as a part})$.

But, as Lewis argues in a letter to Bigelow and Pargetter,²⁰ their view is committed to magic packed into the necessary connections that flow from the fact that these pro-

portion relations hold between distinct universals. In short, it is magic *that* (P2*) is true. Bigelow and Pargetter reply that their explanatory goal is to explain (CO-INT) and that their explanation of *it* is illuminating, even though these portion relations might be primitive or mysterious (Bigelow & Pargetter 1989, 8). Moreover, if these portion relations are objectionably magical, the parthood relation that pictorialists use to explain (CO-INT) is objectionably magical, but since the latter is not, the former are not (Bigelow & Pargetter 1989, 9).

However, as Katherine Hawley (2010) argues, it is plausible for pictorialists to suppose that composition is analogous to identity. As Lewis notes, a structural universal for pictorialists just *is* its parts (Lewis 1986a, 33, 34) and, as the early Armstrong says, a part of a structural universal is partially identical with it (Armstrong 1975, 154; 1978b, 123). The doctrine of composition as identity (hereafter CAI) can be used to explain any modal mystery surrounding parthood in terms of the non-mysterious notion of identity. By contrast, the intelligibility or lack thereof of (P1*) has to fend for itself. Hence the analogy between (P1) and (P1*) breaks down (Hawley 2010, 132).²¹

Armstrong's non-mereological account of structural universals is more promising than Bigelow and Pargetter's. Its main cost is an ontology of states of affairs. At this point independent debates must be factored in, especially debates about states of affairs. For if we have independent reasons to believe in states of affairs, Armstrong's account is a straightforward systematization of structural universals in terms of pre-existing ontology. If we do not believe in states of affairs for whatever reason, the cost of his account goes up.

6. Mereological Accounts of Structural Universals

Thus far we have supposed that there are two options available in constructing an account of the compositional nature of structural universals:

- (i) The mereological mode of composition, which obeys uniqueness.
- (ii) Some *sui generis*, non-mereological mode of composition.

For Lewis, one guiding idea behind this dichotomy is that mereological composition necessarily involves uniqueness. In a letter to Reinhardt Grossmann, who – like Armstrong – adopts an ontology of states of affairs, Lewis argues:

But constituency is not the relation of part to whole. Else there would be no difference between the state of affairs of Plato kicking Socrates and the state of affairs of Socrates kicking Plato – for these states of affairs have the same constituents. Constituency is not mereological. It just isn't. Nor is it something that is almost mereology but not quite. There is no mereology but mereology.²²

Not everyone is on board with such a strict extensionalist construal of what counts as mereological in debates concerning structural universals (Bennett 2013, 101-2;

Hawley 2010, 124-25; Mormann 2010, 212; Westerhoff 2004, 386-87). In metaphysics more broadly, many philosophers accept *at least* the *intelligibility* of formal systems of non-classical or non-extensional mereology and of pluralist ways of conceiving of parthood and composition.²³ It is just not analytically true that mereological composition involves uniqueness. The intuition that it does comes from our ordinary, unphilosophic idea of combining *particulars* into complex *particulars*. But, as Lewis admits in a loosely related context, ‘universals defy intuitive principles. But that is no damaging objection, since plainly the intuitions were made for particulars’ (Lewis 1983, 345). Moreover, the source of the intuition is questionable given that some metaphysicians nowadays regard the hypothesis that a statue (particular) and lump of clay (particular) are distinct but have the same parts as coherent. These considerations have helped pave the way for new mereological accounts of structural universals. In this section we will consider two such proposals by Hawley and Karen Bennett.²⁴

Hawley favors a non-isomorphic variant of pictorialism: *methane* and *butane* are distinct but share the same parts (*hydrogen*, *carbon*, and the *bonding* relation), much like the statue and lump of clay are distinct but have the same parts for those who believe in coincident material objects. In addition, she sees no reason why mereological composition must obey uniqueness (hereafter non-unique composition). Now, as we saw in Section 5, pictorialists can explain (CO-INT) using CAI. The fact that mereological composition obeys uniqueness does not figure in this explanation. So pictorialists who accept non-unique composition are free to exploit the demystifying power of CAI when explaining (CO-INT) (Hawley 2010, 126-27). To illustrate, *methane* and *butane*’s relationship to the same parts is, on this view, analogous to the statue and lump’s relationship to the same particles. In both cases, although some features (like sortal properties) of the resultant complex entities are irreducible, not *all* their features are irreducible (Hawley 2010, 127). In the case of structural universals, features about co-instantiation as expressed in (CO-INT) can be reduced. Even if *methane* is analogously identical with its parts and *butane* is analogously identical with those same parts (where CAI is weakened appropriately), the fact that *carbon* is part of *methane* explains why every instance of *methane* has an instance of *carbon* as a part, ‘just as a molecule’s being a part of a statue explains why the molecule is where the statue is, even if the statue shares all its parts with a distinct lump of clay’ (Hawley 2010, 128).

Issues about individuation remain: how are *methane* and *butane* to be distinguished? We cannot appeal to their parts, given that both universals have the same parts. Hawley suggests that a difference may emerge between the co-instantiation patterns of each universal (Hawley 2010, 129). Each universal characterizes its instances differently. Each universal imposes a distinct structure on its instances. But our explanation cannot end at the level of instances. We need an explanation in terms of the universals themselves. This leads her to propose that *methane* and *butane* stand in distinct composition relations to the same parts. These composition relations not only underpin the variable patterns of co-instantiation across distinct universals that share their parts (Hawley 2010, 129), they also explain why *methane* and *butane* are different – in the same way that distinct composition relations between the statue and its

parts and the lump and those same parts explain why the statue and lump are distinct (Hawley 2006, 490).

However, it follows that for each kind of structural universal that shares its parts with other universals there is a distinct composition relation. This entails a proliferation of composition relations and is thereby costly if each relation is taken as primitive (in some relevant sense of that word). This cost might be mitigated if these composition relations are unified and systematized. One way to do this is to unify and systematize the principles of composition that correspond to the composition relations in our theory, as in Forrest's (2016) mereological account of structural universals. On this new view of his, there are three basic principles or operations (explicitly described in (non-classical) mereological terms) that govern the composition of distinct structural universals from the same parts (the technical details cannot be expounded here). From his three basic principles we can infer the requisite relations of composition on the assumption (accepted by Hawley) that principles of composition reflect relations of composition (cf. Hawley 2006, 490). The proliferation of composition relations is, then, a derivative matter that stems from the (fundamental) relations of composition that correspond to each basic principle of composition. This response is not without its costs. The primitive ideology of Forrest's 2016 theory and any theory like it might be unduly complicated, as Forrest has recently recognized (Forrest 2018, 147). But without this sort of systematization Hawley's theory is full of distinct primitive composition relations that, arguably, offend ontic parsimony. The dilemma remains unresolved.²⁵

Bennett (2013) takes a different tack from Hawley and Forrest. Bennett constructs a non-classical mereology within the isomorphic variant of pictorialism. Her non-classical mereology is founded on a basic distinction between entities having parthood 'slots' and entities having parts that occupy these 'slots'. 'One thing is part of another just in case it fills one of that thing's parthood slots' (Bennett 2013, 83). Her mereology captures the idea that there is further mereological structure in the *slots* that complexes have. One of the attractive features of her mereology is that it is a general theory that accounts for the compositional nature of material objects, states of affairs, and structural universals. It is simpler than Forrest's 2016 mereology and easier to grasp, although it is more ideologically complex than classical mereology. That said, it captures many intuitive aspects of classical mereology such as uniqueness – a.k.a. extensionality. For instance, she derives *Slot Extensionality*: 'composite objects are identical just in case they have exactly the same proper parthood slots' from various axioms and theorems (Bennett 2013, 97).

Bennett deals with Lewis's objection that a whole cannot have the same part multiple times over head on. On her view *methane* has nine slots. Four of the slots are filled by *hydrogen*, another is filled by *carbon*, and the other four are filled by the *bonding* relation. So *methane* has *hydrogen* four times over because *hydrogen* fills four slots (Bennett 2013, 102). However, on her view, structural universals are individuated according to the number of slots they have, as per *Slot Extensionality*. But if *Slot Extensionality* is true, *butane* and *isobutane* are identical because they have the same

number of slots (Fisher 2013). Thus some revision must be made to her mereology. If we drop *Slot Extensionality*, her mereology no longer has the intuitive advantage of capturing uniqueness. At any rate, her mereology is intelligible and can be made consistent.²⁶

7. Conclusion

When it comes to explaining the compositional nature of structural universals we now have a variety of internally consistent theories for realists about universals to choose from. Each theory comes with specific commitments, both ideological and ontological, as we have seen. Future work will need to focus on weighing the costs and benefits of each candidate theory.

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Short Biography

A.R.J. Fisher is a Postdoctoral Research Fellow at the University of Manchester. He is part of the AHRC project *The Age of Metaphysical Revolution: David Lewis and His Place in the History of Analytic Philosophy*. His research interests are metaphysics and the history of philosophy. He has published articles in such journals as *British Journal for the History of Philosophy*, *Journal of the APA*, *Pacific Philosophical Quarterly*, *Philosophical Studies*, *Synthese*, and *The Monist*.

Notes

¹ For an early discussion of structural universals in analytic philosophy under the guise of 'complex characteristics', see (Broad 1933, 101-27). See also (McTaggart 1921, 63-65).

² This principle and every other in this article are stated without quantifiers.

³ Hereafter, following Lewis, I shorten 'being a methane molecule', 'being a hydrogen atom', 'being a carbon atom', and so on to 'methane', 'hydrogen', 'carbon', and so on respectively. He regards 'being a methane molecule' as the longwinded version of 'methane' (Lewis 1986a, 42). To keep things consistent throughout I hereafter label all universals in this manner unless clarity dictates that I use the longwinded version.

⁴ In his later treatment Armstrong highlights the respects in which conjunctive and structural universals are similar so much that he calls conjunctive universals 'structural' (Armstrong 1997, 32). His thought is that conjunctive universals have only properties as parts or constituents, whereas structural universals have properties *and* relations as parts or constituents, which is not much of a difference since properties and relations are both universals. He adds that if conjunctive universals are structural, they are 'simplistic' (Armstrong 1989a, 113) and non-paradigmatic examples of structural universals (Armstrong 1997, 32). As noted, the behavior of the instantiations of conjunctive universals importantly differs from the behavior of the instantiations of structural universals. So we will continue to distinguish between conjunctive and structural universals and leave the former out of the discussion.

⁵ Not all properties that are instantiated by a particular but not instantiated by the parts of that particular are structural. Emergent properties meet this condition but are non-complex and hence not structural (Armstrong 1978b, 69). Also, the fact that certain proper parts of a particular do not instantiate the

structural universal does *not* imply that every part of that particular must not instantiate the structural universal.

⁶ To count as an instance of *methane* a molecule's proper parts must stand in certain (external) bonding relations. If one or more of the hydrogen atoms, say, is not bonded to the carbon atom, our molecule is not an instance of *methane*. But not every instance of a structural universal needs external relations to hold among the parts of the complex particular that instantiates the structural universal. The universal (*just*) *two electrons* is a structural universal, but it is instantiated by (the sum of) two electrons irrespective of whether or how the electrons are (externally) related (Armstrong 1978b, 71). The two electrons could be located at either end of the universe or in disconnected spacetimes. While *methane* captures the idea behind a structural universal more adequately (because it involves the idea of many things arranged in a structure), structural universals like (*just*) *two electrons* have been put to use in theories of structural universals. The former are relationally structural universals and the latter are non-relationally structural universals. In Armstrong's early work he talks as if (*just*) *two electrons* and *being an electron* are universals. But he asserts that *being an electron* might be a natural kind and hence on his view reduced to other universals (Armstrong 1978b, 61-62). In his later work, with a focus on fundamental or ultimate universals due to Lewis's work on sparse properties, Armstrong countenances fundamental or ultimate universals as the first-class properties upon which second-class and third-class properties supervene (Armstrong 1997, 44-46). So (*just*) *two electrons* would count as a second-class property and would be reduced to first-class properties (and relations), which are constituents of first-order states of affairs. Armstrong's account of structural universals is explored in Section 5. However, further discussion about Armstrong's view of fundamental or ultimate universals and more recent talk of joint-carving are left for another occasion.

⁷ For various criticism of Armstrong's account of resemblances among universals, see (Eddon 2007; Edwards 2014, 41-43; Fales 1990, 231; Pautz 1997; Rodriguez-Pereyra 2017). Armstrong develops his account as regards shapes (Armstrong 1997, 55-57) in response to Evan Fales, and as regards color (Armstrong 1997, 57-61).

⁸ Lewis considers the alternative option of multiplying the necessitation relation as opposed to positing structural universals, but says the complication would be 'most unwelcome' (Lewis 1986a, 29). In many cases of causal connection, on Armstrong's view, the necessitation relation holds between conjunctive and structural universals (Armstrong 1978b, 153-54; see also Armstrong 1997, 37-38, 229-30). This would constitute another use of structural universals in his theory of laws. More recently, Armstrong has said that laws are a 'species' of structural universal (Armstrong 2010, 40-41).

⁹ For a later treatment of the nature of number by Armstrong, see (Armstrong 1997, ch. 11).

¹⁰ For a similar theory of modality that identifies possible worlds with complex universals, see (Bigelow 1988; Bigelow & Pargetter 1990, 212-13).

¹¹ The formulation of the possibility of infinite complexity turns on whether universals have their parts or constituents essentially. If a universal is what it is essentially and so its constitution cannot vary from world to world, the argument is best formulated in terms of *epistemic* possibility (Armstrong 1997, 33). For Armstrong's first explicit endorsement of essentialism about universals, see (Armstrong 1989a, 67-68). For a statement of essentialism about universals in the context of genuine modal realism, see (Lewis 1983, 345, n. 5). For relevant discussion, see (Cowling 2017; Hawley 2010, 121-23).

¹² John Bigelow and Robert Pargetter (1989, 1) and Alex Oliver (1992, 95, n. 7) concur. Infinite complexity is also considered to be a compelling reason to believe in conjunctive universals (Armstrong 1978b, 32; 1997, 32; Lewis 1986a, 41, n. 21; Oliver 1992, 95). For *F* might be a conjunctive property such that *F* is composed of *G* and *H*. And *G* might be composed of *I* and *J*, and *H* might be composed of *K* and *L*. And so on ad infinitum. D.H. Mellor objects that the argument from infinite complexity to conjunctive universals begs the question (Mellor 1992, 100-3). He would most likely apply his response to structural universals. For another criticism of this argument, see (Grossmann 1983, 150-53). For a reply to Mellor and another defense of the claim that infinite complexity is metaphysically possible, see (Sider 1995, 365). For discussion on the evidential support of the possibility of infinite complexity, see (Schaffer 2003; 2004, 97).

¹³ Campbell likewise argues that we have no grasp of this *sui generis* mode of composition. Given its obscurity, the price to admit it is too costly (Campbell 1990, 49-50).

¹⁴ Bigelow's (1986) reply to Lewis is in the spirit of the amphibian approach. According to Bigelow, pictorialism can deal with Lewis's objection by introducing the notion of 'natural parts'. Entity *x* is a natural part of universal *U* iff *x* is part of *U* and *x* is a universal. The universal *methane* has four natural parts: *U1*, *U2*, *U3*, *U4*. Each of these natural parts has *hydrogen* as a part. Thus *hydrogen* is a natural

part of four distinct natural parts of *methane*; *hydrogen* is involved in *methane* four times over (Bigelow 1986, 95). In a letter, Lewis raises several objections that center on *what* instantiates the natural parts of structural universals (Letter from David Lewis to John Bigelow, 8 January 1985; David Lewis Papers, C1520, ‘Bigelow, John’, Box B-000661 Folder 1, Princeton University Library). Given that the natural parts of structural universals are universals, they must be instantiated by something. One hypothesis is that *U1* is instantiated by one of the four CH bonded pairs of our methane molecule and that *U2* is instantiated by another CH bonded pair and similarly for *U3* and *U4*. However, it follows that *carbon* is part of *U1*, *U2*, *U3*, *U4*. Furthermore, since the CH bonded pairs perfectly resemble each other, it is reasonable to suppose that they instantiate the same universals; so each CH bonded pair instantiates *U1*, *U2*, *U3*, *U4* – contrary to the hypothesis that each natural part is instantiated by a distinct CH bonded pair. A similar problem arises if we speculate that each natural part is instantiated by one of the four hydrogen atoms of the methane molecule. The 1986 view is not taken up in (Bigelow & Pargetter 1989). So I do not discuss the 1986 view in the body of the text.

¹⁵ As Lewis writes: ‘Why *must* it be that if something instantiates *methane*, then part of it must instantiate *carbon*? ... According to the pictorial conception, that is because *carbon* is part of *methane*, and the whole cannot be wholly present without its part. Fair enough. But on the [magical] conception, this necessary connection is just a brute modal fact’ (Lewis 1986a, 41, his italics).

¹⁶ For Armstrong, structural universals ‘essentially involve’ states of affairs (Armstrong 1988, 312). Structural universals essentially involve states of affairs because structural universals are particularizing universals (Armstrong 1978b, 70) and particularizing universals presuppose the notion of a state of affairs and the notion of a state of affairs-type (Armstrong 1978a, 116-17). A particularizing universal divides its instantiations into specific, denumerable individualized objects. For instance, *being an electron*, when instanced, involves one electron only (Armstrong 1978a, 116-17). Put differently, *being an electron* ‘permits its instances to be numbered’ (Armstrong 1978b, 61). In contrast, *being gold* would not divide its instantiations into distinct particulars, while *being a chunk of gold* would. We would not be able to number the instances of *being gold*, or so Armstrong says. Universal *U* strongly particularizes iff *U* divides its instantiations into non-overlapping particulars. *U* weakly particularizes iff in dividing, *U* fails to divide its instantiations into non-overlapping particulars. *Being 1kg of lead* is a weakly particularizing universal. *Being a human* is a strongly particularizing universal.

¹⁷ More precisely, a structural universal is subtly *more* than a mere conjunction because formal facts about the identity and difference of the particulars involved must be specified; e.g., that it is the *same* carbon atom that is bonded to four *distinct* hydrogen atoms (Armstrong 1997, 36-37, 53). Joan Pagès (2002) has filled out in more detail how formal relations of identity and difference among the parts of the particulars that instantiate structural universals allow us to distinguish between methane molecules, butane molecules, etc.

¹⁸ Campbell criticizes this move by Armstrong too (Campbell 1990, 48-49). Campbell argues that it multiplies universals beyond causal necessity because it admits arbitrarily numbered universals that play no genuine part in the causal make-up of reality. Given that Armstrong opts for a sparse theory of universals and advocates a posteriori realism he should be compelled by these consequences.

¹⁹ From Armstrong’s perspective Lewis begs the question (Armstrong 1986, 85). Relatedly, Forrest says the debate should shift to a discussion about states of affairs and the fact that states of affairs require us (on grounds independent of structural universals) to admit a non-mereological mode of composition (Forrest 1986b, 90). For Lewis’s reply to Armstrong and Forrest, see (Lewis 1986b). For discussion, see (Bennett 2015, 251-52).

²⁰ In this letter Lewis writes:

If we have two universals F and G, what can guarantee that everything instantiates one but not both? What magic enforces

$\alpha) \Box \forall x Fx \text{ iff } \sim Gx?$

Now suppose you told me: it’s because Neg(F, G), and

$\beta) \Box \forall PQ (\text{Neg}(P, Q) \supset \forall x Px \text{ iff } \sim Qx)$

thereby offering ‘Neg’ as a 3rd level logical relation. I now ask: what magic enforces β ? G could only deserve the name ‘*not F*’, Neg could only deserve the name ‘*being the negation of*’, if there were something to enforce α or β . So I have essentially the same complaint of magic whether or not we bring Neg into the story.

Likewise *mutatis mutandis* with *methane* vis-à-vis *carbon*, *hydrogen*, *bonded*; where your 3rd level ‘proportions’ play the role of Neg (Letter from David Lewis to John Bigelow and Robert Pargetter,

28 September 1987, pp. 10-11 of running notes, his italics; David Lewis Papers, C1520, 'Bigelow, John', Box B-000661 Folder 1, Princeton University Library).

²¹ Forrest independently objects that Bigelow and Pargetter's theory cannot distinguish between structural universals and emergent universals (Forrest 2006, 227).

²² Letter from David Lewis to Reinhardt Grossmann, 16 June 1995, p. 2; David Lewis Papers, C1520, 'G', Box B-000665 Folder 12-13, Princeton University Library.

²³ For a sample of pluralist conceptions of part-whole, see (Fine 2010; McDaniel 2009; Westerhoff 2004). For formal discussion of non-classical mereology that is relevant to the metaphysics of structural universals, see (Cotnoir 2015; Mormann 2010). See also the *Philosophy Compass* article on non-classical mereologies by A.J. Cotnoir (2013). For discussion of supervenience principles of structural universals within a context that allows for non-classical mereologies, see (Bader 2013, 355-58).

²⁴ For even more theories of structural universals that are said to count as mereological for one reason or another, see (Forrest 2016; Kalhat 2008; Sharpe 2012). Forrest has offered a number of differing theories over the years. In addition to his 1986 (non-mereological) account and his 2016 (mereological) account there is also his (Forrest 2006) wherein he constructs an ontology of universals according to which universals act as operators of some sort. Universals operate on particulars to compose states of affairs and on each other to compose more complex universals. Since universals are operators, Forrest does away with operations (Forrest 2006, 227). More recently, he has offered yet another theory from a quite different approach to his previous attempts (see Forrest 2018).

²⁵ It is also an open question whether we can adopt Forrest's 2016 theory without committing ourselves to the Platonist ontology within which he frames it (Forrest 2016, 278-80).

²⁶ For discussion of responses to this objection, see (Fisher 2013). For more discussion of Bennett's mereology, see (Cotnoir 2015, 434-36).

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