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Abstract	We examine the argument for ontic structural realism that begins from an alleged "metaphysical underdetermination" afflicting contemporary fundamental physics. Current discussions have focussed on challenging this underdetermination claim. Our purpose here is to examine what follows even if the premise concerning underdetermination is conceded. We consider the additional premises needed to arrive at an endorsement of ontic structural realism, and show that each can and should be rejected. Moreover, the ontic structural realist program faces an analogous metaphysical underdetermination issue of its own. We conclude that the argument fails, independently of whether the alleged metaphysical underdetermination is conceded.	
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# Chapter 5

## Underdetermination as a Path to Structural Realism

AQ1

Katherine Brading and Alexander Skiles

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### 5.1 Introduction

Two general arguments for structural realism have dominated the literature. The first is inspired by John Worrall's claim that the view offers the "best of both worlds" when it comes to the issue of radical theory change [30]. The argument has an *epistemic* conclusion, suggesting a retreat from the full range of realist commitments about what we can know about unobservable entities, to a more modest subset of these commitments, specifically the *structural* features of such entities. Insofar as this argument is successful, it leads to epistemic structural realism (ESR). The second argument considerably ups the ante, moving from an epistemological claim to an *ontological* one. Ontic structural realism (OSR), defended most prominently by James Ladyman and Steven French, is the view that realists ought to endorse the more radical claim that in some sense all there *is* are these structural features. The central argument for this position begins from the so-called "problem of metaphysical underdetermination".<sup>1</sup>

The focus of this paper is the second argument. Originally formulated in the context of quantum physics, the argument has also been applied in the context of spacetime theories, and discussions have typically assumed that the argument is generally sound. Those who have criticized the argument seem to concede that the alleged metaphysical underdetermination *would be* problematic were it to hold, but then go on to argue that it disappears on closer scrutiny of the particular theory in question.<sup>2</sup>

<sup>1</sup> For presentations of this argument, see [9, 11, 13, 22, §1.2].

<sup>2</sup> For example, see [5, pp. 158–160, 7, pp. 30–31, 16, 17]; for criticism of this type of response, see [10]. An exception to the trend is [24].

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AQ3

In this paper we pursue a different line of inquiry: we examine whether, *even if* the alleged underdetermination is granted, we ought to embrace OSR. After outlining what we take the argument from metaphysical underdetermination for OSR to be (Section 5.2), we offer three criticisms, all of which grant for the sake of discussion that our fundamental physical theories are metaphysically underdetermined in the way the proponent of OSR insists (Sections 5.3, 5.4, and 5.5). Influential as the argument has been, we conclude that it is unsatisfactory as a path to OSR (Sections 5.6).

## 5.2 Stating the Argument

In a well-known passage, Ladyman first stated the argument from metaphysical underdetermination as follows:

Even if we are able to decide on a canonical formulation of our theory, there is a further problem of metaphysical underdetermination [...] In the case of individuality, it has been shown [...] that electrons may be interpreted either as individuals or as non-individuals. We need to recognize the failure of our best theories to determine even the most fundamental ontological characteristic of the purported entities they feature. It is an *ersatz* form of realism that recommends belief in the existence of entities that have such an ambiguous metaphysical status. What is required is a shift to a different ontological basis altogether, one for which questions of individuality simply do not arise. [13, pp. 419–420]

In subsequent literature, presentations of the argument have been similarly informal.

We propose to regiment this line of reasoning as a valid argument that proceeds in two stages. The first attempts to establish a *negative* conclusion targeting what French has called “object-oriented” realism [9, p. 168]: roughly, any of the standard realist views according to which our best fundamental physical theories commit us to objects that are at least as fundamental as the physical structures into which those objects figure.<sup>3</sup> The second stage then attempts to derive the *positive* conclusion that OSR is (all other things equal) preferable to its more traditional counterpart.<sup>4</sup> Here is our re-construction of the argument in more detail:

### The argument from metaphysical underdetermination

(P1) Object-oriented realists are committed to objects (that are ontologically basic) having determinate *individuality profiles*: (i) there is a fact of the mat-

<sup>3</sup> French takes the view defended by Psillos [19] as representative. Note that by “object-oriented realist” we also have in mind those who take *neither* objects nor the structures within which they are embedded to be ontologically prior; see e.g. [7].

<sup>4</sup> We take no stance on whether this is the *only* way to formulate the argument, nor do we claim that every proponent of OSR would accept each of its premises. Perhaps there is another way to proceed; we doubt, however, that it will diverge much from the argument we will discuss (though see Section 5.5).

## 5 Underdetermination as a Path to Structural Realism

- 91 ter about *whether* an object is an individual or not, and (ii) if it *is* an individ-  
 92 ual, there is a fact of the matter about how, precisely, it is individuated.<sup>5</sup>  
 93 (P2) If (P1) is the case, then adopting object-oriented realism commits us to  
 94 expecting that our best theories will accurately describe what these individu-  
 95 ality profiles are like.  
 96 (P3) But our best theories fail to offer individuality profiles for their pur-  
 97 ported objects (much less describe precisely what they are): the individu-  
 98 ality status of these objects, as given by our best theories, is *metaphysically*  
 99 *underdetermined*.  
 100 (C1) So object-oriented realism is (probably) false.  
 101 (P4) If OSR is true, then our best theories are not infected with metaphysical  
 102 underdetermination.  
 103 (C2) So, all other things equal, OSR is preferable to object-oriented realism.

104  
 105 As we said before, our strategy is to simply concede premise (P3) for sake of  
 106 argument, and focus on the status of (P1), (P2), and (P4). That said, it is important  
 107 to be clear about what (P3) says. This premise should be read as being amenable to a  
 108 myriad of views about the metaphysics of physical objects. (P3) does not preclude,  
 109 for example, the possibility of theories according to which some types of object  
 110 are individuals while others are not; for all (P3) says, the individuality profile of  
 111 the object-oriented realist's ontology may be very complex indeed. What (P3) *does*  
 112 preclude however, on pain of metaphysical underdetermination, is a metaphysics of  
 113 physical objects on which there is no fact of the matter about whether and how  
 114 objects are individuated (any theory that fails to specify an individuality profile  
 115 for its objects is necessarily *incomplete*). This will be important in what follows  
 116 (Section 5.3).

117 One final point before moving on. The appeals to metaphysical underdetermina-  
 118 tion are sometimes presented with a *semantic* gloss that our formulation lacks. For  
 119 example, French writes:

120 The imposition of permutation symmetry ensures a kind of *referential inscrutability* which  
 121 is manifested in both horns of the underdetermination: on the particles-as-individuals view  
 122 we lose the possibility of specifying which label is associated with which individual; on  
 123 the alternative, we don't have individuals at all. Only in the former case does some form  
 124 of causal theory of reference get any purchase, but it's tenuous at best. And given that  
 125 the physics cannot tell us which case corresponds to how the world is, the question natu-  
 126 rally arises: if the realist cannot specify to what it is she is referring—veiled individuals  
 127 or non-individuals—then to what extent can she claim to be referring to objects at all? [9,  
 pp. 175–176, emphasis added]

128 In other words, the “underdetermination” prevents the standard realist not only  
 129 from discerning the individuality profile of her ontology, but even from making  
 130 out her claim to be referring to objects at all! As far as we know, this version of the  
 131

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132  
 133  
 134 <sup>5</sup> We leave the restriction to *ontologically basic* objects implicit throughout, for consideration later  
 135 (Section 5.5).

136 argument has not been addressed at all in the literature; while not denying its possi-  
 137 ble importance, we shall not discuss it here.

### 140 5.3 Object-Oriented Realism and Premise (P1)

142 According to premise (P1), a commitment of object-oriented realism is that there is  
 143 a fact of the matter about *whether* objects are individuals or not—and if so, there is  
 144 a fact of the matter about *how* they are individuated. In this section, we argue that  
 145 the object-oriented realist has good reason to reject this premise.

#### 148 5.3.1 Support for (P1)

150 French and Ladyman support (P1) by appeal to recent history of physics as well  
 151 as the testimony of physicists themselves. The first claim is that the concept of  
 152 object inherited from classical physics involves a commitment to those objects *as*  
 153 individuals. In their [11], they focus on atomism in the late nineteenth and early  
 154 twentieth centuries, writing:

155 How was the content of atomism cashed out? Or, equivalently, how was the “nature” of  
 156 atoms understood? Briefly and bluntly put, atoms were understood as individuals where the  
 157 metaphysical nature of this individuality was typically explicated in terms of substance or,  
 158 more usually in the case of physicists at least, in terms of the particles’ spatio-temporal  
 159 location. Thus, one of the most prominent and ardent defenders of atomism, Boltzmann,  
 160 incorporated such an understanding of the nature of atoms in terms of their individuality in  
 161 Axiom I of his mechanics. The content of atomism was thus cashed out explicitly in terms  
 162 of the metaphysical nature of atoms. [11, pp. 35–36]

163 The point is that the axioms that underpin classical Maxwell-Boltzmann statistics  
 164 include individuality in the concept of object, in the sense that a state and its permuta-  
 165 tion are counted as distinct states.

166 The second claim they make is that quantum statistics were seen by the physicists  
 167 of the time as undermining the view that quantum particles are individuals. The  
 168 development of quantum mechanics included the development of both Fermi-Dirac  
 169 and Bose-Einstein statistics, in which a state and its permutation are not counted as  
 170 distinct states. The connections between individuality, permutation invariance, and  
 171 different statistics can be challenged,<sup>6</sup> but French and Ladyman are making a case  
 172 based on history, and their point is that, at the time, physicists saw these develop-  
 173 ments in quantum mechanics as undermining the view that quantum particles are  
 174 individuals. French and Rickles briefly summarize the history as follows:

175 We shall call this view—that quantum particles are, in some sense, not individuals—the  
 176 Received View. It became fixed in place almost immediately after the development of  
 177 quantum statistics itself [...]. Thus at the famous Solvay Conference of 1927, Langevin

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180 <sup>6</sup> Such as in the work of Simon Saunders; see especially [27] and [28].

## 5 Underdetermination as a Path to Structural Realism

181 noted that quantum particles could apparently no longer be identified as individuals, and  
 182 in that same year both Born and Heisenberg insisted that quantum statistics implied that  
 183 the “individuality of the corpuscle is lost” [...]. Some years later, in 1936, Pauli wrote  
 184 to Heisenberg that he considered this loss of individuality to be “something much more  
 185 fundamental than the space-time concept” [...]. [12, p. 221]

186 The implication French seems to draw from these considerations is that once we  
 187 are committed to an ontology of particles, we are also committed to providing an  
 188 individuality profile for those particles (i.e. to discussing whether these particles are  
 189 individuals or non-individuals). This is the support offered by French and Ladyman  
 190 for (P1).

191 Other arguments—from metaphysics and from logic—might be invoked by  
 192 someone wishing to maintain (P1), and we will discuss these considerations in  
 193 Section 3.3 below.<sup>7</sup> Our focus here is on the argument for OSR that has dominated  
 194 the literature, where the support for (P1) is the historical evidence. How convinced  
 195 should we be of (P1) on this basis? Well, it is not clear that this support for (P1)  
 196 works, even on its own terms, because it is not clear that French and Ladyman’s  
 197 story is the right way to read the historical evidence.

198 It is worth saying a few more words about this. We do not dispute that the  
 199 belief that quantum mechanical particles are not individuals was held to represent an  
 200 important difference between classical physics and quantum physics, by many of the  
 201 leading physicists of the time. However, French’s own work has shown that quantum  
 202 mechanics can in fact support an interpretation of its particles as individuals: crucially  
 203 for the argument from underdetermination, the question of whether quantum  
 204 particles are individuals or non-individuals is underdetermined by the physics. The  
 205 physicists that French cites, as believing that quantum mechanics leads to the “loss  
 206 of individuality” of corpuscles, believed this because they believed that the particles  
 207 that are the subject-matter of quantum mechanics are described by quantum  
 208 mechanics in such a way that they are determinately non-individuals. What then,  
 209 might these same physicists have believed about the status of quantum particles, if  
 210 they had come to believe that quantum mechanics does not determine whether such  
 211 particles are individuals or non-individuals? Might they not have concluded that  
 212 the shift implied by quantum mechanics is not from individuals to non-individuals,  
 213 but from individuals to particles for whom the categories of individual and non-  
 214 individual do not apply?

215 Well, so much for speculative history. Regardless of what they would have said,  
 216 we think that the latter answer—that there can be objects that are not determinately  
 217 individuals or non-individuals—is a viable response, and one that should be on the  
 218 table. (We will come to metaphysical and logical reasons why this might be prob-  
 219 lematic in a minute, but we will develop this a bit further first.) Consistent with this  
 220 response is an approach to the objects of physics that we term “law-constitutive”.

AQ4

221  
 222  
 223  
 224 <sup>7</sup> Indeed, French’s continued endorsement of (P1) is related to his logical investigations (see French  
 225 and Krause [2006]).

### 5.3.2 A Law-Constitutive Approach to Objects

We suggest that a law-constitutive approach to the objects that are the subject-matter of a physical theory is viable, and allows for ontologically basic objects that may be individuals, non-individuals, or not determinately either. This last option asserts that ontologically basic objects may lack an individuality profile, contra (P1). Moreover, such objects need not be such that they can be “structurally reconceived”.<sup>8</sup> If we are right, then the rejection of (P1) is consistent with object-oriented realism when combined with a law-constitutive approach to the objects of physics.

It is worthwhile, then, saying a little about the “law-constitutive” approach to the objects that are the subject-matter of a physical theory. That is to say, a necessary (and sufficient, in the strong version) condition of something to *be* a physical object is that it satisfy the laws of that physical theory. The view says something stronger than that to be a certain *kind* of object is to satisfy a certain system of laws. That claim is perhaps uncontroversial. The view we are offering makes the far more radical claim that what it is to *be* a physical object *at all* is to satisfy a certain system of physical laws: there is no concept of physical object that can be given prior to the specification of the laws. This is *not* to say that objects ontologically depend upon our *theories* about what those laws are, or even upon the laws themselves. The proposal is simply that physical theory exhausts all there is to say about what it is to be a physical object: no prior, or theory-independent, conditions of objecthood are to be had.<sup>9</sup>

This gives us a sense in which the physical notion of object has some autonomy from (and can be considered apart from) the metaphysical and logical notions (of which more below). It opens up a third notion of object. Brading [1] has recently argued that the historical roots of the law-constitutive approach go back at least to Newton. Since the support for (P1) offered by French and Ladyman appealed to the authority of historical figures, this history is not irrelevant. Newton is explicit in his writings on natural philosophy that he is offering an account of body suitable for—and restricted to—the purposes he has in mind (his mathematical natural philosophy), and that for something to *be* such a body (a physical body) it must move in accordance with the laws.<sup>10</sup> The claim is that Newton proposed a weak version of

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<sup>8</sup> And even if they can, further argument is required to establish (C2), as we discuss below.

<sup>9</sup> There is no guarantee that when we work out the details with respect to the specific laws that we find in this, the actual world, we will arrive at an account of physical object that can indeed serve as their subject-matter. Furthermore, there is no guarantee that this strategy will generate one unified kind of physical body: perhaps the bodies that serve as the subject matter of the laws when gravitation is included will turn out not to be identical to those that serve as the subject matter of the laws when electrical phenomena are at issue. Thirdly, there is no guarantee that the law-constitutive approach to physical bodies will deliver individuals. But these issues are all to be distinguished from the philosophical viability of the law-constitutive approach as a possible account of what it is to be a physical body. We say something more about the issue of philosophical viability below.

<sup>10</sup> For further discussion, see [1].

## 5 Underdetermination as a Path to Structural Realism

271 the law-constitutive view, according to which a necessary condition for something  
 272 to be a physical body is that it satisfy the laws of motion (but other conditions are  
 273 also required).

274 For our purposes, the crucial point is this: if we adopt this approach to physical  
 275 objects then, unless dictated by the laws, the individuality profile required for phys-  
 276 ical objects by premise (P1) need not, after all, obtain. We have a viable notion of  
 277 object of which the object-oriented realist may avail herself, thereby rejecting (P1)  
 278 as giving necessary conditions on objecthood.

279 For French and Ladyman, a realism that commits us to physical objects, but fails  
 280 to determine the individuality or otherwise of those objects, is so strange that they  
 281 reject it in favor of a commitment to “pure structure” as ontologically basic. Our  
 282 view is that individuality is distinct from object-hood, and that the “metaphysical  
 283 underdetermination worry” over individuality can be avoided in a less dramatic-  
 284 sounding manner. By appealing to the law-constitutive account of physical objects,  
 285 we can pull apart objecthood and individuality in a very natural way: if a theory  
 286 makes no commitments concerning whether or not the objects it purports to be  
 287 about are individuals, then we need not conjoin a metaphysics of individuals versus  
 288 non-individuals to that theory in order to have a physical notion of object for our  
 289 theory to be about. In such a case, requiring that we discuss these objects in terms  
 290 of individuality (and perhaps even commit ourselves one way or another on the  
 291 matter) demands that we go beyond the content of the theory: we have to add an  
 292 interpretational layer not warranted by what the theory itself says. Expressed in this  
 293 way, the alleged “strangeness” of a commitment to objects that is not accompanied  
 294 by a metaphysics of individuality doesn’t sound strange at all—at least not to us.

295 These grounds for the rejection of (P1) would be cold comfort to the object-  
 296 oriented realist if the law-constitutive approach necessarily led to structuralism via  
 297 a different route. French and Ladyman suggest the possibility of a law-constitutive  
 298 view when writing about Cassirer’s structuralism:

299 Charge, like the other intrinsic properties, features in the relevant laws of physics and  
 300 according to Cassirer, what we have here is a reversal of the classical relationship between  
 301 the concepts of object and law (Cassirer [2], 131-2): instead of beginning with a “definitely  
 302 determined entity” which possesses certain properties and which then enters into definite  
 303 relations with other entities, where these relations are expressed as laws of nature, what  
 304 we now begin with are the laws which express the relations in terms of which the “enti-  
 305 ties” are constituted. From the structuralist perspective, the entity “constitutes no longer the  
 306 self-evident starting point but the final goal and end of the considerations [...]”. [11, p. 39]

307 This is a law-constitutive view of the entities that serve as the subject-matter of  
 308 physics, in a structuralist version, since laws express *solely relations* and objects are  
 309 *wholly constituted by* these relations.

310 But notice: whether the structuralist outcome follows from the law-constitutive  
 311 approach depends on the nature of physical laws, including whether those laws  
 312 attribute intrinsic properties to objects. In itself, the law-constitutive approach to  
 313 physical objects is neutral with respect to structuralism: adopting the approach is  
 314 consistent with, but does not entail, a structuralist reading of the objects that are the  
 315 subject-matter of those laws.



316 In sum, the suggestion is that we have a viable concept of physical object that  
 317 does not entail a substantive further issue about whether those objects are individ-  
 318 uals or not. This is a concept of physical objecthood that is consistent with the  
 319 alleged underdetermination, but which does not necessarily conceptualize objects  
 320 structurally, and certainly does not eliminate them in favor of structure. It is not our  
 321 aim here to explicate and defend the law-constitutive approach.<sup>11</sup> Our purpose here  
 322 is simply to draw attention to this alternative realist position, and to highlight how  
 323 it can be used to dissolve worries about “metaphysical underdetermination”.

### 326 *5.3.3 Objects as Individuals: Requirements from Logic* 327 *and Metaphysics*

329 The law-constitutive view of objects concerns the concept of physical object, but we  
 330 have also to address concerns from metaphysics and logic. The questions about what  
 331 conditions an object has to satisfy have long been given a double-sided treatment,  
 332 having both a metaphysical and a logical face (think of Aristotle’s treatment of indi-  
 333 viduals). On the metaphysical side, an object must be countable. On the logical side  
 334 it must be capable of serving as an object of predication.<sup>12</sup>

335 Do the metaphysical and logical notions require that an object be determinately  
 336 individual or non-individual, and if so, how does this affect (P1)? The issue of indi-  
 337 viduality concerns whether an object can be named such that it may be uniquely  
 338 re-identified at later times and across possible worlds. Our question is therefore  
 339 whether being countable and/or serving as objects of predication presuppose a fact  
 340 of the matter about whether the objects in question are individuals.

341 Consider first the metaphysical requirement that objects must be countable. Tra-  
 342 ditionally, this rests on the prior condition that objects can be named. However,  
 343 quantum mechanics casts doubt on this condition. One way to interpret the count-  
 344 ability requirement is that there be a determinate answer to the question “how  
 345 many?”. There are numerous examples from quantum theory in which the most nat-  
 346 ural description of the objects involves numerical distinctness without commitment  
 347 to naming the objects. Paul Teller [29, p. 128] has a discussion of this issue where  
 348 he argues for the superiority, in certain contexts, of the Fock space representation  
 349 of atomic electrons: we model the electrons in a particular atom using occupation  
 350 numbers, which are numbers describing how many times each property is instanti-  
 351 ated, with no regard to “which” particle has which of the properties. In other words,  
 352 we get the kinds of electron, plus the number of electrons instantiating each kind,  
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355 <sup>11</sup> That is a much bigger project, to be carried out elsewhere. Among the issues to be addressed  
 356 are constitution (what precisely is being constituted in any give case (objects, properties, etc.)) and  
 357 instantiation (the relationship between a theory and its subject-matter, more generally).

358 <sup>12</sup> If we restrict this to being an object of *sortal* predication the link between the metaphysical  
 359 and logical aspects, as two sides of the same coin, becomes evident since (on many views) sortal  
 360 predicates provide conditions for counting.

## 5 Underdetermination as a Path to Structural Realism

361 but no labels enabling us to refer to any one electron in particular—we don't name  
 362 the electrons. Thus, in quantum mechanics there can be a determinate answer to the  
 363 question “how many?” independently of whether we name the objects in question.

364 From this example we see that the metaphysical requirement that objects be  
 365 countable can be met without appeal to individuality. Thus, the issue of countability  
 366 is independent of whether the objects concerned are individuals or not. More than  
 367 that, the requirement of countability does not depend on whether or not the objects  
 368 are determinately individuals or not.

369 In order to talk about objects we require a logical notion of object: we must  
 370 be able to apply predicates. One point in the debate seems to be the claim that  
 371 the possibility of logical predication depends on appeal to metaphysically robust  
 372 objects—objects that can be named and then re-identified across possible worlds,  
 373 and over time. However, Simon Saunders [25, 26] has shown that the logical notion  
 374 of object, as object of predication, is a weaker notion, requiring only numerical  
 375 distinctness.

376 Saunders has argued for a version of Leibniz's Principle of the Identity of Indis-  
 377 cernibles on the basis of which the above example of Fock space poses no problem  
 378 for the logical notion of object because it admits two-place relations that cope with  
 379 numerical distinctness for otherwise identical objects: “ $x$  is one meter away from  
 380  $y$ ” (for example) gives numerical distinctness by failing to be true when  $x = y$  and  
 381 being true when  $x \neq y$ . Saunders writes:

382 Consider the spherically symmetric singlet state of two indistinguishable fermions. Each has  
 383 exactly the same mass, charge, and other intrinsic properties, and exactly the same reduced  
 384 density matrix. Since the spatial part of the state has perfect spherical symmetry, each has  
 385 exactly the same spatiotemporal properties and relations as well, both in themselves and  
 386 with respect to everything else. But an irreflexive relation holds between them, so they  
 387 cannot be identified (namely “... has opposite component of spin to ...”). [26, p. 294]

388 In Saunders' terminology (following [21]), fermions are “weakly” discernible.  
 389 Weak discernibility is indeed weak: we cannot refer to one of the two objects in  
 390 preference to the other. Nevertheless, we can state of the pair that there are two  
 391 objects, and we can make assertions concerning the properties of those objects.  
 392 Thus, these objects serve as objects of predication, in the weakened sense given  
 393 by Saunders' analysis, enabling Saunders to draw the following conclusion:

395 I think they [French and Ladyman] are mistaken in their view that failing transcendental  
 396 individuality, the very notion of object-hood is undermined by particle indistinguishability  
 397 in quantum mechanics [...] It is true that from exact permutation symmetry it follows that  
 398 such particles [...] may in certain circumstances not be uniquely identifiable, in the sense  
 399 that it may not be possible to refer to one member of the collective rather than another. But it  
 400 does not follow, from logical principles, that such particles cannot be objects of predication.  
 401 Indeed they can [...]. [25, p. 131]

402 The logical notion of object does not require that there is a fact of the matter about  
 403 whether objects are individuals or not. Logic *is* sensitive to individuality and lack  
 404 thereof: if we enrich our language by adding names to our objects, this will be  
 405 relevant logically in certain contexts. However, this sensitivity is not relevant to the

406 point that we wish to make here: serving as an object of predication does not depend  
407 on prior determination of the status of the object with respect to individuality.

408 In sum, metaphysics and logic appear to require countability as a condition of  
409 objecthood, but not individuality.<sup>13</sup>

410 The conclusion Ladyman draws from this is that structurally reconceived objects  
411 are admissible, but that the scientific realist's objects (since they must satisfy the  
412 individuality criteria of (P1)) are not. We claim that this inference is not justified,  
413 given the availability of the law-constitutive alternative. We shall say more about  
414 this in Section 5.5.

### 417 *5.3.4 Numerical Diversity as a Criterion of Objecthood*

419 Pooley [17] also argues that the realist should focus on *numerical diversity*. For  
420 Pooley, however, numerical diversity is sufficient for individuality. Thus, he rejects  
421 our characterization of individuality as concerning whether an object can be named  
422 such that it may be uniquely re-identified at later times and across possible worlds.  
423 Instead, he distinguishes between “haecceitistic individuality” (for which we reserve  
424 the term “individuality”) and “non-haecceitistic individuality” (for particulars which  
425 satisfy the numerical diversity condition, but neither of the further conditions of  
426 having transworld and over-time identity conditions.) We think that he is right to  
427 focus attention on numerical diversity, but that his association of individuality with  
428 numerical diversity is potentially misleading, and that our taxonomy is preferable,  
429 for the following reasons.

430 Adopting Pooley's terminology, metaphysical underdetermination becomes, in  
431 the context of spacetime theory, underdetermination between haecceitistic and non-  
432 haecceitistic interpretations of the individuals that are the spacetime points of space-  
433 time theory. This, Pooley suggests, is not a troubling form of underdetermination:  
434 the non-haecceitistic interpretation is the “core” realist position, which the realist  
435 may or may not supplement with haecceities. He writes: “If this is the only choice  
436 to be made, it hardly constitutes an interesting threat to the realist's belief in the  
437 existence of spacetime points” [17, p. 10].

438 A mere re-labelling of both options as concerning “individuals” rather than “indi-  
439 viduals” versus “non-individuals” does not make a legitimate underdetermination  
440 go away, of course. If such underdetermination exists, then the realist faces a sys-  
441 tematic underdetermination of the identity conditions of its basic constituents (the  
442 spacetime points); if this seemed troubling on Ladyman's “individuals versus non-  
443 individuals” formulation, then it remains troubling on Pooley's “haecceitistic ver-  
444 sus non-haecceitistic individuals” formulation. We should make it clear that Pooley  
445 never implies that the re-labelling removes the problem; for him, the re-labelling

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449  
450 <sup>13</sup> Bosons, in contrast to fermions, do not satisfy this countability requirement.

## 5 Underdetermination as a Path to Structural Realism

451 is a preliminary step towards denying the alleged metaphysical underdetermination  
452 for the theories he considers.<sup>14</sup>

453 The advantage of our approach, and our terminology, is that we use the term  
454 “object” as neutral between (a) haecceitistic individuals, (b) non-haecceitistic indi-  
455 viduals, and (c) particulars for whom there is no determinate fact of the matter as  
456 to whether they are haecceitistic or non-haecceitistic individuals. This is important  
457 because it includes the possibility of objects with no determinate individuality pro-  
458 file. As a result, it allows for the possibility that we do not have to decide between  
459 (a) and (b): that we lack the resources to do so does not indicate a metaphysical  
460 underdetermination; rather, it indicates that (c) is the appropriate category for the  
461 objects of the theory in question.

462 Pulling together what we have learned so far, the conclusion is that the object-  
463 oriented realist has available a route for rejecting (P1), should she so choose. The  
464 considerations of this section, including the work of Saunders and Pooley, show that  
465 *countability* is the crucial criterion for objecthood. This, and not individuality, is the  
466 test for objecthood that can be brought to bear on candidate “objects” arising from  
467 the law-constitutive approach to physical objects.

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## 470 5.4 ESR, Object-Oriented Realism, and (P2)

471

472 The conclusion (C1) of the argument from metaphysical underdetermination is the  
473 rejection of object-oriented realism. There are two targets here. The explicit target is  
474 the standard scientific realist, with her full range of beliefs concerning unobservable  
475 objects. However, if the step from (C1) to (C2) is to succeed, the epistemic structural  
476 realist option must also be ruled out by the rejection of object-oriented realism. In  
477 our opinion, the advocate of ESR can—and should—reject (P2).

478 First, (P2) is nothing more than the *denial* of ESR, which Ladyman himself casts  
479 as a form of object-oriented realism, accepting a world consisting of “intrinsically  
480 individuated objects with intrinsic natures” [14, p. 28]. What (P2) says, recall, is  
481 that being an object-oriented realist entails that not only that each object has a  
482 determinate individuality profile, but also that this profile can be uncovered by the  
483 physical theories which describe and refer to them. Yet according to proponents of  
484 ESR, this is precisely what the pessimistic meta-induction shows us we cannot have  
485 (Section 5.1): according to them, we *cannot know* what the objects these theories  
486 refer to and describe are intrinsically like.

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490 <sup>14</sup> Pooley argues persuasively that his non-haecceitistic version of substantivalism is clearly the  
491 better interpretation of current spacetime theory than the haecceitistic one, and therefore that there  
492 is no genuine metaphysical underdetermination facing the realist when it comes to the status of  
493 spacetime points. Pooley also rejects the alleged underdetermination with respect to quantum par-  
494 ticles. He is among those who reject French and Ladyman’s claim that a (haecceitistic) individuals  
495 interpretation is a genuine option, arguing that quantum particles satisfy numerical diversity but  
fail both transworld and over-time identity.

496 But now the problem with the argument's inclusion of (P2) should be clear.  
 497 On one hand, proponents of ESR deny that we can—much less *should*—expect  
 498 our best theories to assign an individuality profile to each (type of) object, since  
 499 part of what the objects of our best theories are intrinsically like is how they are  
 500 “intrinsically individuated”, in Ladyman’s phrase. But on the other hand, (P2) just  
 501 takes for granted that our best theories can provide us with epistemic access to facts  
 502 about these objects are intrinsically like: in short, the premise just states that ESR is  
 503 false. For it denies the characteristic epistemological claim of this view, by claiming  
 504 that we should expect our best theories to describe the intrinsic nature of physical  
 505 objects. In the absence of considerations supporting (P2), which have yet to be  
 506 offered, we have a stand-off between ESR and OSR. Insofar as the argument from  
 507 metaphysical underdetermination is intended to push us beyond ESR, and to OSR,  
 508 it cannot be the *argument* that is doing the work: (P2) suffices.

509 Note that this route for rejecting (P2) is open not just to advocates of ESR,  
 510 but also to *any* object-oriented realist who claims that we have limited epistemic  
 511 access to the individuality profiles of the objects of physics. Even object-oriented  
 512 realists who are realist with respect to the intrinsic qualitative properties attributed  
 513 to objects by our best scientific theories may reject (P2). For instance, consider  
 514 the form of realism offered by Psillos [20].<sup>15</sup> On this view, though we do have  
 515 epistemic access to more than the structural content of our theories, we do not have  
 516 enough to secure knowledge of the world’s underlying individuality profile. The  
 517 dispute is then over whether this epistemic cautiousness amounts to an “*ersatz* form  
 518 of realism”, as Ladyman [13, p. 420] alleges, or to a discovery about our epistemic  
 519 situation in the world (be that in principle, or contingent on this particular point of  
 520 our scientific development). In short, the dispute is no longer over whether meta-  
 521 physical underdetermination poses a difficulty to object-oriented realists. Rather,  
 522 at issue is whether forms of object-oriented realism that are epistemically humble  
 523 enough to reject principles like (P2)—by far the most popular strain in the recent  
 524 literature—are “realist” enough. If there is a genuine dispute to be had here, it has  
 525 little to do with metaphysical underdetermination.<sup>16</sup>

526 In sum, the advocate of ESR should most certainly reject (P2), and the standard  
 527 object-oriented realist should not concede (P2) without a further fight.  
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534  
 535 <sup>15</sup> Psillos offers a version of scientific realism, but explicitly denies that the scientific realist should  
 536 be committed to the claim that “two” worlds related by the shuffling of bare particulars are in fact  
 537 two distinct worlds [20, pp. S19–20].

538 <sup>16</sup> Notice that a scientific realist who endorses the law-constitutive view of objects will insist that  
 539 these laws fully determine whether there is a determinate fact of the matter as to the individuality  
 540 or non-individuality of the objects that are the subject matter of the theory in question; thus, in  
 rejecting (P1), she by-passes the force of (P2).

## 5.5 Reductive vs. Eliminative OSR and (P4)

Our final criticism of the argument from underdetermination starts off with the observation that there are *two* varieties of OSR available—both of which are reflected in French and Ladyman’s presentations of the view.

When articulating OSR, French and Ladyman at times appear to argue for the *elimination* of objects in favor of structure. In early presentations, the metaphysical conundrums that OSR attempts to avoid require “a shift to a different ontological basis altogether” [13, p. 420], one in which objects play nothing more than “a heuristic role allowing for the introduction of the structures which then carry the ontological weight” [8, p. 204]. Once they have played this heuristic role, “the objects can be dispensed with” [11, p. 42].

In other presentations, however, there is a shift in terminology towards “reconceptualization” of objects in structural terms, coupled to the suggestion that structures are *ontologically prior* to objects.<sup>17</sup> The reconceptualization of objects in structural terms is the claim that objects are nothing over and above the “nodes” in a web of relations. As such, it weights the objects and relations equally, and does not give ontological priority to either. One role for the argument from metaphysical underdetermination is, we take it, to get us from this “mere reconceptualization” of objects to a claim of ontological priority for structures (that is, to the rejection of object-oriented realism and the adoption of OSR).

Viewed in this role, the argument proceeds as follows: (i) premise (P1) remains as before: objects must have an associated individuality profile if they are ontologically basic; (ii) yet if, however, objects are ontologically derivative upon structures, no such individuality profile is required; (iii) the objects of physics do not satisfy the individuality conditions; therefore (iv) the ontological priority of structure over objects is established.

Before we get to the main objection, note that this subtle shift (from taking the argument from metaphysical underdetermination to support *eliminative* OSR, to instead taking it to support *reductive* OSR) invites further questions when seen in light of the tenability of the law-constitutive view of objects (Section 5.3). In the absence of an argument from “reconceptualization” of objects in terms of structures to the ontological priority of the latter to the former, the option of remaining an object-oriented realist while giving up the requirement that objects must have a determinate individuality profile appears to remain on the table. However, in their recent treatment of the argument from underdetermination, Ladyman and Ross [15, p. 138] retreat from (P1), endorse reconceptualization, and then comment that this is a “thoroughly structuralist” position. This seems to imply that were the object-oriented realist to concede reconceptualization, she would thereby have conceded the debate to OSR. The option of remaining an object-oriented realist while giving up the requirement that objects must have a determinate individuality profile is, on this account, a delusion.

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<sup>17</sup> For just one example, see [11, p. 37].

586 There are two ways to think about this, so far as we can see. On the one hand,  
 587 if reconceptualization yields ontological parity of relations and relata, then further  
 588 arguments are required to show that either object-oriented language or relations-  
 589 oriented language more appropriately “reflects basic ontology”, and the object-  
 590 oriented realist need not concede yet.<sup>18</sup> On the other hand, the advocate of OSR  
 591 could be claiming that the lesson of reconceptualization is that structure is *onto-*  
 592 *logically prior* to its decomposition into relations and relata, thereby resisting the  
 593 push towards the relations versus relata debate. This requires that we distinguish  
 594 *structuralism* from a commitment to the ontological priority of *relations*, something  
 595 that has not been the case (at least not clearly so) in the structural realism debate to  
 596 date.

597 But set these issues aside: a worse problem with the shift from eliminating  
 598 objects to “reconceptualizing” them is that it reveals how OSR is a victim of its own  
 599 argument. Premise (P4), recall, says that OSR is not affected by the metaphysical  
 600 underdetermination that would (allegedly) infect our best theories if object-oriented  
 601 realism were true; if it *were*, then adopting OSR would be medicine as lethal as  
 602 the disease. Now, we have distinguished between proponents of OSR who *eliminate*  
 603 physical objects from those who merely accord them a *less fundamental* status. But  
 604 this potential disagreement among proponents of OSR is clearly *no less metaphysi-*  
 605 *cal* than the dispute between object-oriented realists about whether objects are indi-  
 606 viduals or not. For the dispute between eliminative and reductive OSR is a dispute  
 607 about *what exists*, and these are of course paradigmatically metaphysical disputes,  
 608 no more settled by the details of the relevant physics than for the object-oriented  
 609 realists.

610 Thus by trading in object-oriented realism for OSR, we have traded one pair of  
 611 metaphysically underdetermined interpretations for another. In short, the claim that  
 612 OSR does not infect our fundamental physical theories with metaphysical underde-  
 613 termination—i.e., premise (P4)—is false. Moreover, we can also run the argument  
 614 from metaphysical underdetermination against (OSR) as follows:

- 615
- 616 (P5) If OSR is true, then there is a fact of the matter about whether objects exist  
 617 or not.
  - 618 (P6) If (P5) is true, then we should expect our best theories to say whether  
 619 objects exist or not.
  - 620 (P7) But our best theories fail to say whether objects exist; whether they do  
 621 or not is underdetermined by the interpretations offered by eliminative and  
 622 reductive OSR.
  - 623 (C3) So OSR is (probably) false.
- 624

625 Juha Saatsi [24] has also recently suggested that OSR is a victim of its own  
 626 argument. He claims that “the structuralist proposal only makes matters worse, for  
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629 <sup>18</sup> See the further arguments in [15] for the structuralist position, and the arguments of Chakravartty  
 630 [6] in favor of object-oriented realism.

## 5 Underdetermination as a Path to Structural Realism

631 with such an alternative structuralist ontology available there would be three instead  
 632 of two to choose from!” [p. 12]. If this is the case, then premise (P4) must be  
 633 rejected, and the argument fails to progress to the positive conclusion (C2). Such  
 634 an outcome might be resisted, as Saatsi notes, if it can be argued that the ability of  
 635 OSR to accommodate the “common core” of the competing interpretations breaks  
 636 the impasse. However, we think that the escape from underdetermination does *not*  
 637 last long. We reject (P4) because of the metaphysical underdetermination *internal* to  
 638 the radical structuralist program itself, not simply between it and the object-oriented  
 639 options. Our best fundamental theories underdetermine the correct metaphysics of  
 640 structure (elimination versus reduction), whether it can accommodate the interpre-  
 641 tations offered by traditional realists or not.

642 Another response to our objection is that there is considerable dialectical pres-  
 643 sure to keep objects around, and this mitigates the ontic structural realist’s problem  
 644 with metaphysical underdetermination. For example, its proponents need a response  
 645 to this notorious objection: structures are sets of relations, and relations require  
 646 objects in order to be instantiated; so their ontology, consisting of nothing but rela-  
 647 tions, is either Platonic or incoherent. However, this objection is no problem for  
 648 proponents of non-eliminative OSR, for they can claim that structural relations *do*  
 649 have relata while their eliminative rivals cannot. The slogan “no relations without  
 650 relata” requires only that there *be* nodes in the structure (which the non-eliminativist  
 651 accepts), not that the nodes be ontologically independent of the structure (which  
 652 she denies).<sup>19</sup> Similarly, French reintroduces non-structural, non-fundamental ele-  
 653 ments into the ontology of OSR in order to deal with various other challenges  
 654 [9, pp. 178–184]. But again, these considerations for preferring reductive OSR to its  
 655 more extreme counterpart is certainly not constrained by physics anymore than prin-  
 656 ciples and arguments about the metaphysics of individuality are for object-oriented  
 657 realists. Why are proponents of OSR allowed to break the metaphysical underdeter-  
 658 mination by doing metaphysics, but not realists who are friendly to objects?

659 In this paper we have taken no stance on whether it *would* be problematic if  
 660 our fundamental physical theories were metaphysically underdetermined. However,  
 661 what we have shown in this section is that if it *is*, then OSR offers no escape from it.

## 664 5.6 Conclusion

666 Let us recap. We have presented the argument from metaphysical underdetermi-  
 667 nation as consisting of three premises (P1–3), a negative conclusion that rejects  
 668 object-oriented realism (C1), a further premise (P4), and a positive conclusion that  
 669 asserts OSR (C4). We have argued that the object-oriented realist should reject (P1),  
 670 and that there is available an account of objects—what we have called the law-  
 671 constitutive approach—that allows her to do so. We have argued that the epistemic

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674 <sup>19</sup> Chakravarty’s own response on behalf of eliminative (OSR) is to claim that rejecting the slogan  
 675 as conceptually incoherent is “question begging” [4, p. 872].



676 structural realist should certainly reject (P2), even if she does not reject (P1), and  
 677 that object-oriented realists of any stripe have reasons to question (P2). Thus, insofar  
 678 as the argument is intended to remove the competitors of OSR (standard scientific  
 679 realism and ESR) from the game, it fails. Furthermore, we have also argued that  
 680 the further premise (P4) needed to move to the positive conclusion, asserting OSR,  
 681 cannot be maintained.

682 So what path should the proponent of OSR take from here? One option is to  
 683 modify our reconstruction of the argument; but the onus is on her to offer an explicit  
 684 and valid argument in support of her desired conclusions, and to show that her  
 685 premises do not face the same challenges as we have presented here. We think that  
 686 the prospects are not promising.

687 In the face of this negative evaluation, it is important not to throw the baby out  
 688 with the bath water, and to retain the important insights gained from the OSR pro-  
 689 gram. With this conclusion in mind, it is worth noting that much of Ladyman et al.'s  
 690 [15] recent structuralist manifesto is independent of the success (or failure) of the  
 691 argument from metaphysical underdetermination. Nevertheless, this argument *is* the  
 692 central argument by which OSR was introduced, it continues to play a central role  
 693 in the discussion, and thus deserves independent scrutiny. Our conclusion is that we  
 694 should look elsewhere than the argument from metaphysical underdetermination  
 695 when seeking reasons to adopt OSR.

696  
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766 **Chapter-5**

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