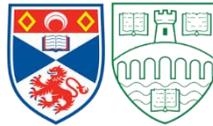


THE UNIVERSITY OF SAINT ANDREWS

The Mereology of Emergence

A THESIS

Submitted to the Faculty of the
St Andrews and Stirling Graduate programme in Philosophy



For the Degree

Master of Letters in Philosophy

Director: Aaron J. Cotnoir, Ph.D.

By Ryan M. Miller

I hereby declare that the attached piece of written work is my own work and that I have not reproduced, without acknowledgment, the work of another.

2019

0. Abstract

The debate about the ontological innocence of mereology has generally been framed as a debate about the plausibility of Universal Fusion. Ontologically loaded fusions must be more than the sum of their parts, and this seems to violate parsimony if fusion is universal. Less attention has been paid to the question of what sort of emergence mereological fusions must exhibit if they are irreducible to their parts. The philosophy of science literature provides several models of such strong emergence. Examining those models suggests that the difficulty with emergent fusions has at least as much to do with extensionality as it does with Universal Fusion. Some accounts of emergence fail to ensure irreducibility when combined with extensional mereologies. The most promising model for the strong emergence of ontologically loaded fusions fails to validate Anti-Symmetry, which naturally leads to failures of extensionality. These results suggest that the focus on Universal Fusion may have been misplaced.

Contents

0. Abstract.....	i
1. Introduction	1
1.1 Framing the Mereological Innocence Dispute	1
1.2 Meta-Ontological, Ontological, and Mereological Assumptions.....	3
2. Off-Label Strong Emergence	7
2.1 Chalmers' Not-So-Strong Emergence	7
2.1.1 Defining Chalmers' Strong Emergence	7
2.1.2 A Mereology for Chalmers' Strong Emergence.....	8
2.1.3 Chalmers' Not-so-Strong Emergence.....	11
2.2 Toner's Strong Holism.....	13
2.2.1 Defining Toner's Strong Emergence	13
2.2.2 A Mereology for Toner's Strong Emergence.....	15
2.2.3 Toner's Strong Holism.....	18
3. Titrated Strong Emergence	19
3.1 Defining Wilson's Strong Emergence with O'Connor et al.	19
3.2 Koons' Attempt at a Mereology for Wilson's Strong Emergence	23
3.3 A Better Mereology for Wilson's Strong Emergence	26
4. Conclusion.....	30
5. Cited	32

1. Introduction

1.1 Framing the Mereological Innocence Dispute

There is a longstanding intuition that ontology is bound up with mereology: we need to know something about parthood in order to inventory the world (Varzi, 2005, 2014). One contending view of parthood holds that composition is ontologically innocent, and so we need only inventory the non-overlapping objects¹ (typically the atoms).² This might be because composition is identity (Baxter, 1988), because composition is relevantly similar to identity (Lewis, 1991, p. 81; Sider, 2007), or because wholes and parts are just alternative but non-rivalrous ways of counting (Baxter, 2014).³ Peter van Inwagen, on the other hand, takes it that the supposed innocence of composition is a scam, and the identity analysis which is supposed to justify it is unintelligible (1994). He instead develops a theory on which composed entities deserve a place in our inventory over and above that of their proper parts (van Inwagen, 1995).

Our inventory of the world depends on which view is right. If our preliminary ontology contains an entity clearly composed of proper parts, then we need to know whether composition is loaded in order to determine whether it makes the final list. On the other hand, if we assume that composition is innocent we must know whether entities on our preliminary list are composed (and hence overlap⁴ the atoms) in order to know whether they should appear in our final ontology. Three entries from Jessica Wilson (2015)'s list of positions in the metaphysics of science therefore have clear mereological analogs:

- Eliminativism: deny that entities composed of proper parts exist (Mereological Nihilism)

¹ Which is to say, disjoint. "Dxy=def $\exists z(Pzx \ \& \ Pzy)$ " Definition 4 from Cotnoir and Varzi (Cotnoir & Varzi, forthcoming, p. 23).

² In fact, this is just Varzi's definition of composition-as-identity: "CI" =def Your inventory should include an entity you are committed to, x, if and only if x does not overlap any other entity y that is itself included in the inventory" (2014).

³ See Cotnoir (2014) for overview and background of this family of positions.

⁴ "Oxy =def $\exists z(Pzx \ \& \ Pzy)$ "—Definition 2 in Cotnoir and Varzi (forthcoming, p. 23).

- Reduction: deny that composed entities are distinct from their proper parts (Composition as Identity)
- Strong Emergence: affirm that composed entities should count separately from their proper parts

Distinguishing these three makes clear why van Inwagen (1994) considers the innocence of composition a scam: the view amounts to Reduction, and hence a rejection of both Eliminativism and Strong Emergence that bears philosophical costs. Of course, the freedom of composition was never intended to be a freedom from philosophical costs (obviously Reduction pays many of those), but rather a freedom from parsimony costs for composed entities (which seemingly only Reduction accomplishes). If composition is loaded, it had better be restricted, or the ontology will seem profligate. If composed entities don't bear any cost in ontological parsimony, however, then there is no counterweight to the advantages of Unrestricted Fusion.⁵ In van Inwagen's influential presentation, the merits of this mereological axiom are taken to be central to the dispute (1987, 1995, 2006).

In this dissertation my presentation will take the opposite direction: assuming that there are strongly emergent entities, what does their irreducibility tell us about their mereological structure? If a composed entity is irreducible to its parts, then the fusion of those parts must be "a real physical operation, and not [merely] a mathematical or logical operation on predicative representations of properties" (Humphreys, 1997). Or in van Inwagen's parlance, fusion will have to be "a causal relation, or at any rate nearly coextensive with one" (1987). The literature offers at least three characterizations of such causal fusion, and hence three accounts of Strong Emergence. The first is the sort often traced to J.S. Mill and C.D. Broad, given careful exposition by David Chalmers (2008). I argue that its causal fusion is too weak to ground mereological Strong Emergence—its wholes remain reducible to its parts.

⁵ After all, it's undeniably algebraically convenient, respects the parallels with plurals and sets (Goodman, 1956; Uzquiano, 2014), and avoids vague or anthropocentric restrictions (Lewis, 2001, p. 212).

The second theory of causal fusion on offer is often traced to Aristotle and Aquinas, and is now defended by Patrick Toner (2008) and Anna Marmodoro (2019). I argue that its causal fusion is (ironically) too strong to ground mereological Strong Emergence—its parts become reducible to its wholes. The third theory of causal fusion I canvas has its roots in Ibn Sina, and is now associated with Timothy O’Connor (1994; O’Connor & Jacobs, 2003; O’Connor & Wong, 2005), dubbed “Strong Emergence” by Jessica Wilson (2015), and given a mereology by Rob Koons (2014). I argue that this kind of causal fusion does ground mereological Strong Emergence—but that the axiom of Classical Mereology it fails to validate is Anti-Symmetry, not Universal Fusion.

Van Inwagen may reject these accounts of emergence as attempts to answer the unanswerable General Composition Question, since they purport to tell us what makes an entity irreducibly composed (Koons, 2014). Whether they successfully answer that difficult question or not, however, they do establish that there are extremely tight constraints on any possible answer. My investigation therefore suggests that opponents of the innocence of composition should worry less about Universal Fusion and more about whether they can meet the sharp constraints on Strong Emergence imposed by the metaphysics of science.

1.2 Meta-Ontological, Ontological, and Mereological Assumptions

Focusing this dissertation on the connection between mereology and the metaphysics of science requires making certain meta-ontological, ontological, and mereological assumptions. While I do not endorse it whole-heartedly in all contexts, I propose to circumscribe my investigation with a Quinean meta-ontology: to exist is to instantiate a property which appears in the best scientific explanation of an empirical phenomenon.⁶ This framing goes beyond Quine’s Dictum that “to be is to be the value of a

⁶ There are important disputes here about what counts as the most canonical form of a theory and about the relationship between the best current theories and the theories of a completed science; I don’t believe that anything I say here hinges on the answers to these questions. See Frege (1980), Quine (1960, 1969), Toner (2006), and Van Inwagen (2009) for the development of this meta-ontological program. Such properties may need to be

bound variable” (W. V. O. Quine, 1948) to include Alexander’s Dictum that “any candidate for being which cannot be made out as capable of playing some causal role can be discarded” (Cargile, 2003). In fact, as in Quine’s own view, it goes beyond both to insist that the causal role be identified by a scientific explanation of an empirical phenomenon (Harman, 1967).

This meta-ontology is apt because it divides the sides of the dispute in the desired way. First, it is fair: Varzi (2014)’s defense of ontological innocence accepts at least the main clause explicitly, as does van Inwagen, the leading proponent of ontologically loaded fusion (2009). Neither the Lewisians nor van Inwagen are likely to accept the restrictive clause as a general meta-ontological claim, but all of the surveyed authors who support the existence of ontologically loaded emergent fusions nonetheless think that the leading examples are in principle accessible to empirical science.

Second, the Quinean meta-ontology assigns all of the established views to the intuitively appropriate side. Baxter (1988, 2014)’s strong version of Composition-as-Identity need not be handled separately from Lewis, Sider, and Varzi’s Weak Composition-as-Identity position because the differences that strengthen Baxter’s version are inexpressible in a framework that only allows univocal existence and identity.⁷ We therefore need contend with only one meaning of innocence. Further, in the Quinean framework, existence requires pulling explanatory weight. This makes Hawley (2014)’s thought that fusions add ontological commitment but not explanatory complexity (mereological Epiphenomenalism), the Baxter-Lewis-Sider-Varzi view that fusions exist but do not add ontological commitment (mereological Reduction), and the view that fusions do not exist (mereological Eliminativism) indistinguishable.⁸ The Quinean meta-ontology achieves this feat by paraphrasing away

fully explanatory in the sense of Lonergan (1992) and natural in the sense of Lewis (1983, 2001) and Sider (2011) in order to appear in such theories, but I won’t defend the specifics here.

⁷ As Turner (2014) explains, Baxter’s strong composition-as-many-to-one-identity thesis is bound up with a non-univocal view of existence and a weak version of Leibniz’s Law.

⁸ We can thereby ignore the amicus curiae briefs on behalf of eliminativism by non-eliminativists, e.g. van Inwagen (1994) and Yi (1999). These don’t seem to have convinced anyone, though of course they do highlight real

entities that fail to do unique explanatory work, and only including in the ontological inventory those entities which cannot be eliminated by such paraphrase. The feasibility of this paraphrase strategy is deeply controversial,⁹ but here it is philosophically advantageous because it focuses our attention on the kind of entities that exist rather than on the meaning of existence. Again, too, it is accepted by both sides of the dispute: paraphrase is central to Varzi (2014)'s distinction between counting and countenancing and also to van Inwagen (1995)'s eliminativism about everyday material objects. An ontologically innocent fusion is subject to paraphrases of the sort Van Inwagen gives for artifacts—it is a pseudo-object better understood as a relation of other objects than as a thing in its own right.¹⁰

Third, the Quinean meta-ontology allows us to move easily among talk of entities, properties, and powers. I take it that the basic dispute about the ontological innocence of composition is whether fusions are *entities* to be included in our ontological inventory. In order to focus on the differences with both dualist and reductionist conceptions, however, much of the literature on emergence focuses on emergent *properties* or *powers* where “talk of powers is simply shorthand for talk of what causal contributions possession of a given feature makes (or can make, relative to the same laws of nature) to an entity's bringing about an effect, when in certain circumstances” (Wilson, 2015). In the Quinean framework we need not worry over-much about this distinction, because entities are whatever instantiates properties,¹¹ and properties are whatever has value in explaining effects. I will take note of this distinction when it matters for the argument, without belaboring in each case how we can move from knowledge of one to consequences for another.

philosophical distinctions among the views, e.g. Calosi (2016) has already shown that Strong Composition as Identity implies Eliminativism and is incompatible with Strong Emergence.

⁹ Though I consider strategies like Sider (1999)'s “underlying truth” method equivalent for these purposes.

¹⁰ See Rea (1998) and Toner (2006) for ontologies of such pseudo-objects.

¹¹ This doesn't preclude properties themselves being entities, e.g. Toner (2006) suggests that properties instantiate PROPERTY, and that PROPERTY is thus self-instantiating. Whether we need to count properties separately is discussed below.

Fourth, the Quinean meta-ontology allows us to sidestep the thorny dispute over what counts as a “novel” property that would prevent paraphrasing an emergent entity.¹² Good scientific explanations avoid causal over-determination, so novel properties are just properties that do explanatory work without introducing over-determination.¹³ The Quinean meta-ontology generates all the same conditions for loaded fusions that Clayton (2008) and Wilson (2015) set for metaphysical Strong Emergence: the denial of Eliminativism, Epiphenomenalism, Reduction, and Over-Determination.¹⁴

In addition to bringing a strong Quinean meta-ontology on board, the paper will be streamlined by making several ontological assumptions. As the above discussion indicates, I will be working in a polycategorical ontology that at least speaks of objects and properties, though without prejudice to the possibility that one might be paraphrasable in terms of the other, or that some properties might be objects or some objects might be properties. I am worried about the ontological load of composition, not its ideological load (W. V. Quine, 1951, 1983; Cowling, 2013), and the ontological load in the Quinean meta-ontology is born by whatever fundamentally instantiates the property. I will also generally assume what van Inwagen (2011) calls a relational ontology, in which parts are in the same category as the whole. When I speak of the proper parts of an emergent object, I will assume that they are objects as well, for much the same reasons as Cameron (2014). This is in keeping with most of the emergentist literature, which considers the emergence of biological objects from chemical ones, or the emergence of mental properties from physical ones, but generally remains within an object, property, or

¹² Such novel properties are just non-structural universals instantiated by the fusion. See Hawley (2010) for a good account of structural universals; we can then consider non-structural universals by remotion.

¹³ For an extended treatment of what constitutes causal overdetermination, see Merricks (2001). Toner (2008) shows that the concept is just as relevant for those who hold to event- rather than object-causation.

¹⁴ Wilson also demands that Strong Emergence reject Dualism, but this is trivial in the mereological case, since the relevant kind of dependence is the parthood relation, and without its putative parts being related by parthood, an entity just isn't a fusion.

powers frame for the discussion of a given case of emergence. The exception is section 2.2, where I engage Toner’s application of Koslicki’s Neo-Aristotelian Thesis, a constituent ontology.

Finally, I will assume Classical Mereology except where otherwise specified. Given the debate at the heart of the paper, this is obviously a very non-neutral presumption, but given the earlier formalization, widespread usage, and expressive power of Classical Mereology I think the burden of proof and clarity lies with those whose positions are non-classical. This means that when discussing characterizations of emergence that do not explicitly reference mereology, I will assume all of the axioms of Classical Mereology except those that conflict with the claims about emergence being made. When there are multiple axioms that could be weakened in order to accommodate the claims about emergence being made, I will argue explicitly for the most fitting approach, retaining as much of the expressive power of Classical Mereology as possible.

2. Off-Label Strong Emergence

2.1 Chalmers’ Not-So-Strong Emergence

2.1.1 Defining Chalmers’ Strong Emergence

David Chalmers is keen to distinguish weak and Strong Emergence. Weak emergence is the sort “often tacitly invoked by theorists in cognitive science and in the theory of complex systems” requiring “further levels of explanation” (David J. Chalmers, 2008). Strong emergence, by contrast, is traceable to “the British emergentists of the 1920s” and “threaten[s] the completeness of the catalogue,” yielding a “radical metaphysical expansion in our conception of the world” (David J. Chalmers, 2008).

Nonetheless, Chalmers initially defines both kinds of emergence in epistemic terms. A “phenomenon is *strongly emergent* [when it] arises (in some sense) from the low-level domain, but truths concerning that phenomenon are not *deducible* even in principle from truths in the low-level domain,” whereas in merely weak emergence the phenomenon is only “unexpected” but “nevertheless deducible in principle” (David J. Chalmers, 2008).

Chalmers takes in-principle in-deducibility to mean that strongly emergent “high-level truths are not conceptually or metaphysically necessitated by low-level truths” but they still arise by means of “nomological supervenience” on the lower level that serves as their emergence base (2008). In other words, we can read the “arise” in Chalmers’ definition as “supervenes upon” but only because of contingent facts about our world—namely the natural laws. The supervenience is therefore not modally rigid, so it counts as weak rather than strong supervenience in Jaegwon Kim’s classification (1984).¹⁵ Moving from layers of properties to the mereological structure of entities, we can gloss Chalmers’ notion of Strong Emergence as the case where the whole is weakly but not strongly supervenient on the parts.¹⁶

2.1.2 A Mereology for Chalmers’ Strong Emergence

Chalmers’ criterion for Strong Emergence is compatible with Classical Mereology. First, Classical Mereology implies weak supervenience. Classical Mereology uses Remainder¹⁷ as its decomposition axiom, and Remainder implies PP-Extensionality¹⁸—“decomposition is unique; whenever a thing has proper parts, it is the only thing with just those proper parts” (Cotnoir & Varzi, forthcoming, p. 27). Whatever has just those proper parts must then be identical with that thing, and by Leibniz’ Law, whatever parts are indiscernible from those parts are those same parts, ergo any identified fusions with indiscernible parts must be identical. Identicals are indiscernible, so whatever has an indiscernible fusion must have indiscernible parts. The axioms of mereology are clearly necessary if true (Nolan, 2011), so by the Necessitation Rule, necessarily whatever has an indiscernible fusion must have

¹⁵ A *weakly supervenes* on B just in case “Necessarily, for any x and y, if x and y share all properties then x and y share all properties in A (Kim, 1984, 1987). A *strongly supervenes* on B just in case “For any worlds w_i and w_k , and for any objects x and y, if x has in w_i the same B-properties that y has in w_k , then x has in w_i the same A-properties that y has in w_k ” (Kim, 1987, citing an unpublished paper by Brian McLaughlin).

¹⁶ This is not to claim that Chalmers’ view about properties *entails* this view about parts—the structure of the entities may not directly mirror the structure of the properties. Rather, this paper is investigating various possibilities for the emergence of entities, and one such possibility is the theory Chalmers advances about properties.

¹⁷ “ $\forall x \forall y (\sim Pxy \rightarrow \exists z \forall w (Pwz \leftrightarrow (Pwx \& Dwy)))$ ”—Axiom 4 in Cotnoir and Varzi (forthcoming, p. 25).

¹⁸ Formally “ $\forall x (\exists w PPwx \rightarrow \forall y (\forall z (PPzx \& PPzy) \rightarrow x = y))$ ”—Theorem 2.1 in Cotnoir and Varzi (forthcoming, p. 27).

indiscernible parts. Classical Mereology thereby guarantees the weak supervenience of fusions on their parts. Second, Classical Mereology fails to establish modally rigid strong supervenience. It might seem as though an indiscernible emergence base in another possible world is identical (and hence by Leibniz's Law has the same emergent fusion), but using Leibniz' Law in modal contexts requires rigid designators (Smullyan, 1948)—and the rigidity of the fusion is the aim of the proof.¹⁹ It therefore seems reasonable to presume Classical Mereology as the parthood structure for Chalmers' variant of Strong Emergence.

Of course Classical Mereology is also compatible with strong supervenience, however: if composition is identity, then fusion would be modally rigid. From a purely logical perspective, Classical Mereology therefore seems neutral between Chalmers'-style strong emergentist and Reduction views about the ontology of composition. There are, however, two sources of pressure on this neutrality, and thus two reasons to think that Classical Mereology might be more compatible with Reduction than Chalmers' Strong Emergence.

First, Gabriel Uzquiano (2014) suggests that modal Classical Mereology should be understood as more than the union of typical modal logic axioms and Classical Mereology: it should have an explicitly modal decomposition axiom. Such a modal decomposition axiom would guarantee the modal rigidity of composition, ensuring that fusions strongly supervene on their parts. Uzquiano offers two arguments in favor of his proposal, one offensive and one defensive. The offensive argument is that such a modal decomposition axiom is actually a weaker addition than the parallel required to make plural logic modally rigid (Uzquiano, 2014, see 2011). Almost everyone accepts that sets and plurals are modally rigid, so it seems ad hoc to reject a weaker modal axiom system for mereology. The defensive argument is that those who accept Composition as Identity are already committed to a modally rigid mereology, whereas those who are opposed to Composition as Identity are generally opposed to PP-Extensionality

¹⁹ For a model of Classical Mereology where the necessity of parthood fails, see Uzquiano (2014).

(Uzquiano, 2014).²⁰ In other words, they are opposed to the in-world strength of Remainder, not to making it modally rigid. Nonetheless, there are difficulties with both the offensive and defensive arguments. On the offensive side, if mereological fusion is supposed to be a logical model of a physical or causal process, then parallels with obviously acausal sets and plurals do not seem convincing. On the defensive side, emergentists like van Inwagen might object to Composition as Identity because it is difficult to formulate well rather than any opposition to extensionality (1994) and prefer to give up Universal Fusion rather than Remainder (1987).

Second, van Inwagen (1987, 2006) suggests that emergent entities, unlike sets, have different parts at different times, in conflict with Classical Mereology. By Universal Fusion the parts at each time would have a fusion, yet those fusions would not be identical with the emergent fusion since they would continue to fuse the same parts, in contravention of PP-Extensionality at the time when the parts are the same. This argument, however, relies on a naïve view of persistence. If a fusion persists through time it presumably does so by enduring or perduring. If it endures in a presentist way, then the fusion only fuses its present parts. To speak of its parts at other times is analogous to speaking of its parts in other worlds,²¹ and so tense-rigidity would require a tensed decomposition axiom in the same way that modal rigidity requires a modal decomposition axiom. The presentist emergentist naturally has as little incentive to adopt such an axiom as in the modal case. If the fusion endures in a four-dimensional way, then its properties need to be time-indexed (van Inwagen, 1990). This implies an explicitly time-indexed decomposition axiom in order to make fusions time-index rigid, and again the emergentist may freely decide not to adopt such an axiom rather than rejecting Universal Fusion. If a fusion perdures, then its

²⁰ The allegation seems to be based on Uzquiano's belief that denying Identity is more plausible or popular than denying Essentialism as a solution to Rea (1995)'s Problem of Material Constitution. In support, the Stanford Encyclopedia does call it the "standard" and "most popular" view (Wasserman, 2018). This strategy claims that coincident objects can be made of the same parts.

²¹ Many presentists are already committed to this close analogy of time and modality, e.g. Markosian (2004) and Prior (2003). Van Inwagen (1990) argues that all endurance theorists *must* be so committed.

various temporal parts are *not* strictly identical to one another (van Inwagen, 1990), and the fusion of those *temporal* parts is unchanging. In ordinary four-dimensional perdurance, then, there is no fusion which changes its parts (Sider, 2001). Van Inwagen's argument may pose issues for growing-block theorists, but that's far from a general objection to marrying Chalmers' Strong Emergence with Classical Mereology. Van Inwagen argues from personal-identity considerations against perdurance theories of persistence for emergent entities, but there are many reasons to reject such arguments quite apart from any attachment to Classical Mereology. He therefore gives us no reason to doubt the appropriateness of Classical Mereology for Chalmers' understanding of Strong Emergence.

2.1.3 Chalmers' Not-so-Strong Emergence

Unlike other emergence theorists, Chalmers envisions the separability of emergence and downward causation. In strong downward causation, "the causal impact of a high-level phenomenon on low-level processes is not deducible even in principle from initial conditions and low-level laws," whereas in merely weak downward causation the causal impact is "deducible in principle but is nevertheless unexpected" (David J. Chalmers, 2008). "In principle," Chalmers thinks, "one can have...strongly emergent qualities without strong downward causation" (2008). Chalmers describes this situation as an "epiphenomenalist picture" (2008), but this seems too broad-brush. If the putative strongly emergent entity does not exhibit even weak downward causation, then the entity is indeed epiphenomenal (and so in our Quinean meta-ontology does not exist). If the strongly emergent entity exhibits merely weak downward causation, however, then it is still pulling some explanatory weight. The trouble is that since the high-level entity is weakly supervenient on the lower levels, the effects will be over-determined: the initial conditions and low-level laws will have a hand in the same effects as the emergent entity.

As Jessica Wilson (2015) notes, this is more frequently referred to as non-reductive physicalism than Strong Emergence, and carries with it the obligation to explain why the over-determination is

unproblematic. Here, however, we need not enter into the debate about whether over-determination arguments always provide strong reasons for eliminativism, nor the verbal dispute about what constitutes Strong Emergence. It suffices to note that such putative non-reductively physical entities, with comprehensively over-determined causal powers, have no claim to existence in a strictly Quinean meta-ontology. Whatever the explanatory virtues of referring to such an object in the vernacular, it can be paraphrased away, and so forces us into no additional ontological commitments.

In order to avoid over-determination, Strong Emergence must be coupled with strong downward causation, violating the causal closure of the physical.²² If the emergent reality violates causal closure of the physical, however, then it cannot be identical with the mere Classical mereological fusion of its physical parts. After all, according to Classical Mereology, the fusion exists as soon as its parts do, even if those parts are space-like separated. In order for the fusion to exist, on the Quinean meta-ontology, it has to actually play its downward causal role (otherwise it wouldn't yet instantiate a property appearing in the best explanation of an empirical phenomenon). In order for the emergent fusion to be identical with the Classical mereological fusion, then, the downward causation must begin as soon as the parts come into existence. The converse is also true: the emergent property can't be instantiated before the coming into existence of the parts or it can't be ascribed to the fusion of those parts. But if the fusion has strongly emergent physical effects while its parts are at space-like separations then the coming into existence of a part has caused physical effects outside its light-cone, in violation of special relativity.²³ The fusion demanded by Unrestricted Fusion thus cannot be identical with the fusion which violates the causal closure of the physical, in contravention of PP-Extensionality.²⁴

²² Meaning "Every lower-level physically acceptable effect has a purely lower-level physically acceptable cause" (Wilson, 2015).

²³ Quantum entanglement can't produce superluminal causal effects outside of the origin light-cones of the particles (Franson, 2008).

²⁴ In the way Cotnoir and Varzi define Fusion as a least upper bound (forthcoming, p. 29), fusions are always unique by anti-symmetry regardless of the decomposition axiom chosen, but those who reject PP-Extensionality

The worry here is not the same as van Inwagen's. Parts can have different fusions at different times. Fusions with different modal properties (one would survive the movement of its parts, the other would not), however, cannot be the same fusion.

Thus while Chalmers' variant of Strong Emergence is itself compatible with Classical Mereology, when so combined it is not strong enough to force us to bear an ontological load. It therefore seems to be off-label: a form of emergence which is not really very strong. Fusions that do add to our ontological load must result from even stronger forms of emergence which force us into correspondingly weaker mereologies.

2.2 Toner's Strong Holism

2.2.1 Defining Toner's Strong Emergence

The Thomistic theory propounded by Patrick Toner (2008) is a much stronger form of emergence than Chalmers', positing non-over-determined causal powers incompatible with weak supervenience. As shown above, Classical Mereology guarantees such weak supervenience, so Toner's Strong Emergence is incompatible with Classical Mereology. Instead, Toner proposes that humans are substances that "have no substantial parts,"²⁵ instead being "macrophysical objects that are, in the relevant sense, simple" (2008). A great deal, of course, depends on the "relevant sense." If Toner's claim were merely that humans are mereological atoms, that might be implausible but would not imply a revisionary mereology. Toner, however, rejects Unrestricted Fusion in favor of an ontology with exactly two kinds of entities: atoms and emergent macrophysical objects (2008).

Nonetheless unlike van Inwagen (1995), Toner holds that "once composition occurs, the only object that remains is the emergent substance: nothing remains 'down there' at the microphysical level

would be tempted to use a very slightly weaker definition of fusion as "an upper bound that has no upper bound as a proper part," which is only unique if PP-Extensionality holds (Cotnoir & Varzi, forthcoming, p. 157).

²⁵ Toner uses "substance" to mean "an object with non-redundant (i.e., irreducible) causal powers" (2008), i.e. any entity sanctioned by the Quinean meta-ontology. So Toner's claim is that macrophysical entities do not have other entities as parts.

(with any causal powers of its own)" (2008). This suggests that for Toner emergence is a purely diachronic rather than synchronic relation, again leaving macrophysical objects as mereological atoms. While Toner is ambiguous on this point, this nevertheless seems like an uncharitable reading. First, it would leave macrophysical objects as absolutely simple, rather than only simple "in the relevant sense." Second, it would leave Toner with only atoms, since macrophysical objects would be merely macrophysical atoms, lacking parts. Third, it results in an implausible sense of emergence, because it would make all second quantizations²⁶ where more particles enter than exit cases of emergence. In second quantizations, the particles entering the quantum interaction are annihilated, while the particles exiting the interaction are newly created. These are generally treated as single-level diachronic interactions rather than cases of emergence: e.g. no-one tends to describe a newly created fermion as "made up of," "a fusion of," "composed by," etc. a just-annihilated boson. If the criterion for emergence is only that nothing remains after fusion occurs, however, then when many particles are annihilated and few are created, second quantizations should count as emergent.

A more plausible reading leans on Toner's assertion that atoms are "nominally present" in macrophysical objects, by which he means that the macrophysical objects have spatial parts that are qualitatively similar to the atoms which gave rise to them by diachronic emergence (2008).²⁷ That rules out simple second quantization cases, since e.g. the created standard model bosons do not have spatial parts like the annihilated fermions, nor would the created standard model fermions have spatial parts like the annihilated bosons. This emergence of macrophysical entities from atoms is nonetheless unlike the synchronic emergence discussed by Chalmers because the atoms that form the diachronic emergence base have "lost their identities" in giving rise to the macrophysical object (Toner, 2008). This

²⁶ See Wiki ("Second quantization," 2017).

²⁷ Koons (2019) also adopts this view: "we should not say that organisms have other thermal substances as parts. Rather, in the process of organismic development or ingestion, some thermal substances are destroyed and replaced by empirically and qualitatively indistinguishable copies that form virtual parts of the organism."

view is closer to that of Humphreys (1997) because the synchronic emergence base is somehow “used up” in the fusion and the properties of the spatial parts, while qualitatively similar to those of the atoms in the emergence base, are *all* “owned” by the macrophysical object (Toner, 2008). As Anna Marmodoro puts it “A substance emerges as a single, individual entity, when *we* turn the *parts* of the whole into *properties* of the whole” (2019).²⁸ This must be more or less Toner’s view, since he thinks substances have only spatial parts (or, at least, only one non-spatial material part), and “a spatial part is simply a geometrically defined section of the substance” (Toner, 2008). To say that the table has a bottom part is just to say that “bottom” is predicated of the table at a particular location. Toner’s macrophysical substances are then non-atoms in that they have parts in some sense (spatial parts, properties, perhaps a single non-spatial material proper part, etc.) but “relevantly simple” in that these parts are not material atoms of the sort that might serve as a diachronic emergence base.

2.2.2 A Mereology for Toner’s Strong Emergence

While I think this diachronic-only-emergence interpretation is faithful to the text of Toner (2008), there are two further considerations which suggest that Toner cannot ignore the sense in which his macrophysical objects are not simple but composed. The first is that merely spatial parts cannot change their locations, yet the properties Toner discusses seem to move, as e.g. when oxygen perfuses tissues. Some part or parts (e.g. 16 protons, neutrons and electrons, an oxygen molecule, a hemoglobin molecule, a red blood cell) seem to be responsible for the motion. Second, Toner holds to a constituent ontology, specifically Kathrin Koslicki’s Neo-Aristotelian Thesis, according to which properties of a substance *are* parts of the substance (Toner, 2013). Toner is therefore committed to some kind of synchronic emergence base by which the various spatial properties have a substantial fusion, even if the synchronic emergence base of the substance is not to be identified with its diachronic emergence base.

²⁸ Marmodoro thinks this emergence is a “conceptual operation” performed for “pragmatic considerations” (2019), but this controversial conventionalism doesn’t affect the mereology.

The second quantization analogy again rears its ugly head: surely fusion on this picture is an annihilation of atoms (the diachronic emergence base) and a creation of properties (the synchronic emergence base), but in what sense are the latter truly fused?

Toner's answer is that structural (non-material) parts (i.e. forms) are fused in virtue of a substantial form, which is itself a structural part of the substance, and a unique particular rather than a universal (2013).²⁹ This avoids the difficulty outlined above for Chalmers' variant of Strong Emergence by denying Unrestricted Fusion: two properties only have a fusion when a substantial form is also a part of that fusion (substance). Since the substantial form comes into being with the fusion, where the fusion is strongly emergent there would be no non-strongly-emergent fusion of the parts. Toner thus need not deny PP-Extensionality.³⁰ The trouble with this approach, which attempts to marry Strong Emergence to semi-Classical Mereology³¹ by treating substantial forms as immediate proper parts of substances, is that it is vulnerable to Aristotle's Third-Man Argument. Gail Fine (1995) formulates the premises of the infinite regress argument against Platonic separated forms as follows:

(OM-TMA) For any maximal set of Fs at level n, there is exactly one form of F at level n+1 over it.

(SP) Any form of F is itself F.

(NI) Nothing is F in virtue of itself.

Now we slightly reformulate the premises with Toner's version of the Neo-Aristotelian Thesis rather than Plato as the target:

²⁹ This use of 'structural' is distinct from its general use in the emergence literature, where it means 'predicated of the whole but reductively so,' e.g. mass.

³⁰ This is important for Toner because he accepts Weak Supplementation (at least dialectically) and his ontology satisfies Over-Supplementation (because two distinct entities which are not parts of each other must have their own substantial forms, which are distinct structural parts), which together imply PP-Extensionality.

³¹ I say semi-classical because Toner uses Restricted Fusion and Weak Supplementation.

(OM-TMA*) For any f s which are all the proper parts of the fusion F , there is exactly one substantial form of F , in virtue of which all the f s are proper parts of F .

(SP*) The substantial form of F is itself an f .

(NI*) Nothing is an f in virtue of itself.

OM-TMA* follows from Aristotelianism about substance in the framework of Toner's semi-Classical Mereology: Toner restricts the existence of fusions to substances, takes each substance to have a number of non-overlapping proper parts (its forms and at least one material part), and takes these to be unified (made parts of the one substance) by the unique substantial form of the substance. The forms, too, require unification, because for Toner forms are just configurational states, and a substance can have many different such states. Even the substantial form needs something to make it a part of the substance, since configurational states are configurational states *of* something, without which there is no substance.

SP* is just Toner's application of the Neo-Aristotelian Thesis. NI* follows from Weak Supplementation: the substantial form of F cannot, as a bare substratum, be the sole proper part of F —it can only be an f if there are other f s which it can unify into F . The substantial form therefore cannot be an f in virtue of itself. All the other f s are only f s in virtue of the substantial form. So now, in virtue of what is the substantial form of F an f (SP*)? Not in virtue of an accidental form or material part, because that would violate OM-TMA*. Not in virtue of itself, which would violate NI*, or in virtue of nothing, which would also violate Weak Supplementation. Not in virtue of a super-substantial form, which would trigger a regress. Like Chalmers' version of Strong Emergence, Toner's runs aground on the strength of its decomposition axiom.

Thankfully for Toner, he is only dialectically committed to Weak Supplementation, seeing it as argumentative support for his core Aristotelian-Thomist ideas about substance (2013). Toner's denial

that the synchronic emergence base is identical with the diachronic emergence base gives an opening to adopt a weaker decomposition axiom, Strong Company,³² for the fusion of nominally present parts that synchronically compose the substance. Now rather than considering the formal part as one with special powers, we can merely specify it as a part which underlaps³³ every other part. The part underlaps itself since it is an improper part of itself, so NI* comes out false and the Third Man Argument fails. Now Toner can be as ambivalent as Aristotle about whether grounding flows from the composite substance or the substantial form (Graham, 1990), because neither endangers the unity of the fusion: the former is its least upper bound and the latter is its greatest lower bound.

This model also gives us a good mereological reason for Toner (2010)'s claim that substances cannot be parts of substances. To be unified as a substance, a fusion would require a substantial form that underlaps all the parts it overlaps. If that substantial form were underlapped by the substantial form of the larger substance, then it would be unified with the larger substance and not an independent entity. If the substantial form of the smaller substance were not underlapped by the substantial form of the larger substance, then not all of the parts of the larger substance would be underlapped by its substantial form, in contradiction with the claim that the larger fusion is a substance.

2.2.3 Toner's Strong Holism

Given this mereology, however, the wholes and parts involved in the synchronic aspect of Toner's Strong Emergence don't seem to have separate existence. The substantial form surely lacks independent causal power because it is merely a configuration of the other parts into a whole. It is a particular, but not one separable from the whole in activity or existence. The other parts need not count separately because they are wholly grounded in either the emergent fusion or the substantial form. The premise of emergence was that complex *partial* grounding relations might add up to

³² " $\forall x \forall y (PPyx \rightarrow \exists z (PPzx \ \& \ \sim Pzy))$ "—Axiom 4.24 in Cotnoir and Varzi (forthcoming, p. 125).

³³ " $Uxy =_{df} \exists z (Pxz \ \& \ Pyz)$ "—Definition 3 in Cotnoir and Varzi (forthcoming, p. 23).

emergent wholes which have powers unattributable to the parts. When a putative entity is wholly grounded in a single other entity, parsimony can always reduce the wholly grounded entity. It is after all this sort of grounding that leads Jonathan Schaffer (2007, 2009, 2010) to describe his view as monism and not merely priority holism. Toner's variant fails to count as Strong Emergence in Wilson (2015)'s sense because it denies the distinctness of the wholes and parts—not for the usual reductive reasons, but rather for Aristotelian substance holism. Whereas Chalmers' Strong Emergence turned out to be compatible with a decomposition axiom so strong that we need not count fusions separately in our ontology, Toner's understanding of Strong Emergence turns out to be most compatible with a decomposition axiom so weak that we need not count *parts* separately in our ontology. Toner's Strong Emergence also seems off-label, but for the reason that its wholes do not seem to arise from their parts, which suggests some kind of dependence relation.

3. Titrated Strong Emergence

3.1 Defining Wilson's Strong Emergence with O'Connor et al.

Mereological investigation thus supports Jessica Wilson (2015)'s claim that only variants of emergentism which insist on the distinctness of wholes and parts and exclude over-determination can properly be called Strong Emergence.³⁴ The price of such positions is that they deny the causal closure of the physical. O'Connor and Jacobs (2003) give a positive account of such Strong Emergence, in which:

1. The emergent whole is a “causal consequence” of the action of the microphysical parts in a certain complex context.

³⁴ Strongly Emergentist views also need to affirm the real causal efficacy of the whole (lest they fall into epiphenomenalism) and the dependence of the whole on the parts (lest they fall into dualism). Neither of these temptations need be surveyed here, since the former is ruled out by our meta-ontology and the latter does not connect the existence of levels to whole-part relationships.

2. The powers of the whole are “basic,” which is to say that they are not duplicative of the powers of the parts, and necessary in explaining future states of the microphysical parts (“downwards causation”).

The strongly emergent whole is to be understood as a mereological fusion, because it is “simply the mereological sum” of its microphysical parts (O’Connor & Jacobs, 2003). O’Connor and Jacobs (2003) give two possible non-dualist interpretations of this fusion:

1. “A new object emerges and continues to depend for its existence on the structure that generated it: the underlying composite system and the new thing none the less interact with each other as distinct units – strictly speaking, there are a bunch of physical simples that jointly interact with the emergent object – so that the emergent object affects other things in its environment only via affecting the originating system”
2. “The new object is itself the composite system: the simples jointly compose the object, which has a distinctive thisness and some distinctive features.”

In the first case, O’Connor and Jacobs suggest, the emergent object would be identical to the fusion of its parts with nomological necessity, but possibly metaphysically distinct (2003).³⁵ This strikes me as a red herring—if identity is not metaphysically necessary in general, there is no obvious reason why particular identities might be necessary. If option (2) is construed as *only* the whole interacting causally with outside objects, then it’s unclear what reason could be given for supposing that the parts continue to exhibit their own thisness, and option (2) seems equivalent to Toner’s variant of Strong

³⁵ There might be other ways to try to parse what O’Connor and Jacobs (2003) mean here. Clearly their worry is to distinguish their view from a kind of emergent dualism, but cashing out dualism in terms of the independence of individuality rather than, as O’Connor and Wong (2005) and Wilson (2015) do, the independence of existence makes things confusing, since they never explain what it is for individuality to be dependent or independent. Perhaps their worry is that the emergent object might cease to have its emergence base as *parts*, rather than mere external dependencies, and so they are covertly appealing to Lewisian partial identity. Our mereological treatment just stipulates that the relationship between an emergent whole and its synchronic emergence base is parthood.

Emergence. Once these two strong construals are dismissed, the distinction between options (1) and (2) seems to be whether the whole interacts directly with non-parts—option (2)—or does so only through its parts—option (1). Construed in this way, option (1) is still compatible with Wilson’s Strong Emergence in our Quinean framework, because the emergent powers of the whole could be the best explanation for otherwise inexplicable powers of the parts.³⁶

What is important for avoiding dualism (and the Problem of Material Constitution) on either construal is PP-Extensionality: there cannot be any distinct non-emergent fusion of the same parts. Avoidance of non-reductive physicalism is then only possible if the non-emergent fusion does not exist (as shown above regarding Chalmers’ Strong Emergence), meaning that Wilson’s variant of Strong Emergence must deny Unrestricted Fusion. The dependence of emergent wholes on their emergence-base parts may be “dynamic and causal, not static and formal (in a quasi-logical sense)” (O’Connor & Wong, 2005), but it still carries mereological implications. Discerning the formal implications, however, requires sorting out the details of the dynamic causal picture. O’Connor and Wong (2005) are happy with the messy model of option (2) from O’Connor and Jacobs (2003), leaving the details of how dependence is secured and over-determination avoided as “a matter for empirical theory, not a priori analysis.”

Since Wilson’s understanding of Strong Emergence is intended to be incompatible with strong supervenience, O’Connor and Wong (2005) allow that in the outcome of that empirical investigation “there might be two objects having identical intrinsic physical properties...and existing in the same external circumstance, yet one has [an emergent fusion] and the other lacks it.” Since identical intrinsic physical properties means an identical intrinsic microphysical constitution in the Quinean framework,

³⁶ E.g., Van Inwagen (1995) and O’Connor and Jacobs (2003) both appeal to mental properties as (at least among) the non-duplicative causal powers of the emergent object, but the reason for believing in the existence of such properties might be an inference from the behavior of the parts.

there are two ways of reading this. The first reading takes the “two objects” phrasing literally. Since for the microphysical parts to be an object they must have a fusion, here we have one emergent (ontologically loaded) and one ontologically innocent fusion. Now what happens if parts of the ontologically innocent object become an emergence-base? The ontologically innocent fusion can’t become an ontologically loaded one, because they have different essential properties (e.g. if the emergent fusion is a dog, a non-dog cannot be later identical with a dog).³⁷ But since the ontologically innocent fusion is just that—innocent—it has no properties which can be supplanted by the emergent fusion, so it does not cease to exist. PP-Extensionality guarantees the uniqueness of the fusion, so it must be both innocent and loaded, which is a contradiction. The second reading, more charitably, paraphrases the second ‘object’ as the *ps* which are its synchronic emergence base. Now O’Connor and Wong’s claim just amounts to the denial that the emergent fusion even weakly supervenes on the parts. The repeated claim that emergent fusions are supervenient (O’Connor, 1994; O’Connor & Jacobs, 2003)—intended to prevent accusations of dualism—must then be understood as a mere global supervenience (O’Connor & Wong, 2005), which does not entail weak supervenience (Kim, 1987).

Merely globally supervenient emergent fusions, however, are subject to a dilemma from Jaegwon Kim. Global supervenience itself, Kim notes, is inadequate to ensure dependence (1987), and if the emergent reality fails to be dependent upon its parts then it seems more like a spawned entity (dualism) than a fusion. O’Connor and Wong’s response is that the dependence is *causal*, and therefore operates with whatever modal force you take efficient causation to have (2005). If the dependence is causal, however, Kim’s causal exclusion argument suggests cutting out the middle man and merely ascribing all of the causal powers to the emergence base (1999). O’Connor’s defense is that it is “implausible” to ascribe novel physical effects in complex systems to “rather elusive” novel properties of

³⁷ O’Connor and Jacobs (2003) defend that emergent fusions have such essential properties.

the parts rather than to emergent fusions (1994). O'Connor et al.'s emergent fusions seem no less elusive, however, since their existence does not weakly supervene on their parts, but only on the global microphysical state, and their powers, too, are employed only on their parts but rather cause downward changes in the general microphysical state. Causes and effects *might* be partitioned in such a way as to avoid circularity and over-determination, but O'Connor et al. have given precious little direction to their proposed biophysics research program, leaving it seeming "otiose and dispensable" (Kim, 1999).

3.2 Koons' Attempt at a Mereology for Wilson's Strong Emergence

Rob Koons (2014) takes up O'Connor et al.'s basic diachronic causal approach to emergence, but suggests two further structural elements to make it less otiose. The first is Power Migration, in which Koons avoids causal exclusion and over-determination arguments by positing that the powers of the parts which might rival those of the whole are in fact transferred to the whole—leaving the parts with only their essential powers, just enough to guarantee their continued existence in the Quinean ontology.³⁸ The second is Instrumentation, in which Koons avoids accusations of dualism by positing that the whole acts only on and through its parts, grounding and directing all of their non-essential powers. Koons assumes that this transeunt action is synchronic, which avoids causal circularity since the dependence of the whole upon the parts is diachronic.

Koons claims that this additional structure gives a model of emergence which validates "all of the axioms of classical extensional mereology (with the exception of arbitrary sums)" (2014). First he argues for the ordering axioms by noting that proper parts in his model are grounded by the whole, and that grounding is transitive and asymmetric. Koons' model only *partially* grounds parts in the whole,³⁹

³⁸ Strictly speaking, this move alone does not prevent over-determination because the essential powers of the parts could rival the powers of the whole. It does give a clear direction for avoiding such over-determination, however, by making the essential powers of the parts things like mass for which the corresponding properties of the whole are obviously reducible rather than novel. Properties of the parts which might be closely entwined with the supposedly novel powers of the whole can be transferred.

³⁹ Koons can't mean the ground of wholes in parts, because on his model wholes *aren't* grounded in their parts (on pain of circularity), rather, they're grounded in the process participated in by those parts at an earlier time.

however, since he insists that they exist as their own entities with their own essential properties and primary powers, capable of persisting through the demise of the whole. Jonathan Schaffer showed that partial grounding is *not* necessarily transitive (2012). Schaffer's solution is to make grounding contrastive, but since Koons' grounds are fundamental mind-independent entities rather than interest-dependent explanations, that route is unavailable here.

Next Koons argues for Strong Supplementation as the appropriate decomposition axiom for this understanding of Strong Emergence. The reasoning proceeds in two steps, attempting to prove both Mereological Linearity⁴⁰ and Very Strong Companionship,⁴¹ which jointly imply Strong Supplementation. Koons' argument for Mereological Linearity is that Power Migration cannot involve two entities directly receiving powers from the part, and conversely that no part can be immediately instrumentalized by two wholes. While this is equivalent to van Inwagen (1995)'s claim about the jealousy of lives, however, it is neither obvious nor implied by the considerations Koons places on Strong Emergence. It might seem, for instance, that an electron in a covalent bond could be an instrument of two atoms, or that a cell of an organ used by two conjoined twins could be an instrument of two lives. Nor is it clear that two entities cannot directly receive powers from the same part, since Power Migration only transfers those powers relevant to the powers of the whole. The two wholes may be of different types to which different powers are relevant, or cooperate so as to not require the same powers, and Instrumentation is only partial grounding so there can be multiple partial grounds. The appeal to Mereological Linearity therefore appears ad hoc.

The argument for Very Strong Companionship seems comparatively straightforward, at least if Mereological Linearity is granted. Strong emergence is supposed to be diachronically causally

⁴⁰ "x is a part of y, y is a part of x, or x and y are disjoint (non-overlapping)" (Koons, 2014).

⁴¹ "If x is a proper part of y, then there is some z such that z is a proper part of y, z is not a part of x, and x is not a part of z" (Koons, 2014). Cotnoir and Varzi show that if the classical ordering axioms hold, this is equivalent to their Strong Company (forthcoming, pp. 122, 127, 128n71).

dependent on parts interacting in complex ways. If Power Migration has already given all the relevant powers to one entity and/or Instrumentation has already subordinated all the activities of the parts, then there is no complex interaction to foster Strong Emergence. Strong Supplementation is therefore fully compatible with Wilson's view of Strong Emergence, though this view of emergence does not imply Strong Supplementation without a seemingly ad hoc appeal to Mereological Linearity. Remainder, however, does not seem compatible with this model of Strong Emergence. If we assume that the complex interactions which foster Strong Emergence sometimes require three or more immediate proper parts, then absent Unrestricted Fusion there will be no maximal remainder. Koons is therefore fudging slightly when he claims to recover all of Classical Mereology other than Unrestricted Fusion.⁴²

The advantage of Koons' additional structure for Strong Emergence is that it makes more obvious why the emergent realities really *are* fusions, rather than merely being higher-level entities of a novel kind that are nonetheless causally dependent on the lower-level entities which comprise their emergence bases. If those fusions have a fairly conventional mereological structure, that makes them less otiose. Unfortunately, Koons' structural considerations make Wilson's understanding of Strong Emergence more vulnerable to Kim's criticism that it is dispensable. Koons claims that Power Migration transfers the ground of the powers from the parts to their emergent fusion, but that Instrumentation means the action of the fusion on outside entities only comes through the parts acting on each other. The properties of the fusion only find a place in scientific explanations by acting on outside observers, but outside observers are only ever acted upon by the parts, and even the action of those parts is explained by the action of other parts. Koons suggests that we can know the existence of the fusion by the novelty of the powers exhibited by the parts: "electrons are enabled to do things by their inclusion that they couldn't have done in the wild" (2014). But why would it be more implausible to ascribe those

⁴² The size of the gap depends on Koons' choice of definition for fusion, which he fails to specify—Cotnoir and Varzi give examples (forthcoming, p. 158).

novel properties (whatever they may be) to a new physical fusion, rather than straightforwardly to the complex interactions of the parts (more turbulence than emergence)? How could novel properties of the parts, exhibited only in complex interactions, be more elusive than a whole which acts only in and through its parts, by grounding the secondary powers of those parts?

3.3 A Better Mereology for Wilson's Strong Emergence

Let's examine in detail the one example Koons (2014) gives of detectable emergent behavior:

I have the power to speak, a power that I can exercise in a Hobbesian state of nature. Now suppose that I am in fact part of a political community that enables me to speak in specifically political settings, such as a jury or a town meeting. Clearly my power of speaking takes on new dimensions thanks to my incorporation into a larger whole.

This more naturally looks like *downward* than *upward* Power Migration. Koons has not given the political community the power to speak, but the community has given Koons-qua-juror the power to convict, a power which he would lack absent the community. Political theorists sometimes speak as if the power of violence were transferred to the state, but the real, physical power for violence is neither given up to the state nor acquired from the state. What might be acquired from the state is the power to *punish*, a power not previously possessed by any individual. The political community surely does depend on the individuals who make it up, but this is principally a synchronic dependence on their acceptance or recognition of its authority (Searle, 2010). Surely no change in the community's attitudes or actions is possible without a change in the attitudes or actions of the individuals, so that synchronic dependence looks like weak supervenience (List & Pettit, 2011, p. 59). Individuals are dependent upon the state, but seemingly in a diachronic way—a state's loss of legitimacy only has concrete effects on individuals over time. As in Koons' analysis, however, it seems that the political community only directly acts on and through its parts.

The picture Koons paints thus seems to more naturally support an inverted version of his view. In this inverted account, strongly emergent wholes exhibit synchronic dependence on their parts in the form of weak supervenience. Power Migration transfers the novel powers of the emergent whole downwards to the parts, allowing the whole to act diachronically on and through those parts.

Koons only intends his social picture to be an analogy for the emergence of real substances, but taking the analogy seriously as the basis for the inverted model buys us a great deal. First, weak supervenience is, on its own, a sufficient marker of dependence for Kim to relinquish charges of dualism (1987). Koons' own view also prevents dualism, but only by positing unobserved upward Power Migration, so this perspective is considerably less otiose. The fact that the whole continues to act directly only on and through its parts suggests, as in Koons' rendering, that it really is a mereological construct rather than some other kind of entity. Finally, the irreducibly holistic origin of the powers exercised by the parts means that the powers of the whole are in no way dispensable, even if we only directly observe the powers of the parts. The trick, of course, is showing that the novel observed powers are irreducibly holistic in origin. For the political case, Margaret Gilbert (2006, 2013) gives a thoroughgoing defense of this claim. For the biological case, O'Connor et al. already take the principal novel properties to be mental and ascribe those mental properties to a numerically single thinker. If the observed properties can only be grounded in a unity, then they can only be grounded in the whole, and the emergent fusion is indispensable. This account therefore leans on a factor that goes beyond novelty, but one already present in the views of those who advocate Wilson-style Strong Emergence.

Koons (2014) considered and rejected this inverted version of his view for two reasons. First, by making the downward causality diachronic, it denies that transeunt action is instantaneous. Strongly emergent realities are supposed to be regular scientific entities, however—not ethereal Cartesian minds—so I'm not sure why downward causation should have any special claim to immediacy. Certainly in the political case there is good evidence against immediacy, and in the biological case there is no

evidence for it. Second, Koons worried that the inverted version forced the persistence conditions of the parts to change along with the existence of their strongly emergent fusion. In the political case, thinkers from Aristotle through Rousseau to contemporary anthropologists have certainly taken this to be the case: humans outside political communities surely acquire food and mates very differently than those inside them.⁴³ In the biological case, organic homeostasis changes the free energy of chemical reactions, biasing their frequency and products (Philips & Milo, 2015). Plausibly that means the conditions for persistence of chemical compounds change inside and outside the organism. If the conditions for persistence were the same, after all, then you would expect the effects of persistence to be the same.

If this inverted-Koons view is the right account of Wilson-style Strong Emergence, what mereology does it imply? The main result is that it does not seem to demand extensionality. As Toner (2006) notes, a band and a basketball team may have the same parts—and indeed both supervene on the properties of those parts—but that does not make them the same. They ask different commitments of their members, and therefore as Gilbert (2013) explains, grant them different powers. Aaron Cotnoir (2010) suggests that denying extensionality may be a natural result of rejecting Anti-Symmetry, however, and in these models Anti-Symmetry does not seem to hold universally. For the political case, consider that some institutions, like the Harvard Corporation, are legally defined as having their board members as their parts—while others, like the United Nations, have other institutions as their member parts. As with the band and the basketball team, two institutions may have the same ordinary parts. But now suppose that two clubs both have the same ordinary members and each other as members.

⁴³ This is borne out by contemporary anthropological research, which reveals that the mode of subsistence is dependent on the mode of social organization (Dunbar, 1993; Sandeford, 2018). Civilization is capable of generating agricultural wealth, but only civilization can protect such wealth.

We have a parthood loop, and both Anti-Symmetry and extensionality naturally fail, without any recourse to strange physics or metaphysics as in Cotnoir (2013).

Thankfully, as Cotnoir points out, “the anti-extensionalist can agree that Classical Mereology is almost entirely correct, with the sole exception that it runs together mereological equivalence and identity” (2010). Fusions can be mereologically equivalent (in that they have the same parts)—but since Strong Emergence is a real process involving specific properties—fuse those parts differently and hence not be identical fusions. Making this distinction, however, does not impinge on any of the structure of Classical Mereology. In fact, Universal Fusion has advantages for the emergentist. It’s extremely convenient to refer to non-emergent maximal remainders like “the cancerous part of the organ” or “the citizens who do not hold a government post.” Certainly these could be referred to using sets or plurals rather than as fusions, but treating them as fusions allows conveniently combining them in the same logic as the emergent fusions and their parts, which is useful since they causally interact. The immune system fights the cancer, even if the cancer unlike the immune system is a non-emergent reality fully reducible to its parts, the mutated cells. In the Quinean meta-ontology this reduction may be indistinguishable from elimination, but that need not keep us from treating countably real (or ontologically loaded) and merely countenanced (or ontologically innocent) entities in the same logical structure.

So much for composition, what about a decomposition axiom for Wilson’s variant of Strong Emergence? Unlike in Koons’ analysis, we have no reason to deny Remainder. Unrestricted Fusion gives us maximal remainders, no matter how many parts are causally required for a particular strongly emergent fusion. The causal network need consider only the atoms and the strongly emergent fusions, while the mereology treats the loaded and innocent fusions as equivalent. Meanwhile, the inverted proposal seems to support Very Strong Companionship just as well as Koons’ version. An entity which weakly supervenes on a single entity cannot avail itself of our single-power-bearer argument for the

indispensability of emergence, and hence cannot be distinguished from the entity on which it supervenes in the Quinean ontology. Mereological Linearity fails because it is dependent on Anti-Symmetry, but that doesn't mean that the model satisfies only Very Strong Companionship and not Weak Supplementation. Models which satisfy Very Strong Companionship but not Weak Supplementation can be gunky (Cotnoir & Varzi, forthcoming, p. 127), but in Wilson's variant of Strong Emergence the grounding relationship runs from parts to wholes, and gunky models lack fundamental entities, whereas grounding is supposed to be well-founded and hence require them (Dixon, 2016). Wilson's Strong Emergence therefore requires at least Weak Supplementation, but seems neutral on Over-Supplementation,⁴⁴ so it is also compatible with Remainder.

As Cotnoir and Bacon point out, the loops in this account make it not a well-founded mereology (2012), but this does not imply that the ground of wholes in their parts is not well-founded. That ground is ensured by the weak supervenience of fusions on their parts. A loop is formed when two or more fusions have each other as parts and the same other proper parts. Each fusion can only change when its parts change, but since their relationship to each other is symmetric, that means the looped fusions can only change when there is a change in their non-looping proper parts. The looped fusions thus weakly supervene entirely on the proper parts which do not participate in the loops, so the loops have no impact on the well-foundedness of the grounding relation. Inverting Koons' model thus yields a mereological model which fails to validate Anti-Symmetry or PP-Extensionality, but has Universal Fusion, popular decomposition axioms, and well-founded grounding.

4. Conclusion

The debate concerning the ontological innocence of composition can be understood as a dispute about whether non-trivial fusions are always reducible to their parts or sometimes exhibit strongly

⁴⁴ " $\forall x \forall y (POxy \rightarrow \exists z (PPzx \ \& \ Dzy))$ " (Cotnoir & Varzi, forthcoming, p. 111).

emergent characteristics. If fusions can exhibit strongly emergent characteristics, then those fusions need to be counted separately in our inventory of the world. If the properties of fusions are always reducible to those of their parts, then we need not count them separately. In a strongly Quinean meta-ontology, emergent characteristics must feature in scientific explanations.

A survey of three theories about how emergent characteristics can feature in scientific explanations revealed that only Jessica Wilson (2015)'s notion of Strong Emergence, which mandates downward causation and insists on the irreducibility of parts to wholes, can yield ontologically loaded fusions. David Chalmers (2008)'s account of Strong Emergence only mandated weak supervenience but not downward causation. That made it compatible with Classical Mereology, but PP-Extensionality and Universal Fusion then ruled out downward causation, which meant that emergent fusions in Chalmers' sense failed to feature in scientific explanations. Meanwhile Patrick Toner (2008)'s account of emergence turned out to be incompatible with even weak supervenience and yielded a gunky mereology that prevented wholes from being grounded in their parts. In contrast to Chalmers' account which failed to make wholes irreducible to their parts, Toner's failed to make parts irreducible to their wholes. In both cases overlapping entities only needed to be counted once, meeting Varzi (2014)'s definition of ontological innocence.

Wilson's account, on the other hand, ensures that wholes and parts must be counted separately, because they both play a role in scientific explanations. Rob Koons (2014) suggested that the parts count because of a diachronic effect on the whole, while the whole counts because of a synchronic effect on the parts, yielding an extensional mereology with Restricted Fusion and Strong Supplementation. Koons' attempt, while helpfully precise, seemed to falter since it secured the dependence of wholes on their parts in an unobservable manner and made its mereological claims on the basis of sometimes dubious scientific assumptions. I instead proposed an alternative framework for Wilson's notion of Strong Emergence on which parts count because they ground the wholes which

synchronically weakly supervene on them, while wholes count because they transfer novel powers to their parts, undertaking diachronic downward causation by acting on and through those parts. This approach yielded a non-extensional and non-antisymmetric mereology with Universal Fusion and either Weak Supplementation or Remainder as its decomposition axiom.

Up to now the debate over the ontological innocence of composition has centered on the plausibility of Universal Fusion, following van Inwagen (1987, 1995, 2006). This study, however, suggests that the focus may be better placed on extensionality. The two attempts at modeling Strong Emergence which validated PP-Extensionality led to reducing wholes to parts or parts to wholes. The view of Strong Emergence which prevented reduction in either direction led to a model which failed to validate Anti-Symmetry and thus PP-Extensionality, but retained Universal Fusion. Van Inwagen's moderate answer to the Special Composition Question may be coherent, but it is not supported by the existing literature on emergence. If we take the philosophy of science literature seriously, we end up with quite narrow conditions on the possibility of ontologically loaded fusion.

11,248 words

5. Cited

Baxter, D. L. M. (1988). Many-One Identity. *Philosophical Papers*, 17(3), 193–216.

<https://doi.org/10.1080/05568648809506300>

Baxter, D. L. M. (2014). Identity, Discernibility, and Composition. In A. J. Cotnoir & D. L. M. Baxter (Eds.), *Composition as Identity* (pp. 244–253). Retrieved from

<https://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199669615.001.0001/acprof-9780199669615-chapter-13>

Calosi, C. (2016). Composition, identity, and emergence. *Logic and Logical Philosophy*, 25(3), 429–443.

- Cameron, R. P. (2014). Parts Generate the Whole, But They Are Not Identical to It. In A. J. Cotnoir & D. L. M. Baxter (Eds.), *Composition as Identity* (pp. 90–108).
<https://doi.org/10.1093/acprof:oso/9780199669615.003.0005>
- Cargile, J. (2003). On “Alexander’s” Dictum. *Topoi*, 22, 143–149.
- Chalmers, David J. (2008). Strong and Weak Emergence. In P. Clayton & P. Davies (Eds.), *The Re-Emergence of Emergence: The Emergentist Hypothesis from Science to Religion* (pp. 244-).
Oxford: Oxford Univ. Press.
- Clayton, P. (2008). Conceptual Foundations of Emergence Theory. In P. Clayton & P. Davies (Eds.), *The Re-Emergence of Emergence* (pp. 1–29). Retrieved from
<https://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199544318.001.0001/acprof-9780199544318-chapter-1>
- Cotnoir, A. J. (2010). Anti-Symmetry and Non-Extensional Mereology. *The Philosophical Quarterly*, 60(239), 396–405. <https://doi.org/10.1111/j.1467-9213.2009.649.x>
- Cotnoir, A. J. (2013). Strange Parts: The Metaphysics of Non-classical Mereologies. *Philosophy Compass*, 8(9), 834–845. <https://doi.org/10.1111/phc3.12061>
- Cotnoir, A. J. (2014). Composition as Identity: Framing the Debate. In A. J. Cotnoir & D. L. M. Baxter (Eds.), *Composition as Identity* (pp. 3–22).
<https://doi.org/10.1093/acprof:oso/9780199669615.001.0001>
- Cotnoir, A. J., & Bacon, A. (2012). Non-Wellfounded Mereology. *The Review of Symbolic Logic*, 5(2), 187–204. <https://doi.org/10.1017/S1755020311000293>
- Cotnoir, A. J., & Varzi, A. C. (forthcoming). *Mereology*. Oxford: Oxford University Press.
- Cowling, S. (2013). Ideological parsimony. *Synthese*, 190(17), 3889–3908.
<https://doi.org/10.1007/s11229-012-0231-7>

- Dixon, T. S. (2016). What Is the Well-Foundedness of Grounding? *Mind*, 125(498), 439–468.
<https://doi.org/10.1093/mind/fzv112>
- Dunbar, R. I. M. (1993). Coevolution of neocortical size, group size and language in humans. *Behavioral and Brain Sciences*, 16(4), 681–694. <https://doi.org/10.1017/S0140525X00032325>
- Fine, G. (1995). Third Man Arguments. In *On Ideas: Aristotle's Criticism of Plato's Theory of Forms*.
Retrieved from
<https://www.oxfordscholarship.com/view/10.1093/0198235496.001.0001/acprof-9780198235491-chapter-15>
- Franson, J. D. (2008). Generation of entanglement outside of the light cone. *Journal of Modern Optics*, 55(13), 2117–2140. <https://doi.org/10.1080/09500340801983129>
- Frege, G. (1980). *The Foundations of Arithmetic: A Logico-Mathematical Enquiry into the Concept of Number* (2nd Revised edition; J. L. Austin, Trans.). Evanston, Ill: Northwestern University Press.
- Gilbert, M. (2006). *A theory of political obligation: Membership, commitment, and the bonds of society*. Oxford ; New York: Oxford University Press.
- Gilbert, M. (2013). *Joint Commitment: How We Make the Social World*.
<https://doi.org/10.1093/acprof:oso/9780199970148.001.0001>
- Goodman, N. (1956). A world of Individuals. In I. M. Bochenski, A. Church, & N. Goodman (Eds.), *The Problem of Universals: A Symposium* (pp. 13–31). Notre Dame, IN: University of Notre Dame Press.
- Graham, D. W. (1990). *Aristotle's Two Systems*. Retrieved from
<http://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780198243151.001.0001/acprof-9780198243151>
- Harman, G. (1967). Quine on Meaning and Existence, II. Existential Commitment. *The Review of Metaphysics*, 21(2), 343–367. Retrieved from JSTOR.

- Hawley, K. (2010). Mereology, Modality and Magic. *Australasian Journal of Philosophy*, 88(1), 117–133.
<https://doi.org/10.1080/00048400802587341>
- Hawley, K. (2014). Ontological Innocence. In *Composition as Identity* (pp. 70–88). Retrieved from
<https://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199669615.001.0001/acprof-9780199669615-chapter-4>
- Humphreys, P. (1997). How Properties Emerge. *Philosophy of Science*, 64(1), 1–17.
<https://doi.org/10.1086/392533>
- Kim, J. (1984). Concepts of Supervenience. *Philosophy and Phenomenological Research*, 45(2), 153.
<https://doi.org/10.2307/2107423>
- Kim, J. (1987). “Strong” and “Global” Supervenience Revisited. *Philosophy and Phenomenological Research*, 48(2), 315. <https://doi.org/10.2307/2107631>
- Kim, J. (1999). Making Sense of Emergence. *Philosophical Studies*, 95(1), 3–36.
<https://doi.org/10.1023/A:1004563122154>
- Koons, R. C. (2014). Staunch vs. Faint-Hearted Hylomorphism: Toward an Aristotelian Account of Composition. *Res Philosophica*, 91(2), 151–177.
- Koons, R. C. (2019). Thermal substances: A Neo-Aristotelian ontology of the quantum world. *Synthese*.
<https://doi.org/10.1007/s11229-019-02318-2>
- Lewis, D. K. (1983). New work for a theory of universals. *Australasian Journal of Philosophy*, 61(4), 343–377. <https://doi.org/10.1080/00048408312341131>
- Lewis, D. K. (1991). *Parts of Classes* (J. P. Burgess, Ed.). B. Blackwell.
- Lewis, D. K. (2001). *On the Plurality of Worlds*. Wiley-Blackwell.
- List, C., & Pettit, P. (2011). *Group Agency*. <https://doi.org/10.1093/acprof:oso/9780199591565.001.0001>
- Lonergan, B. (1992). *Insight: A Study of Human Understanding* (5th ed.; F. E. Crowe & R. M. Doran, Eds.). Toronto, ON: University of Toronto Press.

- Markosian, N. (2004). A Defense of Presentism. *Oxford Studies in Metaphysics*, 1(3), 47–82.
- Marmodoro, A. (2019). *Structure versus whole versus one*. 239–250. Edizione ETS.
- Merricks, T. (2001). *Objects and Persons*. Retrieved from
<http://www.oxfordscholarship.com/view/10.1093/0199245363.001.0001/acprof-9780199245369>
- Nolan, D. (2011). The Extent of Metaphysical Necessity. *Philosophical Perspectives*, 25(1), 313–339.
<https://doi.org/10.1111/j.1520-8583.2011.00218.x>
- O'Connor, T. (1994). Emergent Properties. *American Philosophical Quarterly*, 31(2), 91–104.
- O'Connor, T., & Jacobs, J. D. (2003). Emergent Individuals. *The Philosophical Quarterly*, 53(213), 540–555. <https://doi.org/10.1111/1467-9213.00330>
- O'Connor, T., & Wong, H. Y. (2005). The Metaphysics of Emergence. *Noûs*, 39(4), 658–678. Retrieved from JSTOR.
- Philips, R., & Milo, R. (2015). How much energy is released in ATP hydrolysis? In *Cell Biology by the Numbers*. Retrieved from <http://book.bionumbers.org/how-much-energy-is-released-in-atp-hydrolysis/>
- Prior, A. N. (2003). *Time and Modality*. Clarendon Press.
- Quine, W. V. (1951). Ontology and Ideology. *Philosophical Studies: An International Journal for Philosophy in the Analytic Tradition*, 2(1), 11–15. Retrieved from JSTOR.
- Quine, W. V. (1983). Ontology and Ideology Revisited. *The Journal of Philosophy*, 80(9), 499–502.
<https://doi.org/10.2307/2026110>
- Quine, W. V. O. (1948). On What There Is. *The Review of Metaphysics*, 2(5), 21–38.
- Quine, W. V. O. (1960). *Word And Object*. Retrieved from
<http://archive.org/details/in.ernet.dli.2015.529086>
- Quine, W. V. O. (1969). *Ontological relativity: And other essays*. New York: Columbia University Press.

- Rea, M. C. (1995). The Problem of Material Constitution. *The Philosophical Review*, 104(4), 525–552.
- Rea, M. C. (1998). Sameness without identity: An Aristotelian solution to the problem of material constitution. *Ratio*, 11(3), 316–328.
- Sandeford, D. S. (2018). Organizational complexity and demographic scale in primary states. *Royal Society Open Science*, 5(5), 171137–171152. <https://doi.org/10.1098/rsos.171137>
- Schaffer, J. (2007). From nihilism to monism. *Australasian Journal of Philosophy*, 85(2), 175–191. <https://doi.org/10.1080/00048400701343150>
- Schaffer, J. (2009). On What Grounds What. In David J. Chalmers, D. Manley, & R. Wasserman (Eds.), *Metametaphysics* (pp. 347–383). Oxford ; New York: Oxford University Press.
- Schaffer, J. (2010). Monism: The Priority of the Whole. *The Philosophical Review*, 119(1), 31–76.
- Schaffer, J. (2012). Grounding, transitivity, and contrastivity. In F. Correia & B. Schneider (Eds.), *Metaphysical Grounding: Understanding the Structure of Reality* (pp. 122–138). Cambridge: Cambridge University Press.
- Searle, J. (2010). *Making the Social World: The Structure of Human Civilization*. <https://doi.org/10.1093/acprof:osobl/9780195396171.001.0001>
- Second quantization. (2017). In *Wikipedia*. Retrieved from https://en.wikipedia.org/w/index.php?title=Second_quantization&oldid=767039207
- Sider, T. (1999). Presentism and Ontological Commitment. *The Journal of Philosophy*, 96(7), 325–347. <https://doi.org/10.2307/2564601>
- Sider, T. (2001). *Four-Dimensionalism: An Ontology of Persistence and Time*. Retrieved from <https://www.oxfordscholarship.com/view/10.1093/019924443X.001.0001/acprof-9780199244430>
- Sider, T. (2007). Parthood. *The Philosophical Review*, 116(1), 51–91. Retrieved from JSTOR.

- Sider, T. (2011). *Writing the Book of the World*. Retrieved from <http://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199697908.001.0001/acprof-9780199697908>
- Smullyan, A. F. (1948). Modality and Description. *The Journal of Symbolic Logic*, 13(1), 31–37. <https://doi.org/10.2307/2268137>
- Toner, P. (2006). Meta-Ontology and Accidental Unity. *The Philosophical Quarterly*, 56(225), 550–561. <https://doi.org/10.1111/j.1467-9213.2006.458.x>
- Toner, P. (2008). Emergent substance. *Philosophical Studies*, 141(3), 281–297. <https://doi.org/10.1007/s11098-007-9160-6>
- Toner, P. (2010). On Substance. *American Catholic Philosophical Quarterly*, 84(1), 25–48. <https://doi.org/10.5840/acpq20108412>
- Toner, P. (2013). On Aristotelianism and Structures as Parts. *Ratio*, 26(2), 148–161. <https://doi.org/10.1111/rati.12003>
- Turner, J. (2014). Donald Baxter’s Composition as Identity. In *Composition as Identity* (pp. 225–242). Retrieved from <https://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199669615.001.0001/acprof-9780199669615-chapter-12>
- Uzquiano, G. (2011). Plural Quantification and Modality. *Proceedings of the Aristotelian Society*, 111(2.2), 219–250. <https://doi.org/10.1111/j.1467-9264.2011.00307.x>
- Uzquiano, G. (2014). Mereology and Modality. In S. Kleinschmidt (Ed.), *Mereology and Location* (pp. 33–56). Retrieved from <https://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199593828.001.0001/acprof-9780199593828-chapter-3>

- van Inwagen, P. (1987). When Are Objects Parts? *Philosophical Perspectives*, 1, 21–47.
<https://doi.org/10.2307/2214142>
- van Inwagen, P. (1990). Symposia Papers: Four-Dimensional Objects. *Noûs*, 24, 245–255.
<https://doi.org/10.2307/2215526>
- van Inwagen, P. (1994). Composition as Identity. *Philosophical Perspectives*, 8, 207–220.
<https://doi.org/10.2307/2214171>
- van Inwagen, P. (1995). *Material Beings*. Ithaca, NY: Cornell University Press.
- van Inwagen, P. (2006). Can Mereological Sums Change Their Parts? *The Journal of Philosophy*, 103(12), 614–630.
- van Inwagen, P. (2009). Being, Existence, and Ontological Commitment. In David John Chalmers, D. Manley, & R. Wasserman (Eds.), *Metametaphysics: New essays on the foundations of ontology* (pp. 472–506). Oxford : New York: Clarendon Press ; Oxford University Press.
- van Inwagen, P. (2011). Relational vs Constituent Ontologies. *Philosophical Perspectives*, 25(1), 389–405.
<https://doi.org/10.1111/j.1520-8583.2011.00221.x>
- Varzi, A. C. (2005). Mereological Commitments. *Dialectica*, 54(4), 283–305.
<https://doi.org/10.1111/j.1746-8361.2000.tb00286.x>
- Varzi, A. C. (2014). Counting and Countenancing. In A. J. Cotnoir & D. L. M. Baxter (Eds.), *Composition as Identity* (pp. 47–67). Retrieved from
<https://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199669615.001.0001/acprof-9780199669615-chapter-3>
- Wasserman, R. (2018). Material Constitution. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Fall 2018). Retrieved from
<https://plato.stanford.edu/archives/fall2018/entries/material-constitution/>

Wilson, J. (2015). Metaphysical Emergence: Weak and Strong. In T. Bigaj & C. Wüthrich (Eds.), *Metaphysics in Contemporary Physics* (pp. 345–402). New York: Brill.

Yi, B.-U. (1999). Is Mereology Ontologically Innocent? *Philosophical Studies: An International Journal for Philosophy in the Analytic Tradition*, 93(2), 141–160.