Physicalism, Scientific Respectability, and Strongly Emergent Properties

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The core difference between emergentists and their physicalist critics is their understanding of what counts as metaphysically basic. Terrence Horgan puts the difference between physicalists and emergentists as follows: "A physicalist position should surely assert, contrary to emergentist… that any metaphysically basic facts or laws - any unexplained explainers, so to speak – are facts or laws within physics itself." (Horgan 1993, 560, quoted in Crane 2010) The possibility of genuine emergence depends, at least in part, on our understanding of the completeness of physicalism: Can the physicalist assume some version of physics that contains a complete set of *unexplained explainers*? I will argue that it cannot.

Philosophers in the late Twentieth Century found many reasons to embrace physicalism and it has played an especially prominent role in the philosophy of mind. As Sven Walter and Heinz-Dieter Heckman note:

> the hallmark of today's physicalism is […] the contention that mental properties are either identical to or at least somehow realized, determined or constituted by physical properties. If judged only by head counting, physicalism was undoubtedly the uncontested champion of 20th century philosophy of mind. (Walter and Heckman 2003, v)

On a superficial level, physicalism appeared to provide a clear criterion distinguishing the real from the unreal: To be real is to be constituted or somehow determined by the fundamental physical constituents of the universe. However, criticisms have targeted the difficulty of giving a precise and plausible formulation of what is meant by the term "physical". In his recent book, Daniel Stoljar presents a set of important arguments against a variety of formulations of the view and I will not rehearse those arguments here.[1] (Stoljar 2010)

Physicalism is a slippery cluster of views and it has taken a variety of forms. (Dowell 2006) Even given the diversity of philosophical positions associated with physicalism we can identify a set of relevant commitments concerning metaphysical fundamentality that most physicalists would endorse. Very roughly, the first is the assumption that *the physical world is causally closed.* The second is the assumption that *individuation involves unique causal powers*. (Kim 1999) The third concerns individuation and involves a commitment to *Hume's dictum*. Jessica Wilson explains Hume's dictum as the view that "there are no metaphysically

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[1] Stoljar is chiefly concerned with the challenge of formulating a definition of physicalism rather than with fundamentality and completeness, the central topics of this paper.

necessary connections between distinct, intrinsically typed, entities." (Wilson 2010) The converse of Hume's dictum is the claim that if there *are* metaphysically necessary connections between entities or/properties then they *are not* distinct. What would it mean for the physicalist to guarantee that there are no properties or entities that are distinct of the physical? As I will ague below, in attempting to prevent the existence of properties that are metaphysically distinct from the physical, the physicalist is forced into an implausible view of what can count as the basic physical level.

David Papineau claims that the dominance of physicalism is largely due to empirical considerations. (Papineau 2001, 7) Appeals to non-physical factors in scientific explanation were associated with degenerate research programs and dead ends, whereas reductive methodological strategies and physicalist ontological assumptions are associated with highly fruitful and progressive research programs in the natural sciences.[2] (Stoljar 2010, 13) Thus, in recent decades, according to Papineau, philosophers have assumed that the only way to align oneself with scientific rationality is to embrace some form of physicalism. Very roughly, the epistemic virtues that we tend to associate with scientific rationality include an aversion to miracles and mysteries, and an attraction to the prospect of non-enthymatic, explanations.

Section Two discusses some of the strengths and weaknesses of physicalism before turning to standard objections to emergence in Section Three. Transients and generative fundamentals are introduced and explained in Section Four before being put to work as part of an argument against the physicalist claim of ontological completeness. Section Five explains the difficulty that physicalists face in their efforts to block ontologically relevant interactions. The purpose of the central argument of the paper in Sections Four and Five is to convince readers to hesitate before accepting physicalist anti-emergentist arguments. Standard strategies that are intended to block the possibility of emergent properties come at a cost; they rule out a range of ways that the world could be prior to inquiry. In this respect an ontology that is amenable to the possibility of emergent properties can claim to be more open to the progress of scientific inquiry than physicalism.

I. "…and there's no more to say"

In recent decades, the focus of arguments concerning emergence and reduction has been to figure out how much of the higher-level action in nature; minds, economies, biological properties and the like, is determined by the micro-level goings on in our physics. The degree and manner of this determination have been ongoing topics of philosophical debate. A key challenge involves understanding the content of the ontology that our best account of the microphysics provides. The view that the results of physics should determine our ontological commitments is known as physicalism.

What exactly, does our physics tell us about the kinds of things that exist? Even the most avid physicalist must admit that this is not something that can be straightforwardly read off the results of our best science. Even this minimal interpretive problem means that

[2] Stoljar makes a similar point about empirical evidence in support of physicalism. He notes that the denial of physicalism does not involve any obvious logical contradiction or conceptual error. He compares its status to that of the theory of evolution or of continental drift. Denying physicalism, he argues, is not philosophically absurd, but it does put one in conflict with science and scientifically informed common sense.

physicalists cannot completely delegate ontological questions to the physicists. Furthermore, physicalist ontological commitments must be a work in progress. We can be confident of this because, judging from the history of science, some non-trivial portion of contemporary physical theories will soon end up in the scrap heap of discredited theories.

Despite not knowing what their precise ontological commitments should be, physicalists generally seem wedded to the claim that every fact is, in some sense, a consequence of the principles and conditions that obtain at the fundamental physical level (whatever that level might turn out to be). So, for example, while it might be natural to think that the laws of chemistry did not exist in the very early, pre-chemical history of the universe, physicalists claim that all the facts about later chemical phenomena are somehow already baked into the initial state of the physical universe. On this view, a similar story can be told for biological, psychological, moral, and economic facts. For the physicalist, there is never anything genuinely new – at least in the ontological sense of novelty.

Over the years, anti-reductionists have responded in various ways, arguing for instance that the explanatory role of high-level generalizations is such that they cannot be reduced to some lower-level set of facts without loss of explanatory power. To use Hilary Putnam's example, while a physical description can capture the details of a particular square peg, it cannot explain, in general terms why a one-inch square peg will not fit in a one-inch round hole. (Putnam 1975) Geometrical explanation is not the same as physical explanation and attempting to do without geometry means sacrificing valuable generality in our explanations. This, of course, is an argument from epistemological convenience rather than ontology and it is unlikely to be threatening to the physicalist. Furthermore, in the late 20th century most philosophers in the Anglo-American tradition happily embraced so-called non-reductive physicalism, where higher-level generalizations, explanations, functions, special sciences, etc. were ontologically dependent on the physical without higher-level theories and truths being reducible to the theories and truths of physics.

A related line of response, due to Louise Antony and others, points out that there are features of some concepts that require their bearers to have appropriate historical properties in addition to physical properties. For example, my aunt can be distinguished from an imaginary microphysical duplicate of my aunt in virtue of having had the right sort of history. (Antony 1999) This is because anything that falls under the concept 'aunt' can only do so by virtue of having the right kind of history. The physicalist response to specific examples of differences that are not physically determinable – like the difference between my aunt and her microphysically indistinguishable copy – is either to argue that these differences are unreal, or to claim that the truth of sentences mentioning these differences can be explained via a supervenience relation on the real action at the micro-level. The latter strategy is presented in its most well-known form in the work of David Lewis.

Lewis asserted that the entire set of facts concerning the actual world supervenes on the most basic facts. "All there is to the world", he writes, "is a vast mosaic of local matters of particular fact". (Lewis 1986, ix) On Lewis' view the local matters of fact in our microphysics can be understood to be "an arrangement of qualities. And that is all. There is no difference without difference in the arrangement of qualities. All else supervenes on that." (Ibid) Lewis' view was that all facts ultimately supervene on the fundamental *physical* facts, so the way to interpret his talk of qualities in the account of Humean supervenience is, presumably, in terms of physical properties. So, for example, elsewhere he writes: "The world is as physics says it is, and there's no more to say." (Lewis 1999, 34 cited in Hall 2012) If correct, this view rules out the possibility of strong emergence absolutely. There can be nothing new under the sun or anywhere else for that matter, that wasn't already somehow included in the great mosaic of basic Lewisian facts.

As we shall see, this position comes at a cost, insofar as it requires us to rule out some (otherwise scientifically respectable) ways that physics might turn out to be. However, before turning to the argument of this paper it is worth pointing out a difficulty that Lewisian physicalism shares in common with physicalism more generally. Lewis' metaphysics suffers from a tension between its fundamentalism about basic facts and his commitment to the world being as physics says it is. The reason for this is his characterization of the fundamental level as a set of particular space–time points, with values such as mass and charge at each point. As Mark Bickhard (2011) and others have noted, it is very difficult to make sense of the claim that the relations involved in quantum entanglement supervene on particular points and their individuated values. (See also Butterfield 2007)[3]

Apart from the tension between Humean supervenience and physics, Lewis' view faces the challenge of accounting for the apparent ontological role of interaction. On a more general level, inquiry seems to show that interactions can change the character of constituents in some way. For example, in some cases it seems that participation in a structural whole can change the probability that a part will behave in one way rather than another. To take a relatively mundane example, it is well known that becoming part of a crowd will change the likelihood that a person will engage in violent or anti-social behavior.[4] Or, to take an example from particle physics, our current theories concerning the nature of quarks describe them as existing only in combination with other quarks. In very rough terms, the identity of a quark depends essentially on its relationship to other quarks.[5] Interactions of this kind are, of course, the inspiration for emergentist metaphysics.

Followers of Lewis contend that there will always be a way to explain collective phenomena as supervening on basic matters of local fact. Perhaps there is some highly gerrymandered way of making this contention true. But what about facts concerning unforeseen relations or structures? Should the physicalist confidently deny the possibility of emergent properties resulting from interactions and acting on the properties of their constituents? In order to rule out the kind of novelty that might arise through unforeseen interactions - especially the downward causal agency of structures and interactions - the physicalist must assume that all possible interactions are already included somehow in the constituents ahead of time.[6] In effect, in a manner reminiscent of Leibniz's monads, the

[3] Lewis also faces the challenge of reconciling vector fields like electromagnetism with the idea that there is a fundamental level of points with single values. Since vectors seem intrinsically relational it has struck critics like Bickhard (2011), Karatsokas (2009), and Butterfield (2007) as a significant obstacle. See Busse (2009) for an attempt to reconcile Humean supervenience with vector fields. At the very least, this problem points to the absence of an easy fit between Lewisian metaphysics and modern science. It also suggests that an ontology inspired by contemporary physics would not necessarily look like the foundationalism envisioned by Lewis.

[4] Reicher (2001), provides an account of emergent features of crowd psychology. Other examples of apparent downward causal power are discussed in Symons (2002) and Mitchell (2009).

[5] See Griffiths (2008) for an account of the phenomenon of color confinement in quarks.

[6] Something like this is presumably what Shoemaker, 2002, attempts to do in his discussions of emergent properties. On Shoemaker's view the ultimate physical micro-entities have micro-latent causal powers, which manifest themselves only when the entities are combined in ways that are emergence-engendering. In addition to the micro-manifest powers that account for their behavior in other circumstances, micro-physical properties have the entire range of emergent micro-structural properties suited to whatever interactions they might engage in.

fundamental parts cannot be permitted any genuine interaction, while presumably containing within themselves a representation of all possible states of affairs. While Leibniz told us that his monads had no windows, he suggested that they are coordinated by God. It is unlikely that contemporary physicalists would be willing to pay that or some other transcendent price solely in order to block strong emergence.

Blocking interaction and emergence is not an easy feat. Given how much we are required to pack into the micro-level, we might begin to wonder what it means to call oneself a physicalist. Indeed the recent literature attempting to define physicalism shows that it is extremely difficult to generate an acceptable characterization of what counts as physical that is both non-trivial and non-question-begging. (Stoljar 2010)

In spite of the challenge of giving a good definition of physicalism, recent arguments against emergentism in the philosophy of mind have simply assumed that physicalism (however it ends up being defined) can provide a complete fundamental ontology. This paper argues that this assumption is unwarranted. There has been a very active and sophisticated debate concerning the status of physicalism in recent decades.[7] Most philosophers have attempted to provide formulations of physicalism that can avoid standard objections like Hempel's dilemma (1969, 1980). However, there are few explicit arguments for physicalist completeness claims. This completeness is essential to arguments against the possibility of strongly emergent properties.

In the 1990s Jaegwon Kim provided the clearest and most influential example of the argument against strongly emergent properties. Kim famously argued that putatively higher-level properties are causally preempted by their underlying physical constituents. Kim contended that the causal closure of the physical world means that strongly emergent properties (on his account these are properties of wholes that possess the synchronic downward causal power to act on their parts) cannot be included in the causal order of nature insofar as they are always preempted by the causal powers of their parts. This preemption admits no exceptions.[8]

In response, proponents of emergence deny that a purely physical ontology has the resources to account for all metaphysically basic features of reality. There are a variety of ways to argue that there are aspects of the natural world that the physicalist cannot account for.

II. What is emergence and how do physicalists argue against it?

The claim that a property is emergent involves a judgment about the way it relates to something prior, more basic, or more fundamental. Therefore, one's understanding of the more basic, prior, of fundamental will inform one's view of emergence. So, for example, so-called strongly emergent properties are distinguished by being emergent relative to the ontologically fundamental features of our metaphysics. From a physicalist perspective, in order to qualify as strongly emergent, such properties should not be deducible from the laws and initial conditions

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[7] For example, Janice Dowell edited a special issue of *Philosophical Studies,* entitled 'Formulating Physicalism' that includes a set of excellent overviews of the debate including her own introductory essay (Dowell 2006).

[8] Kim (2007) now argues that physicalism does not capture all the facts about reality, specifically, it does not account for facts about qualitative states. See Kim (1998) and Symons (2002).

of the (ideal) physics of the actual world. In the present paper, when I mention the laws of physics, I will be talking in an idealized manner about the laws governing the behavior of a system. The system that interests physicalists is, of course, the whole universe. However, the argument which follows will challenge the notion that we can straightforwardly conceive of the kinds of system boundaries that would correspond in any straightforward way to the boundaries of the universe.

There are good reasons to believe that our metaphysics ought to have some kind of foundational story to tell with respect to, for example, the sources of reality or causal power. For example, positing a metaphysically fundamental level is a way of avoiding the problem of causal drainage. (Kim 2004) An ontologically fundamental level is posited in order to ensure that responsibility for notions like causal power or reality is not deferred indefinitely. (See, for example, Schaffer 2003)

Without a fundamental level, we might worry that causal power and reality will simply drain away; the concern is that a turtles-all-the-way-down ontology would fail to provide a rationally satisfying metaphysics. However, nature does not necessarily conform to what we would regard as rationally satisfying. Nature might not satisfy us, but independently of how the world actually is, we can evaluate metaphysical systems according to whether or not they provide a coherent account of the fundamental level. It is easy to imagine a metaphysical system that, because of internal conceptual problems, is subject to drainage problems. So, for example, if our metaphysician asserts that composites are real by virtue of being composed of real parts, and if she says that everything is composed of parts, then her metaphysics fails by virtue of being subject to reality drainage. It faces a regress, wherein responsibility for ensuring that a composite is real is assigned to the level of the parts immediately below any given level. In order to block reality drainage in her mini-metaphysics, the metaphysician could assert that at some level there are real and non-composite objects. Non-composite objects would be the fundamental objects in this system out of which all others are ultimately composed and from which composites derive their reality.

There are other reasons to strive for a coherent account of the fundamentals, but the most basic reasons seem to be an interest in finding a way to ground our judgments concerning the reality or derived reality of some features of the natural world as opposed to others. The apparent cost of abandoning this kind of the project is the risk of relativism with regard to individuation. The kinds of foundational stories that metaphysics provides, allows a way of justifying our capacity to decide that certain features of the natural world are real while others are not. Given these goals, our account of the fundamentals would fail in case of the existence of some real features of the natural world that escape our foundational project. Completeness serves as a way of preventing this kind of failure. One of the jobs of completeness is to block the metaphysical drains.

The goal of many traditional accounts of strong emergence has been to explain the relationship between emergent properties and the ontologically fundamental level. It is difficult to avoid the idea that emergent properties must be understood as novel relative to some more basic substratum. Even non-ontological versions of emergence are committed to such a relation. For instance, advocates of conceptual and weak emergence focus on the epistemic or objective mathematical properties of some properties. We can understand conceptual emergence as the view that there are properties which are novel relative to some theory or relative to our epistemic capacities. This is the least philosophically contentious kind of emergence since it makes no ontological claims. More philosophically interesting than conceptual emergence is weak emergence. This is the view that there are weakly emergent properties which are, in some sense objective formal properties of the systems in question, but which only appear via some informationally incompressible process.[9] Neither of these kinds of emergence is as conceptually puzzling as strong emergence.

In recent decades most philosophers have denied the existence of strongly emergent properties - properties which are emergent relative to the real ontological or causal fundamentals of the natural world. (See Kim 2004) Strong emergence is generally thought to be objectionable insofar as it is understood as emergence relative to those fundamental properties which serve to ground reality or causal power. A rough initial statement of the ontological as opposed to the merely epistemological problem of emergence runs as follows: If one believes that new things emerge over the course of natural history and if one wishes to avoid supernaturalism then one faces the problem of showing how nature can give rise to something new without getting something for nothing.

Ontological accounts of emergence, when combined with a commitment to the individuation of natural kinds via unique causal powers, are thought to introduce an intolerable causal competition between the powers of the emergent property and the powers of its constituents. Of course this problem isn't unique to emergentism. As discussed above, all non-basic properties run into something like the problem of preemption given the account of individuation which sees the genuine reality of some kind or property as being dependent on its possession of a unique causal power.

Take, for example, the property of being an organism. Kim challenges the claim that it is strongly emergent along the following lines: Can the organism really act on its constituents? Wouldn't this require that in acting on its constituents, the emergent property is changing the very things that make it what it is? If so, then wouldn't the identity of the organism be changing in such a way as to make it impossible to say that it is acting on itself? Taken in its strictest sense, it looks like the idea of a system acting on its own constituents reduces to absurdity. The apparent contradiction that seems implicit in such cases implies that the putative causal powers of higher-level properties are always causally preempted by the properties of their underlying physical constituents. So, while we can certainly identify new patterns and phenomena for instrumental or other reasons, these can only be shown to be 'real' or, to constitute 'natural kinds', given the identification of a unique set of causal powers. According to Kim, downward causation can make sense only if we give it a conceptual interpretation: "That is, we interpret the hierarchical levels as levels of concepts and descriptions, or levels within our representational apparatus, rather than levels of properties and phenomena in the world." (Kim 1999, 33)

From one perspective, advocates of strongly emergent properties seem to be subject to a basic confusion concerning the purpose of metaphysical inquiry. After all, most metaphysicians hope that their account of the fundamentals will provide a complete or closed theory. If our theory locates all causal powers at the level of the ontologically basic units of our metaphysics, the claim that there will be new causal powers which are not had by those units

9 For instance, Mark Bedau (1997) defines weakly emergent features of a system as those which can be derived from the microdynamics of the system only by an exhaustive simulation. Thus, weakly emergent properties are some subset of the properties of a computational simulation which are distinguished by reference to an epistemic agent's inability to predict their appearance without having first run each step in the simulation.

will seem straightforwardly contradictory. This is how I read the basic line of argument in Kim's challenge to emergentism.

However it would be a mistake to assume that advocates of strongly emergent properties simply misunderstand the metaphysician's job-description. Consider an alternative possibility: It could be that if one argues for strong emergence one could be signaling an admission of failure with respect to the task of generating a complete account of the fundamentals. If one claims that non-fundamental properties are real or that they possess causal powers that are not possessed by units at the fundamental level, one is claiming that something more than the proposed list of fundamentals is needed for a complete account of reality or causal power.

At this point, the advocate of fundamentalist metaphysics might respond that one can opt for an aposteriori view of the fundamentals such that whatever this additional extra emergent something is, it can simply be added to the proposed list of fundamentals in order to ensure completeness.[10] As we shall see, an ad hoc strategy of adding to the list of fundamentals as required by new evidence can be shown not to suffice; metaphysics can fail with respect to the project of generating a complete list of fundamentals even when we allow our account of the fundamentals to be modified aposteriori. The possibility of an incomplete fundamental metaphysics turns out to be unavoidable and cannot be remedied by the simple addition of extra principles or categories. This is because, even in cases where the present and future states of the natural world are completely captured by some set of fundamental principles, the possibility that these principles themselves are the result of the process of emergence cannot be excluded.

It is important to emphasize that while the present argument for strong emergence is pessimistic with respect to the metaphysical project of foundationalism, it not an argument against the possibility of mechanisms accounting for emergent properties. On the contrary, according to the view presented here, emergent properties are assumed to be natural, insofar as the mechanisms which give rise to them can be specified. As such, the argument presented here does not pose any new barriers to the provision of naturalistically respectable explanations of specific emergent properties. While emergent properties are not necessarily indicators of trouble with respect to scientific explanation, they do indicate an obstacle to the ambition of metaphysical fundamentalism and particularly to naïve physicalism.

III. Interaction and transients

This section introduces the argument against the completeness of physicalism. As we shall see, even if physicalism could provide a complete inventory of all facts about the actual state of the world, it still couldn't block the possibility of strong emergence. Furthermore, even if some suitably supplemented or ideal version of physics provided a complete explanation of all facts about present and future states of nature without recourse to emergence and even if this physics seemed to provide a deterministic story about past states of the system, there remains the possibility that its description of the past could mistakenly exclude the possibility of emergence. Appeals to the completeness of a metaphysical system - including arguments

[10] Or the fundamentals can be modified in some other way in order to ensure completeness.

that depend on the causal closure of the physical and the maximal generality of physics – do not rule out the possibility of emergence.[11]

Any cycle or set of cycles in a system of states can have as predecessors what are known in engineering and mathematics as transients. As we shall see, transients can precede any cycle or system built out of any set of rules. This general result applies to any proffered characterization of the physical in the same manner that it applies to cycles of states in the formal computational or engineering contexts. In what follows, the rules governing the systems in question will be known as *generative fundamentals*. Generative fundamentals are the set of total states of a system and the possible transformations on that set. A transient will be defined simply as a state that features in a sequence of states of a system that has a first member. (Booth 1967) This way of understanding transients is similar to the concept of transients as they appear in a Markov chain analysis. However, for the purposes of the present article, I will not assume anything about probability or any assumptions concerning randomness. In a Markov chain if there is some non-zero probability that the system will never return to a state, we say that this state is transient. If a state is not transient, it is recurrent. For an overview of Markov chains see Booth (1967).

For any generative fundamentals, *F* the possibility of transients entails the possibility that *F* results from some other generative fundamentals *F**. There will be some cases where *F** is epistemically inaccessible from the perspective of agents in some system governed by *F*.

Properties in some system governed by *F* can be such that, relative to the successor or predecessor system, they can be called emergent. The kind of emergence exhibited by these systems can be called strongly emergent insofar as the novel system's generative fundamentals differ from the system that preceded it in such a way that different sets of generative fundamentals do not give rise to the same properties. Given the account of transients presented below, the generative fundamentals governing the later system would not be sufficient to account for all the metaphysically basic features of reality. The purpose of the argument from transients is simply to note a limitation on attempts to use the completeness of some set of generative fundamentals as the basis for an argument against emergence.

After describing how we can characterize the role of ontological fundamentality in our metaphysical theory in general terms, I will describe the ideas of generative fundamentals and transients in detail. From there, the paper explains some of the kinds of scenarios that physicalists must exclude a priori in order to block the possibility of emergence. Specifically, we will consider cases where a complete physicalist ontology excludes interactions from which new generative fundamentals can emerge. I will argue that some of these candidates for exclusion are perfectly respectable from a naturalistic perspective. Given that interactions of this kind admit of the kinds of explanation, investigation, manipulation, and intervention that naturalists hope for, I conclude that the price the physicalist pays for excluding emergence is unacceptably high.

Physicalism does not exclude properties that are distinct from physicalist generative fundamentals. By being distinct from the generative fundamentals, I mean not derivable from

[11] Tim Crane describes the role of the generality of physics claim in current emergence debates as follows: The claim that all properties have physical properties (the denial of Cartesian dualism) I shall call the generality of physics… We believe that the laws of physics apply unrestrictedly across the universe; there are no regions where these laws fail or break down…for the laws to have this generality, then all the objects to which they apply must have the kinds of properties which these laws concern: physical properties. Everything in space-time has (or has parts that have) these properties: for example, mass, temperature, electrical charge, and so on. (2010, 28)

the generative fundamentals and not included in the set of states stipulated by the generative fundamentals. More importantly, in attempting to prevent the existence of properties that are metaphysically distinct from the physical fundamentals, the physicalist is forced into an implausibly restrictive view of what can count as fundamental.

There are strikingly few examples of philosophers providing arguments for the completeness claim. At a minimum, such an argument involves ensuring that one's metaphysical system is complete in the formal sense; namely that it captures all the truths that can be formulated in the language of the system. Asking after the formal completeness of physicalism involves determining whether there are physical facts that cannot be derived from some set of initial conditions and the laws of physics. If all such propositions are derivable, physics can be said to complete with respect to the physical facts. The prospect of being able to capture all the truths of physics without recourse to an ontology that includes, at a minimum, some mathematical entities famously eluded naturalists like Quine is remote. (Quine 1981) For the sake of this paper we shall grant that physics could be complete in this sense, although the prospects of this actually being the case seem permanently beyond reach.

Unlike the sense of completeness familiar from the study of formal systems, the metaphysical completeness of a system is not only a matter of capturing all the facts that can be stated in the language of the system. It also involves arguing for the adequacy of the language of the system. It is necessary to argue that nothing real is being forgotten or excluded from the system's inventory. So, in addition to formal completeness, metaphysical systems should be evaluated relative to their power to represent the world adequately. Standard criticisms of physicalism in the philosophy of mind target the adequacy of physicalism in this way.[12] Physicalists need to explain how metaphysically significant explananda like qualitative experiences or numbers can be reconciled with or explained in terms of one's physicalist ontology. Thus, from the perspective of the metaphysician, it is not simply enough to claim that physicalist principles suffice to capture all the physical facts. One must also explain why it is that there are no non-physical facts, where a non-physical fact is a fact that is not identical to a physical fact or somehow determined by physical facts.

Physicalists assume that there is some sense in which physicalism can be understood to provide a complete inventory of all facts about the actual state of the world. This step leaves physicalism vulnerable to the criticism of being ad-hoc or question-begging in its dispute with emergentism; the "…and there's no more to say" step.

One way to understand the behavior of a system is to specify the possible states it can occupy and to provide some account of how the system changes from state to state. With this in mind, we can reconsider the problem of emergence in terms of the relationship of the putatively emergent property to some specified set of states and transformations. Different kinds of fundamentality will result in different sets of states and transformations. Let's call these sets of possible states and transformations, books of the world.

The physicalist favors some books over others. In our time, physicalists will reject books whose narratives violate physical conservation principles. These principles serve as

[12] The knowledge argument, qualia inversion arguments (Lycan 1973, Shoemaker 1982) zombie arguments (See Chalmers 1996 especially Chapter 3) and other arguments involving the specialness of phenomenal judgment and qualitative experience are directed at the view that physicalism fails to account for central features of conscious experience.

meta-transformations that govern physical reasoning about possible transformations from state to state. To accept these or any other meta-level constraint involves reducing the space of possible books of the world from, for example, the space of logically possible books to the space of what we might call the extended nomologically possible books of the world.[13] Restricting books via the conservation laws still includes worlds with alternative physical laws to the actual.

Conservation principles are simply features of our physics that hold certain kinds of values to be invariant over time.[14] There are a variety of ways that a book might exhibit this kind of invariance. For example, given some set of *n* possible states, we might be concerned with the set of possible cycles through those states which preserve information and include all states. Let's call these *1-cyle books*. So, for example, given a set of four possible states {a,b,c,d} and the constraint that our book contain a single circuit and conserve information, the following books of the world would be possible :

Book1	Book 2	Book 3	Book 4	Book 5	Book 6
a to b	a to c	a to d	a to d	a to d	a to b
b to c	c to b	d to b	d to b	d to c	b to d
c to d	b to d	b to c	b to c	c to b	d to c
d to a	d to a	c to a	c to a	b to a	c to a

These books tell a story in which an agent at any step in the successive unfolding of the system would, in principle, be able to determine the entire sequence of steps in the history of the system. Even if an agent did not know how many possible states there are in its world, given the knowledge that the universe behaves like a 1-cycle book, the agent could be sure that there are *n*-1! sets of possible books. Why would a metaphysician confine herself to 1-cycle books of the world? The advantage of these books is that given knowledge of a single state of the system at an instant, an agent who has access to the book would know everything about the system. Ordinarily, physicists are not that optimistic and neither, I suppose, are physicalists. They recognize, instead, that the conservation principles permit the existence of independent subsystems. What do we mean by subsystems here? Well, in addition to the six cases we described above, we could add cases like the following

Book 7	Book 8	Book 9	Book 10
a to b	a to c	a to a	a to a
b to a	c to a	b to c	b to b
c to d	b to d	c to d	c to c
d to c	d to b	d to b	d to d

[13] Nomologically possible worlds are those which obey the same laws of physics as the actual world. The set of extended nomologically possible worlds are those which obey some metaprinciples of physics, like the conservation principles, but which do not necessarily contain the same physical laws as our own.

[14] See Suskind and Hrabovsky 2013 for an introduction to conservation principles as meta-principles in physics.

and so on. If we allow subsystems that are independent of one another and that obey conservation principles, we will find *n*! possible books (24 in this case). We could call this larger, more inclusive, set *the multi-cycle books*.

Alternatively, we could imagine not caring about the conservation laws, such that we would drop any restriction on possible transformations among states. In this case there would be n^n sets of books where *n* (again) is the number of possible states that the system can be in. In this case, we could say that our choice of book would be constrained only by logical possibility. Most of the stories included in this set of books would violate conservation principles of various kinds.

As we begin to read one of these forbidden books we quickly encounter a phenomenon known as transience. A transient state is simply one that is part of a sequence of states with a first member. If the state is part of a finite sequence of states which does not have a first member, then that state is in a cycle. Transients are anathema to physics insofar as they fail to be deterministic into the past. The laws of physics as we know them are symmetrical or time reversal invariant. Physicists say that laws are invariant under time translation. Transients are not. In a system with set of states {a,b,c,d} dropping any restrictions would allow for transformations that go:

a→a		a→b
b→a		b→a
c→a	or	c→a
d→a		d→c

Any system whose possible states and transformations allow for more than one arrow out or in, or whose states lack an in arrow would have transients. Theoretical physicists might not like transients, but in nearly all other scientific contexts, they are ubiquitous. For example, any science which uses computational models will have to find some way to cope with transients. Any book of the world that is generated by computational modeling is likely to exhibit behavior that does not comport with conservation principles of the usual sort. In cellular automata,[1] for example, transients will appear in most runs of the system and systems that exhibit reversibility or conservation will be a tiny minority.[2]

In systems like cellular automata, initial states follow transition rules such that they tend towards an oscillator. This means that after some finite sequence of steps, the cellular automaton will enter into a repeating cycle of states. Note that these systems do not preserve information concerning past states of the CA. Instead, they feature transients that are not accessible once the system has entered into an oscillating sequence of states. Clearly, the

[1] Cellular automata are abstract objects which can be characterized in terms of a quintuple set: {Cells, Cell Space, Cell State, Neighborhoods, Rules}. Where *cells* are the basic objects or elements of the CA each having some individual state depending on the rules of the CA. *Cell space* is defined as the set of all cells and their values at some time. *Neighbors* are the set of cells surrounding some any center cell and *rules* are the transition functions of cell states, mapping cell spaces to cell spaces. (Hu Richa. and Xiaogang Ru 2003, 1047) The rules of the CA are defined as being maximally general with respect to the cells in the model and the application of rules updates each cell synchronically. (See also Symons 2008)

[2] Steve Wolfram showed that among the 256 elementary cellular automata with two colors and nearest neighbor rules for transformations, only 6 exhibit a reversible output. (2002, 436) Irreversibility is a characteristic of most cellular automata. It's worth noting too that the elementary cellular automata constitute a small subset of the set of algorithms which we might wish to consider.

algorithms governing CA are different from the kinds of transformations we would usually associate with physical laws.

Earlier we saw how one could constrain one's choice of book in accordance with conservation principles.

Notice now that an agent whose universe is the result of fundamentals organized according to the algorithm of a cellular automaton might be in a position to propose a book that accords with the sequence of states in the oscillator. We could imagine an agent at some state in the oscillator, believing that she had accounted for the entire past, present and future of her universe while ignoring the possibility that her present cycle is compatible with another book in which the rules could have generated transient states prior to the initiation of the first run of the oscillator that she now inhabits. We will return to this point in greater detail below.

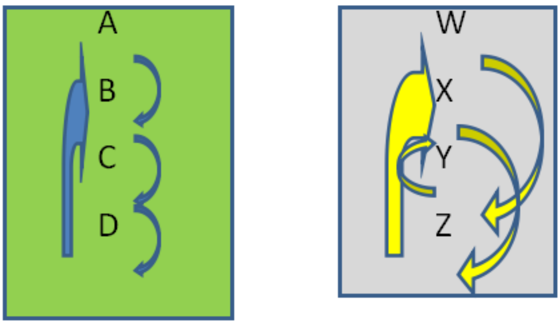
IV. Blocking Interaction

Returning to systems that are constrained by the kinds of conservation principles that interest physicists we recognized that books obeying conservation principles include what we called multi-cycle books. As we saw above if we include isolated loops and subsystems in a system of n states, the number of transformations that preserve invariance is $n!$. So, to summarize, this $n!$ set of books would include transformations with discrete subsystems but it would exclude books with transients.

Given that there are $n!$ systems of fundamentals, some of which can have distinct cycles or subsystems, let's consider an example of their behavior. When we think about these possible, physically law abiding subsystems, it can be fruitful to think of them as networks with their own specific sets of laws. At this stage we can consider both networks as written in a book which we will call Φ.

Networks 1 and 2, pictured below, are a representation of the story told by Φ. At this stage one might ask whether it is legitimate to understand these as isolated, law governed systems or as consequences of the laws governing some system that is composed of networks 1 and 2. In this case, let's simply stipulate that Φ contains two distinct oscillators or networks and that Φ is also consistent with conservation principles. Φ does not specify any interaction between the two networks.

NETWORK 1 NETWORK 2

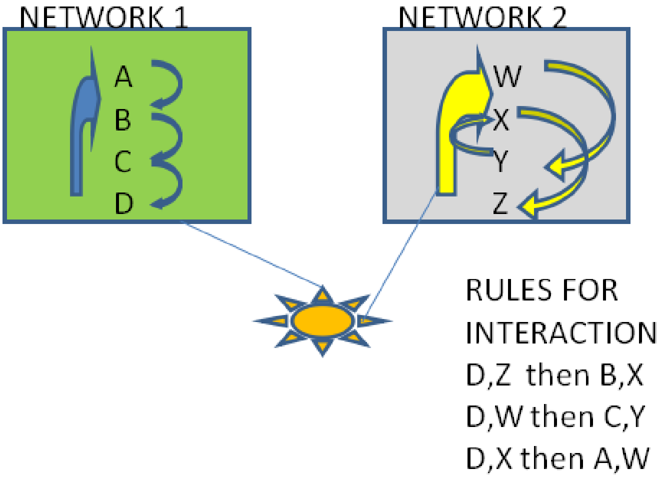


A,B,C,D,A,B,C,D,A... W,Y,X,Z,W,Y,X,Z,W...

Now, imagine, for the sake of the present argument that one is interested in possible ways that these two networks *could* interact. While no such rules for interaction are included in Φ, one could ask whether Φ excludes interaction or simply leaves such interaction undetermined? From the physicalist perspective, the only books worth having are complete books and therefore we should assume that interaction of Networks.

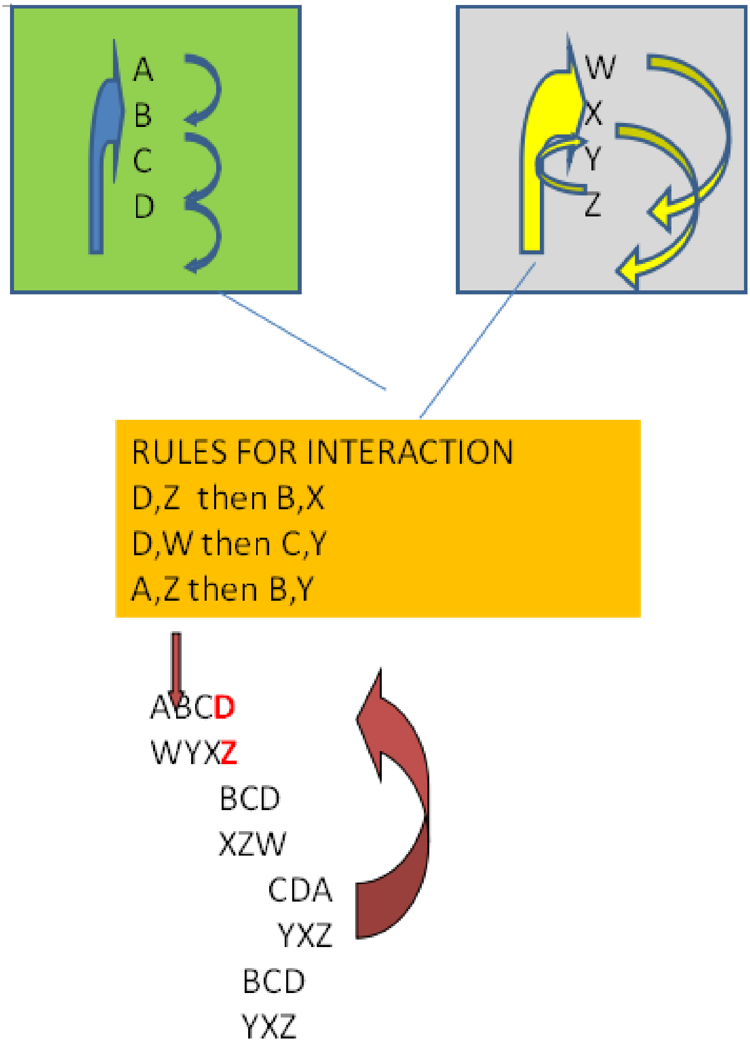
1 and 2 is excluded by Φ.

The methodological problem with the physicalist's view of fundamentals is becoming apparent. When building a set of fundamental metaphysical principles, what does it mean to simply claim completeness by specifying the fundamentals and then adding the condition that there are no events other than the events determined by the fundamentals. This would be equivalent to claiming the completeness of *Principia Mathematica* by simply stipulating that it captures all truths of arithmetic; that no truths of arithmetic are unprovable in the system of PM. So, when we define Φ for any sufficiently complex or interesting cases, the anti-emergentist cannot simply forbid the interaction of sub-systems by fiat without ruling out possible interactions in an ad hoc manner. I will provide a more extensive defense of this claim below.



At this stage, let's assume that there *are* possible interactions between the two networks that are contingent with respect to Φ. This would mean that Φ was an incomplete book of the world. For the purposes of the present argument, the source of the interaction rule is not important. So, for example, given our two networks described above, let's arbitrarily introduce some new rule, call it the interaction rule, which gives us a new book Φ*.

Φ*, as pictured here, is a new book which results from adding interaction rules to Φ. So, beginning with A in Network 1 and W in Network 2, let's consider the way that the systems unfolds in light of the interaction rules specified. Notice that here the interaction rules are taking as their inputs, the results of the action in the distinct networks. Let's assume that the system begins with A in Network 1 and W in Network 2. If the Networks give as outputs the antecedents of the interaction rules then the activation rule determines the consequent. Twelve steps after beginning at AW we notice that the system returns to DZ but that the combination of A and W drops out and will not reappear in the future runs of the system. This is an example of what we earlier called 'transient'. The steps are illustrated in the figure below.



After an initial run and with the rules of interaction in place we can see Φ* as a new system governed by a new set of functions in which the combination AW no longer appears. The sequence of states that characterize Φ* are as follows:

DBCDCDABCD...
ZXZWYXZYXZ…

and the set of functions that characterize the behavior of the cycle that Φ* produces (given initial starting point at AW) are as follows:

If A then B
If B then C
If C then D
If DBCD then C
If ABCD then B
If W then Y
If X then Z
If Y then X
If ZXZ then W
If YXZ then Y

Interaction rules can introduce transient states (like A,W) and can generate new patterns that are subject to generalizations that do not hold, or are even in violation of the rules given in the networks in isolation. So, for example, Φ* generates a sequence in Network 1 such that: ABCDBCDCDABCD… In this sequence, DBCDC is clearly a violation of the ABCD rule. However once we can only observe the behavior of the cycle that Φ* produces after the transient state has passed, the notion that there really are relevant Network 1 rules to violate becomes difficult to see.

The starting points or the initial conditions are important to the role of the interaction rule we introduced to generate Φ*. So let's consider some alternatives. Alternative initial conditions result in alternative sets of transformations governing the networks. For example, beginning with DX also results in a transient state, but in this case, it leaves the original rules governing Network 1 unchanged. By contrast, the initial conditions plus the interaction rules modify the behavior of Network 2.

D A B C D B C D C D A…
X   Z Y X Z X Z W Y X Z…

(D,X) is left transient, Network 1 is unchanged, Network 2 has appears to be governed by new rules.

We could canvass other possible sets of initial conditions. For example, starting Φ* at BZ does nothing. It never allows the activation of the interaction rules. In this case, it would not be possible to distinguish between the behavior of Φ* or Φ. The interaction rules would be forever dormant and would never have had the occasion to manifest.[3]

So, what can we conclude from toy cases like these? In the way I set up the case here, initial conditions are arbitrary with respect to the rules of the networks as are the rules for interaction. Once we include the rules for interaction, depending on the initial conditions, the resulting system Φ* can exhibit transient states. What should be striking is that once it enters

[3] Elsewhere, (Boschetti and Symons 2011) the mechanism for emergence that is sketched here is explored in greater detail. In that paper we explain the minimal conditions for novel patterns in interacting computational systems.

into its cycle, the resulting system will show no evidence of these transient states and may instead exhibit a new set of rules governing both networks.

The transients aren't conserved in the new arrangement Φ*.

Φ* can, given some initial conditions, comprise a new set of functions on the original set of states. Note that in our example, in order for the new arrangement to be in place, the old functions are required to govern the sub-network. In this sense, the original laws are subordinated to the rules of interaction. From the perspective of the physicist living in the new cycle with its new fundamental laws, the transients are simply irrelevant; they aren't conserved. As we saw, the initial conditions are also crucial in the specification of the consequences of interaction. Given some sets of initial conditions we can have a new total system with a new set of transformations in Φ* or we can see no difference at all between Φ* and Φ.

Obviously, the new arrangement only comes into place if there is the possibility of interaction. If there is no interaction, then there will be no question of the interaction laws trumping the local or sub-network laws.

The physicalist must make sure that there are no interactions of this kind in the future. One way to block the possibility of interaction between sub-networks in a system, would be to make all sub-networks fall into a single cycle such that there would be no genuine subsystems. This would require us to rule out books with subsystems, even though they are in compliance with the conservation principles and form a large part of the extended nomologically possible set of books described above.

As we can see, in order to block the possibility that distinct subsystems might interact, the anti-emergentist must limit consideration of the extended nomologically possible, to those systems which do not permit emergence. More precisely, these would be systems in which apparently distinct subsystems are in fact coordinated. This coordination of the subsystems would serve to preclude the possibility of interaction effects of the kind discussed here. However, this blocking strategy for the fundamentalist comes at the price of constraining consideration of the set of books in an apparently question begging manner. Not only are we restricting the books of the world to those that comply with conservation principles, now we are ruling out books that have subsystems that obey conservation principles, just in case they might interact in the future. Since they don't say they won't, then let's stipulate that they won't in order to block emergence.

That price might be worth paying if it really blocked emergence and if it provided completeness for physicalist fundamentalism. Unfortunately for the physicalist it fails to do so. It is logically possible that we could live in a world that is accurately accounted for by a finished physics with a set of functions that determine the behavior of the system and are deterministic in the forward and reverse time directions. It is also possible, however, that these physical laws are the product of a process like Φ*. If so, then there may have been a history over the course of which there was at least one transient state. As we have seen, it is possible therefore that there is no way to recover this history from exhaustive knowledge of the present laws of nature. These laws of nature may have emerged from different laws via a simple process whose character cannot necessarily be gleaned from the current laws themselves. As such, the laws or fundamentals in this case are not complete.

To summarize, as we have seen, even in cases where there is only one system or law which does not admit of any genuine novelty, it's always possible that this law-like system is itself an emergent consequence of a natural history which includes transient states. Even a closed, cyclical system governed by laws preserving backwards and forwards determinism could itself be an emergent feature of some prior or more fundamental metaphysical principles. Therefore, the fact that a book's laws govern the system in a way that is backwards deterministic might be the result of past processes that are not! This odd result stems from the simple fact that because our current state is part of a cycle we should not be led to the false conclusion that all prior states must always have been part of the same cycle.

While this result might seem to pose a merely skeptical challenge to physicalism, it does have a constructive element. The present account is constructive insofar as it shows how we might unpack the kinds of processes that led to some cycle or system. For example, it is possible that by isolating subsystems in the appropriate way, in our case by isolating the behavior of individual networks from the rules of interaction, it might be possible to reconstruct the mechanism by which the new system Φ* emerged. In such a scenario, if we assumed that the Φ* laws we observed at a later state were fundamental, then our set of natural laws would be the emergent product of interactions or mechanisms that would remain forever hidden from us. Notice that by isolating a sub-system we may be able to recover the laws governing that Network in isolation. So, if we know how to control interactions we have the prospect of rebuilding the process that led to the resulting system.

According to the view presented here, we should expect the possibility of nomologically contingent interaction of sub-systems. In such cases we could find an instance where the joint action of the two systems is such that the result is emergent with respect to those systems. In order to block this contingency we might posit some third more fundamental principle or system. If this third law subsumes the generalizations of the initial two subsystems, we revert back to a one-rule scenario. However, as we have also seen, even if the one-rule scenario accurately represents our current situation, it fails to block the possibility of emergence.

V. Conclusions

In this paper, we have seen that the physicalist's view of fundamentality leads to an ad hoc rejection of naturalistically respectable books of nature. So, unlike previous criticisms of physicalism, the current argument is not concerned with the question of how much is packed into the fundamentals, but rather, with the ways physicalists exclude the possibility of interaction and emergence from consideration from the outset.

Physicalist completeness claims are directed to present and future states such that it cannot exclude the kinds of transients discussed here, nor can it do justice to the kinds of historical properties that Louise Antony and others have noted. (Antony 1999) As such, physicalism cannot exclude the possibility that the physical fundamentals themselves are emergent features of some more fundamental metaphysical principles. As we have seen, it is possible to grant completeness with respect to present and future states and still allow for the possibility of emergence in the past. So, the argument presented in this paper provides a plausible, and naturalistically respectable way of making sense of the possibility of historical properties for which physicalist fundamentalism cannot account.

Even if we dismiss the possibility of transients as an exotic, skeptical worry about the past, as we have seen, the physicalist will have to find ways to exclude contingent interactions in the future. Insofar as it is complete with respect to future facts physicalism must exclude nomologically contingent possibilities of interaction whose results lead to new generative fundamentals. In other words, only events that are a necessary consequence of the fundamentals can take place. However, there is a price to be paid for completeness with respect to the present and future.

As we saw, one way of blocking nomologically contingent future interactions is to claim that possibilities for interaction are already somehow accounted for in the fundamental physical properties. On this view, we simply assume that the fundamentals determine the outcome of every possible future interaction such there are no nomologically contingent interactions. This is equivalent to the denial of the possibility that there are systems with subsystems that obey conservation principles. This restriction on the space of possible books of nature is motivated solely by the concern that these subsystems might interact in some unanticipated manner.

Common sense tells us that interactions can change the character of their participants. For example, it is common for emergentists to argue that participation in structural wholes can change the nature of the parts. As discussed above, in order to rule out this kind of novelty and especially the possibility that structures might exhibit synchronic downward causal powers, the fundamentalist must include all possible fates of the constituents in the fundamentals ahead of time. In effect, each part contains within itself some feature that makes it determinable how it will be in all possible states of affairs and interactions. On this view, physical properties cannot be permitted any interaction not already determinable given the fundamentals alone.

So, while it appears that there could be worlds with distinct subsystems governed by conservation principles, the physicalist regards them as only apparent possibilities. Such worlds only appear to have distinct subsystems since according to the physicalist they are coordinated by some more basic single-cycle book. The trouble with physicalism is that it excludes too many naturalistically respectable kinds of worlds solely for the purpose of blocking the possibility of emergent properties.

On the view defended here, it was a mistake to for physicalists to assume that delegating ontological questions to physics suffices for their philosophical purposes. However, this does not mean that ontology should be an armchair enterprise. Ontological arguments should be supported by evidence. I hope to have shown that contemporary physicalism does not exemplify this virtue and is, instead, motivated by the goal of blocking the possibility of strong emergence. A more modest form of physicalism; naturalistic in spirit and guided by attention to our best science rather than some idealized form of 19^{th} century physics would no longer be motivated by fundamentalist metaphysics and would be open to the possibility of genuine emergence. At the very least, I hope to have shown that once we admit the possibility of interaction and the incompleteness of our putatively fundamental ontology, arguments against emergence appear much less convincing.

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