Emergents from Fusion*

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This is a critical discussion of Paul Humphreys's fusion view of emergence, focusing on the basal loss feature of his ontology. The discussion yields some general morals for special science ontology.

1. Introduction. In a series of papers (1996, 1997a, 1997b, and 2000), Paul Humphreys presents an original vision of what special science ontology *might be*.[1] Humphreys's speculative proposal—call it *fusion emergentism*—is based on "taking singular interactions ['fusions'] as the basis of one form of emergentism" (Humphreys 1996, 53).

What is most distinctive in fusion emergentism is Humphreys's property fusion operation, which takes property instances (at the *i*th level) and generates an emergent property instance (at the $i + 1$st level) with novel causal powers. When property instances at the generating *i*th level are fused, the individual property instances are destroyed and are nonindividuable within the emergent fusion existing at the $i + 1$st level.[2] Call this the *basal loss* feature of fusion emergentism.

Humphreys argues that this idiosyncratic feature allows fusion emer-

*Received January 2004; revised November 2006.

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‡I am grateful to the editor, Paul Humphreys, Timothy O'Connor, Krisztina Orbán, Paul Snowdon, and Georg Theiner for discussion and comments, and to Michael Martin for valuable advice on restructuring.

1. The key paper for the fusion apparatus is Humphreys 1997a. All references are to this paper unless otherwise stated.

2. Sometimes I will use "property" when I mean "property instance" for stylistic reasons. Later on, I also use the term "state," where a particular's being in a certain state just is its instantiating a certain property at a time or over a period of time. It is important for Humphreys that fusion operates on property instances rather than properties; because of the primacy of singular causal interactions, there need be no general supervenience laws. (See Appendix for discussion.)

Philosophy of Science, 73 (July 2006): 345–367. 0031-8248/2006/7303-0005$10.00
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https://doi.org/10.1086/515413 Published online by Cambridge University Press

gentism to escape the causal exclusion and downward causation arguments (spelled out in the next section) that threaten traditional nonreductive supervenience ontologies. His thought is that if the basal property instances no longer exist, then they cannot compete as causes with the emergent property instances that they engender.

I shall argue that certain consequences of this novelty that fusion emergentism introduces undermine the innovation.

The plan of the paper is as follows. In the first part of the paper (Section 2), I situate fusion emergentism in its dialectical context. I begin by telling the standard story about emergence and discussing the perceived difficulties for it, using this as a springboard to introduce the fusion view. In the second part of the paper (Sections 3 to 5), we focus on the basal loss feature of the fusion view as a solution to the exclusion worries for emergents. I start out by teasing out certain peculiarities of Humphreys's perception of the exclusion worries. I then argue that basal loss generates serious problems for understanding complex nonemergent properties had by systems with emergent properties generated by fusion. On top of this, I show that, given Humphreys's understanding of the sense in which emergents are novel, basal loss is gratuitous for securing the ontological autonomy of emergents. The upshot of this part of the paper is that basal loss is both problematic and unmotivated. However, this is not to say that we have nothing to learn from the fusion view. In the final part of the paper (Section 6), I draw certain morals about special science ontology from the failings of the fusion view. In particular, I examine the major source of hostility to emergentism: the entrenched idea that special science properties are *realized* properties. I try to discern the roots of its entrenchment and the extent of its viability.

2. The Standard Story about Emergence. The basic shape of an emergentist account depends on how it treats the perennial themes of emergentism: novelty, dependence, antireductionism, and complexity. Indeed, there may not be a single "correct" way—as has been sometimes supposed—to develop emergentist themes. Various emergentisms may even coexist. Since our concern here is with *ontologically* antireductionist pictures of the special sciences, we will limit ourselves to ontological varieties of emergence. (This is neither to deny that the perennial emergentist themes may be developed epistemologically nor to say that ontological varieties of emergence have no epistemological consequences.)

The received picture of emergence in contemporary discussions about special science ontology derives from that bequeathed to us by the British emergentists, with C. D. Broad's discussion in *The Mind and Its Place in*

https://doi.org/10.1086/515413 Published online by Cambridge University Press

Nature being (perhaps) the most influential.[3] Broad's picture is a form of what we shall call *supervenience emergentism*. Broad's commitment to the *supervenience* of emergent properties is evident in the following often-cited passage:

> No doubt the properties of silver chloride are completely determined by those of silver and of chlorine; in the sense that whenever you have a whole composed of these two elements in certain proportions and relations you have something with the characteristic properties of silver chloride.
>
> 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 [the same] properties. (Broad 1925, 64)

Under the influence of Broad's discussion and Jaegwon Kim's exploration of the parallels between nonreductive physicalism and emergentism (see Kim 1992 and related essays in Kim 1993), the standard way to develop emergentism throughout the 1990s was to argue that because the idea of supervenience consists of two main components, *dependence* and *determination*, and because emergence too exhibits these components, emergence is a "species of supervenience." *A*-properties depend on *B*-properties if and only if *B*-properties are necessary for *A*-properties and *A*-properties are determined by *B*-properties if and only if fixing *B*-properties suffices to fix *A*-properties (Van Cleve 1990, 221–222).

Let us now develop supervenience emergentism in full generality. The basic ontology of an emergentist account consists of emergent laws and emergent entities.[4] There are two types of emergent laws: *manifestation laws* codify the conditions—where requirements may be both qualitative and quantitative—under which emergent entities appear, and *behavioral laws* characterize the behavior of emergent entities. (Epiphenomenal accounts of emergents will have no behavioral laws.)

On supervenience emergentism, emergence is a species of noncausal, "pure" supervenience. The idea of supervenience involved here is that of a "required-sufficiency" relationship (McLaughlin 1995, 1997), on which the having of a certain sort of property requires having a property of another sort that is sufficient for it. This supervenience is "pure" because

3. See McLaughlin 1992 for discussion. See also O'Connor and Wong 2002.

4. Entities can be any of individuals or substances, properties, facts, processes, events, though discussion has generally focused on emergent *properties*, since emergentists have traditionally been substance monists. I have chosen to use "entity" as a catchall for the sake of generality in developing the canonical emergentist doctrines.

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it holds in virtue of nothing other than the fundamental (emergent) supervenience laws (see Appendix). These laws are emergent because they are not laws of physics, and they are fundamental because they are not metaphysically necessitated by any other laws, even together with initial conditions. Entities are emergent if they appear in the consequent of at least one fundamental emergent manifestation law.[5]

However, supervenience emergentism is not the *only* form of ontological emergence. A natural way to understand the emergence relation is as a *causal* relation. This generates a distinctive form of emergence on which emergent entities are the causal effects of basal entities. Call this view *causal emergentism*. On causal emergentism, fundamental emergent causal laws dictate the dynamics of emergents, specifying their production conditions (manifestation laws) and behavior (behavioral laws). Once again, these laws are (one) emergent because they are not laws of physics and (two) fundamental because they are not metaphysically necessitated by any other laws, even together with initial conditions; and entities are emergent if they appear in the consequent of at least one fundamental emergent manifestation law.

Humphreys's fusion view falls into the causal camp, and this partly explains why many reject it as a *kosher* form of emergentism.[6] Causal emergentism, however, has a distinguished ancestry. It was first articulated by Mill—the father of British emergentism—in his *Logic* (1843). He did not use the term "emergent," which G. H. Lewes later coined, but developed his account on the basis of his distinction between homopathic (i.e., nonemergent) and heteropathic (i.e., emergent) effects and laws. Details of Mill's system need not detain us; Mill's emergentism is causal because, for Mill, homopathic and heteropathic laws are *causal* laws, and homopathic and heteropathic effects are effects of *causal* interactions.[7]

As is clear, the crucial difference between supervenience and causal emergentism is whether emergence is a causal relation. Since we earlier introduced supervenience emergentism via its sharing *dependence* and *determination* components with supervenience, a natural thought is that

5. See O'Connor 1994, McLaughlin 1997, and Kim 1999 for examples of supervenience emergentism.

6. Other examples of causal emergentism are O'Connor and Wong 2005 and the form of emergentism targeted by Unger 2006. Strictly speaking, Humphreys's account of emergence is meant to apply to a larger class of phenomena than the causal views, since his account is supposed to be based on "interactions," causal or otherwise. However, it is simplest to see his view as a variant on the causal view since his interaction view also understands emergents as products of some process and also because we don't have a good grip on noncausal processes which are dynamic. This simplification does not affect my arguments.

7. See O'Connor and Wong 2002 for more discussion.

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these conditions might also distinguish between the two views. This is not the case. While causal processes are typically diachronic, the definitions of *dependence* and *determination* do not preclude time-indexed versions of these notions.[8] Indeed, given determinism, it is easy to formulate diachronic supervenience theses that characterize certain varieties of causal emergentism.[9]

Here are some differences. For supervenience emergentism, *fixing* the intralevel laws doesn't fix the interlevel laws, since interlevel laws are fundamental. But the interlevel manifestation laws relate properties across levels. Thus, fixing the basal entities *and* the interlevel manifestation laws suffices to fix the emergent entities. This entails the supervenience of emergents on basals.

Take a snapshot of the world *now*. On supervenience emergentism, if I take the minimal physical base of the world *now* and all fundamental laws (this includes all interlevel manifestation laws), then I get the natural world in its entirety *now* (exclude abstracta, for emergentists are primarily concerned with natural properties). Not so for causal emergentism. On the latter, if I wanted the natural world in its entirety *now*, I would need to take the minimal physical base at genesis and all fundamental causal laws, and let the world run its course (assuming determinism).

The literature may have ignored causal views of emergence for a long time, but do they warrant any interest intrinsically? Taking the case of fusion emergentism in particular, Humphreys claims that the fusion emergentist has a response to the causal exclusion and downward causation arguments where the supervenience emergentist doesn't. We can develop

8. One may wonder why I speak of time-indexed versions of supervenience, since supervenience relations are standardly defined without reference to time (see, e.g., the definitions in the Appendix). The commitment to *synchronic* supervenience in discussions of emergence, however, is all but implicit. Emergence is inevitably contrasted with reductionism where, e.g., pain at some time t is understood to just be the firing of a certain sort of nerve fiber at t and where the key difference between emergence and reduction is the denial of reducibility in the case of the former (see Kim 2006, e.g.). This is strengthened by the commonplace accusation that nonreductive physicalism (NRP) is really a closet form of emergentism, since the relation between basal and supervenient properties in NRP is definitely not understood diachronically.

9. Doing so may require enlarging the supervenience base to include the absence of defeaters. Note also that even where supervenience theses can characterize the covariation relations of emergents and bases, in particular causal emergentisms, these need not be diachronic; whether they are hinges on the possibility of simultaneous causation and whether any emergent manifestation laws involve simultaneous causation. I take it as obvious that the mere fact that supervenience theses may be formulated for causal emergentism does not make it a species of supervenience emergentism, since supervenience is not a "natural" relation but merely captures patterns of modal dependent variation.

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the causal exclusion problem by considering the contemporary problem of mental causation, which we can cast as an antinomy:

(1) *Nonidentity*. Mental properties are not identical with physical properties.
(2) *Causal Closure (Completeness) of the Physical*. Every caused physical event has a sufficient prior physical cause. (A stochastic version of this thesis would claim that the objective probability of every physical event is fixed by prior physical events and laws alone.)
(3) *Causal Exclusion*. There is at most one complete and wholly independent causal explanation for any given event or sequence of events.
(4) *Causal Relevance of the Mental*. Mental events are partly determinative of some physical events.
(5) *Causal Homogeneity*. The mode of causation between mental events and physical or mental events is, in general, metaphysical terms, the same as that holding among purely physical events.

These theses are jointly inconsistent; every combination of four theses constitutes an argument against the fifth. If we take (1), (2), (3), and (5), we have the generic causal exclusion argument with mental epiphenomenalism, that is, not-(4), as its conclusion.[10] We may generalize the causal exclusion argument from the case of mental causation to special science causation at large by substituting events described by the appropriate special science in place of mental events in premises (1), (4), and (5) above.

Kim (1992, 1999) argues that both upward and same-level causation entail downward causation; this is called the *downward causation argument*. Consider a property M, at nonfundamental level l and time t_1, that causes another property M^*, at nonfundamental level l and time t_2. Since M^* is a property at a nonfundamental level, by hypothesis, it has emergence base, P^*, at t_2 and level l-1. Kim sees a tension in this situation because there appear to be two competing answers to why M^* is instantiated at t_2: first, M^* is instantiated at t_2 because M at t caused it (ex hypothesi); second, M^* must of (at least) nomological necessity be instantiated at t_2 because its emergence base, P^*, is present. Given that P^*'s presence at t_2 alone suffices to guarantee M^*'s instantiation at t_2, P^*'s

10. Humphreys is mistaken in thinking that were it not for the prevailing physicalist dogma, the exclusion argument could be run in reverse against physical causes (4, note 3). The situation is clearly asymmetric. Except for phenomenalists, pre-established harmonists, occasionalists, and the like, *the mental is not causally closed*. This asymmetry is entirely independent of any prejudice against the mental—consider the excruciating pain felt upon sitting on a pin. Many mental-mental causal chains also have physical intermediaries, e.g., communication via speech.

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presence apparently jeopardizes *M*'s causal responsibility for *M**. Kim suggests that the only coherent description of the situation where *M*'s causal responsibility for *M** is preserved is this: *M* causes *M** via causing its emergence base *P**. The moral is that emergents can only be brought about by bringing about their supervenience bases.

What alarms Humphreys is that the conjunction of the two arguments appears to result in contradictory conclusions: the causal exclusion argument withholds from emergents downward causal powers which the downward causation argument demands. If we generalize the causal exclusion argument for causation among events described by the special sciences at large, we have the unacceptable conclusion that there is *no* special science causation. The task, then, is to surmount the difficulty raised by the two arguments.[11]

3. Fusion Emergentism and Basal Loss. I now introduce Humphreys's ontological assumptions and notational preliminaries and then discuss the motivations behind fusion emergentism in detail.[12] Remember that the point of going through all this is to see how fusion emergentism circumvents the causal exclusion worries.

We begin by laying out some simplifying assumptions. It is easiest to

11. Humphreys's view of the combined threat of the causal exclusion and downward causation arguments is not unorthodox; it is shared by Kim (1999, 2006), among others. For the record, I do not endorse either argument, but that is a story for another occasion. Here I limit myself to several brief remarks.

The dialectical role of the downward causation argument is to force any emergent causation to take place via downward causation of basal properties (resulting in the contemporaneous instantiation of the supervenient emergent). This then facilitates the next argument that since the emergence base *B* (of the emergent property doing the causing) is likely to be as good a candidate as a cause of *B** (the base of the emergent effect *E**) as the emergent property *E* itself, emergents end up as overdetermining causes. It is then argued that overdetermination is exceedingly rare, and so the efficacy of emergents is suspect. (See, e.g., Kim 1999.)

Notice that the second argument *does not* employ the premise of physical causal closure but, instead, relies on arguing that *B* (the emergence base of *E*) has a good claim to be a cause of *B** (the emergence base of *E**) to generate overdetermination. The main problem is that though *B* has a good claim to be a cause of *B**, it is not obvious that *B*, unlike *E*, qualifies as a *direct* cause of *B**. Presumably only (fairly) direct causes can qualify as symmetrical overdeterminers of an effect; otherwise we would have massive overdetermination in the physical realm anyway from causes of direct causes, and causes of those causes, etc., undermining the "no systematic overdetermination in the actual world" clause. There are several other ways of countering the argument which I cannot go into here for lack of space. I discuss these arguments in Wong (2007).

12. I introduce only the minimal metaphysical and notational elements relevant to my discussion. For the complete details, see Humphreys 1997a.

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illustrate the dynamics of fusion within a levels of nature ontology (adopted here only for expository convenience): "(L) There is a hierarchy of levels of properties L_0, L_1, . . . , L_n, . . . of which at least one distinct level is associated with the subject matter of each special science, and L_j cannot be reduced to L_i, for any $i < j$" (5).

What is not an emergent property instance is either a primitive or a structural property. A *primitive* property is a property that is neither structural nor emergent. A property, *P*, is *structural* if and only if "proper parts of particulars having *P* have some property or properties not identical with *P*, and this state of affairs is constitutive of the state of affairs of the particular's having *P*" (O'Connor 1994, modified from original definition in Armstrong 1978). I will also assume that aggregate properties (i.e., properties of aggregates) do not differ metaphysically from structural properties but will not defend this assumption. (Note that aggregates can also be built up from emergents.)

Humphreys also assumes an event ontology, where events are property instantiations at a time (Kim 1973). Events, so understood, are the relata of causation.[13] Humphreys formally represents events as follows: $P^i_m(x^i_r)$ denotes an *i*-level entity, x_r, instantiating an *i*-level property, P_m, for $i > 0$. Properties and entities are indexed to the first level at which they are instanced. Now introduce Humphreys's fusion operation [.*.]. If $P^i_m(x^i_r)(t_1)$ and $P^i_n(x^i_s)(t_1)$ are *i*-level property instances (i.e., x_r's exemplifying P_m at t_1, etc.), then the fusion of these two property instances, $[P^i_m(x^i_r)(t_1)*P^i_n(x^i_s)(t_1)]$, produces an $i + 1$-level property instance, $[P^i_m*P^i_n][(x^i_r)+(x^i_s)](t_2)$ (which can also be written as $[P^{i+1}_l][(x^{i+1}_l)](t_2)$, but the notation masks an ambiguity regarding the operation of fusion on objects—where notational precision is unnecessary, I use a simplified notation). Humphreys is uncommitted about the exact nature of the fusion operation pending further empirical work: fusion possibly characterizes more than one type of interaction; it is not necessarily causal, presumably dynamic, usually diachronic, and is a "real physical operation" as opposed to a merely logical one.[14]

The key feature of a fused property instance $[P^i_m*P^i_n][(x^i_r)+(x^i_s)](t_2)$ is that it is a unified whole, in the sense that its causal effects *cannot be correctly represented in terms of the separate causal effects of its constituents*. Moreover, within the fusion the original property instances $P^i_m(x^i_r)(t_1)$ and $P^i_n(x^i_s)(t_1)$ no longer exist as separate entities, and they do not have all their *i*-level causal powers available for use at the $i + 1$-level. But note that the objects themselves will often retain their separate identities; typically, they

13. Thus, to speak of one event causing another just is to speak of one property instantiation at some time causing another property instantiation at some time.

14. For Humphreys, archetypal fusion phenomena are cases of emergence involving quantum entanglements (Humphreys 1997b, S342–S344).

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will be merely concatenated, as with $[(x_r^i)+(x_s^i)]$ in the example above.[15] A peculiarity of fusions is that they *do not supervene* on basal properties, for there is no appropriate supervenience base. The basal properties that were fused no longer exist; they have become the $i+1$st property instance.[16]

(Why do the basal property instances *disappear*? Humphreys tells us that some of the causal powers of the basal property instances are exhausted in fusing into the emergent property instance [Humphreys 1997a, 10]. The simplest explanation for why this is tantamount to basal property instances disappearing is that Humphreys is assuming a causal theory of properties—on which properties are individuated by the causal powers that they bestow on their possessors [Shoemaker 1980]. Since the basal properties no longer have all their causal powers, assuming a causal theory of properties, one is entitled to claim that they no longer exist.

Thus, fusions are not realized properties, since realized properties coexist with their subvening realizers.[17])

How does fusion emergentism escape from the twin terrors of the downward causation and causal exclusion arguments?

Consider first the downward causation argument. Unlike supervenience emergents, fusion emergents have no synchronic supervenience bases; so there can be no tension in the form of competing explanations for the instantiation of the emergent property, since fusion emergents don't cooccur with their basal causes, and the argument cannot get off the ground.

15. What Humphreys calls "concatenation" (i.e., [.+.]) is *not* a Boolean operation but is best understood as *aggregation*. It is stronger than mereological fusion because it is likely subject to (spatiotemporal) locality constraints. Humphreys 2000 discusses fused (emergent) objects; I will not be concerned with them here.

16. "[W]hen emergence occurs, the lower level property instances go out of existence in producing the higher level emergent instances" (10). This claim is repeated later in the same paper: "[I]t is false to say that the *i*-level property instances co-occur with the $(i+1)$st level property instance. The former no longer exist when they fuse to form the latter" (13).

17. The basic idea behind realization is that the *realized* property is characterized in terms of its "causal role," where what fills this role is the *realizer* property, and both realized and realizer properties are properties of the same (individual) system. For the purposes of this paper, we need not settle on a precise definition of the realization relation, for my primary concern is to bring out the contrast between emergent and realized properties. We need only assume that realized properties have the following features: (1) realized properties are not identical to their realizer properties; (2) realized properties supervene on their realizers but not vice versa; (3) realized properties cooccur with their realizers; (4) the instantiation of realized properties is explained by the instantiation of their realizers. The fourth feature distinguishes realized properties from supervenient emergent properties since the latter are linked by brute laws to base properties.

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The diagnosis: First, the argument misconstrues the way fusion emergents are actually brought about. The instantiation of fusion emergents is not due to the instantiation of their synchronic supervenience bases; they are the causal effects of their bases, which, because they are destroyed upon fusion, cannot be co-instantiated with the emergents. Second, the downward causation argument fails to "give sufficient credit to the ontological autonomy of emergents" (Humphreys 1997a, 13). Given that fusion emergents have novel causal powers, an emergent E may *directly* cause another emergent E^* without first causing its emergence base B^*.

As for the causal exclusion argument, Humphreys's position there is awkward. It is characterized by his rejection of the causal closure of the physical and his fear of rabid overdetermination. Since he buys into causal exclusion and rejects systematic overdetermination (5, note 4), it is crucial for Humphreys that fusion emergents don't coexist with their bases. He believes that if emergents coexisted with their bases—as is the case in supervenience emergentism—we would then "have the exclusion problems all over again," for if emergents don't coexist with their bases, then they won't have to compete as overdetermining causes (personal communication; see also 14). I think Humphreys's response is mistaken; he both *overestimates* the power of the causal exclusion argument and *underestimates* the ontological autonomy of emergents, which he asserts.

Humphreys's solution begins to look suspect once one realizes that this response appears to force the fusion emergentist to concede that fusion cannot work through simultaneous causal processes (contrary to his explicit allowance of this possibility), since the cause and effect would be contemporaneous, and given Humphreys's perception of the exclusion problem, the emergence base and the emergent would compete as overdeterminers. Since both simultaneous causation and simultaneous fusion processes are prima facie possible, it seems unlikely that the *mere* lack of a competing synchronic emergence base is the proper solution to the exclusion worries.

4. The Problem of Basal Loss. This brings us to the most peculiar and implausible feature of fusion emergentism: the destruction of emergence bases upon the generation of fusion emergents. The knee-jerk reaction of orthodoxy to this feature can be traced to its confidence that special science properties are realized by or somehow "composed" of lower-level properties. However, although "compositional" accounts of special science ontology are widely accepted, it is unclear what philosophical baggage they require; until we are clear on what exactly we are committed to—and *why*—it cannot constitute an argument against fusion emergentism. (We discuss these accounts in the concluding section.) I suggest that we

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consider instead the consequences of this peculiar feature for structural properties, for here we can bring out just why the ontology is implausible.

The basic idea is this. Consider a system *s* with emergent property *E*. The basal properties giving rise to *E* also constitute myriad nonemergent, structural properties of *s*. If these lower level properties literally ceased to be in fusing into *E*, then so, it seems, would those structural properties. These structural properties may include those crucial to the proper functioning of the system.

Let me illustrate with the specific case of the neurophysiological and the mental. Consider when neurophysiological properties N_1 and N_2 fuse to form emergent (mental) property $[N_1{*}N_2]$.[18] Because N_1 and N_2 undergo fusion they will cease to exist. But it is plausible that neurophysiological properties are also recruited in local and global excitatory and inhibitory brain states that are nonemergent. These brain states are complex states involving the instantiation of more than one neurophysiological property. Since they are neither emergent nor simple states, they are structural brain states. (By "brain states" I mean collections of dynamic measurable quantities associated with certain anatomical regions of the brain, e.g., V1, or even more fine grained areas.)

There is overwhelming scientific evidence that brain states are involved in multiple functions: they are recruited in a variety of tasks, only some of which are their primary tasks.[19] An example is feedback control, which is ubiquitous in the nervous system, both in motor areas and sensory systems. In sensory systems, it is clear that information fed back for control purposes is not solely for controlling these sensory systems but also contributes to behavioral decisions, emotional states, and motor control. Hence feedback control is a phenomenon that should be maintained independently of the emergence of mental or other complex states. Consider, for example, how duration and trajectories of saccadic eye movements can be explained by optimization processes where the nervous system tries to extract maximal information from the sensory input (Guitton et al. 2003). However, since N_1 and N_2 expire in fusing into $[N_1{*}N_2]$, all other structural states they underwrite will also expire.

Collapsing structural properties is not the only problem; a second prob-

18. A number of neuroscientists, most prominently the late Francisco Varela, have argued that mental processes are emergent from neurophysiological processes, where the sense of emergence is not a merely epistemic one. Varela speaks of the emergent novel processes as "[having] their own features, lifetimes and domains of interaction" and also possessing downward causal powers, whereby they can "govern or constrain local interactions" (Thompson and Varela 2001, 419).

19. I am indebted to Gergő Orbán for discussion of the empirical evidence behind this claim.

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lem concerns neurophysiological correlates. Notice that on Humphreys's metaphysics, when we have mental properties we have *no* neurophysiological properties—or at least those neurophysiological properties that we take to be correlates of mentality will *not* be copresent. (This claim has to be slightly qualified, for there are perhaps many tiny steps from the neurophysiological to the mental. But we still wouldn't have the correlative neurophysiological properties; they would expire in fusion operations.)

To be fair, Humphreys's recommendation is to "stop thinking of these issues exclusively in terms of mental properties, and to look for examples in more basic sciences" (Humphreys 1997a, 15). But the two problems are *general*: the collapse of structural properties threatens any empirical situation where basal properties are involved in multiple functions. The correlation problem threatens any situation where special science properties have empirically established lower-level correlates which are copresent. (Note that the correlation problem doesn't require lower level correlates to be always contemporaneous with the special science property, X, in question; they may, e.g., be a cause of X, in which case their appearance will typically temporally precede that of X. The only requirement is that these lower-level correlates persist beyond the appearance of X.)

The problems arise from a neglect of structural properties in fusion emergentism. There are aggregates that "piggyback" on the same basal properties that also give rise to emergents, and these separate processes can be contemporaneous. There is no reason why structural properties should have to expire upon the genesis of emergents.

Two replies are available to Humphreys.

The first reply is that structural properties have robust "backup systems," such that when the basal properties that constitute the structural properties are destroyed they will be alternatively "realized" by a backup basal property. (Note that if structural properties have "configurational plasticity," the backup basal property need not be of the same type as the original basal property.) If this response is invoked, the situation with realization must be analogous to that of causation in cases of preemptive causal overdetermination. (So, we'll have preemptive "realizer" overdetermination.) The potential alternate realizer is "preempted" by the actual "realizer" but kicks in when the actual "realizer" is unavailable. But of course there is no reason to believe that there are backups for basal properties in the actual world which are constantly available in actual restricted situations, or even in the actual world.

The second reply takes us to the heart of the issues. It is a gross simplification that the causal situations we are concerned with involve only *single* property instances; for example, there are exactly two basal property instances B_1 and B_2 which fuse to produce emergent instance $[B_1{*}B_2]$, leaving no basal properties. In actual situations, there is a plurality of

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available basal property instances, and only *some* of them will fuse to form emergents. The others remain to support structural properties and perform basal causal duties in the system; thus structural properties won't collapse.

Though the reply is sound, it is not available to Humphreys given his perception of the exclusion problem. Remember that it is crucial for Humphreys that fusion emergents don't coexist with their bases; otherwise we relapse into the exclusion problems. If bases remain, they will compete as overdeterminers with emergents, threatening the causal efficacy of emergents. So he resolves the problem by simply eliminating the basal competition upon the production of emergents. If Humphreys is right about how to think of the exclusion problems, then he cannot avail himself of the reply from the plurality of basal instances. If some basal instances remain to constitute structural properties, they will compete with emergents produced by the fused basal instances as overdeterminers.[20]

On the other hand, if all basal instances are exhausted in fusion, then structural properties and functions which depend on these will also be destroyed. So Humphreys is caught in a dilemma: either structural properties collapse and emergents face no causal competition, or structural properties subsist and emergents face efficacy worries "all over again."

I will now argue that this is a false dilemma for the fusion emergentist, resulting from a cluster of related errors: misunderstandings of overdetermination and the exclusion problems, and an underappreciation of the powers of emergents.

5. Basal Loss Is Unmotivated. The basic idea of overdetermination is that there can be multiple *distinct* causes of *an effect*, each of which is sufficient by itself for bringing about that effect. Standard accounts of supervenience are not committed to overdetermination, because the basal and super-

20. In correspondence, Humphreys has responded that properties entering fusion can, and usually will, be complex properties with multiple components. If we assume that properties are individuated by the causal powers they bestow on their possessors, it is correct to say that the fusing properties cease to exist even though many of their components persist. The question is then whether basals retain enough of their causal powers to sustain aggregate phenomena—and yet not retain those that would overlap with the causal powers of emergents so as not to compete as overdeterminers. Humphreys maintains that such complex properties can both produce emergent properties through fusion and continue to maintain lower-level effects. Moreover, this need not be ad hoc: in ordinary causation some properties of the original cause persist (the hammer retains its hardness) while others don't (its momentum is transferred to the nail). The parts of the original complex property that remain can then play a completely different, and purely basal, causal role from the emergent property. Though I don't deny that such a harmonious scenario is possible, the challenge to Humphreys is to demonstrate that this will *always* be the case.

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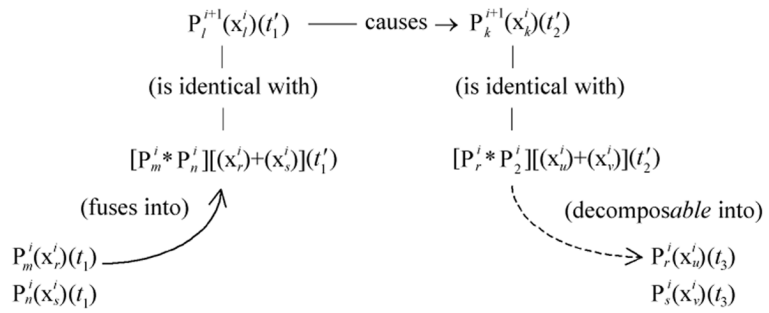


Figure 1. Taken from Humphreys 1997a. © 1997 by The Philosophy of Science Association.

venient properties are not distinct, as the base (at least) nomologically necessitates the supervenient and they are even spatiotemporally coincident. Fusion emergents, however, may compete with basal properties as overdeterminers, since the link between the basals and the emergent fusion is causal, and the properties are strongly distinct. But distinctness of emergents and bases only means that they *can* compete as overdeterminers *if some range of their effects overlap* (i.e., if their causal profiles partly overlap).

In order to ascertain whether the causal profiles of fusion emergents and bases partly overlap, we need to know how the dynamics of fusion emergents goes in general. Humphreys does not say much on this point, but he does provide the diagram shown in Figure 1. In our earlier discussion of the fusion emergentist response to the downward causation argument, we saw that the argument fails to "give sufficient credit to the ontological autonomy of emergents" (Humphreys 1997a, 13) since there is no reason why an emergent *E*—with novel causal powers—cannot *directly* cause another emergent *E** without first causing its emergence base *B**. If it is part of the regular behavior of emergents to directly engender other emergent properties, then there may be evidence that fusion emergents have some novel causal powers.

Notice also that the claim that emergents are ontologically autonomous is prima facie in tension with their being overdetermining causes. Since *unhappily* systematic overdetermination by emergent and basal properties would require that they have very similar causal profiles (the limit case is when they have exactly similar profiles), that would undermine the claim of the ontological autonomy of emergents. At this point we are compelled to answer two questions: What does ontological autonomy amount to? And what measure of it do emergents possess? I suggest we answer these

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questions by considering the sense in which emergents have novel causal powers.

Humphreys's (1997a) condition (7) on emergent properties is:

(7) A property is emergent only if it has novel causal powers.

But he does not discuss what he means by "novel." The only related remark is a note to condition (7) on the role of novelty in Kim's arguments: "[N]ovelty of causal powers seems to play no role in Kim's central argument [i.e., the downward causation argument]. Even if mental properties produced familiar physical consequences that could also be brought about by physical properties, the argument would still hold" (8, note 10). In fact, the whole point of the downward causation argument is to compel emergent mental properties to produce the same physical consequences that can also be brought about by physical properties. The note continues: "The use of novelty is primarily in characterizing the difference between emergent and nonemergent properties, for it is an essential feature of emergent properties that they be new" (8, note 10). However, this passage does not explain the role emergents play in overall dynamics of systems. And yet, as I have emphasized, this role is crucial: responses to the causal exclusion and downward causation arguments differ depending on the powers of emergents.

Consider what would happen if emergents produced *merely* the familiar physical consequences:

(1) Would they alter the probability of later physical events? If yes, the probability of later physical states is not completely fixed by prior physical states, in which case emergents supplement the underlying dynamics of systems rather than compete as overdeterminers.

(2) If emergents produced merely the familiar physical consequences without altering the probability of later physical states, then Humphreys's worries about overdetermination are valid. But such properties fail to qualify as emergents, by condition (7).

(3) One might suppose that novel causal powers are merely causal powers that do not supervene on underlying physical causal powers, not causal powers to produce novel outcomes.[21] But this account cannot be correct, because if causal powers are not individuated by their causal profiles, we lose any grip on the notions of sameness or difference of causal powers. To take a sundry example, *being a wooden knife* and *being a steel knife* are properties of objects that both have the power to cut butter, but neither property supervenes on the other and yet they have *the same* causal power—*being able*

21. A referee for this journal suggested this in response to my claim about how to understand the novel causal powers of emergents.

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to cut butter. Thus, novel causal powers must mean *powers to produce novel effects*.

Several remarks on the causal powers of emergents clarify Humphreys's position. He writes that the fusion emergent is a "unified whole in the sense that its causal effects cannot be correctly represented in terms of the separate causal effects of the properties entering the fusion" (Humphreys 1997a, 10). However, this remark is still opaque. The sense in which the causal effects of emergents cannot be adequately represented by the separate causal effects of basal properties may be due to more mundane reasons, such as disjoint vocabularies of sciences at different levels, and our current lack of appropriate bridge principles. Later in the paper, he writes that "[We] have given a construal of what $i + 1$-level emergent properties might be [and] shown how they can have causal powers that are *new in the sense that they are not possessed by their i-level origins*" (14; my italics). Here is our answer.[22] If *this* is the sense in which fusion emergents have novel causal powers, then the overdetermination worries are invalid. Novel causal powers must mean *powers to produce novel effects*, as I've argued. If basal properties *don't* possess the causal powers of emergents, then they *can't* cause the same effects; *so they can't compete as overdeterminers*. Other things might threaten—say, if causal closure of the physical is correct—but *not* overdetermination.

The upshot of our discussion in the previous two sections is that the basal loss feature of the fusion view is both problematic and unmotivated. However, this is not to say that we have nothing to learn from the fusion view. In the concluding part of this paper, I draw certain morals about special science ontology from the failings of the fusion view. In particular, I examine the major source of hostility to emergentism: the entrenched idea that special science prop-

22. Elsewhere (1997b), Humphreys discusses novelty in the context of criterion for emergence. Two suggestions he makes there are relevant. The first is that novelty means that emergent properties are *qualitatively different* from basal properties. He does not say what this exactly comes to, but presumably emergent properties are of a different type or kind from basal properties. Humphreys may have had something stronger in mind, but mere difference in type holds for household varieties of functional properties and their token realizers—given the multiple realizability of functional properties—yet we do not think that functional properties (ontologically) emerge from their token realizers. So qualitative difference is insufficient as a sole criterion for emergence, though it is likely necessary. Humphreys's second suggestion is that different laws apply to emergent properties: "entities of type B are emergent from entities of type A iff entities of type B have type A entities as constituents and there is at least one law that applies to type B entities that does not apply to type A entities" (1997b, S342). This suggestion is similar to the one in terms of novel causal powers.

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erties are *realized* properties. I try to discern the roots of its entrenchment and the extent of its viability.

6. Conclusion and Moral: The Return of Causal Emergentism. Let me sum up my argument: I began by probing the fusion emergentist account of structural properties by considering the consequences of the basal loss feature of the fusion process for structural properties. I argued that since basal properties that fuse to become emergents may also constitute nonemergent, structural properties—which may, for all we know, be indispensable to the proper functioning of the system in question—if basal properties were destroyed in fusing into emergents, then so would these structural properties. The collapse of structural properties threatens any empirical situation where basal properties are involved in multiple functions. A second, but related, problem that I raised was the correlation problem: for the range of special science properties that have empirically established lower-level correlates with which they are copresent, if we are to treat them as fusion emergents, then, as the framework stands, we appear to be committed to denying the copresence of their lower-level correlates, which is empirically implausible.

I then argued that a misunderstanding regarding overdetermination lay behind the rationale for the basal loss feature. Given Humphreys's understanding of the novel causal powers of emergents, basal and emergent properties don't have causal profiles that overlap significantly and thus cannot compete as overdeterminers across the range of their effects, which was the original worry.

Emergents *supplement* the underlying dynamics—and indeed have a range of other effects—rather than merely overdetermine physical effects (though this might be the case for a certain range of physical effects); systematic overdetermination will not plague *all* higher-level causation. Note that while I am not here denying that fusion characterizes a possible variety of emergent properties, I do think that, given the foregoing considerations, it is very implausible that it might apply to the distinctive features of any actual macroscopic systems.[23]

The (positive) moral that the problem of the collapse of structural

23. I am not here denying that there are phenomena, such as quantum entanglements, that fit the fusion framework. Though the basal loss feature may be a characteristic of quantum entanglements, it strikes me that considerations about causal exclusion and overdetermination play no role in understanding the relation between composite systems and their component systems there, and a fortiori do not motivate the theorist to posit basal loss on those grounds. Thus, any plausibility of the basal loss feature gained with respect to the case of characterizing quantum entanglements does not automatically transfer to the case of the special sciences generally, where it is agreed that the causal exclusion considerations have some force.

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properties for fusion emergentism illustrates is that there are *very tight* relations between basal and higher-level properties in the actual world, and any candidate ontology of the special sciences must in *some* way preserve their intimate coexistence in systems. Thus, eliminating basal properties in order to secure the efficacy of special science properties is not an option. But this does not mean that "compositional" or "realization" accounts of all special science properties are the only viable options available. A revised version of fusion emergentism without the basal loss feature—or indeed many other strains of emergentism—might qualify too. Which ontology is correct will depend on such factors as whether the causal closure of physics holds and general empirical adequacy.

I earlier identified "compositional" and "realization" accounts as the source of the orthodox displeasure with nonstandard ontologies like fusion emergentism. Here I want to briefly examine the genealogy of these ideas. The source of these entrenched beliefs can be traced to our intuition that certain paradigm special sciences, chemistry and biology, are interested in entities that are *composed of* lower-level entities: molecules by atoms, macromolecules by molecules, and so forth. The sense of "composition" here is *very elusive*. Some philosophers take it to be mereological, some not.

The relation between "compositional" accounts of special sciences and "realization" accounts is not immediately clear, partly because it is unclear what counts as a "compositional" account. In the literature, "compositional" accounts appear to be asserted (on the basis of the amorphous intuition of everything being "made up" of physical things) rather than argued for (e.g., Martin 1997), while the "realization" account is backed by a valid argument (Papineau 1995).

The argument for physical realization requires three premises. The first is the causal closure of the physical, (2) above. The second is the premise of causal relevance of the mental, (4) above. And the third is a "no systematic overdetermination" premise. It follows that mental and physical causes of physical effects are not generally independent causes but are ontologically dependent (Papineau 1995). Considerations from multiple realizability rule out *type* identifications of mental with physical properties; the best candidate is then the notion of *realization*. There is no consensus notion of realization, but let us adopt Papineau's. (The details are less important, for my concern is with the dialectical situation at large.) He defines it as follows: "The mental fact that person X has mental property M is realized by the physical fact that X has physical property P if and only if M is a higher-level property—a property of instantiating some lower-level property with certain features R—and P's instantiation in X has these characteristics R" (Papineau 1995, 237). Given

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the argument for physical realization, we can easily construct an argument that mental properties must be realized by *complex* physical properties:

> The argument for physical realization establishes that mental properties are realized by physical properties, but it does not say which physical properties. It is insane, however, to think that fundamental physical properties, like mass, or charge, might be the sole realizers of mental properties, since the causal powers of these simple properties are quite far in complexity from those required for mentality. So it must be that complex physical properties realize mental properties.

This line of argument is effective if one finds the premises palatable. It is important to note that the argument *requires* the causal completeness of physics. Philosophers have often expressed the "compositional" view as if it were an obvious truism given today's science. While the "composition" intuition seems to capture the paradigm cases of chemistry and biology, it fails to explain why it is not intuitively obvious that mental properties are "composed" of neurophysiological properties (since the "compositional" view is supposed to be obvious). Hence the compositional view requires a background allegiance to and argument from the causal completeness of physics. (This is the other moral of our discussion.)

My point is that if what is obvious about the "compositional" view is that physics is causally complete, then it is open to the (ontological) emergentist to reject this alleged completeness. In fact, the (nonepiphenomenal) emergentist research program is founded on the rejection of the causal completeness of physics. The emergentist may be proven wrong in the endgame, but the causal completeness of physics is not completely obvious given the state of today's science (consider, e.g., consciousness-collapse interpretations of quantum mechanics by Wigner 1961 and Stapp 1993)—though the burden is on the emergentist to show this. What the emergentist is not free to reject is the intimate coexistence of lower-level and higher-level properties in the actual world.

Appendix

This appendix clarifies the sense in which emergents produced by fusion fail to supervene on basal properties. (Naturally there is no failure in the case of aggregation.) Consider first the definition of modal-operator strong supervenience:

> *Modal-Operator Strong Supervenience*. A-respects strongly supervene on B-respects $=_{df}$ necessarily, if anything has some property F in A,

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> then there is at least one property G in B such that that thing has G, and necessarily everything that has G has F. (McLaughlin 1995, 25)

It is trivial to show that fusions do not supervene on basal properties in the sense of *synchronic* modal-operator strong supervenience: there is no supervenience base. Supervenience is not salvageable even if the supervenience base is enlarged—I have already argued against alternate backup "realizers." (In order to prevent the collapse of structural properties, the fusion emergentist has to somehow retain some basal properties. Even though we now have candidates for supervenience bases in the form of these basal properties, emergents still won't supervene, in general, for reasons given at the end of the next paragraph.)

Now consider the possible worlds formulation of strong supervenience, often captured by the slogan "no difference in the supervenient without a difference in the base."

> *Strong Supervenience*. A-respects strongly supervene on B-respects $=_{df}$ for any possible worlds w and w^* and any individuals x and y, if x in w is a B-twin of y in w^*, then x in w is an A-twin of y in w^*. (McLaughlin 1995, 24)

Consider the fusion of $P^i_m(x^i_r)(t_1)$ and $P^i_n(x^i_s)(t_1)$ into an $i+1$-level state, $[P^i_m{*}P^i_n][(x^i_r)+(x^i_s)](t_2)$. Note that if one considers only the states involved in the *onset* of the emergent fusion, that is, comparing states at t_1 and t_2, there is no failure of supervenience in the sense of $i+1$-differences without i-differences, though modal-operator strong supervenience fails even at this stage—an artifact of the formulations. But $i+1$st causal powers are not constrained by ith causal powers, in which case independent variation of $i+1$st entities from ith entities is possible, so post-onset emergent states should not in general supervene. Intuitively, the emergent entities can "fire" without basal level entities "firing."

There are a number of other reasons why emergents need not supervene. For Humphreys, emergents are produced by *singular* causal interactions, so it is not necessary that there are emergent laws in the sense of something like Broad's trans-ordinal laws or Mill's heteropathic laws. This is not to say that the singularist *cannot* allow for laws. While singularists are not committed to laws, they could nevertheless believe in them; a singularist could allow that, in fact, Fs always cause Gs. Laws would then be exceptionless generalizations over singular fusings and defusings. Thus, if the singularist allowed for laws there could in fact be supervenience laws for fusion emergents. But Humphreys considers singular causes as fundamental regardless of whether causal laws can be formulated for them;

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he rejects the idea that there *must* be causal laws for every causal scenario (Humphreys 1997a, 13).

Given this rejection, one can see why it is not the case that the class of emergents characterized by fusion *must* supervene, for the supervenience of emergents on the classical supervenience ontology is secured by fundamental trans-ordinal laws, and these are not present generally in the fusion cases, as is obvious from the second clause of McLaughlin's (1997) definition of emergent properties, which is representative of the classical ontology: "If P is a property of w, then P is emergent if and only if (1) P supervenes with nomological necessity, but not with logical necessity, on properties the parts of w have taken separately or in other combinations; and (2) some of the supervenience principles linking properties of the parts of w with w's having P are fundamental laws. [A law L is a fundamental law if and only if it is not metaphysically necessitated by any other laws, even together with initial conditions]" (McLaughlin 1997, 39). On the classical ontology, both emergent and structural properties supervene on basal properties, but since emergent properties are *nonstructural*, supervenience in the case of emergent properties must be sui generis; it is not a matter of constitution, identity, realization, causation, or any of the typical relations that ground supervenience; it is a matter of fundamental, nonderivative emergent laws that must be "simply swallowed whole with that philosophic jam which Professor Alexander calls 'natural piety'" (Broad 1925, 55). As we have seen, these fundamental manifestation laws are not generally present for fusion emergentism.[24]

The final reason why it is not necessary that fusion emergents *must* supervene is that the argument for supervenience from the completeness of physics[25] is unavailable here, since fusion emergentism entails the failure of physical causal closure.

24. One question that arises is how a commitment to downward causation on the part of classical emergentists can be squared with their supervenience ontology. The answer is that the fundamental supervenience laws restrict the patterns of covariation of emergents and bases, and any emergent causation must be consistent with these.

25. The "manifestability" argument for supervenience runs as follows. The first premise is that of the causal completeness of physics. The second premise is the "manifestability of the mental," that "if two systems are mentally different, then there must be some physical contexts in which this difference will display itself in differential physical consequences, or at least in differential chances for such consequences." It follows that mental differences without physical differences are impossible. "[The first premise] tells us that physical identity guarantees identity of physical consequences or chances thereof. And [the second premise] tells us that mental difference requires the possibility of different physical consequences or chances thereof. So physical identity rules out mental difference [i.e., the mental supervenes on the physical]" (Papineau 1995, 229).

Note that the "manifestability" argument for supervenience differs from the overdetermination argument for physical realization. The former argument shows that "the

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The orthodox stance is that emergents *must* supervene (Crane 1999; Kim 2006). Here I have shown that there is nothing scandalous about fusion emergents not supervening. Any negative sentiments toward fusion emergentism due to supervenience failure must be traced to other, deeper sources, for failure of supervenience can count as an argument against fusion emergentism only in the light of other reasons.

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physical always *co-varies* with the mental, and the argument [is] that physical variation is needed to produce external evidence for mental variation. [The latter argument shows] that the mental is ontologically *inseparable* from the physical, and the argument [is] that such a separation would imply an absurd proliferation of causal overdetermination" (Papineau 1995, 235).

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