



# Asymmetry cannot solve the circularity/regress problem of property structuralism

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## Abstract

Strong dispositional monism (SDM), the position that all fundamental physical properties consist in dispositional relations to other properties, is naturally construed as property structuralism. J. Lowe’s circularity/regress objection (CRO) constitutes a serious challenge to SDM that questions the possibility of a purely relational determination of all property essences. The supervenience thesis of A. Bird’s graph-theoretic asymmetry reply to CRO can be rigorously proved. Yet the reply fails metaphysically, because it reveals neither a metaphysical determination of identities on a purely relational basis nor a determination specifically of identities in the sense of essences. Asymmetry is thus not by itself sufficient for a solution to CRO. But it cannot even help to answer CRO when a model for the determination of essences is taken as a basis. Nor is asymmetry necessary for a reply, as property structures may well be symmetric. A metaphysics of dispositional properties as grounded in a purely relational structure faces serious obstacles, and the properties would not be fundamental. Since essence and grounding are notions of metaphysical priority, there can be no essentially dispositional metaphysically fundamental properties, and the prospects of a “coherentist” metaphysics of basic properties are dim. A modal retreat that refrains from a post-modal conception of essence and simply claims that fundamental properties play dispositional roles by metaphysical necessity is unsatisfactory.

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## 1 Introduction: Strong dispositional monism and the circularity/regress objection

Strong dispositional monism (SDM; 2007a: pp. 72–73) as defended by A. Bird is the view that *all* fundamental physical properties *consist in* dispositions relating them to other properties. The view is naturally understood as an instance of a general idea of structuralism in metaphysics, according to which for a certain kind of objects, there is nothing more to these objects than the network of relations between them. Thus, mathematical structuralists hold that mathematical objects are nothing but positions in an abstract mathematical structure (Shapiro 1997); ontic structural realism maintains that to the extent that talk of physical particles remains legitimate at all, such objects have no primitive or intrinsic individuality, but somehow depend on a fundamental global structure of physical relations (French 2014); and R. Dipert has argued that concrete reality is an asymmetric graph and that the individuation of objects “can arise through relations alone.” (1997: p. 349) Placed in this context, SDM amounts to property structuralism.

Sceptics have generally worried that in one way or another structuralists must already presuppose at least some objects of the kind in question as given in order to install the structures in which all those objects are supposed to be merged. In the following I will deal with SDM and one particular sceptical challenge of that brand. J. Lowe’s circularity/regress objection (CRO) argues that if, following SDM, it is assumed that *all* physical properties *consist in* dispositional *relations to other* such properties, then no property gets its identity fixed, because the required fixation of identities “generates either a vicious infinite regress or a vicious circle.” (2006: p. 138) In reply, Bird maintains that the essences and identities of all properties can be “determined *relationally* rather than *intrinsically*.” (2007a: p. 139; 2007b: p. 527) Relying on R. Dipert’s (1997) graph metaphysics of concrete reality, Bird (2007a: ch. 6; 2007b) argues that graph theory shows that under certain conditions the identities of a range of entities – properties, in the case of SDM – can be determined by the pattern of relations alone that hold between these properties. He propounds a supervenience claim: provided that only asymmetric graphs are concerned, the identities and differences of objects in a graph supervene on the graph’s relational pattern.

I will argue that CRO highlights a serious problem concerning the metaphysical determination of purely dispositional property essences. I will offer a technically sound reconstruction of Bird’s supervenience claim, but show that asymmetry results contribute scarcely anything to the solution of the determination problem: asymmetry is neither by itself sufficient to reveal a determination of purely relational essences, nor can it help to account for a purely relational determination of essences if a general model of determination of essences is taken as a basis, nor are there good reasons to think that asymmetry would be necessary for property structuralism.

More specifically, I will argue the following theses: *Sects. 2–3*: The monist’s core problem is to provide an account of how the essences of all physical properties can be metaphysically determined solely by dispositional relations, and CRO creates serious doubts about SDM’s ability to solve the problem. *4–5*: Bird’s supervenience

claim is indeed true in the sense that the number of numerically different objects in an asymmetric structure supervenes on the structure's relational pattern. What is more, such graphs deliver unique role properties for those objects. 6–7: However, those non-trivial results by themselves cannot answer CRO: they neither establish that what appears to be determined is identity in the sense of *essence*, nor do they reveal that identity in any sense is metaphysically *determined* by relational patterns. Asymmetry does specify the conditions under which a relational determination of essences would be individuating, but no reasons can be found why they should be; symmetric property structures may well be impossible. 8: What is more, results about asymmetric graphs cannot even *help* to answer CRO, because even if a model of metaphysical determination is granted, the idea of a determination of essences on a purely relational basis faces particular problems that are not eased by results concerning asymmetry. 9: Purely dispositional properties might be construed as resulting from a purely relational structure, but such a structuralist metaphysics faces serious obstacles, and the properties would not be fundamental. 10: Since essence and grounding are notions of metaphysical priority, there can be no essentially dispositional metaphysically fundamental properties, and the prospects of a “coherentist” metaphysics of basic properties are dim; nor is a retreat from post-modal notions and a revitalisation of plain claims of strong necessities satisfactory. Section 11 concludes.

## 2 The strong monist's problem concerns the metaphysical determination of essences

According to dispositional essentialism, at least some physical properties are potencies (to adopt Bird's term, 2007a: p. x), i.e. they are essentially dispositional: it is essential to them that they bestow particulars that have them with dispositions or powers. Potencies are thereby essentially related to other physical properties as stimuli and manifestations of the dispositions in question. For example, charge may be assumed to essentially bestow things with the disposition to experience a force (manifestation) in an electric field (stimulus).<sup>1</sup> A claimed advantage of the view is that it accounts for strong natural laws such as that by strict necessity, charged particles in electric fields must experience forces (Bird 2007a: ch. 3). Strong dispositional monism (SDM; cf. Bird 2007a: p. 72) is a two-fold strengthening of this position. *Strong* dispositionalism says that the powers associated with a potency are not only essential to that property, but “that they are the essence of the property”, that “they constitute what it is to be that property”, that potencies “consist of...essential powers.” (2007a: pp. 72–73). Strong dispositional *monism* contends that *all* fundamental physical properties are purely dispositional in this sense (Bird 2007a: p. 46,

<sup>1</sup> This example of electric force = field strength · charge is simpler than Coulomb's law (cf. 2007a: p. 45 on charged particles attracting and expelling other charged particles; cf. Bird 2012: Sect. 4) in that it involves only monadic properties and a single particle.

137, 139; 2007b). CRO is best construed as challenging this contention that strong dispositionalism can be true of all the properties in question.

I will assume that dispositional essentialism is attractive only as a specifically essentialist (in contrast to a modal) metaphysics (cf. Azzano 2019). An account of necessitarian laws (2007a: p. 46), in particular, is hardly convincing if in the final analysis it consists in nothing more than a straightforward derivation of one modal claim (that necessarily everything that is Q and E is also F) from another, (that Q is necessarily correlated with the truth of a counterfactual conditional that, if E were present, F would be present). Bird's book is written during the hot phase of a paradigm shift in metaphysics from a modal to the new post-modal framework of neo-Aristotelian essence and grounding. His less technical statements are characteristically couched in terms that indicate the post-modal framework, such as (*real*) *essence* (2007a: pp. 45, 136), *nature* (136), *ground* (3), laws *springing from* properties (2), laws *flowing from* essences (5), powers *constituting what it is to be* a property (72), the essence of a property being *determined by* its relations to other properties (137), identity being *dependent on* a relational pattern (146), or identities being *fully determined* by such a pattern (146). In his more technical elaborations, by contrast, he draws on the modal toolbox. Thus, dispositions are characterised by counterfactual conditionals (43), the idea of necessitarian laws flowing from dispositional essences is realised by a derivation in a language of quantified modal logic (46), essences are specified by metaphysically necessary (bi-)conditionals (45–46) and related to transworld identities (72, 136), and claims of dependence and determination are modelled in terms of supervenience (139, 146). The adequate way to deal with this situation, I think, is to first advance CRO in essentialist terms, then reconstruct Bird's technical reply in the modal framework in which it is put forward, and finally investigate whether those modal results reveal a convincing rebuttal of the essence-theoretic worry underlying CRO.

So let us first ask how CRO ought to be understood. Taking up Molnar's statement that for a dispositionalist "each power gets its identity from its manifestation" (2003: p. 195), Lowe argues that if SDM is assumed, "*no property can get its identity fixed*, because each property owes its identity to another, which in turn owes its identity to yet another—and so on and on, in a way that, very plausibly, generates either a vicious infinite regress or a vicious circle." (2006: p. 138) Note that these formulations do not deal with relationships of identity *between* entities, but with the identity *of* one given entity, a power or property. In what I take to be Bird's most felicitous reformulation of the problem, he construes it as one concerning the determination of property essences: "According to the dispositional essentialist, ...the essence of...a property is determined by its relations to other properties." (2007a: p. 137) Indeed, when K. Fine writes in his seminal paper that "one of the central concerns of metaphysics is with the identity of things, with what they are" (1994a: p. 1), he uses "identity" not in a relational sense, but in the sense of essence. Bird confesses a neo-Aristotelian construal of essence when he writes that he will "follow Aristotle in taking the essence of an entity to be that whereby a thing is what it is" (2007a: p. 137), and he insists that he is concerned with a conception of "*real* essences" that "concern the nature of the property in question and are not merely reflexions of the meanings of the corresponding terms." (2007a: p. 45) With the ordinary relational

sense of “identity” in mind, one may ask, for example, “What about Hesperus and Phosphorus?”, and the answer is a relational statement of identity, “They are identical, Hesperus = Phosphorus.” In the essentialist sense of “identity”, in contrast, one can ask concerning one particular object, “What about Socrates?”, and the reply is not a relational statement, but a loaded instance of predication, “Socrates is essentially human.” We may thus distinguish identity in the essentialist sense as monadic identity from identity in the ordinary relational sense, because in a typical statement of essence we predicate a monadic property (*human*) of the object in question.

In Fine’s canonical notation (1995: p. 241), facts of essence are expressed by prefixing a sentence such as “Socrates is human” with a relativized box operator to yield a sentence “ $\Box_{\text{being Socrates}}$  Socrates is human”. Thus, it is due to the essence or (monadic) identity of the object(s) specified by the predicate in the index, Socrates, that Socrates is human. For our limited purposes, we may simplify matters by admitting singular terms for particular entities in the index and approaching a “predicational” instead of a “sentential mode” (1994b: p. 54) by writing an indexed box followed by a monadic predicate, as in “ $\Box_{\text{Socrates}}$  being human” or, more formally, “ $\Box_{\text{Socrates}} \lambda x: x \text{ is human}$ ”. The dispositional essentialist’s claim that the property of electric charge, *Q*, is essentially dispositional may then be written as:

$$\Box_Q \lambda x: \forall y: y \text{ has } x \rightarrow (y \text{ is disposed to experience an electric force } F \text{ in an electric field } E),$$

in words: charge *Q* is essentially such that every particular that has it is disposed to experience force *F* in a field *E*.

With regard to a metaphysically principled issue such as the purely relational determination of essences, it seems wise to focus on the most austere available construal of real essence. First, Fine introduces neo-Aristotelian essence in terms of a revival of the idea of real definition (1994a; see also 1994b: pp. 66–69). For example, we may not only say that our notion of {Socrates} is defined in terms of a set with a certain member, but that the singleton itself, as an object, is defined as the set that has Socrates as its sole member. Having Socrates as a member is essential to the singleton by being a constituent part of the set’s real definition. This explains why it is not also true that Socrates is essentially a member of the singleton, for that is not part of Socrates’s real definition. For an Aristotelian, Socrates’s real definition would rather be being such-and-such matter (bones, flesh) in the form of a human being. Likewise, containing oxygen is essential to water, in that oxygen features in the real definition of water, i.e. being hydrogen and oxygen bonded in a certain manner. Secondly, I suggest that we target a narrow notion of constitutive rather than a liberal notion of consequential essence (cf. Fine 1994b: pp. 56–61; see Koslicki 2012: pp. 190–195 for a critical defence of constitutive essence vis-à-vis Fine’s highlighting of consequential essence; cf. Wang 2019: pp. 43–44). It follows from the real definition of being the set with Socrates as its sole member that {Socrates} has Socrates as a member and is such that  $1 + 1 = 2$ , or that everything is self-identical. But these inferred properties are not, in the constitutive sense, essential to the set, as they are not part of its real definition: “constitutive essence is directly definitive of the object.” (Fine 1994b: p. 57) Arguably we ought to aspire to understand the exact nature of (alleged) pure potencies and not content ourselves with an undifferentiated

bunch of things that the dispositionalist assumes to follow from that nature. Thirdly, we ought to focus on immediate rather than mediate essence (cf. Fine 1994b: pp. 61–62). If being human is essential to Socrates and having Socrates as a member is essential to {Socrates}, those two facts of essence may be chained so as to yield the result that {Socrates} essentially has a member that is human. But having a member that is human is not, in the immediate sense, essential to the set, as it is not part of the set's real definition, which is being the set that has Socrates as its sole member.

Thus, a dispositional essentialist may hold that the real definition of charge Q is that having this property bestows things with the disposition to experience F in E and that therefore, in the immediate and constitutive sense, bestowing that disposition is essential to Q. Yet she would deny that in that same sense it is essential to Q to bestow that disposition and being such that  $1 + 1 = 2$ , or that everything is self-identical, as one would have to say under a consequential account; and she would deny that in the immediate-constitutive sense it is essential to Q to bestow a disposition to experience something that causes acceleration when in E, as one would have to say under the mediate account of essence if it is assumed that it is essential to force to cause acceleration.

In order to be able to capture SDM, the notion of essence must be demanding in a fourth way as well. The “strong” part of SDM amounts to the view that there is strictly nothing more to potencies than their essential dispositional profile. Bird goes so far as to state that “potencies just are their dispositional powers.” (2007a: p. 46) We may adopt a strengthened version of the essentiality operator, “ $\Box^*$ ” with indices, in order to state that the predicate that follows specifies the full or complete essence of the entity in question. In this demanding sense, we would maintain that an entity's full essence reveals its complete “ontic content”, as we may perhaps dub what Aristotle and Fine refer to as *what an entity is*. I assume that full essence is the target of real definition. For example, we want to be able to say, and perhaps want to endorse, that having Socrates as its sole member is the full essence of {Socrates}. The view would be that the singleton is not a self-standing individual that is somehow related by set membership to Socrates and only to him, but that there is strictly nothing more to the singleton than set formation applied to Socrates alone. Similarly, the contention of SDM clearly is that, say, charge is not the property that it is partly due to a primitive particularity, individuality, or haecceity, in the way an Armstrongian “thick” particular is the thing it is partly due to the “thin” particular it involves (1989: pp. 94–96). That would allow for two possible properties having the very same dispositional profile but being different due to their distinct haecceities, a case explicitly rejected by Bird (2007a: pp. 72–73). Nor is charge the property it is partly due to a purely qualitative, quiddistic aspect, for SDM is explicitly opposed to quidditism. Instead, the position is that charge consists in nothing more than dispositional relations to other properties such as field strength and force.

It may be thought that facts of full essence are special cases of relational identity after all. For it could seem that we can specify the full essence of {Socrates} by saying that the singleton *is* the set that has Socrates as its sole member. But first, that “is” can hardly be ordinary identity. In one way or another, it must be a specifically essentialist “*IS*” in order to express the intended fact of essence (cf. Fine 2015: p. 308). Secondly, the view presupposes that full essence must always be individuating,

so that there can be no two different entities with the same full essence and each entity of the kind in question has its unique full essence. This assumption, however, could be contended. For example, mathematical structuralists (Shapiro 2008) may hold that  $i$  and  $-i$  in the complex numbers plane are numerically distinct even though they are not distinguished by their full essences, as they are both exhaustively characterised by the  $i/-i$ -role of, say, being square roots of  $-1$ . It would seem that in such cases statements of (full) essence are irreducibly plural:  $i$  and  $-i$  ARE the two different square roots of  $-1$ . The crucial point here is not that indistinguishability of full essence across different things really occurs in any particular case, but that essence and individuation are two different notions. CRO is best construed as a problem concerning essence, not individuation.

### 3 CRO constitutes a *prima facie* challenge to SDM of accounting for a relational determination of property essences

When Bird writes that the essence of a property is determined by its relations to other properties, we may ask what should be meant by “determination”. Bird is explicit that CRO is not an epistemic challenge concerning the empirical accessibility of strong potencies (2007a: pp. 133–135; cf. Wang 2019: p. 46). Determination in a descriptive or conceptual sense, as when one says that an object is determined by applying a suitable concept to it, is not the issue either (cf. Wang 2019: p. 46 on a “semantic thesis”). It may well be the case that we can provide a conceptually coherent description of the intended purely dispositional essence of a potency but that nevertheless a serious metaphysical problem arises of how any entity can have that full essence. This suggests that CRO ought to be construed as a problem concerning the purely relational metaphysical determination of essences of pure potencies (cf. Ingthorsson 2012: p. 532).

In a later paper, Lowe himself (2010: pp. 13–14) rephrases CRO as a challenge concerning the individuation of dispositional properties. First, however, it is far from clear why the strong monist should be committed to claiming that the dispositional essences of properties are individuating. Suppose the monist manages to account for a purely relational determination of property essences. In principle, she could admit different properties with the same essential profile, just as  $i$  and  $-i$  play the same mathematical role in the complex plane, or declare herself ignorant on the question whether two or more different properties can have the same full essence. Secondly, a focus on individuation would distract from the more basic and more urgent problem of how essences, individuating or not, can be determined in a purely relational manner at all. The target of CRO, after all, is dispositional essentialism, not a dispositional “individuationism”.<sup>2</sup>

<sup>2</sup> Lowe himself allows for entities that are not individuals, because they are not individuated, and mentions entangled electrons as a possible example (2012: p. 217). Given this principled possibility, it would have been more plausible to construe CRO as concerning the determination of identity in the (essentialist) sense of what an entity is than to focus on individuation.

In an initial characterisation of CRO, Bird offers a fruitful analogy to semantic determination: “if one holds that all words had their meaning given by explicit definitions, then it is clear that the chains of definitions would have to be circular and that this circularity is vicious.” (2007a: p. 132) In the relevant sense, explicit definition involves a direction of semantic priority, in that the meanings of the defining expressions are semantically prior to the meaning of the defined expression. The observation is compelling: on the assumption that the meanings of all expressions are given by explicit definition in that sense, no meanings whatsoever can come about, because the chains of definition would either run in a circle or into infinity. Similarly, when essence is construed in terms of real definition, it is highly plausible that essence involves a direction of ontological or metaphysical priority. Arguably, the ontic material featuring in the real definition of an object is metaphysically prior to the object defined.

In his original formulation, Lowe uses phrases strongly indicating metaphysical priority when he writes that on SDM, no property *gets* its identity *fixed*, because each property *owes* its identity *to* another (2006: p. 138).<sup>3</sup> Likewise, Bird’s formulations that powers *constitute* what it is to be a certain potency (2007a: p. 72) and that relations to other properties *determine* a potency’s essence (2007a: p. 137) suggest metaphysical priority. In Fine’s framework, the very fact that field strength *E* and force *F* feature in the assumed essence of charge *Q* amounts to the fact that *Q* ontologically depends on *E* and *F* (Fine 1995), just as {Socrates} depends on Socrates in a sense entailing metaphysical priority of the member over the set. Similarly, if oxygen features in the real definition of water, then oxygen is *ipso facto* revealed as metaphysically prior to water. Let us therefore work with a construal of essence as involving metaphysical priority. We will reconsider this issue of priority in Sects. 9–10. As in the case of semantic definition, the observation is compelling that no essences can arise if the chains of real definition run in a circle or into infinity.

More accurately, reflecting on the two dilemmatic horns of vicious circularity and of a vicious regress, it seems reasonable to adopt a *principle of non-cyclicity*, which says that in no chain of facts of (full) essence,  $\Box_{x_1}^* \varphi_1, \Box_{x_2}^* \varphi_2, \dots, \Box_{x_n}^* \varphi_n$ , the starting object  $x_1$  may feature in property  $\varphi_n$  (cf. Fine’s rejection of reciprocal constitutive essences in 1994b: p. 95, and Fine 2015: p. 307 on the asymmetry of essentialist *IS*) and a *principle of well-foundedness*, which says that every (non-cyclic) chain of facts of essence has an end (cf. J. Schaffer’s principle in 2010: p. 37 that “all priority chains terminate”; for proper formulations of well-foundedness for grounding see Bliss & Priest 2018: p. 6 and Dixon 2016). Non-cyclicity would be violated, for example, if it were assumed that charge essentially bestows the disposition on particles to experience a force in an electric field and that, in turn, electric field strength essentially bestows the disposition (say, on spacetime points) to exert

<sup>3</sup> Note that while Lowe (unfortunately) rephrases CRO as a problem concerning individuation, he explicitly presents it as a problem about determination and indicates that by “fixing” of identities he has always meant metaphysical determination: “individuation...is a *determination relation between entities*: the relation between *x* and *y* that obtains when *x* determines or ‘fixes’...*which* entity of its kind *y* is.” (2012: p. 217; emphasis in the original).

forces on charged particles. Well-foundedness may be contested for the priority relation of grounding, either in principle (on metaphysical infinitism, see Bliss & Priest 2018: pp. 9–10, 17–28) or for special situations (cf. Fine 2001: p. 27: if infinite descending mereological complexity is possible and if parts ground their wholes, then there can be portions of reality with grounds to infinity). However, we need not investigate and defend the two principles in more detail at this point. For the point of the asymmetry reply to CRO is not to defend either cyclic or infinite chains of facts of essence. Rather, its promise is to understand, in a holistic way, all property essences as determined by a relational *pattern*. (On metaphysical coherentism in contradistinction to structuralism see Sect. 10.)

Bird rephrases CRO not only as concerning *determination* of essence and identity, but also, and more officially, as concerning essence and identity being *determinate* rather than *indeterminate* (2007a: pp. 136–137). Note first that regarding essence (or nature, 136), determinateness is not the same as individuation. Words can have determinate meanings without having unique meanings; synonymy is not semantic indeterminacy. Likewise, objects or properties may have determinate essences without having unique, individuating essences.

Secondly, with respect to identity in the relational sense, we must further distinguish between identity (and difference) of things in one and the same possible world and transworld identity or identity between things in different possible worlds (cf. Lowe 2012: pp. 223–226). Bird's worry with regard to CRO is that "identity of dispositional character" might be "insufficient to account for transworld identity." (2007a: p. 136) Determinateness of transworld identity, however, is closely linked to the question of whether full essences are individuating. If all things of a given kind have unique, individuating full essences, then those essences dictate determinately true and false transworld identities of the ordinary singular form  $a=b$ ; if not, it is an open question whether identities of that singular form are generally demanded. So it seems that like the demand of individuation, the demand of determinate transworld identities distracts from the more basic and more urgent question of how essences could be metaphysically determined in a purely relational manner at all. In the reconstruction and assessment of Bird's supervenience claim that will follow, we will keep an eye both on the question of whether this claim lives up to the ambition of accounting for transworld identities and on the issue of to what extent determinateness of transworld identities is a reasonable constraint on a structuralist ontology of properties in the first place.

Thirdly, essence and transworld identity are closely linked, since in the modal framework, facts of essence are formulated as *de re* necessities ( $a$  is necessarily  $F$ ) and the standard semantics of such necessities rests on a notion of identity of entities across different worlds ( $a$  is  $F$  in all possible worlds in which  $a$  exists). We may therefore approach the question of whether asymmetry of relational patterns can account for a metaphysical determination of identity in the (monadic) sense of essence by investigating whether it accounts for relational identity in the transworld sense.

Finally, however, determination of essence in the post-modal sense remains the crucial problem. For suppose we grant that if a property consists in nothing more than its dispositional relations, then every possible property with the same built-in relations is identical to that property (cf. Bird's rejection of (QB1) in 2007a: p. 72).

Still, the sceptic asks how there can be a realm of entities the essences of which dictate such criteria of transworld identity. This sceptical challenge is reasonably motivated. For if a range of non-dispositional properties, or at least of properties with a non-dispositional aspect, is given, an account of a determination of essences of purely dispositional properties in terms of those given properties as stimuli and manifestations may, perhaps, at least get started. But if there is no such basic range of properties, CRO diagnoses that the assumed determination of dispositional essences can only turn out viciously circular or viciously regressive.

In sum, if CRO is construed as demanding an account of how the essences of all physical properties can be metaphysically determined in a purely relational manner, it in fact constitutes a *prima facie* challenge to SDM, one that demands a theoretic answer.

In the following two sections, I will show that Bird's supervenience claim can be interpreted as a non-trivial thesis about asymmetric graphs that can be rigorously proved. In the subsequent sections, however, I will argue that in spite of its technical correctness, the asymmetry reply to CRO fails metaphysically, because the supervenience in question reveals no metaphysical determination of property essences.

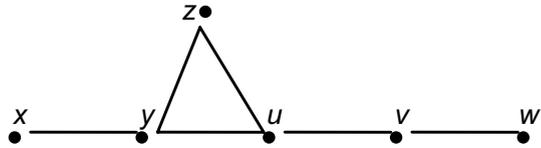
#### 4 The asymmetry reply says that identity and distinctness in asymmetric structures supervene on relational patterns

The idea of Bird's graph-theoretic reply to CRO is that the problem of either circular (or cyclical) or regressive chains of determination can be circumvented, because provided it has the form of an asymmetric graph, the total pattern of dispositional relations between the properties fixes all the properties' essences simultaneously. We need not rehearse the official set-up of mathematical graph theory.<sup>4</sup> Basically, a graph is a certain range of objects, called its "nodes" or "vertices", together with a range of occurrences of a certain relation R holding between some of these objects, the graph's "edges". Since we are not concerned with the distinction between systems and structures that shapes mathematical structuralism (Shapiro 1997), I shall call such a range of objects with its token relations a *structure*. For the dispositionalist the objects (nodes) are the physical properties, relation R is Bird's second-order manifestation relation that holds between a power and its manifestation, and the edges are the different tokens of R holding between properties.<sup>5</sup>

A structure is *asymmetric* just in case there exists no non-trivial automorphism on it. This means that there is no non-trivial permutation of the objects in the structure, i.e. no one–one mapping  $\pi$  of objects on objects other than the identity mapping, that fully maintains the obtaining and non-obtaining of relation R, so that  $R(x,y)$  iff  $R(\pi(x),\pi(y))$ . A very simple symmetric structure consists of two objects with a symmetric and irreflexive relation between them. Obviously when the two objects are mapped on one another the relational pattern is maintained. No such mapping exists

<sup>4</sup> For the basics see Diestel (2000: ch. 1). See Dipert's critique of the set-theoretic approach (1997: pp. 343–345) and Oderberg's reaction (2012: pp. 213–220).

<sup>5</sup> I will adopt Bird's simplification and not take into account a disposition's stimulus.

**Fig. 1** An asymmetric structure

for the asymmetric structure depicted in Fig. 1 (cf. Bird 2007a: p. 140 Fig. 6.2, with a labelling by variables for further purposes), as is evident from the figure’s geometrical asymmetry.

Suppose that the physical properties form such an asymmetric structure. The proposal seems to be that then each property is characterised by a unique position within the structure and that this position can be specified just by describing how the manifestation relation is distributed without reference to any particular property the identity of which is presupposed. The total relational pattern alone suffices to determine all identities of properties at one stroke – or so the claim.

Bird’s official reply to CRO consists in a supervenience claim to the effect that, as far as asymmetric structures are concerned, the identity and distinctness of the objects in a structure supervene on the structure’s pattern of relations.<sup>6</sup> The subvening properties concern the pattern of relations holding within the graph, the manner in which relation  $R$  obtains between the graph’s objects. The supervening properties are expected to concern the “identity and distinctness of the vertices”, hence identity in the relational sense. I therefore suggest that we start with construing the supervening properties as cardinality properties, i.e. properties specifying the number of numerically different objects in a structure – what mathematicians call a graph’s *order*.

The supervenience thesis under consideration then becomes: for asymmetric structures, their number of objects supervenes on their relational pattern. Application of the general definition of strong supervenience yields the thesis that any two possible asymmetric property structures that differ with respect to the number of their objects also differ with respect to a property that concerns the pattern of relations holding between the objects.

An algebraic consideration reveals that the supervenience thesis should indeed obtain. Two structures are alike in their relational pattern just in case there is an *epimorphism* (or surjective homomorphism) between them, i.e. a total surjective function  $f$  mapping the objects of the first onto those of the second so that  $R(x,y)$  iff  $R(f(x),f(y))$ . Two structures have the same number of objects just in case there is a bijection, or one–one mapping, between the objects of the one and the objects of the other. So in order to show that for asymmetric graphs sameness in relational pattern entails sameness in the number of objects, it suffices to show that for such graphs every epimorphism is a bijection. Assume for *reductio* that there are two

<sup>6</sup> See his thesis (S\*): “The identity and distinctness of the vertices of a graph can supervene on the structure of that graph.” (Bird 2007a: p. 139) By “structure” he means what I call “pattern of relations”.

asymmetric structures with an epimorphism which is not bijective because it maps two different objects  $a$  and  $b$  of the first onto one and the same object  $a'$  of the second. Clearly then  $a$  and  $b$  cannot be distinguished by the way they are R-related to the other objects in their structure; for if they were, the obtaining and non-obtaining of R could not be preserved by mapping  $a$  and  $b$  both onto  $a'$ . But then there is a relations-preserving one–one mapping of the objects of the first structure onto themselves that maps  $a$  onto  $b$  and vice versa—a non-trivial automorphism, in contradiction to the assumption that both structures are asymmetric.

This result is not identical to the observation that graph order is an invariant property, which holds for symmetric and asymmetric graphs alike. Since invariants are defined as properties shared by all isomorphic graphs, isomorphic graphs trivially share their order because every isomorphism is a bijection and bijections preserve cardinality. By contrast, a universal thesis of a supervenience of order on relational patterns is true only with respect to asymmetric structures. However, this supervenience cannot be all that Bird is up to, partly because there are also *symmetric* structures the patterns of which demand a certain number of objects.<sup>7</sup> A model-theoretic instead of an algebraic construal will not only do better justice to the wording of Bird's claim; it will also enable us to go beyond a thesis concerning relational identity and difference of objects in structures and establish a result specific to asymmetric structures that offers candidates for the purely dispositional identities of properties in the monadic, essentialist sense.<sup>8</sup>

I will construe the subvening relational pattern properties in terms of structures satisfying what I will call form descriptions. Consider once more the example of the asymmetric structure depicted in Fig. 1. Assume an arbitrary one–one mapping of the objects in the structure onto singular variables “ $x$ ”, “ $y$ ”, ... (equivalent to a labeling of the objects), as depicted in the figure. A complete form description of the structure results by conjoining descriptions of all cases in which relation R obtains as well as of those in which it does not obtain, in the following way:

$$(*) \text{Rxy} \wedge \text{Ryz} \wedge \text{Ryu} \wedge \text{Rzu} \wedge \text{Ruv} \wedge \text{Rvw} \wedge \neg \text{Rxz} \wedge \neg \text{Rxu} \wedge \text{etc.}$$

The idea of the supervenience thesis now is that not only does the present structure happen to satisfy form description (\*) with six objects, but *every* asymmetric structure that satisfies it without containing irrelevant extra objects contains exactly six different objects. The same does not universally hold for symmetric structures. For example, the form description of a structure of two objects in a symmetric and reflexive relation R (“ $\text{Rxy} \wedge \text{Ryx} \wedge \text{Rxx} \wedge \text{Ryy}$ ”) is also satisfied by a single object R-related to itself. Description (\*), by contrast, *cannot* be satisfied with less than six objects.

<sup>7</sup> See Bigay (2010: p. 46). A simple example is the symmetric structure of two nodes standing in a symmetric but irreflexive relation.

<sup>8</sup> The following proofs are tailor-made for Bird's claim. For advanced model-theoretic results concerning different kinds of structural symmetry and indiscernibility see Caulton & Butterfield, Theorem 2 (2012: p. 58) in particular, which, however, does not exactly cover Bird's claim.

## 5 In asymmetric structures, the number of objects supervenes on relational patterns, and they provide unique role properties for their objects

To generalise, assume a structure-spanning two-place relation  $R$ , such as Bird's manifestation relation, and let predicate "R" stand for  $R$ .<sup>9</sup> Consider possible purely relational *form descriptions* of structures: conjunctions of open sentences " $R\alpha\beta$ " and " $\neg R\alpha\beta$ " with singular variables " $x_1$ ", " $x_2$ ", ..., " $x_n$ " in the place of the meta-variables " $\alpha$ " and " $\beta$ ". A variable *assignment* is a function  $\lambda$  that assigns objects in a structure to variables " $x_1$ ", " $x_2$ ", .... A structure *satisfies* a form description *under*  $\lambda$  (in short:  $\lambda$ -satisfies it) just in case all conjuncts come out true given that assignment. (More accurately, " $R\alpha\beta$ " is  $\lambda$ -satisfied iff  $\lambda(\alpha)$  stands in  $R$  to  $\lambda(\beta)$ , " $\neg R\alpha\beta$ " is  $\lambda$ -satisfied iff " $R\alpha\beta$ " is not  $\lambda$ -satisfied, and " $\varphi \wedge \psi$ " is  $\lambda$ -satisfied iff  $\varphi$  and  $\psi$  are both  $\lambda$ -satisfied.<sup>10</sup>) A form description is *plainly*  $\lambda$ -satisfied by a structure just in case it is  $\lambda$ -satisfied and all objects in the structure are values of  $\lambda$  for variables in the description. This only means that the structure involves no extra objects not captured by the description at all; it does not already require that the structure satisfies the description with a least possible amount of objects. A structure (*plainly*) *satisfies* a description (period) just in case it (plainly)  $\lambda$ -satisfies the description under some  $\lambda$  or other.

The supervenience result to be proved then reads:

(SR) Any two possible asymmetric structures that differ with respect to their number of objects always also differ with respect to which purely relational form descriptions they plainly satisfy.

As usual, an assignment need not be one–one: it may assign the same object to two or more different variables. Assume, however, one particular assignment  $\lambda^{\leftrightarrow}$  that one–one maps the objects of a structure to variables " $x_1$ ", " $x_2$ ", ..., " $x_n$ ". The structure then evidently plainly  $\lambda^{\leftrightarrow}$ -satisfies a form description " $S(x_1, x_2, \dots, x_n)$ " that is constructed as follows:  $S$  contains as a conjunct formula " $R\alpha\beta$ " just in case the object assigned to  $\alpha$  stands in  $R$  to the object assigned to  $\beta$  and otherwise contains the negation " $\neg R\alpha\beta$ ", and  $S$  contains nothing else. We shall say that " $S(x_1, x_2, \dots, x_n)$ ", or  $S$  for short, is the structure's *complete form description*<sup>11</sup> under  $\lambda^{\leftrightarrow}$ : it captures all facts concerning the obtaining and non-obtaining of  $R$  in the structure and nothing more. A description is a structure's complete form description, period, just in case it is one under some assignment or other. For simplicity, we can speak of *the* complete form description of a structure under  $\lambda$ , since two different such descriptions merely differ in the order of their conjuncts.

For further purposes, we begin by showing something stronger than is required for SR: an asymmetric structure's complete form description under a one-to-one assignment  $\lambda^{\leftrightarrow}$  is not also satisfied by the same structure under any assignment that

<sup>9</sup> I am grateful to Nick Haverkamp for his enormous help in elaborating the proofs in this and the following section.

<sup>10</sup> I use double quotation marks both for ordinary and for quasi-quotes.

<sup>11</sup> I use open formulas instead of sentences (see the state descriptions in Caulton & Butterfield 2012: p. 59 et seq.) because they better suit the idea that nothing more than a structure's relational pattern is specified.

one–one exchanges the objects that the original assignment assigns to variables. More accurately, a *permutation*  $\pi$  of the values of an assignment  $\lambda^{\leftrightarrow}$  is any one–one mapping of those values onto themselves. A *permuted assignment*  $\pi(\lambda^{\leftrightarrow}(\dots))$  for a given assignment  $\lambda^{\leftrightarrow}$  assigns object  $\pi(u)$  to a variable iff  $\lambda^{\leftrightarrow}$  assigns  $u$  to that variable, for some permutation  $\pi$  other than the identity mapping. The thesis is that an asymmetric structure's complete form description under  $\lambda^{\leftrightarrow}$  is not satisfied by it under any permuted assignment  $\pi(\lambda^{\leftrightarrow}(\dots))$ . *Proof:* Consider an arbitrary asymmetric structure's complete form description under an assignment  $\lambda^{\leftrightarrow}$ . Assume for reduction that there is a permuted assignment  $\pi(\lambda^{\leftrightarrow}(\dots))$  under which the description is satisfied, too. For any (not necessarily distinct) variables  $\alpha$  and  $\beta$  in the form description, “ $R\alpha\beta$ ” would then be satisfied under  $\lambda^{\leftrightarrow}$  iff it is satisfied under  $\pi(\lambda^{\leftrightarrow}(\dots))$ . Due to the satisfaction conditions of descriptions under assignments, this means that  $R$  would hold between  $\lambda(\alpha)$  and  $\lambda(\beta)$  iff  $R$  holds between  $\pi(\lambda(\alpha))$  and  $\pi(\lambda(\beta))$ . But then there would be a non-trivial automorphism on the structure, namely  $\pi$ , in contradiction to the structure's assumed asymmetry. (Note that as  $\lambda^{\leftrightarrow}$  has all and only the objects in the structure as its values,  $\pi$  would indeed be a permutation of those objects.)

On this basis, we can establish that if  $S$  is a structure's complete form description (under some assignment) then, for any two different variables  $\alpha$  and  $\beta$  in  $S$ , the non-identity “ $\alpha \neq \beta$ ” logically follows from  $S$ . *Proof:* We now only need to consider a rather special case of non-trivial permutations, namely, permutations that involve nothing more than a swapping of two objects. As every assignment  $\lambda^{\leftrightarrow}$  underlying the construction of a complete form description is a bijection between the variables in the description and the structure's objects, each relevant permutation of this “swapping” kind exchanges two objects,  $\lambda^{\leftrightarrow}(\alpha)$  and  $\lambda^{\leftrightarrow}(\beta)$ , for different variables  $\alpha$ ,  $\beta$  in  $S$  and is the identity mapping for all the other objects in the structure. Let us call such a permutation the  $\alpha/\beta$ -permutation of  $\lambda^{\leftrightarrow}$  for  $\alpha$  and  $\beta$ . The idea in the background is that if there is no non-trivial automorphism on a structure at all, there *a fortiori* is no non-trivial automorphism that simply swaps two different objects and keeps the rest of the structure fixed. From the result proved above it follows that if  $S$  is an asymmetric structure's complete form description under  $\lambda^{\leftrightarrow}$ , then there are no two variables  $\alpha$  and  $\beta$  such that  $S$  is also satisfied under the “swapped” assignment  $\pi(\lambda^{\leftrightarrow}(\dots))$  for the  $\alpha/\beta$ -permutation  $\pi$ . However, since  $S$  is a long conjunction, this means that for any two variables  $\alpha$  and  $\beta$  in  $S$ , some conjunct in  $S$  must change from being satisfied to not being satisfied by moving from  $\lambda^{\leftrightarrow}$  to  $\pi(\lambda^{\leftrightarrow}(\dots))$ . Thus, for any two  $\alpha$ ,  $\beta$  in  $S$ , there is a conjunct in  $S$  which is satisfied under  $\lambda^{\leftrightarrow}$  but not under  $\pi(\lambda^{\leftrightarrow}(\dots))$ . However, moving from  $\lambda^{\leftrightarrow}$  to  $\pi(\lambda^{\leftrightarrow}(\dots))$ , where  $\pi$  is the  $\alpha/\beta$ -permutation, is tantamount to holding  $\lambda^{\leftrightarrow}$  fixed and replacing all occurrences of  $\alpha$  in  $S$  by  $\beta$  and vice versa. Therefore, for any two different variables  $\alpha$ ,  $\beta$  in  $S$ , there is a conjunct  $C$

in  $S$  which is  $\lambda^{\leftrightarrow}$ -satisfied but which, by replacing  $\alpha$  by  $\beta$  and vice versa, is turned into a formula  $C^{\alpha\beta}$  that is not  $\lambda^{\leftrightarrow}$ -satisfied. But  $S$  is complete; so if  $C^{\alpha\beta}$  is not in  $S$  because it is not  $\lambda^{\leftrightarrow}$ -satisfied, then its contradictory must be  $\lambda^{\leftrightarrow}$ -satisfied and hence be a conjunct in  $S$ . The upshot is that for any two variables  $\alpha, \beta$  in the complete form description  $S$  of an asymmetric structure under an assignment  $\lambda^{\leftrightarrow}$ , there are two formulas  $C$  and  $\neg C^{\alpha\beta}$  in  $S$ , each containing  $\alpha$  or  $\beta$  or both, that are contradictories under  $\alpha$ - $\beta$ -exchange, or  $\alpha/\beta$ -contradictories for short, in the sense that  $\neg C^{\alpha\beta}$  is converted into  $\neg C$  by replacing  $\alpha$  by  $\beta$  and vice versa.<sup>12</sup>

Let us now consider assignments in general (that need not be on-one) and say that a formula  $A$  logically follows from a form description  $S$  just in case if  $S$  is satisfied by a structure under an arbitrary assignment, then  $A$  must also be satisfied by the structure under that assignment. If, as has been proved above for asymmetric structures, for any two  $\alpha, \beta$   $S$  contains an atomic conjunct  $C$  as well as its  $\alpha/\beta$ -contradictory  $\neg C^{\alpha\beta}$ , then for any two  $\alpha, \beta$  the non-identity “ $\alpha \neq \beta$ ” logically follows from  $S$ . For assume that both  $C$  and its  $\alpha/\beta$ -contradictory  $\neg C^{\alpha\beta}$  are in  $S$ . By additionally assuming “ $\alpha = \beta$ ”, the exchange of  $\alpha$  and  $\beta$  in  $\neg C^{\alpha\beta}$  regarding  $C$  can be reversed by substitution of assumed identicals, the result being two contradictory formulas  $C$  and  $\neg C$  that refute the assumed identity. To only consider one type of cases, if the conjunct that has its  $\alpha/\beta$ -contradictory in  $S$  is  $C = “R\alpha\delta”$  for some variable  $\delta$  distinct from  $\alpha$  and  $\beta$ , then  $\neg C^{\alpha\beta} = “\neg R\beta\delta”$ , which, when “ $\alpha = \beta$ ” is assumed for reduction, yields “ $\neg R\alpha\delta = \neg C$ ”, so that “ $\alpha \neq \beta$ ” can be derived from  $C$  and  $\neg C^{\alpha\beta}$ .<sup>13</sup>

In sum, from the complete form description  $S$  satisfied (under a suitable  $\lambda^{\leftrightarrow}$ ) by a certain asymmetric structure containing  $n$  objects, all the pairwise non-identities “ $\alpha \neq \beta$ ” logically follow for any two of the  $n$  variables “ $x_1$ ”, “ $x_2$ ”, ..., “ $x_n$ ” in  $S$ . It follows that this form description can only be satisfied by a structure under a bijective assignment with respect to the  $n$  variables. Therefore the description can be plainly satisfied only by a structure with exactly  $n$  objects.

This establishes SR. Consider two asymmetric structures with different numbers of objects  $n$  and  $m$ . Each of them plainly satisfies a complete form description (under a suitable  $\lambda^{\leftrightarrow}$ ). But the first can be plainly satisfied only by structures with exactly  $n$  objects, the other only by structures with exactly  $m$  objects. It follows that neither of the structures plainly satisfies the other’s complete form description. Therefore any two possible asymmetric structures with different numbers of objects always also differ with respect to which form descriptions they plainly satisfy.

In this way, Bird’s official supervenience claim, construed as SR, concerns relational identity and difference of objects in a structure, not monadic identity or essence.

<sup>12</sup> The non-existence of “swapped” assignments follows from asymmetry, and it entails that the structure in question does not collapse in the sense that at least two of its objects can be fused without this making a change to the obtaining and non-obtaining of  $R$ , so that its relational pattern can be realised on a reduced domain. However, a structure of two objects in a symmetric irreflexive relation does not collapse, although its objects can be swapped. So the notion fails to capture a “natural kind” of structures.

<sup>13</sup> Here are the other two cases: (ii) Conjunct  $C$  with its  $\alpha/\beta$ -contradictory in  $S$  contains  $\alpha$  (or  $\beta$ ) twice, as in “ $R\alpha\alpha$ ”, the two conjuncts being “ $R\alpha\alpha$ ” and “ $\neg R\beta\beta$ ”. (iii)  $C$  contains both  $\alpha$  and  $\beta$ , as in “ $R\alpha\beta$ ”, its  $\alpha/\beta$ -contradictory in  $S$  being “ $\neg R\beta\alpha$ ”. In both cases the assumption of “ $\alpha = \beta$ ” leads to “ $R\alpha\alpha \wedge \neg R\alpha\alpha$ ” by substitution of assumed identicals, so that “ $\alpha \neq \beta$ ” logically follows from  $S$ .

The proof of SR, however, provides us with the resources to go beyond a mere thesis of supervenience of cardinality on relational pattern. Intuitively, what strong monists assume as the essences of purely dispositional properties is captured by the properties' total relational roles with respect to all the other properties in the structure spanned by the manifestation relation. Our set-up allows for a precise formulation of such total roles. We start with a complete form description " $S(x_1, x_2, \dots, x_n)$ " of a structure under a bijective assignment  $\lambda^{\leftrightarrow}$ . Select one variable, say " $x_1$ ", and form the existential closure for all the remaining variables. The result " $P(x_1)$ " is an open sentence " $\exists x_2 \exists x_3 \dots \exists x_n S(x_1, x_2, \dots, x_n)$ " that applies to the object assigned by  $\lambda^{\leftrightarrow}$  to the chosen variable " $x_1$ ", provided that the domain of quantification comprises all and only the objects in the structure. More generally, an existentially quantified formula of this kind *applies to* an object *within* a structure just in case the structure satisfies the formula following the quantifiers, " $S(x_1, x_2, \dots, x_n)$ ", under an assignment that assigns the object in question to the single free variable in the quantified formula and objects in the structure to the other variables.

There is such a complete role description " $P(x_i)$ " for each object in the structure. Within the structure in question, " $P(x_i)$ " *uniquely* applies to the value of  $\lambda^{\leftrightarrow}$  for " $x_i$ ",  $\lambda^{\leftrightarrow}(x_i)$ . That is to say, " $P(x_i)$ " expresses a total-role property which is, within the structure, *uniquely* possessed by exactly one object, the one assigned by  $\lambda^{\leftrightarrow}$  to " $x_i$ ". *Proof:* Let us focus on the example of " $\exists x_2 \exists x_3 \dots \exists x_n S(x_1, x_2, \dots, x_n)$ " applying to  $\lambda^{\leftrightarrow}(x_1)$ . Assume for reduction that the formula also applies to some other object in the structure, say  $\lambda^{\leftrightarrow}(x_2)$ . This would mean that the complete form description under  $\lambda^{\leftrightarrow}$ , " $S(x_1, x_2, \dots, x_n)$ ", is satisfied by the structure under some assignment  $\lambda^*$  that assigns  $\lambda^{\leftrightarrow}(x_2)$  to " $x_1$ " and objects in the structure to the remaining variables. However, we already know that an asymmetric structure's complete form description can only be satisfied under bijective assignments.<sup>14</sup> So  $\lambda^*$  would have to be a permuted assignment  $\pi(\lambda^{\leftrightarrow}(\dots))$ . But we already know that due to its asymmetry, the structure does not satisfy S under any permuted assignment.

In sum, an asymmetric structure with  $n$  objects is not only characterised by a complete form description that can be plainly satisfied only with exactly  $n$  objects. By  $(n-1)$ -fold existential closure, the description yields expressions of  $n$  different total-role properties that are uniquely possessed by the structure's different objects.

## 6 No determination of identity in the sense of essence is established

Identity and distinctness of objects in asymmetric structures, then, indeed supervene on the relational network in the sense that for such structures, the number of numerically distinct objects supervenes on the structures' relational patterns. In addition, an asymmetric structure's relational pattern specifies unique total relational role properties by which the numerically different objects are distinguished and

<sup>14</sup> This proof via the bijectiveness of possible assignments, in contradistinction to one in terms of cardinality of the object set, extends to infinite structures once infinite languages for form descriptions are admitted. Cf. Caulton & Butterfield (2012: p. 61 n. 38).

differentiated. Any two of them are thereby absolutely discernible, i.e. discernible by different monadic though possibly extrinsic properties (cf. Caulton & Butterfield 2012: pp. 46–50). These results are not trivial. First, SR is not the trivial observation that order is an invariant (see Sect. 4). Secondly, complete form descriptions entail the number of different objects in plainly satisfying structures without involving a notion of numerical identity or difference. The form descriptions only contain the logical vocabulary of first-order logic *without* identity and the two-place predicate “R”. Nor are any formal constraints presupposed for relation R. It can be reflexive, irreflexive, or neither; symmetric, asymmetric, or neither; and so on. All that counts is the asymmetric distribution of R over the structure’s objects, where asymmetry is defined by the lack of a non-trivial automorphism. (However, if R is assumed to be symmetric, as it is in undirected graphs, it must not be reflexive, since in that case asymmetry of a pattern requires that R is instantiated in the form  $R_{xy} \wedge \neg R_{xx}$ .) Thirdly, the unique role properties that distinguish an asymmetric structure’s objects are specified solely with the help of a relational predicate “R” and the resources of first-order predicate logic without identity. In particular, the predicates expressing such roles do not already involve singular reference to any other particular object in the structure. An asymmetric structure’s objects can be absolutely distinguished in a purely relational manner.

Still, it remains to be examined whether these technical results provide the dispositionalist with a satisfactory reply to CRO, construed as a challenge to account for the metaphysical determination of property essences on a purely relational basis. We cannot expect a direct reply to that challenge, as the challenge is formulated in post-modal terms of identity in the sense of essence and of determination, while the supervenience claim is in terms of relational identity and the modal notion of strong supervenience. Still, given that essence can plausibly underlie transworld identity and determination can underlie strong supervenience, we can examine whether this claim is indicative of an account of a relational determination of dispositional essences.

Let us first bracket the issue of determination and ask whether the supervenience result can account for identities in the sense of *essences* by relational patterns. Bird’s interest is in a determination of transworld identities for properties (2007a: pp. 136–137). Like transworld identity, strong supervenience is a modal notion, one that is explained in terms of different possible worlds or, more generally, *possibilia*. It might be expected that in the supervenience result, the modal strength of strong supervenience somehow combines with the fact that the supervening properties concern relational identity so as to provide an account of identity of objects across possible worlds. However, the relationships of numerical identity and difference between properties that Bird presents as supervening on relational patterns are relationships between properties *within one and the same structure*; the relevant sense of identity is world-internal identity. The result is silent on relationships of identity and difference between objects in different possible structures, i.e. on transworld identity. It is incapable of establishing that if property F in a possible structure 1 plays the same total role within *its* structure that property F\* plays in a possible structure 2, then F and F\* are identical. We may grant for the sake of argument that strong supervenience reveals that the supervening properties are “fixed” by the subvening properties

in some sense. Still, the demonstrated supervenience of identity and difference on relational pattern is not the targeted fixing of transworld identities.

What may be taken to be relevant to transworld identity is not the supervenience result per se but the finding that asymmetric structures provide their objects with unique role properties. This can assure us that as long as only asymmetric property structures are concerned, we can, without running the risk of generating a contradiction, identify  $F$  in one world and  $F^*$  in another whenever  $F$  and  $F^*$  play the same total role within their respective structures. For if total roles within structures are unique, doing so can never result in identifying  $F$  in one world with two different properties  $F^*$  and  $G^*$  in another. (For worries concerning combinations of intra-world and transworld identities see Lowe 2010: pp. 17–18, Lowe 2012: pp. 223–226.)

It may be urged that this guarantee is a result in its own right – and perhaps all that ch. 6 of Bird (2007a) is about and all that Bird aims at when he demands determinateness of transworld identity. However, there are reasons for ranking that result as rather minor. First, as pointed out in Sect. 2, CRO is most fruitfully read not as a challenge to account for individuation of pure potencies, but as challenging the very idea that property essences can be metaphysically determined in a purely relational manner at all. Granted, under the assumption of asymmetry, singular transworld identifications of properties in virtue of their total roles will never lead to a contradiction of the form  $F=F^*$ ,  $F=G^*$ , but  $F^* \neq G^*$ . Yet this fact does not explain how there can be properties with purely relational essences that dictate such transworld identities. Also, as we will see, symmetric structures need not lead to inconsistent singular identities.

Secondly, to focus on asymmetric structures is to focus on absolute discernibility, i.e. discernibility of objects by different monadic though possibly extrinsic properties. However, for the result that identity and difference supervene on relational patterns in the sense that the number of objects in a structure supervenes on its pattern, the assumption of asymmetry is not required. Consider a very simple structure of just two objects  $a$  and  $b$  in an irreflexive though symmetric relation  $R$ . Objects  $a$  and  $b$  are weakly discernible due to the irreflexivity of  $R$  (cf. Caulton & Butterfield 2012: pp. 46–50). No structure of the same pattern has less than two objects. The structure is symmetric, though. It does not specify unique role properties for  $a$  and  $b$ . Similarly,  $i$  and  $-i$  in the complex plane are weakly distinguished by the relation of having a square of their difference  $((-i)-i)^2$  of 4, in which no number stands to itself. Yet they play no different mathematical roles.

An example of a symmetric pattern for dispositional (or inherently causal) properties is sketched by J. Hawthorne (2001). To vary a bit, suppose a potency  $P$  reacts with manifestation  $M$  when the stimulus is either potency  $S_1$  but not potency  $S_2$ , or  $S_2$  and not  $S_1$ , and with  $M'$  when the stimulus is both  $S_1$  and  $S_2$ ; suppose further  $S_1$  and  $S_2$  are not distinguished by their stimuli and manifestations and that  $M$  and  $M'$  are somehow distinguished. Potencies  $S_1$  and  $S_2$  would be weakly distinguished by the relation of its making a difference to the activation of  $P$  whether only one of them or both are present. Clearly this relation is irreflexive, as for no single property  $X$  it can make a difference whether only one of  $X$  and  $X$  or both  $X$  and  $X$  are present. But the two potencies are perfectly alike in their total role. Hawthorne has no

problem with admitting such a pattern because he is not a pure dispositionalist: his inherently causal universals have a primitive individuality in addition to their causal profiles. For him, there would be a fact of the matter of whether  $S_1$  or  $S_2$  is instantiated in a particular case, and one may determinately refer to, say,  $S_1$  as the universal that causes  $M$  in *that* particular situation (2001: pp. 213–214).

The case of potencies  $S_1$  and  $S_2$  represents an intuitively possible scenario. Unless she can present principled reasons that exclude symmetric patterns, the strong monist should accommodate it (cf. Lowe 2012: p. 223 against the apriori exclusion of symmetric power structures). On strong monism, we would hardly be able to determinately refer to one property as contrasted with another that plays the same total role in the same structure. What is more, there would not appear to be a fact of the matter of whether only the one or only the other is present in a particular case. There can nevertheless be a fact of the matter of whether only one of them or both are present. And we can refer to the two properties in the plural: the properties that play such-and-such a total dispositional role,  $S_1$  and  $S_2$ . We would not be able to give a determinate answer to the question of whether  $S_1$  in our symmetric potency structure is identical to  $S_1^*$  in another possible world, even though  $S_1$  and  $S_1^*$  do not differ in their total role. But we would not be able to give that answer because we would not be able to formulate the question in the first place. Reference to properties  $S_1$  and  $S_2$  in our structure and to properties  $S_1^*$  and  $S_2^*$  in a structure in another possible world would be irreducibly plural. The strong monist may still highlight the determinate truth of an irreducibly plural identity to the effect that the potencies that play a certain total role in our world *are* the same as the potencies playing the same total role in that other world; just as the mathematical structuralist may insist that the square roots of  $-1$  in our world are the same as the square roots of  $-1$  in any other possible world. No identity that can be formulated would be indeterminate in truth-value. For the same reason no inconsistencies of the sort  $S_1 = S_1^*$ ,  $S_1 = S_2^*$ , but  $S_1^* \neq S_2^*$  would arise; such singular identities could not be stated in the first place.

Thirdly, maybe this irreducible plurality seems peculiar. If so, however, that peculiarity only brings to light the peculiarity of the very structuralist idea of properties consisting in nothing more than relations to each other, just as the absolute indistinguishability of  $i$  and  $-i$  brings to light the characteristic of Shapiro-style mathematical structuralism. Strong monists who abhor symmetric property structures owe us an account of a purely relational metaphysical determination of property essences that would reveal why symmetric structures are impossible on principled grounds. Given that they generate neither inconsistent nor indeterminate identities, it is hardly convincing to simply stipulate an asymmetry constraint that excludes them by brute force.

In sum, the supervenience result indicates no determination of property *essences* because it concerns the supervenience of intra-structural identities and differences on asymmetric patterns while it is silent on transworld identity. What is true is that asymmetry is the condition under which objects in structures are assigned unique total roles, so that they are absolutely distinguishable. This is a rather minor result, though, first, because no account is provided of how there can be property essences that dictate transworld identifications of properties by their total roles and, secondly, because symmetric structures with only weakly distinguishable properties

are intuitively possible and would generate neither inconsistent nor indeterminate transworld identities.

## 7 No metaphysical determination of identity is established

If the supervenience result does not establish that identity in the required sense of *essence* can be accounted for in a purely relational manner, does it at least reveal how identity in any relevant sense can be metaphysically *determined* by relational pattern alone?

A first well-known point is that even strong supervenience that has the strength of metaphysical necessity does not by itself amount to metaphysical determination (Bennett and McLaughlin 2018, Sect. 3.5). Even one-way supervenience does not. Density one-way supervenes on mass plus volume, but mass, likewise, one-way supervenes on density plus volume and volume on mass plus density (Fine 2001: p. 11). Such cases of supervenience violate the directedness of metaphysical determination: given that determination is a relationship of metaphysical priority, it cannot be the case that volume helps to determine density and at the same time density helps to determine volume.

It is hard to find such a directed metaphysical determination of identity and distinctness by relational pattern described in the detailed proof of SR. At its core SR says that an asymmetric structure's plainly satisfying a certain complete form description entails its containing exactly so-and-so many different objects (that play such-and-such distinguishing total roles). After all the stage-setting in the proof, the crucial step is that an asymmetric structure's complete form description entails the pairwise non-identities " $\alpha \neq \beta$ " for every two different variables  $\alpha$  and  $\beta$  in the description. The entailment is logical consequence in a first-order logic with identity. The relevant logical inference patterns are most simple. For example, if the two conjuncts in a complete form description that are  $\alpha/\beta$ -contradictories are " $R\alpha\delta$ " and " $\neg R\beta\delta$ ", with  $\alpha \neq \delta \neq \beta$ , then " $\alpha \neq \beta$ " can be inferred by a simple application of the Non-Identity of Discernibles,  $\varphi(\alpha), \neg\varphi(\beta)$   
 $\therefore \alpha \neq \beta$ :

$$R\alpha\delta$$

$$\neg R\beta\delta.$$

$$\therefore \alpha \neq \beta$$

Surely the applicability of this logical inference pattern does not reveal a metaphysical determination of the fact expressed in the conclusion by the premise facts.

More generally, a logical consequence need not reflect a metaphysical determination. A conjunction " $p$  and  $q$ " logically entails both of its conjuncts, but it arguably is the two facts that  $p$  and that  $q$  that jointly determine (or ground) the conjunctive fact that  $p$  and  $q$ , rather than the other way around (cf. Fine 2012: p. 58). The supervenience result may perhaps suggest a relationship of determination if

the underlying entailments are formulated as presenting strictly *sufficient* conditions for a number of objects:

If an asymmetric structure plainly satisfies relational description S, then its number of objects equals  $n$ .

Perhaps the “if–then” suggests that the relational pattern is somehow basic and that it *supplies* one with a number  $n$  of different objects. But the entailment can equivalently be formulated as presenting a strictly *necessary* condition for the obtaining of a certain pattern:

Only if it contains  $n$  different objects can a structure plainly satisfy description S.

This instead suggests that a number  $n$  of numerically different given objects is *required* for a structure with pattern S. The directedness of metaphysical determination is violated: in the same sense – logical consequence – in which an asymmetric pattern entails distinctness of objects, a certain number of distinct objects is required by the pattern.

The upshot is that although the notion of supervenience has often been used in order to capture what intuitively is a relationship of metaphysical determination, no such determination is revealed by the scrutiny of Bird’s supervenience of identity on relations. At its core the supervenience in question is a matter of logical consequence in first-order logic with identity, which is neutral on metaphysical determination.

With respect to his radically structuralist metaphysics of the concrete world, R. Dipert has proclaimed that “the existence of asymmetric graphs shows conclusively, for the first time in the history of philosophy, that...distinct rela...can be distinct [sic!]... and that this distinctness can arise through relations alone.” (1997: p. 349) This was over-enthusiastic. The mathematics of asymmetry by itself cannot show that numerical distinctness can metaphysically *arise from* a purely relational basis.

## **8 Asymmetry is of no help even if a model for the determination of essences is granted**

It might be urged that the supervenience claim was never meant as a self-standing account of a metaphysical determination of purely relational property essences; that the proposal rather is that given a certain background view about the determination of identities, the supervenience result removes an apparent obstacle to the contention that identity could be determined by relations alone.

Bird (2007a: p. 146 n.) hints at a conception of impredicative identity criteria, which distinguish between objects of a certain kind by predicates that already involve singular reference to or quantification over things of that very kind. However, as L. Horsten (2010: p. 416) has pointed out, a criterion of identity as such

is just a true “theory” to the effect that  $x \neq y$  iff  $\varphi(x)$  and  $\neg\varphi(y)$  for some suitable predicate  $\varphi$ . It need not reflect a directed metaphysical determination of distinctness by contradictory properties. Even a notion of conditions as *grounding* identities (cf. Fine 2016) at best provides one with a model of a determination of relational identity, not of essence. In any event, the sceptic worried by CRO will continue to ask how there *can* be entities the essences of which dictate the proposed criteria.<sup>15</sup>

The monist’s contention could instead be that considerations of asymmetry show that a determination of essences on a purely relational basis is no more problematic than one on the basis of monadic features. So for the sake of argument, let us adopt a simple model or paradigm for a determination of essences. Whenever a plurality of entities is given, it is plausible that the operation of set-formation constitutes a set that essentially has these entities as its members (cf. Fine 1994a). On this basis, a plausible paradigm is a simple monadic bundle theory of particulars, according to which concrete things are just sets of compresent monadic universals. It is not too implausible that on such a view, a thing’s essence consists in the range of universals the compresence of which constitutes the thing and that this essence is metaphysically determined by the universals, the compresence relation, and set-formation.<sup>16</sup> Note that the paradigm satisfies the feature of metaphysical priority that we found to plausibly be connected with the idea of neo-Aristotelian essence: particular things receive their identities by bundling of universals, while the universals do not in turn get their identities through a bundling of anything, but are simply given. We can thus grant that there is nothing wrong in principle with the idea of a metaphysical determination of essences.

Dispositional essentialism is a theory about properties, not about concrete particulars. By analogy with the paradigm, the idea would be to construct first-order properties (the potencies) as bundles of second-order features (their relational dispositional profiles).<sup>17</sup> For example, on the basis of given properties E, F and U, V, two dispositional profile properties can be assumed:  $D_1 =$  being an  $x$  such that  $\forall y: y$  has  $x \rightarrow y$  is disposed to have E when having F (i.e., the property of endowing things with the disposition to experience F when in E) and  $D_2 =$  being an  $x$  such that  $\forall y: y$  has  $x \rightarrow y$  is disposed to have V when having U. It may be assumed that those two second-order properties merge so as to constitute the bundle  $\{D_1, D_2\}$ , which could be identified with a first-order potency essentially exhibiting the two dispositional partial profiles.

For a purely relational determination of property essences, however, the problem arises that bundling by set-formation requires as its input not relations, but monadic properties. Consider a very simple asymmetric structure comprising two entities (potencies, in our case)  $a$  and  $b$  in an asymmetric relation R, so that  $R(a,b)$  but not  $R(b,a)$ . The two structural entities cannot be obtained by bundling, for the only entity to bundle is R, which only gives us one single object  $\{R\}$  where we need two different objects,  $a$  and  $b$ . To remedy this problem, the proposal might be that

<sup>15</sup> See Horsten (2010: pp. 425–6) on circular criteria. Cf. Lowe (2012) on the distinction between identity criteria and individuation.

<sup>16</sup> More sophisticated versions of this view would distinguish a core set of universals as essential, cf. Jago (2018).

<sup>17</sup> Cf. MacBride (2006) for a construal of mathematical entities as bundles based on relations.

asymmetric structures provide several different properties as inputs to the bundling by specifying unique role properties for different pure potencies.

Consider again a simple structure of two objects  $a$  and  $b$  in (asymmetric)  $R$ . The characteristic role for  $a$  would be being an  $x$  such that  $\exists yR(x,y)$ , that for  $b$  would be being a  $y$  such that  $\exists xR(x,y)$ . But what exactly is the property that enters into the bundling process constituting  $a$ ? One proposal is that this property is being an  $x$  such that  $R(x,b)$  that we obtain by instantiating the quantified formula “ $\exists yR(x,y)$ ” with “ $b$ ”. But then object  $b$  must be presupposed as given as what it is, independent of the bundling procedure, in contradiction to the monist’s thesis that all potencies consist in nothing more than relations to other properties. Object  $a$  would be identified with {being an  $x$  such that  $R(x,b)$ }, but since  $b$  would in turn be defined by reference to  $a$ , one would end up with a definition of  $a$  as {being an  $x$  such that  $R(x,\{\text{being a } y \text{ such that } R(a,y)\})$ }, violating non-cyclicity of essence.

Alternatively, one could insist that it is the quantified formula “ $\exists yR(x,y)$ ” itself by which the property entering into the bundling is expressed. But a quantifier requires a domain. A first option would be that the domain for the existential quantifier must be determined in advance in order for the quantified formula to express a determinate property that can constitute an entity’s specific essence. In the simple case at hand this presupposed domain would be the set  $\{b\}$ . So here too object  $b$  with its essence is presupposed as independently given, in contradiction to the monist’s central thesis. A second option could be that the quantified formula makes sense without such a presupposed domain.<sup>18</sup> By beginning a fairy tale with “Once upon a time, there was a king who had a daughter”, one can arguably constitute a fictional person (the king) without presupposing another person (the daughter) as already given, and vice versa. However, what is really going on in this case is the simultaneous constitution of two fictional characters, the king and his daughter, as parts of a single fictional structure in one single act of story-telling. (Cf. Fine 1994b: p. 65.)

A theistically-minded strong monist could suggest that God may play the role of the story-teller in the case of property structures. Thus, the creator said “Let there be two properties standing in asymmetric relation  $R$ !”, and there were two properties in asymmetric  $R$ . But there is a crucial disanalogy. The fairy tale of king and daughter is told, and by this act of story-telling a fictional structure containing two characters exists (or perhaps it has existed all along as an abstract structure and only becomes semantically available through the story-telling). The relation between the act and the fictional structure is not causal, though. More plausibly, the structure is grounded by the act (or perhaps by the possibility of such an act).<sup>19</sup> To dramatise a bit, the fictional structure is but an abstract reflection of the concrete act of story-telling (cf. St. Schiffer 2003: p. 59 on “[f]ictional entities” as “mere shadows of the pretending use of their names”). Creation, by contrast, is standardly construed as

<sup>18</sup> I am indebted to Lorenzo Azzano for calling my attention to this alternative.

<sup>19</sup> If fictional discourse is considered non-factual, the installation of characters by practices may not be an instance of grounding proper; see Fine (2001: p. 28) on the definition of the factual as real or grounded in what is real. Then another notion than grounding is required for the relation between a (possible) practice and the corresponding characters.

a causal relation. Also, the strong monist's potency structure is not thought of as a mere abstract reflection of God's decrees, but as a metaphysically fundamental structure in the concrete world. The view is that in the concrete world,  $a$  and  $b$  exist as fundamental entities that nevertheless consist in nothing more than standing in  $R$  to  $b$ , in the case of  $a$ , and  $a$  standing in  $R$  to it, in the case of  $b$ . An advocate of this view may believe that this fundamental structure is brought about by God, or she may assume that it simply obtains in its own right. Either way, we have not been provided with a glimpse into how there can be such a fundamental structure, given CRO's demand of non-cyclicity and well-foundedness. The underlying picture here seems to be what has recently been called "metaphysical coherentism", but as I will indicate in Sect. 10, there are principled reasons to doubt the metaphysical solidity of that approach.

The result of the previous sections was that while Bird's claim of a supervenience of identity on asymmetric pattern can be rigorously reconstructed, it by itself neither accounts for property identities in the sense of essences nor reveals a metaphysical determination of identities even in the world-internal relational sense. This section has shown in addition that it is not true that a determination of essences by relations is no more problematic than a determination by monadic qualities. It is not true that once a model for monadic constitution such as the bundling view is granted, the only obstacle to extending this model to a purely relational constitution is that distinguishing roles must be specified on a purely relational basis and that the results concerning asymmetric structures supply just this specification. Quite the contrary, the relationalist about the determination of essences faces specific problems not troubling the monadist, which are not eased by results about asymmetry. More specifically, if the property constituting  $a$  is either standing in  $R$  to  $b$  or standing in  $R$  to something for the presupposed domain  $\{b\}$ , the monistic thesis is violated, and the assumed asymmetry of  $R$  does not change this result.

## **9 Purely dispositional properties may be construed as resulting from a purely relational structure, but such a structuralist metaphysics faces serious obstacles, and the properties would not be fundamental.**

Let me summarise the upshot of my overall argument up to this point. CRO is best understood as a challenge to account for a purely relational determination of property essences in view of the double threat of vicious circularity and a vicious regress. An assumption of asymmetry is not sufficient for an account of a metaphysical determination of property essences, as Bird's supervenience result neither accounts for identities in the specific sense of essences nor reveals a metaphysical determination of identities in any sense. Nor is asymmetry helpful when a model for a metaphysical determination of essences such as the bundling model is presupposed; instead, the idea of a purely relational determination of essences confronts serious specific problems. Nor has any reason emerged why asymmetry should be necessary for an account of purely relational potencies. True, asymmetry is the condition for absolute distinguishability of objects in a structure. Yet no principled

reason could be found why pure potencies, if possible at all, should not be weakly distinguished only. The whole issue of asymmetry seems irrelevant to the pressing questions challenging SDM.

In spite of the disanalogies highlighted in the previous section, a reasonable move for the strong monist would be to turn to an account of a simultaneous constitution of all the relationally determined properties, in analogy to the simultaneous constitution of a complete staff of interrelated fictional characters. It has become clear that the primitive view of objects as bundles of properties cannot serve as a model for such a simultaneous constitution. Still, structuralists may bank on sophisticated variants of bundling ontologies, variants that promise to cope with relations in addition to monadic properties and to accommodate arbitrarily complex relational patterns without presupposing *relata* between which the relations are spanned.

A precise account in the vicinity of the bundle approach that systematically copes with *n*-adic features is Sh. Dasgupta's algebraic generalism (2009; cf. Turner 2011 for a discussion of "nihilist" options; both build on Quine 1976). On his view, concrete reality consists in an individuals-free huge holistic pattern of both monadic and relational universals. Technically, he takes *n*-adic universals as ontologically given and offers a machinery of algebraic operations that generate complex patterns of universals; finally, he adopts a property to the effect that some of those patterns (states of affairs, in his framework), and the complete world pattern in particular, in fact obtain. Similarly, the strong monist may consider taking stimulus and manifestation relations as given and constructing complex patterns of them by algebraic operations, so that one of those patterns in fact obtains as the world's basic dispositional structure. It may be noted that Dasgupta assumes no constraint of asymmetry for his patterns, so that once again asymmetry plays no role. Dasgupta rejects a reductive identification of concrete individuals with bundles of structurally integrated universals; in this way, he parts ways with naïve bundle ontologies. One may still assume that the basic individuals-free network grounds a manifold of objects that essentially have the monadic properties and stand in the relations that occur in the underlying network. In a similar way, the strong monist could maintain that while no potencies are part of the fundamental purely relational structure of stimulus and manifestation, that structure grounds a manifold of potencies the full essences of which consist in their mutual relations.

A first major problem concerns the purely relational structure itself. Dasgupta's algebraic apparatus contains operations reminiscent of logical operations such as conjunction. To focus on monadic universals, when universals *F* and *G* are given, so is *F* & *G*. However, operation & does its conjunction-like job only if it sustains characteristic metaphysical entailments. Arguably, the fact that *F* & *G* occurs must metaphysically entail that *F* occurs and that *G* occurs. But *F*, *G*, and & are assumed

to be elements of metaphysically fundamental reality. The question arises of why a metaphysically fundamental element & should behave in such a way that the obtaining of F & G entails that of F and that of G. A seemingly promising answer could be that it is (part of) the full essence of & to behave that way. But the proposal under consideration is that the strong monist engages the machinery of generalism in order to account for full essences of potencies in virtue of which, say, a charged particle in an electric field must, by metaphysical necessity, experience a force. By drawing on generalism, she would already rely on operations such as & having full essences that sustain necessary entailments. (For a detailed argument see Busse 2020.)

Secondly, as I see it, the least problematic step in the approach is the one from the underlying network to a corresponding manifold of objects. Whenever three trees form a triangular formation, it seems natural to disregard the concrete trees and embrace spatial positions in spatial relations as abstract proxies for them. Even Leibniz, the arch-relationalist about space and time, conceded spatial positions in such an abstractive sense (see his definition of “place” in his fifth letter to Clarke, Leibniz & Clarke 2000). Similarly, assuming that one can make sense of an objects-free purely relational network, it seems natural to mirror that network by a manifold of objects the essences of which consist in nothing more than mutual relations.<sup>20</sup> However, those objects would be grounded by the underlying network and hence, on the standard view (on “coherentist” dissenters, see the following section), not belong to the metaphysical foundation of reality. This result is likely to be received with disappointment by the strong monist, whose original contention was that “the fundamental properties of physics...are potencies” (Bird 2007a: p. 5). What is more, if the strong monist’s potencies are assigned that kind of derivative status, one may wonder whether they are apt for doing the metaphysical heavy-duty work they are expected to do, such as grounding necessitarian laws of nature. The ultimate driver in nature would be neither the system of laws of nature nor the manifold of particular potencies, but the purely relational network of stimulus and manifestation relations. If, however, such a network can be made sense of as playing its driving role – a very big “if”, in my opinion – then the essentialist may perhaps content herself with the grounded potencies being the most fundamental physical properties even though they are not absolutely metaphysically fundamental.

Thirdly, and more specifically, the strong monist would have to make sure that her structurally grounded potencies are essentially characterised by relations in the right way. Consider again the fictional structure of a king and his daughter. One may well grant that by being fully grounded by the act of story-telling to the effect that once upon a time, there was a king who had a daughter, the character of the king is essentially related to the daughter. But this can only mean that the character somehow *encodes* having a daughter; surely the character *qua* abstract entity does

<sup>20</sup> Cf. Shackel (2011: p. 11), who against Oderberg (2011) points out that for Dipert the structural objects and their token relations metaphysically depend on the world as a whole. Dasgupta’s (2014) conception of plural grounding may be of help in the abstraction of such a manifold. Note that the fact that the network grounds objects that have certain relational full essences is compatible with the assumption that the relevant facts of essence themselves, that *a* essentially plays relational role R etc., are ungrounded; such facts would nevertheless not count as metaphysically fundamental, because they involve a constituent that is grounded; cf. Dasgupta (2016: pp. 386–387).

not *exemplify* the property of having a daughter; no abstract entity has a daughter (for the distinction between encoding and exemplifying a property see Zalta 2006: Sect. 2). Similarly, the strong monist would have to make sure that her structurally grounded potencies do not merely *encode* standing in stimulus and manifestation relations to other potencies, but that they *really play* the required dispositional roles. The potency of charge, for example, must be shown to really be such that its instantiation by a concrete particle endows the particle with the disposition to experience a force in an electric field. It has been argued forcefully that no properties that really play dispositional roles arise (cf. Barker & Smart 2012: p. 720, Barker 2013: p. 625 on constituting vs. governing and on the very serious *Government Problem* and Jaag’s inference-type problem, 2014: pp. 16–17).

## 10 Since essence and grounding are notions of metaphysical priority, there can be no essentially dispositional fundamental properties, and the prospects of “coherentism” about basic properties are dim

That the strong monist’s potencies turn out as metaphysically derivative entities should not come as a big surprise. The strong monist’s position is that the essences, in the (neo-)Aristotelian sense of “that whereby a thing is what it is” (Bird 2007a: p. 137), of all fundamental physical properties are exhausted by relations to other such properties. The reconstruction of CRO in Sects. 2–3 rests on the supposition that essence in that sense is a notion of metaphysical priority (as indicated by Bird’s use of “whereby”).

J. Wang suggests that we make this priority explicit by an essence-dependence link, according to which, if “y figures in the essence of x, then x depends upon y” (2019: pp. 40–41). I agree that the principle is plausible and that it helps to fix the idea of essence as a priority notion. However, if Fine is right that dependence should be defined in terms of essence (1994b, 1995), it is not clear that we have an independent grip on the priority character of dependence that could stabilise the corresponding grip on essence as involving metaphysical priority. Indeed, E. Barnes (2018) in effect argues that the intuitive notion of dependence (in contradistinction to the more theoretical notion of grounding) is not a priority notion. Also, one may wonder whether dependence can cover priority in general, as grounding is, arguably, a priority notion though the grounded does not always clearly depend on its grounds; a disjunctive fact is fully grounded by any one of its disjuncts but does not clearly depend on it, since the fact may instead obtain in virtue of the other disjunct (cf. Bennett & McLaughlin 2018, Sect. 3.5, on “grounding overdetermination”). An alternative approach might be to establish a close link between essence and grounding, assuming that grounding is a priority notion. Yet the availability and content of such links is a matter of debate (Zylstra 2020: pp. 330–331). As I see it, we have a direct insight into essence as a notion of metaphysical priority, mainly by the elucidation of neo-Aristotelian essence as what pertains to a thing’s real definition. It is in this vein, I assume, that Fine (2015: pp. 306–308) proposes systematising essence and ground as two different, self-standing notions of one thing (or truth)

being constitutive of another:  $x$  grounds  $y$  iff  $x$  is constitutively sufficient for  $y$ , and  $x$  is essential to  $y$  iff  $x$  is constitutively necessary for  $y$ . Thus, Socrates is an essential and therefore necessary member of  $\{\text{Socrates}\}$  in the sense that “[b]eing a set whose sole member is Socrates is somehow *constitutive* of what  $\{\text{Socrates}\}$  is” (Fine 2015: p. 296; set braces added; see Fine 2012: p. 39 for a decidedly constitutive construal of ground, according to which the grounded “*consists in nothing more than*” the grounds). In conjunction, essence and ground define constitutive *IS*. Arguably, to say that  $x$  is in one or another way constitutive of  $y$  is a way to state that  $x$  is metaphysically prior to  $y$ .

In any case, we ought to agree with Wang’s crucial result that metaphysically fundamental properties can have no dispositional (or “causal”) essences (2019: p. 47). More generally, metaphysically fundamental items can at best have essences in a trivial (cf. Wang 2019: p. 44) sense: the essence of a fundamental entity  $a$  is simply to be *it*, to be  $a$ ; the essence of a fundamental property is to be *thus*, to be that simple qualitative way for things to be. In order for a thing or feature to have an interesting, rich essence, as it is assumed by SDM for potencies, it must be *constituted as* having that essence and hence be metaphysically derivative.

It may be thought that the result that fundamental items cannot have non-trivial essences only holds for a construal of fundamental items as ungrounded or, more generally, unconstituted items but not for a Lewisian view of fundamental properties as perfectly natural. First, however, Lewis’s elucidation of perfect naturalness is jeopardised once free recombability of natural properties is severely restricted, as when it is assumed that the co-occurrence of  $Q$  and  $E$  must by strict necessity be accompanied by  $F$ . For part of this elucidation is that the natural properties “characterise things completely and without redundancy” (cf. 1986: p. 60) in the sense that they “figure in a minimal basis on which all else supervenes” (2009: p. 204), and supervenience requires variation in modal space. In the simple exemplary case, the (non-)occurrence of  $F$  would supervene on that of  $Q$  plus  $E$ , so that  $F$  would drop out of the minimal supervenience basis and count as non-fundamental. Secondly, Lewis suggests that we measure degrees of naturalness by the length of a definition of a given property in terms of perfectly natural features (1986: p. 61). So he does endorse the conception of an ideal definition of the non-fundamental in terms of the fundamental; that conception may be viewed as Lewis’s variant of real definition for properties. *Qua* end-points of such definitional chains, the perfectly natural properties would be incapable of further definition. So in Lewis’s framework, too, there is no place for construing fundamental  $Q$  as by definition, or, in a quasi neo-Aristotelian sense, essentially being such that things that have it and occur in fundamental  $E$  must experience fundamental  $F$ . Thirdly, the most striking element in Lewis’s elucidation probably is that sharing of natural properties “makes for qualitative similarity” (1986: p. 60, cf. 1983: p. 13), that they “render their instances perfectly similar in some respect” (2009: p. 204). Barring a definition by shared universals or duplicate tropes or perfectly natural classes in a primitive nominalist sense, he is explicit

that the objective resemblance induced by perfectly natural properties can only be expressed by a primitive, undefinable predicate (1983: pp. 14–15; see Busse 2018). This strongly suggests that when two individuals share a perfectly natural property, there is no informative account of in what way they resemble each other. For Lewis, by saying that the individuals resemble one another in such a basic objective sense that they share a perfectly natural property we have reached metaphysical rock bottom. But if fundamental Q consisted in the counterfactual feature of experiencing F when in E, there would be such an informative account: things sharing Q would be distinguished by and resemble by satisfying the counterfactual. In sum, the project of falling back on Lewis's (of all the people!) conception of fundamental properties in order to defend non-trivial neo-Aristotelian essences for them does not appear particularly promising.

Parting ways with Fine, F. Correia and A. Skiles (2019) aim at a unification of essence and ground for properties by defining both notions in terms of a generalised notion of identity. This notion is propounded as symmetric and hence not assumed to involve metaphysical priority. To simplify drastically,<sup>21</sup> property F grounds property G iff F is a disjunctive part of a complex that is generically identical with G, and F is essential to G iff F is a conjunctive part of a complex that is generically identical with G. First, however, recall that in one place Bird expresses SDM as the view that “potencies just are their dispositional powers” (2007a: p. 46) and that he analyses dispositions by counterfactual conditionals. Thus, the potency of charge would be generically identical to the property of being an  $x$  such that, if  $x$  occurred in a field E, it would experience force F. On the face of it, stating this generic identity just is to state that charge is not fundamental but *is* the property of being an  $x$  such that ( $x$  is in E  $\square \rightarrow x$  experiences F), which is a logical construction out of E, F, and the counterfactual conditional and hence hardly fundamental. For certain cases of fundamental features, we may perhaps admit a symmetric, undirected identity-like locution. Consider a plurality of points in space that form a line. We may want to say that for the points to extend over 1 cm *just is* for the line formed out of them to be 1 cm long, and vice versa (for this kind of locution see Correia & Skiles 2019: p. 643 as well as their references to the relevant literature). We may not want to decide that either the monadic or the plural property is the truly fundamental feature. Intuitively, we have one fundamental fact in two categorically different guises, singular and plural.<sup>22</sup> Yet I seriously doubt that we can make sense along similar lines of the idea that for a thing to have *fundamental* Q *just is* for it to be such that it would experience F in E, for completely different *fundamental* F and E. It is hard to see how with such a claim one would have made progress over the adventurous modal claim that fundamental F simply necessarily co-occurs with experiencing fundamental F in fundamental E.

Secondly, Correia and Skiles assume that generic identity entails necessary equivalence but not vice versa (2019: p. 646). Their reason is that they wish to

<sup>21</sup> Their expression for generic identity combines two open sentences and is variables-binding. I will reproduce their proposal in terms of ordinary identity between properties.

<sup>22</sup> Clearly, this proposal refers to Lewis's (1991) conception of composition as identity.

exclude generic identities to the effect that, for example, being green is identical to being grue before the year 2000 or being bleen in 2000 or later. But if generic identity is necessary equivalence somehow restricted to natural features, it is a restricted modal notion and hence not one that could base post-modal notions of essence and ground. An alternative approach would be to explain generic identity as metaphysical analysis (to borrow C. Dorr's, 2005: Sect. 13, felicitous term, though not the theoretic details): property F would be generically identical to a complex just in case it is or can be metaphysically analysed by that complex. However, on the face of it, we are then back to a notion of metaphysical constitutivity and priority. For example, if being a bachelor is metaphysically analysed as being an unmarried marriageable man, the three features in the analysis appear thereby to be revealed as constitutive of and metaphysically prior to being a bachelor; if water is metaphysically analysed as being hydrogen and oxygen bonded in a certain way, hydrogen and oxygen are thereby revealed as constitutive of and metaphysically prior to water. Correia and Skiles (2019: p. 666) urge that Fine owes us "an informative story of what constitutive relations are." Yet plausible examples of constitutivity and priority abound; we have a paradigm of a priority structure in the iterative conception of sets; and we have a general idea of the behaviour of priority notions, such as an exclusion of cyclic chains and at least a presumption of well-foundedness. The real challenge rather is that Fine's opponents explicate a stable notion of generalised identity that neither involves constitutivity and priority nor collapses into a (restricted) modal notion and is expressive enough to allow for definitions of non-modal notions of essence and ground; and, for our purposes, of a notion of non-trivial essence for allegedly fundamental items. Remarkably, Correia (2017: pp. 57, 60) for his part propounds a notion of real definition with metaphysical priority explicitly built into it, which hence is asymmetric, and relies for its characterisation on a priority-involving concept of grounding and, equivalently (he argues), of relative fundamentality in the sense of *being more joint-carving than*. For this notion, it is an immediate consequence that an item having a real definition cannot be absolutely fundamental.<sup>23</sup>

I have been discussing the asymmetry reply as an attempt to avoid both the horn of circularity and the horn of vicious regress highlighted in Lowe's objection to strong monism. The natural realisation of such an approach would be a "relations first" structuralism, as adumbrated in the previous section, according to which a fundamental relata-free network of dispositional relations grounds a system of purely dispositional properties. That kind of structuralism is a version of metaphysical foundationalism, with the purely relational web forming the fundament. Recently,

<sup>23</sup> The coherence between Correia (2017) and Correia & Skiles (2019) is not evident to me. The tension between the priority-friendliness in (2017) and the priority-reservation in (2019) may have its roots in the difference between a more "representational" attitude in the former and a more "worldly" focus in the latter. – For G's grounding F, Correia & Skiles (2019: p. 14) require that (i) G is a disjunctive part of F and that (ii) F is not in turn a conjunctive part of a disjunctive part of G. This more complex condition does not provide us with the intended asymmetry of ground, however, as long as we do not know why, say, being green before *t* is a disjunctive part of being grue, while being grue before *t* is not a disjunctive part of being green. Some notion of metaphysical priority must be presupposed in order to make this distinction.

metaphysical coherentism has been brought into play as an alternative to foundationalism (and infinitism) (Bliss & Priest 2018). Just as according to epistemological coherentism different beliefs are justified by mutually supporting each other, so according to metaphysical coherentism different entities would be metaphysically explained by mutually depending on or (partially) explaining each other. Thus, while a “relations first” structuralism avoids the horn of circularity (as well as that of regress), coherentism can be viewed as embracing that horn and reinterpreting apparent circularity as mutual backup. Indeed, it has been questioned that grounding is a strict partial order and argued that grounding may well relate things symmetrically (Thompson 2018).

A coherentist variant of strong monism would have to be the target of another paper. Let me only indicate a principled worry. If there is any consensus about grounding, it is that this relationship either is, or is closely linked to, metaphysical explanation (Glazier 2020: p. 121). I would want to say the same about essence and dependence (cf. Fine 2015: p. 296). Just as scientific explanation is not a concept featuring in scientific theories but one of the philosophy of science, ground, essence and dependence are best viewed not as concepts of metaphysics proper or first-order metaphysics, but of metametaphysics (thus, the entries on grounding and essence have their proper place in Bliss & Miller 2020). A theory of physics would hardly be tenable that assumed certain entities and simply claimed that they scientifically explain, say, electric conductivity. Instead, physicists establish their quantum theory of atoms and engage in a practise of accounting for conductivity on that basis (roughly, by the possibility of metallic conduction bands). It is then the task of a meta-discipline called philosophy of science to specify general concepts of scientific explanation and to assess to what extent and in what sense and what way a particular explanatory practice in the sciences fits those concepts. Similarly, a first-order metaphysical theory can hardly be acceptable that postulates certain items and simply claims they ground (or depend on, or metaphysically explain) certain phenomena. Instead, as wide as possible, one ought to be able to state one’s first-order metaphysics without using highly abstract meta-notions such as essence, grounding, or dependence. Only in a secondary or meta-perspective can we ask what essences things have according to that metaphysics and what grounds, metaphysically explains, or depends on what. For the non-symmetric case, first-order theories have been advanced that are comprehensible independently from the use of meta-notions. I am thinking of reductive analyses of determinables in terms of determinates (Rosen 2010: pp. 128–130) and accounts of various forms of generation relations (or building, production, constitution, or g-relations, or grounding mechanisms; see Glazier 2020 for different approaches) such as set formation, composition, or property abstraction. In a meta-perspective, those accounts can plausibly be assessed as instances of a general notion of grounding and of metaphysical explanation. Thus, I believe we can be moderate grounding enthusiasts (as distinct from grounding sceptics, see Koslicki 2020), but only with respect to grounding as

a meta-notion covering first-order operations that are all definitely constitutive in character and therefore exclude reciprocal grounding.

Alleged examples of symmetric ground or dependence, by contrast, appear to be essentially phrased in those very abstract metametaphysical terms. Thus, Armstrongian states of affairs and their constituents are interpreted as mutually dependent on each other (Barnes 2018: pp. 57–58); for the physical world a mutual ontological dependence has been claimed to hold between objects and relations (Esfeld & Lam 2008: p. 32; see Thompson 2018: pp. 118–119 for an interpretation in terms of grounding); and entangled quantum particles have been assumed to depend on each other in a coherentist style with regard to their states (Calosi & Morganti forthcoming: Sect. 6). When the metametaphysical vocabulary is bracketed, those views cannot be stated properly, which, I content, reveals that the positions lack first-order metaphysical substance. I suspect that this is no accident and that in general no tenable first-order descriptions of assumed symmetric grounding and dependence structures can be provided. The reason precisely seems to be that coherentists cannot rely on particular metaphysical analyses or specific constitution and generation relations, as these would bring in metaphysical priority. Thus, one may perhaps proclaim that basic physical properties form a web of items in relationships of mutual dependence or partial grounding or explanation. But the prospects of substantiating such a metametaphysically phrased postulate by a tenable first-order coherentist metaphysics of properties are dim.<sup>24</sup>

Here, it is not my ambition to defend a specific post-modal framework, however. What I am maintaining is that there are strong reasons for thinking that to the extent that we can understand notions of essence and ground as clearly distinct from modal notions, we must understand them as notions of metaphysical priority. As indicated, in his less formal presentations, Bird for his part does rely on post-modal locutions that strongly suggest metaphysical priority: powers *constitute* what it is to be a particular potency, potencies *consist of* essential powers (2007a: pp. 72–73). In reaction to her diagnosis that the notion of essence entails dependence and therefore cannot be applied to fundamental properties, Wang recommends a modal retreat to the effect that “fundamental properties” “necessarily and uniquely, but not essentially play the causal roles that they do” (2019: p. 49).<sup>25</sup> Her view, however, is closer to the double aspect or identity view (Wang 2016: pp. 173–174) and not a variant of SDM. What is more, for those new essentialists who set about accounting for strong necessities by the nature and essence of things and properties, her proposal is an invitation to capitulate. Indeed, what progress can essentialists expect from a time jump decades back into the modal ages?

<sup>24</sup> For a critique of Schaffer’s (2016) “anything goes”-methodology for foundational metaphysics see Busse, forthcoming.

<sup>25</sup> I diagnose a similar modal retreat in Ingthorsson’s (2012: p. 7) proposal that the properties constitute the web of relations rather than being constituted by it; cf. Cross’s (2012) response to Lowe (2010). For an exploration see Azzano (2020).

## 11 Conclusion

Dispositional essentialism is an ambitious metaphysical position. Typically the view is advanced as including a modal claim to the effect that, for example, a charged particle in an electric field must, by strict metaphysical necessity, experience a force. Arguably, however, fundamental properties are simple in the sense that they lack logical structure, in contrast to logical constructions such as the conditional property of experiencing a force when in a suitable field. So the sceptical question arises of why logically structureless properties such as charge, field strength, and force should not freely recombine. A natural approach to address such well-motivated sceptical challenges (see Busse, forthcoming) is to embrace the post-modal framework of essence and ground. Strong dispositional monism is not only a strengthening of dispositional essentialism. It also promises to provide a reply to sceptical challenges when it is construed as structuralism about properties. If physical properties are nothing more than nodes in a structure so that they consist in nothing more than stimulus and manifestation relations to other properties, maybe this explains why their occurrences in the world meet certain modal constraints. Yet property structuralism has been challenged in turn, specifically by the circularity/regress objection, which is most fruitfully construed as questioning a purely relational determination of property essences. A. Bird's well-known reply draws on the asymmetry of property structures. But asymmetry can neither solve the circularity/regress problem on its own, nor does it contribute to a solution, nor does it seem necessary for strong monism. What would be required instead is a detailed metaphysics of a relata-free structure of stimulus and manifestation relations that grounds a corresponding manifold of essentially related properties. Yet such a structuralist metaphysics faces very serious obstacles. Also, since the properties would be grounded and have non-trivial essences, they could not be fundamental. Metaphysical coherentism is hardly a way out, as it would appear to merely proclaim mutual dependencies between items without substantiating those claims by a solid first-order metaphysics. After a retreat from the post-modal framework, however, we would be back where we started, with brute postulates of necessary connections between fundamental features that attract scepticism of how such connections should be possible. In sum, this paper contains no good news for essentialism about fundamental properties and for strong monism in particular.

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## References

- Armstrong, D. M. (1989). *Universals. An opinionated introduction*. Westview Press.
- Azzano, L. (2019). The question of realism for powers. *Synthese*, *196*(1), 329–354.
- Azzano, L. (2020). Dispositional, categoricity, and where to find them. *Synthese, Online First*. <https://doi.org/10.1007/s11229-020-02917-4>
- Barnes, E. (2018). Symmetric dependence. In R. Bliss & G. Priest (Eds.), *Reality and its structure. Essays in fundamentality* (pp. 50–69). Oxford University Press.
- Barker, S. (2013). The Emperor's new metaphysics of powers. *Mind*, *122*(487), 605–653.
- Barker, S., & Smart, B. (2012). The ultimate argument against dispositional monist accounts of laws. *Analysis*, *72*, 714–722.
- Bennett, K., & McLaughlin, B. (2018). Supervenience. *Stanford Encyclopedia of Philosophy*.
- Bigaj, T. (2010). Dispositional monism and the circularity objection. *Metaphysica*, *11*(1), 39–47.
- Bird, A. (2007a). *Nature's metaphysics. Laws and properties*. Oxford University Press.
- Bird, A. (2007b). The regress of pure powers? *The Philosophical Quarterly*, *57*, 513–534.
- Bird, A. (2012). Monistic dispositional essentialism. In A. Bird, B. Ellis, & H. Sankey (Eds.), *Powers, properties, and structures: issues in the metaphysics of realism* (pp. 34–41). Routledge.
- Bliss, R., & Priest, G. (2018). The Geography of Fundamentality: An Overview. In R. Bliss & G. Priest (Eds.), *Reality and its structure. Essays in fundamentality* (pp. 1–33). Oxford University Press.
- Bliss, R., & Miller, J. T. M. (2020). *The routledge handbook of metametaphysics*. Routledge.
- Busse, R. (2018). The adequacy of nominalism about perfect naturalness. *Philosophy and Phenomenological Research*, *XCVI*(2), 443–469.
- Busse, R. (2020). Against metaphysical structuralism: A case study on the apriori dimension within inductive metaphysics. *Grazer Philosophische Studien*, *98*(1), 90–122.
- Busse, R. forthcoming. Categorical Metaphysics and the Reality of the Inference Problem: On Flying Pigs and Fundamental Lawhood. To appear in *Dialectica*.
- Calosi, C., & Morganti, M. forthcoming. Interpreting Quantum Entanglement: Steps Towards Coherentist Quantum Mechanics. *British Journal for the Philosophy of Science*, ahead of print 2018.
- Caulton, A., & Butterfield, J. (2012). On kinds of indiscernibility in logic and metaphysics. *British Journal for the Philosophy of Science*, *63*(1), 27–84.
- Correia, F. (2017). Real definitions. *Philosophical Issues*, *27*(1), 52–73.
- Correia, F., & Skiles, A. (2019). Grounding, essence, and identity. *Philosophy and Phenomenological Research*, *98*(3), 642–670.
- Cross, T., (2012). Review of Anna Marmodoro (Ed.), *The Metaphysics of Powers: Their Grounding and Their Manifestations*. Notre Dame Philosophical Reviews.
- Dasgupta, S. (2009). Individuals: An essay in revisionary metaphysics. *Philosophical Studies*, *145*(1), 35–67.
- Dasgupta, S. (2014). On the plurality of grounds. *Philosopher's Imprint*, *14*(20), 1–28.
- Dasgupta, S. (2016). Metaphysical rationalism. *Noûs*, *50*(2), 379–418.
- Dipert, R. R. (1997). The mathematical structure of the world. The world as graph. *Journal of Philosophy*, *94*(7), 329–358.
- Diestel, R. (2000). *Graph theory* (2nd ed.). Springer.
- Dixon, T. S. (2016). What is the Well-Foundedness of Grounding? *Mind*, *125*(498), 439–468.
- Dorr, C. (2005). What we disagree about when we disagree about ontology. In M. E. Kalderon (Ed.), *Fictionalism in metaphysics* (pp. 234–286). Oxford: Clarendon Press.
- Esfeld, M., & Lam, V. (2008). Moderate structural realism. *Synthese*, *160*(1), 27–46.
- Fine, K. (1994a). Essence and modality. *Philosophical Perspectives*, *8*, 1–16.

- Fine, K. (1994b). Senses of Essence. In W. Sinnott-Armstrong, D. Raffman & N. Asher (Eds.), *Modality, Morality and Belief. Essays in Honor of Ruth Barcan Marcus* (pp. 53–73). Cambridge University Press.
- Fine, K. (1995). Ontological dependence. *Proceedings of the Aristotelian Society*, 95(1), 269–290.
- Fine, K. (2001). The question of realism. *Philosopher's Imprint*, 1, 1–30.
- Fine, K. (2012). Guide to ground. In F. Correia & B. Schnieder (Eds.), *Metaphysical Grounding. Understanding the structure of reality* (pp. 37–80). Cambridge University Press.
- Fine, K. (2015). Unified foundations for essence and ground. *Journal of the American Philosophical Association*, 1(2), 296–311.
- Fine, K. (2016). Identity criteria and ground. *Philosophical Studies*, 173(1), 1–19.
- French, S. (2014). *The structure of the world. Metaphysics and representation*. Oxford University Press.
- Glazier, M. (2020). Grounding and explanation. In M. J. Raven (Ed.), *The routledge handbook of metaphysical grounding* (pp. 121–132). Routledge.
- Hawthorne, J. (Eds.). (2001). Causal structuralism. In *Metaphysical essays* (pp. 211–227). Oxford University Press.
- Horsten, L. (2010). Impredicative Identity Criteria. *Philosophy and Phenomenological Research*, LXXX(2), 411–439.
- Inghorsson, R. (2012). The regress of pure powers revisited. *European Journal of Philosophy*, 23(1), 1–13.
- Jaag, S. (2014). Dispositional essentialism and the grounding of natural modality. *Philosopher's Imprint*, 14(34), 1–21.
- Jago, M. (2018). Essential bundle theory and modality. *Synthese, Online First*. <https://doi.org/10.1007/s11229-018-1819-3>
- Koslicki, K. (2012). Varieties of ontological dependence. In F. Correia & B. Schnieder (Eds.), *Metaphysical Grounding. Understanding the structure of reality* (pp. 186–213). Cambridge University Press.
- Koslicki, K. (2020). Skeptical doubts. In M. J. Raven (Ed.), *The Routledge Handbook of Metaphysical Grounding* (pp. 164–179). Routledge.
- Leibniz, G. W., & Clarke, S. (2000). *G. W. Leibniz and Samuel Clarke: Correspondence*. Edited and translated by R. Ariew. Hackett Publishing.
- Lewis, D. (1983). New Work for a Theory of Universals. In D. Lewis, *Papers in Metaphysics and Epistemology*. Cambridge University Press 1999: 8–55.
- Lewis, D. (1986). *On the plurality of worlds*. Blackwell.
- Lewis, D. (1991). *Parts of classes*. Blackwell.
- Lewis, D. (2009). Ramseyan Humility. In D. Braddon-Mitchell & R. Nola (Eds.), *Conceptual analysis and philosophical naturalism*. Cambridge (Mass.): MIT Press: 203–222.
- Lowe, J. (2006). *The four-category Ontology: A metaphysical foundation for natural science*. Oxford University Press.
- Lowe, J. (2010). On the Individuation of Powers. In A. Marmodoro (Ed.), *The Metaphysics of Powers. Their Grounding and Their Manifestations* (pp. 8–26). London/New York: Routledge.
- Lowe, J. (2012). Asymmetric dependence in individuation. In F. Correia & B. Schnieder (Eds.), *Metaphysical Grounding. Understanding the structure of reality* (pp. 214–233). Cambridge University Press.
- MacBride, F. (2006). What constitutes the numerical diversity of mathematical objects? *Analysis*, 66(1), 63–69.
- Molnar, G. (2003). *Powers: A study in metaphysics*. Oxford University Press.
- Oderberg, D. S. (2011). The world is not an asymmetric graph. *Analysis*, 71(1), 3–10.
- Oderberg, D. S. (2012). No potency without actuality: The case of graph theory. In T. E. Tahko (Ed.), *Contemporary Aristotelian Metaphysics* (pp. 207–228). Cambridge University Press.
- Quine, W. V. O. (1976). Algebraic Logic and Predicate Functors. In W. V. O. Quine (Ed.), *The Ways of Paradox*, second ed. Cambridge, Massachusetts: Harvard University Press: 283–307.
- Rosen, G. (2010). Metaphysical dependence: Grounding and reduction. In D. Chalmers, D. Manley, & R. Wasserman (Eds.), *Metametaphysics: New essays on the foundations of Ontology* (pp. 347–383). Oxford University Press.
- Schaffer, J. (2010). Monism: The priority of the whole. *Philosophical Review*, 119(1), 31–76.
- Schaffer, J. (2016). It is the business of laws to govern. *Dialectica*, 70, 577–588.
- Schiffer, S. (2003). *The Things We Mean*. Oxford University Press.
- Shackel, N. (2011). The world as a graph: Defending metaphysical graphical structuralism. *Analysis*, 71(1), 10–21.
- Shapiro, S. (1997). *Philosophy of Mathematics: Structure and Ontology*. Oxford University Press.

- Shapiro, S. (2008). Identity, Indiscernibility, and *ante rem* Structuralism: The tale of *i* and *-i*. *Philosophia Mathematica (III)*, 16, 285–309.
- Thompson, N. (2018). Metaphysical interdependence, epistemic coherentism, and holistic explanation. In R. Bliss & G. Priest (Eds.), *Reality and its structure. Essays in fundamentality* (pp. 107–125). Oxford University Press.
- Turner, J. (2011). Ontological Nihilism, *Oxford Studies in Metaphysics* vol. 6, ed. by K. Bennett & D. Zimmerman. Oxford University Press: 1–54.
- Wang, J. (2016). The nature of properties: Causal essentialism and quidditism. *Philosophy Compass*, 11(3), 168–176.
- Wang, J. (2019). The essences of fundamental properties. *Metaphysics*, 2(1), 40–54.
- Zalta, E. N. (2006). Essence and modality. *Mind*, 115(459), 659–693.
- Zylstra, J. (2020). Essence. In M. J. Raven (Ed.), *The Routledge Handbook of Metaphysical Grounding* (pp. 324–335). Routledge.

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