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Collapsing Strong Emergence's Collapse Problem

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Abstract:

It is impossible to deduce the properties of a strongly emergent whole from a complete knowledge of the properties of its constituents, according to C. D. Broad, when those constituents are isolated from the whole or when they are constituents of other wholes. Elanor Taylor proposes the Collapse Problem. Macro-level property p supposedly emerges when its micro-level components combine in relation r. However, each component has the property that it can combine with the others in r to produce p. Broad's nondeducibility criterion is not met. This article argues that the amount of information required for r is physically impossible. Strong Emergence does not collapse. But the Collapse Problem does. Belief in Strong Emergence is strongly warranted. Strong Emergence occurs whenever it is physically impossible to deduce how components, in a specific relation, would combine to produce a whole with p. Almost always, that is impossible. Strong Emergence is ubiquitous.

It is impossible to deduce the properties of a strongly emergent whole from a complete knowledge of the properties of the constituent parts of a whole, according to the metaphysical version of Strong Emergence articulated by Broad (1925), when those parts are either isolated from the whole or constituents of other wholes. Taylor (2015, 2017a, 2017b, 2022) proposes a version of the Collapse Problem. Suppose that macro-level property p strongly emerges when micro-level components A and B combine in relation r. However, each component has the property that it can combine with the other in r to produce a whole with p. Broad's nondeducibility criterion is not met, and p collapses into the micro-level.

The Collapse Problem challenges all versions of Strong Emergence. It also challenges theories which presuppose Strong Emergence. For example, the nonindividualist theory of oppression maintains that groups are metaphysically real, over and above the members who compose them (Young 1990). Taylor (2016) maintains that the nonindividualist theory of oppression is best interpreted as a form of Strong Emergence about groups and so that theory is challenged by the Collapse Problem.

This article argues that the Collapse Problem ignores relation r by treating r as a fixed value rather than as a variable. Extrapolations from recent scientific findings strongly suggest that the amount of information required to fully account for r is physically impossible. Strong Emergence does not collapse. But the Collapse Problem does. Belief in Strong Emergence is strongly warranted. It occurs whenever it is physically impossible to deduce how components, in a specific r, would combine to produce a whole with p. Almost always, it is impossible to deduce that. Strong Emergence is ubiquitous.

This article has eight sections. The first section explicates Strong Emergence and the Collapse Problem. The second section considers Baysan and Wilson's attempt to articulate a powers-based version of Strong Emergence that overcomes the Collapse Problem and it presents Taylor's responses to it. This debate will likely result in a draw. The third section presents three objections to the Collapse Problem. It then considers three replies to those objections. The debate will likely stalemate when conducted at that level. The fourth section argues that the Collapse Problem ignores relations. The fifth section argues that the amount of information needed to account for all relations plausibly exceeds the amount of information in the universe. Moreover, accounting for every relation would take more time than the age of the universe. Hence, the Collapse Problem is unable to collapse all supposed cases of Strong Emergence. The sixth section further articulates the argument against the Collapse Problem by comparing it to similar arguments against Laplace's demon. The seventh section considers and rejects the two objections to the argument against the Collapse Problem: the deductions which collapse Strong Emergence need not be physically possible, and that it is irrelevant that those deductions could not occur in the physical universe. The final section has concluding remarks.

1

The section explicates Strong Emergence and the Collapse Problem. There are several versions of Strong Emergence, such as those of Broad (1925), Chalmers (1996, 2006), Merricks (2001), Morrison (2012), Gillett (2016), Humphreys (2016), Wilson (2010, 2013, 2015, 2021), and Baysan (2020). There are also several versions of what Taylor (2015) refers to as “the Collapse Problem” of Strong Emergence, such as those of Broad (1925), Grelling’s criticism of the epistemological account of emergence discussed in Hempel and Oppenheim (1948, 148), O’Connor (1994), Shoemaker (2007), Howell (2009), Taylor (2015, 2017a, 2017b, 2022), Skiles (2016), and Baysan and Wilson (2017). Although the Collapse Problem can be formulated metaphysically, its initial intuitive appeal results from its epistemological articulation, and so this article focuses on Broad’s epistemological criterion for metaphysical Strong Emergence and Taylor’s version of the Collapse Problem.

Broad maintains that it is impossible to deduce the properties of a strongly emergent whole from a complete knowledge of the properties of its constituent parts, either when those parts are isolated from the whole or when they are constituents of other wholes. Properties which can be so deducible are reducible. O’Connor (2021) explains that “Broad uses an epistemological criterion for what he intends to be a metaphysical condition of emergent autonomy.” While that condition will not obtain in some possible worlds, it does obtain in the actual world, according to what Taylor refers to as “natural necessity” (2015, 746). Broad writes:

> Put in abstract terms the emergent theory asserts that there are certain wholes composed (say) of constituents A, B, and C in a relation R to each other; that all wholes composed of constituents of the same kind as A, B, and C in relations of the same kind as R have certain characteristic properties; that A, B, and C are capable of occurring in other kinds of complex where the relation

> is not of the same kind as R; and that the characteristic properties of the whole R(A, B, C) cannot, even in theory, be deduced from the most complete knowledge of the properties of A, B, and C in isolation or in other wholes which are not of the form R(A, B, C).
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> Broad 1925, 61

It could not be deduced from a complete knowledge of the properties of Sodium (Na) and Chlorine (Cl), for example, that they can combine to produce the macro-level properties of Sodium Chloride (NaCl). "So far as we know at present, the characteristic behaviour of Common Salt cannot be deduced from the most complete knowledge of the properties of Sodium in isolation; or of Chlorine in isolation; or of other compounds of Sodium, such as Sodium Sulphate, and of other compounds of Chlorine, such as Silver Chloride" (Broad 1925, 59).

Responding to attempts to epistemologically characterize metaphysical Strong Emergence, Wilson (2021, 151-153) gives two reasons for maintaining that a metaphysical approach is instead required. First, even if Strong Emergence is always accompanied by specific epistemic features, it is nevertheless advisable to characterize Strong Emergence metaphysically. Second, while Broad believes that the in-principle failure of deducibility is indicative of metaphysical novelty, Wilson claims that such failures are not distinctive of Strong Emergence: "Many uncontroversially physically acceptable dependent goings-on are not deducible, even 'in principle', from lower-level physical goings-on, for reasons having to do not with fundamental novelty but rather with, e.g., sensitivity to initial conditions (à la the ‘butterfly effect’) or mathematical limitations of the sort discussed in Boyd 1980, rendering predictions about such goings-on impossible, even given the resources of the entire universe. As such, the proponent of an epistemic characterization of physically unacceptable emergence will need to provide some means of distinguishing unexplained physically unacceptable from unexplained physically acceptable higher-level features” (153).

Taylor (2023) responds by giving four reasons defending an epistemic criterion for metaphysical Strong Emergence. First, an epistemic criterion allows a rational reconstruction of the concept of emergence as it is used in scientific and philosophical practice. Second, the epistemic approach allows a conceptual unification of emergence. Third, “a practice-forward, naturalistic approach” (770) can begin with the shared concept and later investigate its underlying metaphysics. Finally, although metaphysics is underdetermined by epistemic features, such features can point towards a pluralistic and conceptually unified metaphysics of emergence.

In addition to Taylor’s four reasons, proponents of Broad’s epistemic characterization of metaphysical Strong Emergence could give five additional reasons to rebut Wilson’s objections. First, they could decline her advice to metaphysically characterize Strong Emergence, maintaining that the epistemic characterization suffices. Second, they could insist that the actual world is such that the impossibility of deducing the properties of a strongly emergent whole from a complete knowledge of the properties of its parts biconditionally corresponds to that whole being strongly emergent: if a whole is strongly emergent, then it is impossible to deduce that whole from a complete knowledge of its parts;

and if it is impossible to deduce a whole from a complete knowledge of its parts, then that whole is strongly emergent. Partially disagreeing with Taylor's allowing that metaphysics is underdetermined by epistemic features, they would assert that Broad's epistemic characterization does determine metaphysical Strong Emergence in the actual world.

Third, proponents of Broad's epistemic characterization of metaphysical Strong Emergence could maintain that all goings-on which are in principle not deducible are strongly emergent, including those goings-on which are regarded as physically acceptable. Fourth, they could insist that the higher-level features of metaphysical Strong Emergence are physically acceptable, unless the physical is question-beggingly defined to exclude them. Finally, they could claim that although Strong Emergence is not reducible, it is explainable by nomic subsumption: "Although emergent properties are indeed 'unexplainable' in the sense that that they are not susceptible to a *reductive explanation*, this does not mean that they are 'unexplainable' in every sense: the inherence of an emergent property in a particular whole does admit of an explanation by *nomic subsumption*. We can explain its inherence in terms of the nature of the whole and an emergent law. The law of course remains a brute fact. But surely, so do some laws on *any* account of the world" (Gustavsson 2021).

Whereas Broad considers the properties of a strongly emergent *whole*, Taylor articulates the Collapse Problem in terms of a strongly emergent macro-level *property*; see O'Connor (2021) for a survey of the philosophical literature on emergent properties. The Collapse Problem is that any supposed strongly emergent macro-level property inheres in its micro-level emergence base and so it is not genuinely autonomous from its base. That property is reducible. The nondeducibility criterion of emergence is not met. Hence, the purported strongly emergent macro-level property collapses into the micro-level. As Taylor explains:

> Cases of emergence presuppose a distinction between micro-level and macro-level properties. For any purported case of emergence, there are properties that prima facie belong to the micro level, but if they are included in the micro level then the purported emergent fails to meet a necessary condition for emergent autonomy. I call these problematic properties *collapse-inducing properties* because when they are included in the micro level, the purported emergent effectively "collapses," and yet it seems arbitrary to exclude them. Furthermore, this problem does not depend on the details of any particular account of emergence and so applies quite generally.
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> Taylor 2015, 732

To express this in abstract terms, suppose that p is a purported strongly emergent macro-level property. It is said to emerge when components A and B, which exist at the micro-level, combine in relation r. It is a property of A that it can combine with B in relation r to produce p, however, and it is a property of B that it can combine with A in relation r to produce p. It is possible to deduce p from a full knowledge of A and B. So, p is reducible and collapses into the micro-level. According to the Collapse Problem, there are no strongly emergent macro-level properties.

Further, according to the Collapse Problem, a supposed strongly emergent whole collapses. It is a property of Na that it combines in relation r with Cl to produce NaCl, to return to Broad's example, and it is a property of Cl that it combines in relation r with Na to produce NaCl. Again, emergence's nondeducibility criterion is not met. The Collapse Problem applies to every case of supposed Strong Emergence. Taylor writes:

> Broad held that a necessary condition for emergence and a mark of emergence is that an emergent feature of a compound is not deducible from full knowledge its composing elements in isolation. However, sodium has the property of giving rise to a compound that is soluble in water when combined with chlorine, and given this, the water-solubility of sodium chloride does not meet the nondeducibility criterion for emergence. Chlorine has a similar property, from which a similar result follows. The collapse problem for strong emergentism in general follows this pattern: identifying a property that apparently legitimately belongs to the emergence base, such that its presence in the base makes the emergence collapse. Following this pattern, the collapse problem applies generally to any form of strong emergentism.
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> Taylor 2022, 303–4

The Collapse Problem initially assumes the correctness of Broad's nondeducibility criterion. It then maintains that his criterion is never met. It concludes that Strong Emergence does not occur.

It should be mentioned, parenthetically, that Na and Cl are elements. They are atoms, but not simples, and so the Collapse Problem would apply to them. Na and Cl could be deduced with a full knowledge of the properties of their constituent subatomic constituents: protons, neutrons, and electrons. It would be a property of each constituent that it can combine with the other constituents in a relation r to produce either Na or Cl. Although electrons have no known constituents and so are likely simples, the Collapse Problem would apply to protons and neutrons, as they are composed of quarks, which have no known constituents. It would be a property of each quark that it can combine with the other quarks in a relation r to produce a proton or a neutron. If electrons and quarks are not simples, then this process of collapsing would continue until simples were reached. Suppose, however, that the universe is gunky, its parts of "atomless gunk" (Lewis 1991, 20) dividing infinitely, such that each part of the whole has proper parts. In that case, the collapsing of supposed strongly emergent macro-level properties into the micro-level would be endless. Every micro-level would also be a macro-level with respect to its micro-level. Gunk does not bother metaphysical infinitists or coherentists, but it upsets metaphysical foundationalists: "There would be no ultimate ground. Being would be infinitely deferred, never achieved" (Schaffer 2010, 62).

The Collapse Problem presupposes that there is not downward causation (Paolini Paoletti and Orilia 2017). If there is downward causation, then there would be a macro-level property p that could produce downward causal effects on micro-level components A and B, or on some other micro-level entity C, when A and B have combined in relation r to produce

p. Downward causation could then result in the inverse of the Collapse Problem, the Rising Problem. Strong Emergence's Collapse Problem maintains that any supposed strongly emergent macro-level property p inheres in the micro-level emergence base and so p is not genuinely autonomous from its base. However, downward causation's Rising Problem claims that micro-level entities partially inhere in the macro-level and so they are not genuinely autonomous from the macro-level. It would be insufficient to collapse the Rising Problem by reformulating downward causation as a micro-level property—such that a property of microlevel entity C, say, is affected by macrolevel p—as p would still be downwardly causing effects in C.

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Such philosophers as Skiles (2016), Baysan and Wilson (2017), and Dosanjh (2020) offer strategies to exclude collapse-inducing properties from the emergence base. However, Taylor argues that such strategies are gerrymandered. She doubts that there are principled reasons which generally exclude collapse-inducing properties from their emergence base: "A restriction that may protect one set of cases of emergence will permit other cases to collapse, and so an independently motivated, nonarbitrary case must be made for privileging one set of cases of strong emergence over other, apparently equally legitimate sets" (Taylor 2022, 304–5). She maintains that it is highly probable that every version of Strong Emergence succumbs to the Collapse Problem.

It will be useful to consider Baysan and Wilson's attempt to overcome the Collapse Problem and Taylor's responses to it; see also Wilson (2021) and Taylor (2023). According to Baysan and Wilson's formulation of metaphysical Weak Emergence, "token apparently higher-level feature *S* is weakly metaphysically emergent from token lower-level feature *P* [the physical base of *S*] on a given occasion just in case, on that occasion, (i) *S* broadly synchronically depends on *P*, and (ii) *S* has a (non-empty) proper subset of the token powers had by *P*" (2017, 59). *S* synchronically depends on *P*, in Weak Emergence, and *S* has fewer causal powers than *P*. According to their formulation of metaphysical Strong Emergence, "token apparently higher-level feature *S* is strongly emergent from token lower-level feature *P* on a given occasion just in case, on that occasion, (i) *S* broadly synchronically depends on *P*, and (ii) *S* has at least one token power not identical with any token power of *P*" (2017, 59). Although *S* synchronically depends on *P*, in Strong Emergence *S* has at least one causal power which is not present in *P*.

Baysan and Wilson's powers-based formulation and Broad's epistemological criterion could be compatible: (i) *S* has a power which *P* does not have, and (ii) this cannot be deduced from the most complete knowledge of *P*. However, the powers-based formulation and the epistemological criterion could be incompatible: (i) *S* has a power which *P* does not have, but (ii) this can be deduced from knowledge of *P*. While Baysan and Wilson would regard this as Strong Emergence, Broad would consider that power reducible.

It might be thought that there is a second way that Baysan and Wilson's formulation and Broad's criterion could be incompatible: (i) *S* has a proper subset of the powers had by *P*, but (ii) this cannot be deduced from knowledge of *P*. Baysan and Wilson would regard this as Weak Emergence. It might seem that Broad would consider it to be Strong Emergence. However, he writes that "an emergent quality is roughly a quality which belongs to a complex as a whole and not to its parts" (1925, 23). Broad would maintain that if *S* has only a proper subset of the powers had by *P*, then those powers do not belong to *S* as a whole. He would also insist that this is deducible and so those powers are reducible.

Baysan and Wilson provide four strategies to defend Power Emergence, their powers-based version of metaphysical Strong Emergence, against the Collapse Problem. They first propose that even if the *S* inherits the causal powers associated with *P*, *S* indirectly inherits those powers: "Notwithstanding that *P* synchronically necessitates *S*, *P* has these powers only in that *P* is a precondition, in the circumstances, for *S*, which is the more direct locus of the power" (2017, 78–79). Although *S* indirectly inherits those powers, *S* has them directly; *P* has those powers indirectly. Hence, Power Emergence is not threatened by the Collapse Problem.

Taylor (2022) argues that there are serious problems with each of Baysan and Wilson's strategies to overcome the Collapse Problem. Responding to their first strategy, she argues that there are reasons to doubt that their distinction between direct and indirect causal powers can be independently motivated, and so Power Emergence remains vulnerable to the Collapse Problem.

Distinguishing between substantial and lightweight dispositions, Baysan and Wilson's second strategy is to maintain that *S* has the causal power to manifest a substantial disposition, but *P* has the power to manifest only a lightweight disposition: "The intended sense in which the physical base features have dispositions to bring about strongly emergent features here is lightweight, signifying just that the base features are *preconditions* for the occurrence of the fundamentally novel strongly emergent feature, contra physicalism" (2017, 81). Power Emergence is not challenged by the Collapse Problem.

Taylor argues that this second strategy is not successful. Turning to Broad's example, she argues that while Na and Cl must combine to form NaCl in order to manifest water-solubility, NaCl already has that power. Nevertheless, Na and Cl each has the power to combine with the other to form NaCl, and so the base level does have the power to manifest water-solubility. Even if there is a distinction between substantial and lightweight dispositions, and even if *S* manifests the causal power in different way than *P*, *P* and *S* have the same power. Power Emergence is again vulnerable to the Collapse Problem.

Baysan and Wilson's third strategy is to hold that "powers are relativized to sets of fundamental interactions, making room for higher-level features to have powers that are in some sense new" as Strong Emergence requires (2017, 83). They reformulate Strong Emergence as Interaction-Relative Strong Emergence. According to it, "feature *S* is strongly emergent from feature *P* relative to the set $\{F\}$ of fundamental physical interactions, just in case (i) *S* broadly synchronically depends on *P*, and (ii) *S* has at least one power that is not identical with any power of *P* that is grounded only in the fundamental interactions in $\{F\}$" (2017, 86). Even if the new causal power of *S* is inherited from *P*, that power is new because it is not solely grounded in $\{F\}$. The powers of *P* are grounded only in $\{F\}$. Since "relativizing powers to fundamental interactions provides a principled basis for distinguishing dispositions expressing mere preconditions for the occurrence of strongly emergent features from those that more directly or substantively have the novel powers at issue" (2017, 88), Interaction-Relative Strong Emergence avoids the Collapse Problem.

Taylor doubts that Baysan and Wilson's third strategy succeeds. They do not explain how to individuate powers and interactions to defend Interaction-Relative Strong Emergence from the Collapse Problem. They write, for example, that "the power of being able to fall when dropped, in circumstances where one is poised above Earth's surface, is grounded in the gravitational force, as opposed to the other fundamental forces in operation" (2017, 84). Taylor asks how the power to *fall* is individuated from the power to *dive*. Are these distinct powers or instead the same power described differently? Further, it is not clear that it is possible to distinguish between dispositions expressing mere preconditions for strongly emergent features and dispositions which have those features, and it is also not clear that such a distinction would be metaphysical. Interaction-Relative Strong Emergence is undermined by the Collapse Problem if it cannot distinguish those purportedly different kinds of dispositions, or if that distinction is merely pragmatic. Finally, Taylor maintains that the work of distinguishing between metaphysical levels is not performed by Interaction-Relative Strong Emergence. Rather, levels are distinguished by those which involve only fundamental physical interactions and those which also involve fundamental nonphysical interactions. Because Interaction-Relative Strong Emergence does not itself distinguish metaphysical levels, Taylor claims that it is not superior to her explanatory conception of emergence, Explanatory Emergence.

According to Explanatory Emergence, "a macro-level property p is emergent iff there is no available explanation of the fact that the following regularity obtains of natural necessity: *Whenever components A, B, C ... n are combined in relation r, the resulting whole instantiates property p*" (Taylor 2015, 746). Time plays a crucial role in Explanatory Emergence. As long as there is no available explanation of how microlevel components A, B, C ... n combine in relation r to instantiate a macro-level property p, p will be explanatorily emergent. However, a p which had previously been explanatorily emergent would no longer be so, after an explanation becomes available of how A, B, C ... n combine in r to instantiate p.

For their final strategy, Baysan and Wilson maintain that a strongly emergent property must be the property of a strongly emergent object. A strongly emergent object is metaphysically distinct from objects at the physical base. Since this allows a principled distinction between strongly emergent properties and base properties, the Collapse Problem is overcome.

Taylor has four concerns about Baysan and Wilson's final strategy. First, it is the least parsimonious of the four and so the least plausible. Second, it is oriented around specific cases of emergence. Rather than first articulating criteria for Strong Emergence and then determining whether there is Strong Emergence, this strategy instead first identifies phenomena which it regards as strongly emergent and then determines the criteria. Taylor's third concern about Baysan and Wilson's final strategy recapitulates a concern regarding their third strategy: metaphysical levels are not distinguished by Strong Emergence; instead, levels are distinguished by those involving only fundamental physical interactions and those which also involving nonphysical interactions. Lastly, accounts of emergence often involve explanatory gaps. This suggests that Explanatory Emergence should be considered.

Baysan and Wilson could rebut Taylor's objections. They could further argue that their versions of metaphysical Strong Emergence is superior to her epistemic Explanatory Emergence. They would also observe that the viability of Explanatory Emergence as an alternative to Strong Emergence presupposes the success of the Collapse Problem. In turn, Taylor would respond with more criticisms. It is likely that this debate will result in a draw, however, with neither Baysan and Wilson nor Taylor offering arguments that are decisively compelling.

3

This section presents three ways in which the proponents of Broad's version of Strong Emergence, the emergentists, could object to the Collapse Problem. It then discusses three replies that the proponents of the Collapse Problem, the collapsers, could make to the emergentists. Conducted at this level, the debate will likely stalemate. The next sections argue that the Collapse Problem fails on its own terms.

The emergentists could object to the Collapse Problem in three ways. First, they could maintain that it does not respect the spirit of Broad's argument. They could note that any conclusion can be deduced from the appropriate premises. They would then maintain that it was an empirical discovery that Na has the property to combine in relation r with Cl to produce NaCl and that Cl has the property to combine in relation r with Na to produce NaCl. Those combinatory properties were discovered only empirically, not through a priori reasoning and deduction. After those properties have been discovered, it is a simple matter to then construct a deductive argument with that information included in the premises in order to arrive at the conclusion which leads to the Collapse Problem.

Second, the emergentists could claim that while Broad's analysis explicitly excludes the combinatory properties of Na and Cl, the Collapse Problem begs the question by including them. Broadian Strong Emergence maintains that a complete knowledge of the properties of Na and Cl when isolated from each other, coupled with a complete knowledge of such other compounds of Na as Na_2SO_4 and of such other compounds of Cl as AgCl, is insufficient to deduce that Na and Cl can combine to produce NaCl.

Finally, the emergentists could attempt to show, by the employment of irreducibly plural quantification, that the Collapse Problem's argument is unsound because its premises are false. They would say that it is false that (1) it is a property of Na that it can combine with Cl in relation r to produce NaCl, and that (2) it is a property of Cl that it can combine with Na in relation r to produce NaCl. The Collapse Problem presupposes singular quantification, in which a variable takes a singular value and a property is a property of each thing individually. When analyzed in terms of singular quantification, for example, the sentence "Whitehead and Russell are logicians" is equivalent to the conjunction "Whitehead is a logician" and "Russell is a logician." Those sentences contain predicates that distribute over their arguments, applying to each individually.

In plural quantification (Linnebo 2022), though, a variable can take a plural value. Plural predication (MaKay 2006) and plural logic (Oliver and Smiley 2016) further recognize plural denotation and plural collective properties. A plural collective property is a property of some things taken together, not a property of each individually. Plurals cannot always be completely analyzed as singulars. The sentence "Whitehead and Russell wrote *Principia Mathematica*" contains collective predicates that apply to their arguments collectively, not individually. It is not equivalent to the conjunction of "Whitehead wrote *Principia Mathematica*" and "Russell wrote *Principia Mathematica*." That conjunction does not include the information that Whitehead and Russell together wrote *Principia Mathematica*.

Having explained plural logic, the emergentists could agree with Bohn that "such plural logic is nowadays taken seriously by logicians as well as philosophers of language, but unfortunately not equally so by metaphysicians" (Bohn 2012, 212). Substituting emergence and the Collapse Problem for his example, the emergentists could further agree that "this must change because the post-Schafferean debate over the fundamental cardinality of the world is a good example of a contemporary metaphysical debate that stumbles over not doing so" (Bohn 2012, 212). The emergentists could claim that taking plural logic seriously allows the recognition that Na and Cl together have the irreducible plural collective property that they can combine in relation r to produce NaCl.

However, the collapsers could make three replies to the objections of the emergentists. First, the collapsers could maintain that Broad presupposes "a mathematical archangel" (Broad 1925, 70), an ideal cognizer, when he claims that a complete knowledge of the properties of Na and Cl is insufficient to deduce that they can combine to produce NaCl. An ideal cognizer is presupposed because no person or group of persons has complete knowledge of the properties of Na and Cl. The collapsers could then maintain that it is irrelevant how ideal cognizers acquire a complete knowledge of the properties of Na and Cl, whether a priori or a posteriori. Second, they could hold that the Collapse Problem does not beg the question against Broad's argument. Na and Cl have their properties through natural necessity. Even when isolated from each other, it is a necessary natural law that Na has the property to combine in relation r with Cl to produce NaCl and that Cl has the property to combine in relation r with Na to produce NaCl. Finally, they could claim that the Collapse Problem is sound and that they are correct to accept only singular quantification.

The debate between the emergentists and the collapsers will likely result in a stalemate, with each group asserting what the other gainsays. Regarding the Collapse Problem as a mistake, Skiles (2016), Baysan and Wilson (2017), and Dosanjh (2020) seek various strategies to deflate or block it. This article instead assumes the mistake and goes to the end. That is to say, it argues that the Collapse Problem fails on its own terms. The Collapse Problem itself collapses. There is metaphysical Strong Emergence. Although a more minimalist response to the collapse problem would be desirable to "the aesthetic sense of us who have a taste for desert landscapes" (Quine 1948, 23), those who live in temperate rainforests have more sophisticated sensibilities.

4

Although macro-level property p supposedly emerges when its micro-level components combine in relation r, the Collapse Problem maintains that Broad's nondeducibility criterion is not met because each component has the micro-level property that it can combine with the others in r to produce p. This section argues that the Collapse Problem ignores r. It ignores r by assuming that there is only one r in which constituents A and B combine to produce a unique p. Put otherwise, the Collapse Problem treats r as a fixed value rather than as a variable. The Collapse Problem also ignores p by treating p as a fixed value. There will be numerous relations in which constituents can combine, however, and each combination may produce a distinct p. While A and B combine in r_1 to produce p_1, for example, they combine in r_2 to produce p_2 and in r_3 to produce p_3.

The collapsers have the chemical intuition that Na and Cl can combine only in a one-to-one ratio, a 1:1 stoichiometry, NaCl. That intuition is not unwarranted, as NaCl is the only known stable compound of Na and Cl at ambient conditions. Using crystal structure prediction algorithms, however, Zhang et al. (2013) predicted that Na and Cl can combine at pressures ranging from 20 to 200 gigapascals to produce other stable compounds with different stoichiometries, such as $NaCl_3$, $NaCl_7$, Na_2Cl, Na_3Cl, and Na_3Cl_2,. In order to corroborate their prediction, Zhang and colleagues synthesized cubic and orthorhombic

$NaCl_3$ and two-dimensional metallic tetragonal Na_3Cl by placing NaCl in a diamond-anvil cell with excess Na and Cl at high temperature and pressure. Commenting on their research, Ibáñez Insa writes:

> The most intriguing aspect of this work is that it represents the fall of a textbook idol. Under high pressure, the familiar rules of chemistry are modified and the simplicity of highly ionic compounds such as NaCl is totally lost. If $NaCl_3$, Na_3Cl, and other such chemical formulae are possible, one must wonder about the stability under extreme conditions of a plethora of new phases with modified stoichiometries of other "more familiar" compounds. Such compounds could have particularly important implications in geological and planetary sciences, as most of the matter in stars and planets, including Earth, is subject to very high pressures and temperatures.
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> Ibáñez Insa 2013, 1460

Ibáñez Insa suggests several other exotic compounds which might form in the planetary interiors of Earth, Uranus, and Neptune.

Further, the study of Roederer et al. (2023) indicates that naturally occurring neutron-rich nuclei with atomic masses greater than 260 were produced by rapid neutron-capture process (*r*-process) events in ancient stars. An *r*-process event is a nuclear reaction which occurs during neutron star mergers or supernovae, creating the heavy naturally occurring elements. While Oganesson-118 is the heaviest synthetic element, Uranium-238 had been thought to be the heaviest naturally occurring element.

The collapsers maintain that it is a property of Na that it combines in relation r with Cl to produce NaCl and that it is a property of Cl that it combines in relation r with Na to produce NaCl. They further claim that the ideal cognizers could deduce that Na and Cl can combine in relation r to produce NaCl. Na and Cl can combine to produce NaCl under normal pressure. Under sufficiently high pressure, though, Na and Cl can combine to produce other stable compounds. The collapsers ignore pressure. Whether Na and Cl combine to produce NaCl or some other compound partially depends on pressure. Full information about the properties of Na and Cl would not suffice to deduce that they can combine to produce NaCl. To deduce that Na and Cl can combine to produce NaCl requires not only a complete knowledge of Na and Cl, but also knowledge of the pressure.

More generally, the collapsers mention but effectively ignore relation r, treating it as a fixed value. Although the ideal cognizers would need to know only how Na and Cl react under normal pressure to deduce that Na and Cl can combine to produce NaCl, they would also need to know that it is normal pressure that is an aspect of r to deduce that Na and Cl combine to produce NaCl, rather than deducing that Na and Cl combine to produce, say, Na_3Cl_2. The ideal cognizers would need to know how Na and Cl react under every condition that is physically possible in order to know what relations to include or exclude in their deductions.

The collapsers should reply that complete information of the properties of Na and Cl includes how those properties become manifest under different pressures, as well as every other condition which could be relevant. Those conditions would include the isotopes of Na and Cl, the intensity and frequency of atomic forces and chemical bounds, plausibly dark matter and dark energy, the presence of other elements and compounds which could affect how Na and Cl interact, etc. The collapsers should stipulate that the ideal cognizers have complete knowledge of all possible relations of Na and Cl—that is, complete information of how Na and Cl react under every condition that is physically realizable.

In addition to the conditions mentioned above, the collapsers should include conditions which do not obtain, but could obtain given the laws of nature. Many of those conditions would not be directly relevant. Nevertheless, while Na and Cl likely react under 20.01 gigapascals as they do under 20 gigapascals, for example, the ideal cognizers would need to know that. They would also need to know under what pressure, in excess of 20 gigapascals, Na and Cl react differently. Under how many gigapascals do the atomic forces holding the Na and Cl atoms together become unable to do so, resulting in their collapse? Every possible relation in which Na and Cl could enter would have to be included to have complete information of how Na and Cl react under *every* physically realizable condition. The amount of this information would be considerable. Nevertheless, the collapsers should maintain that the ideal cognizers could deduce that Na and Cl can combine to produce, not only NaCl, but all of the other physically realizable compounds.

Broad's discussion of Na, Cl, and NaCl is only illustrative, of course. The collapsers must hold that the ideal cognizers could have complete information of the properties of Na and Cl to deduce how they can combine to produce every physically realizable compound. To decisively collapse Strong Emergence, though, the collapsers must attribute to the ideal cognizers full information about how everything could combine under every physically realizable relation r with everything else. Assume that the ideal cognizers have complete knowledge of the properties of helium (He) and methane (CH_4)—which is itself composed of one carbon (C) atom bonded to four hydrogen (H) atoms—along with all of the other pertinent information constituting r. Strong Emergence would obtain if the ideal cognizers could not deduce whether, as Gao et al. (2020) predict, $HeCH_4$ becomes stable around 105 gigapascals and He_3CH_4 is stable from 55 to 155 gigapascals.

The Collapse Problem maintains that Broad's nondeducibility criterion is not met because each micro-level component has the property that it can combine with the other components in relation r to produce macro-level property p. This section has argued that the Collapse Problem incorrectly assumes that there is only one r in which constituents A and B can combine to produce a unique p. The Collapse Problem treats r and p as fixed values rather than as variables. As the scientific studies discussed above show, however, there will be numerous relations in which constituents can combine. Each combination will produce a distinct p. Strong Emergence obtains if the ideal cognizers cannot deduce each p from every combination of constituents in each r which is possible in the actual world. The next section argues that this is physically impossible for the ideal cognizers to deduce each p.

5

Information is physical, according to Landauer (1996), and so there will be a limit to the amount of information in the universe. This section argues that the quantity of information that the ideal cognizers would require to fully account for relation r in all cases, and so to decisively collapse Strong Emergence, exceeds the amount that is in the universe. Without postulating that the universe is saturated with information, the amount of information which the ideal cognizers would require still plausibly exceeds the actual amount in the universe. This section further argues that even if the ideal cognizers had sufficient information, the time it would take to account for every relation exceeds the age of the universe. As a consequence, even if the Collapse Problem succeeds in some cases, it is unable to collapse all supposed cases of Strong Emergence. Strong emergence does not collapse. But the Collapse Problem does.

It is important that the emergentists not gerrymander their strategies against the Collapse Problem, as Taylor (2022) rightly emphasizes, but it is equally crucial that the collapsers not gerrymander their collapses of Strong Emergence. For the Collapse Problem to successfully collapse Strong Emergence, it is all or nothing at all. The Collapse Problem itself collapses because it cannot always succeed. To always succeed would require physically impossible amounts of information and time. A "no-go" theorem in theoretical physics states that a particular situation is physically impossible (Bub 1999, 5). The Collapse Problem is a no-go.

It will be useful to make three preliminary comments before continuing. First, a reader familiar with physics and cosmology might find the discussion in this section too simplified. Yet, another reader may struggle to comprehend it. The forbearance of both readers is requested. And both will be forgiven for proceeding directly to the next section.

Second, it is beyond the scope of this article to review the voluminous philosophical literature on information. Surveys are provided by Maroney (2009), Sequoiah-Grayson and Floridi (2022), Bub (2023), Martinez and Sequoiah-Grayson (2023), and Adriaans (2024). Finally, although the tilde, ~, is used as a negation sign in logic, for Gough et al. (2006), Vopson (2019a, 2019b, 2021), and Gough (2022) it means "approximately."

Landauer (1961) proposes what is now referred to as Landauer's principle, which holds that "any logically irreversible manipulation of information, such as the erasure of a bit or the merging of two computation paths, must be accompanied by a corresponding entropy increase in non-information-bearing degrees of freedom of the information-processing apparatus or its environment" (Bennett 2003, 501). Landauer (1996) further hypothesizes that thermodynamics and information are linked, and that information is physical. Matter and energy measurably possess information. Bérut et al. (2012), Jun et al. (2014), Hong et al. (2016), and Gaudenzi et al. (2018) experimentally corroborate Landauer's principle, as well as his hypothesis that information is physical.

According to the Collapse Problem, Na and Cl each has the property to combine with the other in relation r to produce NaCl. The Collapse Problem makes essential reference not only to Na and Cl, respectively, but also to r. Since information is physical, where is the information about the properties of Na and Cl in r located? If the information is located in Na and Cl, then the ideal cognizers should be able to discover this by examining each element when it isolated from the other, prescinding from their knowledge that Na and Cl in r constitute NaCl. It is not plausible to attribute a priori discernment to the ideal cognizers, however, as such clairvoyance would likely violate natural laws.

One alternative is that the information about the properties of Na and Cl to combine in r is in neither Na nor Cl but is instead located in r. That relation does not exist in the emergence base but rather exists when Na and Cl together constitute NaCl. Other alternatives are that this information is located in NaCl or in some other medium. Any of those alternatives would allow a modified version of Strong Emergence to escape the Collapse Problem. Although the seemingly emergent properties would collapse into their emergence base, the information about those properties would not collapse and so would be strongly emergent. Such considerations are suggestive but not decisive, however, and so it will next be argued that the amount of information required to fully account for r is physically impossible.

Proceeding from Landauer's hypothesis that information is physical, there have been various attempts to calculate the amount of total energy information in the universe. Lloyd (2000, 2002) estimates that it is 10^{90} bits. Gough et al. (2006) use two independent methods to estimate that the total information of the universe content is ~10^{91} bits. Gough and colleagues calculate that the universe's information content is ~2.4×10^{91} using the first method and that it is ~8×10^{90} using the second. Gough (2008) calculates that the total energy information in the universe is ~10^{87} bits.

Vopson (2019b) formulates a principle of mass-energy-information equivalence, which extends Landauer's principle by hypothesizing that each bit of information has a quantifiable mass; see also Vopson (2022). Following the principles that information is physical and that all physical systems can register information, Vopson shows that the mass of a bit of information at 300 Kelvin (26.85 Celsius) is 3.19×10^{-38} kilograms:

> Within the digital Universe concept, all the baryonic matter has an associated information content. The estimated mass of a bit of information at T = 2.73K is $m_{bit} = 2.91 \times 10^{-40}$ Kg. Assuming that all the missing dark matter is in fact information mass, the initial estimates (to be reported in a different article) indicate that $\sim 10^{93}$ bits would be sufficient to explain all the missing dark matter in the visible Universe. Remarkably, this number is reasonably close to another estimate of the Universe information bit content of $\sim 10^{87}$ given by Gough in 2008 via a different approach.
>
> Vopson 2019b, 4

Each bit has a mass of 2.91×10^{-40} kilograms, assuming an average temperature of 2.73 Kelvin (−270.42 Celsius) of the universe.

The different article referred to above is Vopson (2019a), which hypothesizes that all of the informational content of the baryonic matter in the universe could be stored in bits of information. This allows him to more precisely estimate that $\sim 52 \times 10^{93}$ bits is the information content of the universe's baryonic matter. He hypothesizes that $\sim 52 \times 10^{93}$ bits is sufficient to explain all of the missing Dark Matter in the visible Universe; see also Džaferović-Mašić (2021).

However, Vopson (2021) believes that ~52×10^{93} bits is an overestimate. Vopson (2019a, 2019b) assumes that all of the information bits are stored at the universe's average temperature of 2.73 Kelvin. However, that assumption "is inaccurate because a significant amount of the baryonic matter is contained in stars, intergalactic gas, and dust, which all have temperatures larger than the cosmic microwave background" (Vopson 2021, 2).

Unlike previous attempts to calculate the amount of information contained in the universe, Vopson (2021) uses the information theory of Shannon (1948a, 1948b), according to which the information content of a message is a measure of how much uncertainty is reduced by it. Vopson estimated that each elementary particle in the observable universe holds 1.509 bits of encoded information. He explains: "Due to the mass-energy-information equivalence principle, we postulate that information can only be stored in particles that are stable and have a non-zero rest mass, while interaction/force carrier bosons can only transfer information via waveform. Hence, in this work, we are only examining the information content stored in the matter particles that make up the observable universe, but it is important to mention that information could also be stored in other forms, including on the surface of the space-time fabric itself, according to the holographic principle" (Vopson 2021, 2).

This requires two points of clarification. First, the holographic principle—initially proposed by 't Hooft (1993) but named by Susskind (1995)—states: "The number of fundamental degrees of freedom in any spherical spatial region is given by the Bekenstein entropy of a black hole of the same size as that region. The Holographic Principle is notable not only because it postulates a well-defined, finite number of degrees of freedom for any region, but also because this number grows in proportion to the area surrounding the region, not the volume" (Curiel 2023). Second, Bekenstein (1972, 1973, 1974, 1981, 1983) theorizes that the entropy of a black hole is proportional to the area of its event horizon, so-called "Bekenstein entropy," which is itself proportional to the square of its mass.

Having estimated that each elementary particle has 1.509 bits of information, Vopson (2021) derives a formulate to obtain the number of all elementary particles in the observable universe, adjusting that estimate for how much information each particle would contain, based on the temperature of observable matter. He calculates the amount of information contained in all of the baryonic matter of the observable universe, applying it to the spin, mass, and charge of protons, neutrons, the quarks which constitute protons and neutrons, and electrons. He excludes from his calculations unstable particles, neutrinos, bosons, and antiparticles. He explains: "We have considered all bosons to be force/interaction particles responsible for the transfer of information, rather than storage of information. We also ignored all the anti-particles, as well as all neutrinos" (Vopson 2021, 4). He uses the Eddington number—the total number of particles in the observable universe—which is currently estimated to be 10^{80}. He then multiplies this out to the entire universe. Vopson calculates that total amount of information stored in the baryonic matter of the observable universe is 6.036×10^{80} bits.

That estimate is lower than previous ones. He suggests three possible reasons for this discrepancy. First, previous estimates were of the total information in the universe, whereas he includes only the information stored in particles. Second, he uses information theory, as it gives the most effective information compression. Finally, the universe may contain more information than 6.036×10^{80} bits because information might be stored in other elementary particles or media not accounted for by his study.

Noting that the holographic principle is generally accepted for black holes at the holographic bound, Gough (2022) calculates that the holographic bound of the universe is $\sim 10^{123}$ bits of information. The holographic principle was explained above, but Gough's reference to the holographic bound requires two further points of clarification. First, a necessary condition for the holographic principle is the holographic bound, according to which "the entropy of a system is bounded from above by a quarter of the area of a circumscribing surface measured in Planck areas" (Bekenstein 2000, 339). Second, a Planck area is 2.6121×10^{-70} square meters. A Planck area is the square of a Plank length, $1.616255(18) \times 10^{-35}$ meters, which is considered the smallest length which has physical meaning.

There is a considerable range in the estimates of the amount of information in the visible universe. Vopson (2021) calculates that 6.036×10^{80} bits of information is stored in the observable universe's baryonic matter. Gough (2008) estimates that the total amount of information is 10^{87} bits. Lloyd (2000, 2002) estimates that it is 10^{90} bits. Gough et al. (2006) estimate $\sim 10^{91}$ bits. Vopson (2019a) estimates $\sim 52 \times 10^{93}$ bits. Gough (2022) calculates that that universe's holographic bound is $\sim 10^{123}$ bits. What is crucial, though, is that all of those are estimates of the *actual* amount of information in the universe.

In order to collapse every supposed instance of Strong Emergence, the ideal cognizers would need to be able to deduce that no whole or property could be strongly emergent. To do this, they would need to have complete information, not only of all of the properties of each constituent of every physically actual whole, but also complete information of all of the properties of each constituent of every physically realizable whole. This would include complete information of every physically realizable relation. Even if the ideal cognizers would be able to make the needed deductions, if they did have sufficient information, the time it would take them to make all of those deductions would plausibly exceed the age of the universe since the Big Bang, where estimates range from 11.4 to 13.8 billion years.

The signal speed of the fastest microchip is still approximately one thousand gigahertz (Lewis 2014). Levitin and Toffoli (2009) establish that computers have a speed limit, "the fundamental quantum limit of the operation rate of any information processing system" (4). Processing speed is limited by the minimum time it takes a particle to move from one quantum state to another. There are two independent bounds to this minimum time: The quantum system's energy uncertainty, ΔE, and is the system's average energy, E. The two bounds coincide if $\Delta E = E$. There is no initial state which saturates the bound if $\Delta E \neq E$. Although the bound is only asymptotically attainable if $\Delta E \neq E$, it remains tight for all values of ΔE and E.

Ossiander et al. (2022) found that there is a fundamental limit of classical signal processing. They suggest the feasibility of solid-state optoelectronics up to one petahertz, or one million gigahertz (one gigahertz is one billion hertz, and a hertz is equivalent to *one* *event or cycle per second)*. Although that is fast, the ideal cognizers would need to make deductions involving a virtually unlimited amount complete information about properties and relations, as there is an almost infinite number of physically realizable gradations between any two degrees of temperature or two pascals of pressure.

This becomes even more important if the ideal cognizers do not only make logical deductions but also employ procedures which are generative rather than investigative. A procedure is generative when a true proposition, stating that its outcome is true, is brought about by the execution of that procedure; a procedure is investigative when a true proposition, stating that its outcome is true, exists prior to the execution of that procedure (van Atten 2022, 725). If the ideal cognizers need to generate the information that they use in their deductions, this would require even more time than the already significant amount needed—which is greater than the age of the universe—if their deductions are investigative. Although the Collapse Problem may collapse Strong Emergence in any particular instance, it cannot do so in every case.

In the Collapse Problem's exemplary example, Na and Cl each have the power to combine with the other in r to produce NaCl's power of the water-solubility. The Collapse Problem concludes that the nondeducibility criterion for Strong Emergence is not met. As has been shown, however, there is a virtually unlimited number of relations into which constituents can enter, producing distinct wholes and properties. Hence, it is indeterminate whether the ideal cognizers deduced NaCl's power of the water-solubility before or after that was empirically discovered. The collapsers may assert that this is irrelevant. However, deducing wholes, properties, or powers after they are discovered is no more impressive than predicting events after they have occurred.

The Collapse Problem collapses. There is Strong Emergence. And it is ubiquitous. Almost always, it will be physically impossible to deduce how components, in a specific relation, would combine.

6

To further articulate this article's argument against the Collapse Problem, this section briefly discusses two similar arguments against Laplace's demon. Laplace conjectures that a calculating intellect with complete information about the present location, momentum, and trajectory of every atom in the universe could retrodict everything that has happened and predict everything that will happen:

> We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes.
>
> Laplace 2007, 4

Without referring to Laplace's demon, Lloyd (2000, 2002) calculates the computational capacity of the universe. Based on estimates of the amount of information that the Universe can register and the number of elementary operations that it could have performed since the Big Bang, Lloyd calculates that that the Universe could have performed 10^{120} operations on 10^{90} bits of information (10^{120} bits including gravitational degrees of freedom). If Laplace's demon needs to perform even more operations on additional bits of information to retrodict and predict everything that ever has and will happened, then the demon will not have enough time or information.

Wolpert (2008, 1263) claims that "Laplace was wrong: even if the universe were a giant clock, he would not have been able to reliably predict the universe's future state before it occurred." There are physical limits to the inferential abilities of "inference devices," which are physical devises that recollect, predict, and observe. Showing that such devices share an underlying mathematical structure, Wolpert presents several existence and impossibility results. An inference device has "free will" insofar as how it is setup is not restricted by how any other inference device is setup. Two such devices could not recall, predict, observe, or emulate each other with complete accuracy. Only one device at a single moment in time could infer the others. There cannot be a theory of everything, according to Wolpert, only a "theory of almost everything" (Binder 2008, 885). As the considerations of Llyod and Wolpert strongly suggest that Laplace's demon is impossible, the argument of this article strongly suggests that the information and time needed for the Collapse Problem are physically impossible.

The target of the Collapse Problem can be more precisely specified by distinguishing Inclusive Strong Emergence from Exclusive Strong Emergence. According to Inclusive Strong Emergence, the information about how micro-level entities can combine to produce strongly emergent macro-level properties is included in the micro-level. The Collapse Problem, if successful, shows that Inclusive Strong Emergence is impossible. Exclusive Strong Emergence excludes that information from the micro-level, however, and so it is not challenged by the Collapse Problem. While exclusive strongly emergent properties are possible, it is an empirical question whether such properties actually exist. Broad should be interpreted as advocating for Exclusive Strong Emergence rather than for Inclusive Strong Emergence, as he maintains that that it is impossible to deduce a strongly emergent whole from a complete knowledge of its constituents, either when they are isolated from it or when they are constituents of other wholes.

At this point, the collapsers should make two objections. First, they should maintain that the notion of ideal cognizers is only a metaphor to explain Strong Emergence's nondeducibility condition. Unlike human cognizers, the ideal cognizers have perfect inferential skills and perfect memory, and their deductions are unconstrained by the limits of actual physical reality. In particular, their deductions occur in an environment that allows for indefinitely large amounts of time and space. The deductions of ideal cognizers need not be physically possible, the collapsers should claim, and it is irrelevant that their deductions could not occur in the physical universe. (Mark Bedau is thanked for the suggestions in this and the previous paragraph).

Second, the collapsers should claim that the metaphor of ideal cognizers is dispensable. What is crucial to the Collapse Problem is the existence of the deducibility relations which would result in the purported strongly emergent macro-level collapsing into the micro-level, not whether those deducibility relations ever are deduced, or even could be deduced. (Anthony Dardis, Alex LeBrun, and Michael Raven are thanked for this suggestion). Appealing to those two objections, the collapsers would conclude that Strong Emergence collapses, after all, not the Collapse Problem.

Responding to the second objection, the existence of all of the deducibility relations required by the Collapse Problem—irrespective of any actual deduction—still requires an amount of information that has been plausibly argued to be physically impossible. Hence, not all of those deducibility relations exist and so the Collapse Problem collapses. Further, undeduced deducibility relations would be epistemologically opaque and so they could not provide evidence that the Collapse Problem succeeds.

Replying to the first objection, it requires that the collapsers reject physicalism, the thesis that everything is physical, as the ideal cognizers and their deductions would not be physical. Further, both objections require a leap of faith to believe in the Collapse Problem, as it can only assert but cannot demonstrate that purported strongly emergent macro-level wholes or properties always collapse into the micro-levels.

Speaking of faith, and prescinding from physicalism, some collapsers might propose that the ideal cognizers could be Broadian archangels or gods who have access to more information than is contained in the universe and who are able to make deductions (accompanied peradventure by generative procedures) which require an indefinitely large amount time. Nevertheless, no thesis is philosophically acceptable unless the reasons which support it are convincing. Even if the gods reveal that the Collapse Problem is always able to collapse Strong Emergence, they cannot give such reasons, as that would take more information and time than the universe has. Since the *European Journal for Philosophy of Science* follows a double-blind reviewing procedure and requires that articles have a maximum length of 15000 words, its editors would not accept a submission from the gods. Further, if the divine ideal cognizers are (similar to) the gods of India or Greece, they are not always forthright. And demons, *rākṣasas* and *kakodaimōns*, sometimes pretend to be gods. Finally, the gods might reveal that they are strongly emergent. It is always good to ask the gods for their blessings but never to invite their intervention in philosophical debates.

The collapsers might charge that the Broadian emergentists are also challenged by this article's argument, as those emergentists refer to complete knowledge in defining Strong Emergence. (William A. Rottschaefer is thanked for this suggestion). In his discussion of emergence, however, Broad (1925, 61) writes of "the most complete knowledge," not of "absolutely complete knowledge." He should be charitably interpreted as claiming that the properties of a strongly emergent whole cannot be deduced from the properties of its constituents, even by the ideal cognizers who possess all of the information that is physically possible.

8

Since the ideal cognizers would plausibly require an amount of information which is physically impossible and their deductions would take more time than the age of the universe, the Collapse Problem collapses. Unless the required amount of information is physically possible and the deductions are temporally possible, the Collapse Problem cannot collapse Strong Emergence. In contrast to the likely draws and stalemates between the emergentists and the collapsers discussed in the second and third sections, here the burden of proof decisively shifts to the collapsers. Until that burden of proof is met, the Collapse Problem remains collapsed. Belief in Strong Emergence is strongly warranted. It occurs whenever it is physically impossible to deduce how components, in a specific relation, would combine. Almost always, that is impossible. Strong Emergence is ubiquitous.

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