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Ceteris Paribus Laws, Component Forces, and the Nature of Special-Science Properties[1]

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I. Strict laws and ceteris paribus laws

Laws of nature seem to take two forms. Fundamental physics discovers laws that hold without exception, 'strict laws,' as they are sometimes called; even if some laws of fundamental physics are irreducibly probabilistic, the probabilistic relation is thought not to waver. In the nonfundamental, or special, sciences, matters differ. Laws of such sciences as psychology and economics hold only *ceteris paribus*—that is, when other things are equal. Sometimes events accord with these *ceteris paribus* laws (*c.p.* laws, hereafter), but sometimes the laws are not manifest, as if they have somehow been placed in abeyance: the regular relation indicative of natural law can fail in circumstances where an analogous outcome would effectively refute the assertion of strict law.

Many authors have questioned the supposed distinction between strict laws and *c.p.* laws. The brief against it comprises various considerations: from the complaint that *c.p.* clauses are void of meaning to the claim that, although understood well enough, they should appear in *all* law-statements. These two concerns, among others, are addressed in due course, but first, I venture a positive proposal.

I contend that there is an important contrast between strict laws and *c.p.* laws, one that rests on an independent distinction between combinatorial and noncombinatorial nomic principles.[2] Instantiations of certain properties, e.g., *mass* and *charge*, nomically produce individual forces, or more generally, causal influences,[3] in accordance with noncombinatorial laws. These laws are noncombinatorial in the sense that they govern the production of *single* causal influences. In the typical system, however, multiple causal influences operate in concert to determine the system's behavior. This composing of forces accords with a further nomic principle, which I will call a 'combinatorial law.' The earth exerts gravitational force on a baseball that has been thrown, yet that force alone does not determine the ball's path; the gravitational force combines with other forces acting on the baseball, including other gravitational forces, resulting in the ball's actual behavior. In a Newtonian universe, the earth exerts force on the ball in accordance with a noncombinatorial principle, the Law of Gravitation; the composing of various forces acting on the ball is governed by a combinatorial law the structure of which mirrors the process of vector-summation.[4]

Now consider a candidate *c.p.* law: If a person wants that *q* and believes that doing *a* is the most efficient way to make it the case that *q*, then she will attempt to do *a*. This law is likely to fail if the subject believes that *a* carries with it consequences much more hated than *q* is liked, or if she believes she is incapable of doing *a*, or if she gets distracted from her goal that *q*, or if she suddenly has a severe brain hemorrhage, or . . . It is often thought that the open-ended nature of this kind of list—a list of exceptions, one might say—accounts for the *c.p.* status of special-science laws. I propose instead that there are no exceptions to *c.p.* laws. The antecedent-properties of *c.p.* laws produce their standard effects—the causal influences produced—*every time they are instantiated*. Sometimes, however, these causal influences do not combine in law-governed ways to produce the results we expect, and thus we encounter what appear to be exceptions to special-science laws. On the view I will defend, wanting that *q* always produces the same psychological force. Believing that doing *a* is the most efficient way to make it the case that *q* produces a distinct causal influence, but always the same one. When instantiated together, the combined causal influences typically cause the agent to attempt to do *a*. Nevertheless, there are cases—not all of a piece—where the subject fails to exhibit the expected behavior. In some such cases, these combined forces do not cause the agent to attempt to do *a* because further psychological forces are present; thus, there is a different "resultant force," and the law governing the combination of psychological forces entails a different behavioral outcome. In other cases, the problem lies in the combinatorial law itself: it fails. The possibility of the failure of a combinatorial law constitutes the distinctive nature of special-science domains. The *ceteris-paribus* nature of *c.p.* laws is not so much a feature of *c.p.* laws themselves but of the combinatorial laws of the special-science domains to which *c.p.* laws apply. *Ceteris paribus* laws hold with a standard form of nomic necessity, but in domains where *c.p.* laws reign, the relevant combinatorial laws hold with a weaker form of nomic necessity than does the combinatorial law of fundamental physics, and as a result, the latter sometimes take precedence over the former.

The distinction with which we began can now be formulated more precisely. A *strict law* either is a noncombinatorial law the consequent-property of which is an antecedent-property only of combinatorial laws that always hold *or* is a combinatorial law that always holds (i.e., whenever its antecedent-property—or properties, let this be understood—is instantiated, its consequent-property is as well) and the consequent-properties of which are antecedent properties of laws that always hold. The general idea here is that strict laws always hold, and they apply in domains that are governed by interrelated collections of laws that always hold. A *c.p. law* is a law that (a) always holds but (b) the consequent-property of which is governed by at least one combinatorial law that does not always hold.[5] Call this the 'component-forces view' of *c.p.* laws. Below, I flesh out the view in much more detail. First, however, I say more about the motivation behind the present project and the framework within which my proposal is set.

A provisional anti-reductionism drives the development of the component-forces view. Some special sciences have met with significant success, yet their reduction to fundamental physics has proven difficult, even by fairly lax criteria of reduction. In some cases, the success of a special science may be specious or oversold. Nevertheless, such special sciences as cognitive psychology and cellular biology almost certainly have met with genuine success. Consequently, it is worth attempting to accommodate distinctively special-science properties and laws. I do not, however, mean to establish the anti-reductionist view. There appears to me a strong enough record of reductionist failure—or at least of recalcitrance encountered—that the present proposal, conditioned though it is, merits consideration.

The presentation of the component-forces view may sometimes seem tied too tightly to a controversial view of laws: that laws are contingent relations between universals.[6] The following points, however, mitigate this concern. First, it is likely that the component-forces view can be recast in terms of other influential theories of the laws of nature. For example, David Lewis's account of laws[7] should allow the sorts of property I discuss below; in fact, the method I propose for characterizing component forces utilizes Ramsey-Lewis sentences, a method that fits naturally with Lewis's framework.[8] Thus, the reader should feel free to understand my talk of properties and laws as talk about predicates in a Lewisian axiomatization (or as talk about the natural classes to the members of which those predicates apply) and as talk about the axioms and theorems in the best systematization of the catalogue of local facts of the universe. Once the component-forces view has been sufficiently developed, I formulate its central claims in Lewisian terms (see note 35).

I shall not ignore entirely the general problems raised against the most influential accounts of laws (e.g., the problem of identification).[9] At certain points in the elaboration of the component-forces view, I describe ways in which the component-forces view might help to solve some of those problems. Nevertheless, my brief is *not* to defend the view that there are laws of nature, and I implore the reader to bear this in mind. Rather, my thesis is conditional: if there are laws of nature, the component-forces view makes useful sense of the distinction between strict laws and *c.p.* laws, and of the idea that special sciences attempt to discover *c.p.* laws. Thus, I feel free to harness—without much argument—the machinery of prominent theories of natural law in order to explain how *c.p.* laws could govern special-science domains in a universe with laws of nature.[10]

Let us return to an explication of the component-forces view itself, focusing on some of its distinctive, or at least unusual, features. On the component-forces view, *c.p.* laws differ in important ways from examples typically found in the literature. As they are normally conceived, *c.p.* laws directly connect commonly recognized properties of the domains in question. Fodor, for instance, offers the following as a *c.p.* law of cognitive science: "It is, for example, a law that the moon looks larger on the horizon than it does overhead."[11] On the component-forces view, this way of describing the situation is mistaken; for no *single* law connects a subject's seeing of the moon (in a given circumstance) to her judgment concerning the size of the moon. There is an observed regularity, but it results from the operation of at least two laws: a "special-force" law of psychology and a combinatorial law of psychology. This is one of the primary innovations of the component-forces view, that it interposes special-science forces between properties that are usually thought to be related directly by special-science laws. On the component-forces view, the seeing of the moon causes a force, which may or may not eventuate in a certain judgment; it depends on how that force combines with others present in the system (for example, the causal influences created by the subject's seeing of a horizon line in the vicinity of the moon). The subject matter to which the component-forces view applies overlaps largely with that of commonly discussed *c.p.* laws. Nevertheless, the component forces view aims to account for the relevant phenomena in a superior way.[12]

Also note that on the component-forces view, the distinction between strict laws and *c.p.* laws is not necessarily exhaustive. Consider the status of combinatorial laws of special sciences. On the component-forces view, they are neither strict laws nor *c.p.* laws—simply because they are combinatorial laws that do not always hold. One might wonder whether a more fine-grained taxonomy (one including more than 'strict,' '*c.p.*,' and neither) would shed light on more complex cases. For instance, the consequent-property of a combinatorial law might itself be a causal influence subject to the same, or some other, combinatorial law. In this kind of case, the combinatorial law initially at work meets the second half of the two-part criterion for being a *c.p.* law: its consequent-property is governed by at least one combinatorial law that does not always hold (assuming that the combinatorial law applying at the second stage is not the combinatorial law of fundamental physics).

The component-forces view leaves room for the exploration of more complex cases. It is unlikely, though, that such exploration will uncover any surprising strict laws. Imagine that we find a special-science combinatorial law that always holds; perhaps it somehow transforms causal influences into causal influences, which are then governed by another combinatorial law of the special science in question. Almost certainly, the latter combinatorial law sometimes does not hold; given that our interest is in combinatorial laws of a special science, *somewhere* in the chain of nomic relations, a combinatorial law must be such that it sometimes fails. Thus, if this hypothesized combinatorial law falls into any category other than 'neither,' it will almost certainly be a *c.p.* law; its consequent properties are not governed only by strict laws, and thus it cannot be a strict combinatorial law. Rather, the law is *c.p.* for the very reasons that interest us in the cases of typical *c.p.* laws (as they are construed by the component-forces view): the law always holds but its consequent-properties are ultimately governed by a combinatorial law that does not always hold.

On a straightforward conception of scientific domains, nature contains nomically segregated sets of properties. This jibes with the preceding discussion of the status of combinatorial laws—partly by preventing the appearance of cases even more complicated than those canvassed above—and it also explain the existence of distinct scientific domains[13] in a way that accounts, in particular, for their irreducibility. I am inclined, then, provisionally to embrace this tidy view of isolated domains in nature (with one caveat to come, in section II).[14] Thus, in the exposition of the component-forces view, I presuppose a strict separation of combinatorial principles of different scientific domains, assuming, in particular, that there are no cases where the output of the combinatorial law of one special science can serve as input to a combinatorial law of a distinct domain. Although I would be interested to see whether a version of the component-forces view applies usefully to more complexly interrelated combinatorial laws, my primary focus in the present essay is on the relation between the physical domain and any given special-science domain, specifically, on how a nonreductivist materialism might be made to work or to what extent materialism must be watered down in order to preserve its plausibility given failures of scientific reduction.[15] Thus, in what follows, I firmly distinguish the combinatorial law of fundamental physics from those of the various special sciences; however, I leave mostly unexplored the relation *between* the combinatorial laws of the various special sciences.

What do combinatorial laws of the special sciences combine? What precisely are these causal influences? Component mechanical forces provide a metaphorical model, but something more should be desired. Many authors have thought that special-science properties are, by their very nature, functional-role properties. I would contest this strongly functionalist view;[16] nevertheless, it is useful here to appropriate one of the primary tools of functionalist theorizing: the Ramsey-Lewis method of identifying properties by their causal-functional roles.[17]

Here is the basic idea as it has been used to provide a functionalist account of mental states.[18] A subject is in mental state M if and only if that subject instantiates a property playing M's causal-functional role. That is, to be in a given mental state[19] is nothing more than to be in a state that bears the appropriate causal relations to inputs, outputs, and other mental states: wanting apple juice *just is* whatever mental state combines with the belief that there is apple juice in the refrigerator and the perception of the refrigerator in a certain location to cause the appropriate output commands—the ones that, under normal conditions, move the subject's body towards the location of the refrigerator. The preceding description greatly simplifies the causal role of a desire for apple juice, and even so, it is schematic in certain respects. Nevertheless, the functionalist approach holds that if all of the relevant details were filled in, the state playing the causal role thereby characterized would in fact be the mental state of wanting apple juice.

The Ramsey-Lewis technique allows a formal characterization of M by the precise specification of its causal-functional role:

$$(x)\{x \text{ is in } M \text{ iff } \exists F_1 \ldots \exists F_n[\mathbf{T}(F_1 \ldots F_n,\ I_1 \ldots I_n,\ O_1 \ldots O_n)\ \&\ F_i x]\}$$

where the various I's and O's are antecedently understood predicates (taken to apply to sensory inputs and behavioral outputs on most functionalist accounts of mental properties), and where $\mathbf{T}(F_1 \ldots F_n, I_1 \ldots I_n, O_1 \ldots O_n)$ represents the best theory of the relations that obtain between various mental properties and input- and output-properties. The formula given above characterizes only M. Assuming, though, that $\mathbf{T}$ represents the best theory of mental properties (a completed scientific psychology or fully refined folk psychology, depending on one's brand of functionalism), $\mathbf{T}$ implicitly characterizes all of the other mental properties as well—each corresponding to the value of a distinct F.

Now let us adapt this method, altering it in some rather significant ways. Here I want to use something akin to the Ramsey-Lewis technique as a tool for characterizing (*not* defining or somehow expressing the essence of) the causal influences produced by special-science properties of a given domain. Imagine a Ramsey-sentence of the same form as the one given above, but where I-predicates represent antecedent-properties of the set of *c.p.* laws of a given special-science domain and where O-predicates correspond to observable results, i.e., the results to be explained and predicted by the special science in question. To emphasize, the I-predicates need not refer to input or stimulus properties; they may just as well correspond to what we would normally think of as the internal states themselves (internal mental states, taking psychology as our example).[20] Existential quantification is used in the standard fashion, now quantifying over causal influences. In this way, the

Ramsey-sentence characterizes, by describing their contingent nomic roles, the causal influences produced by the various mental states (including perceptual states). The Ramsey-sentence also specifies the way in which these various causal influences combine nomically to cause mental states as well as observable states. Combinations of causal influences are represented by some of the antecedents of the conditionals of **T**; the consequents of many of these conditionals comprise *O*-predicates, thus, at least in some cases, mapping combinations of causal influences into the instantiation of observable properties. Fully filled in, then, the Ramsey-sentence implicitly expresses the combinatorial law of the special science in question.[21]

It is not obvious that this strategy will work throughout the special sciences. Two points might, however, bolster optimism in this regard. First, assume that the technique described above succeeds in one of the special sciences, e.g., psychology. Then, insofar as other special sciences reduce to that one, the application of the adapted Ramsey-Lewis technique to psychology indirectly characterizes the causal influences at work in those other special sciences and also expresses their combinatorial laws. Second, regardless of whether such reductions are forthcoming, the Ramsey-Lewis technique is quite flexible; it can, for instance, incorporate the use of functors, thereby accommodating the quantitatively expressed relations one frequently finds in the special sciences.

Now we must ask, "How can a combinatorial law fail?" Combinatorial laws are nomic principles and thus should not come into and go out of effect at the convenience of theorists trying to make sense of *c.p.* laws. Part of the solution lies in the relation between fundamental physics and the special sciences. Typically, philosophers who pursue a robust account of *c.p.* laws are nonreductive physicalists. They accord fundamental status to physics because of its generality and because whatever happens would seem to depend on, and certainly cannot conflict with, physical law. Nonreductive physicalists take *c.p.* law-statements to represent a distinctive aspect of the autonomous, i.e., nonreducible, special sciences, while hoping somehow to ground the distinctively *c.p.* aspect of these laws in fundamental physics: when a *c.p.* law does not hold, it is because physical forces have in some way taken precedence over, or interfered with the operation of, special-science forces.[22]

I suggest that we preserve the nonreductive physicalist's picture by locating the priority of physics in the priority of its combinatorial law. A minimal physicalism entails that every existing thing has physical properties and that physics is causally closed. Combining these theses with a nonreductive view of special-science laws seems to allow for a kind of competition: some systems are such that if a special science's combinatorial law were to determine their behavior, that behavior would violate the combinatorial law of fundamental physics; the behavior that should be caused by those systems' physical properties conflicts with the outcome yielded by the combinatorial law of the relevant special science.

This conflict is resolved in favor of physics if the combinatorial law of fundamental physics holds with a stronger form of nomic necessity than the combinatorial laws of the special sciences. It is plausible that physical laws exemplify various forms of nomic relation: nomic necessitation, nomic probabilification, and nomic exclusion are among the likely candidates.[23] Whatever this list includes, nothing intrinsic to *c.p.* laws warrants addition to it: the antecedent-properties of *c.p.* laws are related to their consequent-properties in the standard ways, by, for example, nomic necessitation, probabilification, and exclusion. This is not to say, however, that the peculiar status of *c.p.* laws is not a function of some special kind of nomic relation. The *combinatorial* laws of the special sciences (but only their combinatorial laws!) involve a weaker form of nomic relation—secondary nomicity—than the form that holds in the case of strict laws and *c.p.* laws.

This may seem a bit of a let-down, but all explanation must somewhere run dry. There is good reason to posit various forms of nomic relation, some forms stronger than others (necessitation, for example, being stronger than probabilification). Positing a further form of nomic relation, *secondary necessitation* (*secondary probabilification, secondary exclusion*), does substantive theoretical work by solving extant problems for the theory of *c.p.* laws, which laws we have antecedent reason to believe in.[24] In the end, at least one such unexplained relation is unavoidable if (a) physicalism is true, (b) there are laws of nature in both physics and other natural domains, and (c) the latter laws do not reduce to the former. Helpful things can be said, however, about the relation between physical properties and special-science properties—in particular, about how this relation can ground the failure of the combinatorial law of a special science. This is the topic of section II.

I have emphasized the pre-eminence and the generality of physics. This should not, however, be taken to suggest that the distinctively *c.p.* status of special-science laws depends in any very tight way on the special sciences' lack of generality. Granted, the laws of a given special science fail to apply to significant portions of the universe because no systems in those locales instantiate the relevant properties: economic theory describes the state-transitions in economic systems, psychology in minds. In areas of the universe that lack economic systems or minds, where neither economic nor psychological properties are instantiated, the laws of economics and psychology are moot, in a way that the laws of physics are not.[25] In some contexts, perhaps in explicating physicalism, this is an important fact about special-science domains. Nevertheless, when I talk of the failure of a special science's combinatorial law, this is not meant to be a claim about the generality, or lack thereof, of that special science.

To close this section, I return to a concern bruited at the outset: that all laws, including well-established laws in physics, are *c.p.* laws. If this concern hits the mark, it renders moot the distinction I have drawn between *c.p.* laws and strict laws. What is to be said in favor of the view that all natural laws are *c.p.*? The most influential argument for this view has been what I will call the 'messiness argument.'[26] This argument proceeds from the observation that physical systems rarely, perhaps never, behave as the relevant laws of physics seem to say they should. If a feather is dropped near the surface of the earth, the Law of Gravitation does not accurately describe the behavior of the feather as it falls (and the Law of Gravitation would not specify the behavior of the falling feather even in a Newtonian world). This is not a matter of approximation: the gap between predicted value and actual value yawns. Furthermore, the example of the feather's fall represents the lot of physics; it is the sort of situation one finds in case after case. Thus, all generalizations treated as true law-statements express *c.p.* laws, if they express laws at all; it would seem to follow, then, that the distinction between *c.p.* laws and strict laws is unimportant at best.[27]

The messiness argument has come in for some well-deserved criticism. Newton's Law of Gravitation is part of a system of force laws that, assuming a Newtonian universe, together determine the behavior of objects, including falling feathers. At least in principle, the mathematical process of vector addition captures the way in which these forces combine, and thus there is no reason to attribute *c.p.* status to any of Newton's laws.[28] It is, therefore, beside the point that in many cases a single noncombinatorial law, such as the Law of Gravitation, does not make phenomenologically accurate predictions. One must simply acknowledge that more forces than one are involved. Assuming Newton's second law to be true, the entire set of laws—special-force laws together with the second law—should accurately describe events and processes in the actual world.[29] In contrast, in systems to which *c.p.* laws properly apply—that is, systems that instantiate the properties properly studied by the special sciences—the combinatorial laws of the special sciences sometimes do not hold. A complete inventory of true *c.p.* law-statements and true combinatorial law-statements of the relevant special-sciences do not suffice—even given a fully determinate and correct specification of initial conditions—to describe accurately the systems to which *c.p.* laws properly apply. Thus, a substantive distinction between strict laws and *c.p.* laws survives the messiness argument.

II. C.p. laws, special-science properties, and the problem of causal exclusion

In this section, I flesh out the component-forces view by explaining the relation between special-science properties and physical properties. I also argue that, once the component-forces view is spelled out in this way, it can help to solve one of the outstanding problems in the philosophy of the special sciences, the much discussed problem of causal exclusion, which extends from psychology to many, perhaps all, other special sciences.[30]

Differences in nomic strength do not alone explain how conflict can arise between the combinatorial law of a special science and the combinatorial law of fundamental physics. The combinatorial law of fundamental physics may well hold with a stronger form of nomic necessitation than do the combinatorial laws of the special sciences, but this accounts for the failure of the special sciences' combinatorial laws *only if the instantiation of certain physical properties sometimes precludes the instantiation of the relevant special-science properties*. Yet, given what little has been said thus far about the relation between instantiations of special-science properties and properties of fundamental physics, it would seem that any special-science properties whatever can be instantiated in any physical system whatever. In what follows, then, I develop a view of the relation between physical and special-science properties that clarifies the nature of the conflict at issue and does so in a way that secures the causal efficacy of special-science properties.

In the case of many, perhaps all, special-science properties, the property's nature precludes its co-instantiation with certain physical properties (typically certain complexes of physical properties). The property *searching for a conspecific* can be co-instantiated with a variety of physical properties, but not just any physical properties: a system consisting of a single atom cannot search for a conspecific, because anything that has a conspecific must have organic structure, which is not present in a single atom. Money plays a functional role in an economic system, but not just any physical properties can be co-instantiated with *money*: the creatures whose mental states ground an economic system must be able to recognize and exchange the stuff in question. Any limitations on which physical systems can instantiate perceptual processes or can instantiate the behavior of exchanging in turn constrain which physical things can play the role of money.[31] In a certain sense, then, special-science properties are composite: they comprise definite and limited ranges of physical properties, those typically—but I would say inaccurately—described as the physical realizers (or supervenience bases) of the special-science property in question. Thus, we can think of a given special-science property Q as including a *disjunctive construction* of physical properties, i.e., a disjunction of the various combinations of physical properties that can be co-instantiated with Q.[32] Note, however, that neither this disjunctive construction nor the property complex it expresses is itself a genuine property; for genuine properties have causal efficacy, and the disparate nature of the property's disjuncts render it implausible that instantiations of the property complex have causal efficacy over and above the efficacy possessed in virtue of something's instantiating the specific physical property picked out by one of the disjuncts.[33]

The view just proposed stands at odds with popular realization- and supervenience-based views of the relation between special-science properties and physical properties; for the view on offer denies a sufficiency thesis entailed by those alternatives. On the present view, it is not the case that the instantiation of one of the relevant physical properties (one of those referred to by a disjunct in the construction listing the physical properties that can be co-instantiated with Q) is metaphysically or nomologically sufficient for the instantiation of Q.[34] Thus, the physical properties in question are not realizers of Q, and neither does the instantiation of Q locally supervene on the instantiation of the physical properties in question. Rather, as I see things, a given physical property can, at least in principle, be associated with more than one special-science property: it can appear in two or more disjunctive constructions each of which is a component of a distinct special-science property. Furthermore, it is possible for that physical property to be instantiated in the presence of no special-science properties. From the standpoint of the special sciences, this is a desirable result. The upward trajectory of an arm sometimes has the property of being an attempt to get attention; but sometimes a type-identical physical state—the rising arm—appearing in a type-identical physical environment instantiates no psychological properties at all.

Motivating this picture is a certain understanding of the explananda of the special sciences. Special-science properties have different effects from those of physical properties and the distinctive effects of the former constitute the explananda of the special science in question. Take an observation that we would like psychology to explain: sometimes people run away. *Running away* is not a physical property; it is intentionally loaded, and thus, psychology must account for the instantiation of this psychological property, not for the instantiation of some particular physical property. Nevertheless, that someone is running away carries certain entailments with regard to the physical world, and this explains how it is that the combinatorial laws of the special sciences can come into conflict with the combinatorial law of fundamental physics. If someone runs away, certain appendages must exist and exhibit a certain range of motion; after all, slugs cannot run away, regardless of which psychological properties (if any) they instantiate. In some circumstances a subject's instantiation of *fear* produces a causal influence that, via psychology's combinatorial law, combines with the causal influences produced by the subject's other psychological states to yield an instantiation of *running away*. It can happen, though, that the combinatorial law of physics yields a conflicting outcome. The antecedent-properties of the relevant *c.p.* laws of psychology are instantiated in a system that also instantiates physical properties. The combinatorial law of physics, as it applies to the causal forces produced by those physical properties, might entail a physical outcome that does not appear in the relevant disjunctive construction associated with running; the physical behavior entailed by of the combinatorial law of physics might fall outside the range consistent with the instantiation of *running away*. In this way, the combinatorial law of physics can come into conflict with the combinatorial law of a special science; given the difference in their relative nomic strengths, the combinatorial law of fundamental physics takes precedence.[35]

The view of special-science properties set out above fills a gap in the component-forces view, helping to explain how the combinatorial laws of physics and the special-sciences can yield conflicting outcomes in a single space-time region and thus how the occasion could arise for primary nomicity to trump the secondary nomicity with which the combinatorial laws of special sciences hold. A firm believer in the autonomy of the special sciences should want more, however: she should want *causal* laws in the special sciences. Such laws would seem to require the causal efficacy of special-science properties, and this requires a solution to the problem of causal exclusion.[36] Here is the problem in brief. Assume that instantiations of physical properties are sufficient for the synchronic instantiation of the special-science properties that those physical properties realize (or are sufficient for the instantiation of the special-science properties that supervene on those physical properties). Then, for any two mental states *M1* and *M2* such that we think the former causes the latter, the following argument seems to show otherwise. The realizer of *M1* causes the realizer of *M2*, the appearance of which entails the synchronic instantiation of *M2*. There appears to be no causal work left for the instantiation of *M1* to do. The causal efficacy of *M1*'s realizer, together with facts about realization (or supervenience), fully accounts for the instantiation of *M2*; this precludes causal contribution from *M1*, absent an overdetermination at play (implausibly) in every case of mental causation.

We solve the problem of causal exclusion by focusing on the nature of the consequent-properties of the special sciences' combinatorial laws or, thought of a bit differently, by attending to what should be independently plausible given some reflection on the nature of the various sciences: that they have distinctive explananda. The causal influences generated by a subject's mental states might combine to cause running away, but this form of behavior is *not* identical to its supposed realizer on any particular occasion; nor is it entailed by the presence of the physical properties with which it is co-instantiated. In contrast, worries about causal exclusion presuppose either (a) competition among multiple candidate causes of a *single effect* or (b) competition among multiple candidate causes in a case where there is more than one relevant effect but where all such effects can be fully accounted for by the occurrence of only one of the candidate causes (because of facts concerning realization or supervenience). On the view I have offered, neither condition (a) nor (b) holds in the standard cases covered by special-science laws. Rather, in cases supposed to engender causal exclusion, there are in fact two effects, neither of which, I would maintain, entails the synchronic occurrence of the other. There are two physical states, *P1* and *P2*, and the former causes the latter. There are two instantiations of psychological properties, *M1* and *M2*, and the former causes the latter. Given that a token instantiation of a special-science property does not entail the instantiation of any of the physical properties instantiated with it on that occasion, and vice versa, there is no sense in which either *P1* is sufficient for the instantiation of *M2* or in which *M1* is sufficient for the instantiation of *P2*.[37] A distinct effect is brought about by each of the two causes, *P1* and *M1*, and these two causes do not compete for efficacy in respect of either of the two effects.[38]

The view on offer maintains the causal closure of physics but admits a multiplicity of properties that are not purely physical—as one might expect from nonreductive physicalism. Furthermore, the view expressed here is consistent with the physicalist commitment that each special-science property is co-instantiated with a physical property. According to the view I have recommended, the instantiation of any special-science property entails the instantiation of at least one physical property in the same system or space-time region. Even if one thinks that certain special-science properties (perhaps the ones not easily observable) do not, by their nature, entail the instantiation of any particular range of physical properties,[39] the physicalist commitment can still be motivated by independent evidence: the success of physics in its attempt to provide a comprehensive science the laws of which are inviolate, no matter which special-science properties happen to be instantiated. Thus, one should hold that all special-science properties are co-instantiated with physical properties even if our best account of special-science properties does not entail such co-instantiation.

The approach taken here carries a cost: together with fairly uncontroversial premises, it entails a limited epiphenomenalism. In cases where the instantiation of a special-science property appears to cause the instantiation of a property not in the same special-science domain, this causal relation is mere appearance (*modulo* reductive relations between special sciences). Take the case of an angry subject who smashes down a phone, causing, we would like to say, the disintegration of the phone's major parts. Given that the disintegrated phone does not instantiate any distinctively psychological property, the view I have advocated cannot identify any psychological cause of the phone's disintegrated state. Even if we could justify assigning a causal role to the subject's smashing down of the phone, it would only revive the problem of causal exclusion: instantiations of certain physical properties would also causally account for the phone's disintegrated state, leaving no causal work for the subject's anger or her smashing to do.

We should settle for epiphenomenalism in these cases. Psychology explains why the phone was slammed down but does not causally explain the phone's disintegration. Mind you, the slamming entails that one of a range of physical properties is instantiated, and many of the properties in this range causally suffice for the phone's disintegration. Thus, in light of the psychological details, it is *no surprise* that the phone winds up in pieces. The slamming might therefore be *explanatorily relevant* to the phone's disintegrated state, a situation that generalizes to other such cases. There is, however, no psychological *cause* of the bare disintegration.

Two points remove the sting of this concession to epiphenomenalism. First, this result is just what one should expect from a universe with distinct special-science domains; given the lack of generality of special sciences, any given special science faces a boundary, as it were, where its effects end. Second, note that the properties of many special-science domains are widely instantiated and causally connected, which allows for a wide range of genuinely causal relations in the special sciences: my being hungry causes my going to the refrigerator, which causes my getting of an apple, which causes my eating; at every step, the instantiation of one psychological property causes the instantiation of another. Thus, for very many processes addressed by the special sciences, the problem of causal exclusion is solved, with no epiphenomenalist bullet to bite.

Why, though, is this not some spooky emergentism? Why does this view not presuppose a kind of magical addition of mental properties to the physical world? I have endorsed the existence of nonphysical properties; yet, there is nothing *magical* or *spooky* about these properties, unless nonreductive physicalism itself entails magical goings-on. The naturalistic methodology that motivates a reasoned physicalism should be allowed to yield whatever it yields; this method's results are automatically respectable and nonmagical.[40] It is uncontroversial that we observe instantiations of special-science properties. Thus, they can serve as legitimate objects of scientific enquiry. We are in the same position in respect of the observation of, for example, psychological properties as we are in respect of physical properties. Observation of physical properties is mediated by folk observational concepts that are largely innate. Observation of psychological properties is mediated by folk observational concepts that are largely innate. In both cases, there is a high degree of intersubjective agreement and verification, in experimental contexts as well as in less formal ones. Language learning, for example, depends on the child's ability to recognize the intentions of speakers;[41] our success in developing shared language is one piece of evidence, among many, that psychological properties are not simply cooked up constructions out of which we formulate unfalsifiable special-science theories.

An account of the *appearance* of special-science properties in the universe might, however, introduce at least this much of an emergentist strand: perhaps certain physical processes or temporally extended patterns of physical events cause instantiations of special-science properties. Such physical patterns might constitute developmental processes, in the case of the appearance of psychological properties in humans.[42] Once instantiated, special-science properties can cause the instantiation of other special-science properties. This suggestion is highly speculative, but keep in mind that it involves diachronic causation, not synchronic determination (as in the case of realization- or supervenience-based theories). It is a causal-historical approach, taking its cue from causal-historical views of mental content. On such views, there is no intrinsic property of, say, the subject's brain at time t that necessitates the instantiation of any particular content-property at t. The physical patterns that cause the instantiation of the content-property are historical and may be relational in other ways.[43] This view leaves room for a certain sort of diachronic, transitive causation involving both physical and special-science properties: a physical pattern might cause the instantiation of a mental property which in turn causes the instantiation of further mental properties; but this no more gives rise to causal exclusion than does the fact that, in some sense, all present physical states were caused by the Big Bang.[44]

Finally, one might wonder why the combinatorial laws of the special sciences cohere as often as they do with the laws of physics. I take this to be brute fact, the distasteful brute-*ness* of which is tempered by the two following points. First, as any anguished person (or any economist) will tell you, the coherence is not *that* extensive; weakness of the will, existential confusion, and the failure of idealized models in the special sciences are the order of the day. Second, this mystery is no greater, qualitatively speaking, than the existence of a coherent physical order, i.e., a system of physical laws that does not yield conflicting results; thus, the coherence of special-science and physical laws, so far as it goes, does not constitute a new kind of mystery in the natural world.[45]

III. Component forces, absolute exceptions, and dispositional essentialism

This section contrasts the component-forces view with two other theories of *c.p.* laws, arguing that, in certain respects, the component-forces view holds the advantage. Consider first a view of *c.p.* laws advocated by Jerry Fodor.[46] Fodor claims that *c.p.* laws hold with nomic necessity of the standard sort but only in the range of situations delimited by the *c.p.* clause: "if it's a law that $M \rightarrow B$ ceteris paribus, then it follows that you get Bs whenever you get Ms *and the ceteris paribus conditions are satisfied.*"[47] As emphasized above, the component-forces view entails no such qualification: *c.p.* laws are never defeated—period—although combinatorial laws sometimes are. This difference between the two views allows the component-forces framework to accommodate something Fodor would like a theory of *c.p.* laws to handle: absolute exceptions.[48]

Special-science properties are, in Fodor's view, multiply realized, and he describes absolute exceptions accordingly. As Fodor sees things, the antecedents of at least some *c.p.* laws have realizer-types no instantiations of which cause realizers of the consequent-properties of those laws. Such realizer-types and their tokens constitute absolute exceptions to the laws in question. Here Fodor is partly responding to worries raised by Stephen Schiffer,[49] most notably, the worry that some realizers of the antecedent-property of a *c.p.* law might themselves constitute defeating conditions for that law, conditions that we should want the law's *c.p.* clause to deem "not equal."

By interposing causal influences between what we would normally think of as the antecedent- and consequent-properties of a special-science law, the component-forces view provides a framework for accommodating absolute exceptions (although talk of realizers should be dropped). Take psychological property *M1*, and assume that physical property *P1* is among those that can be co-instantiated with *M1*. It could be that in the nomologically possible systems in which minds can exist, *P1* causally contributes, via the combinatorial law of fundamental physics, to the instantiation of a physical state outside the range of physical states appearing in the disjunctive construction allowed by the effect normally associated with *M1* (say, the form of behavior that, given a typical psychological context, *M1* eventuates in, via psychology's combinatorial law). The result would be the instantiation of a psychological property *M1* not followed by the instantiation of what we would normally (but wrongly) think of as its direct effect. This does not require literal *exceptions* to *c.p.* laws: their antecedent-properties produce their standard causal influences each and every time. In this way, the component-forces view can accommodate the appearance of absolute exceptions, should such appearances show themselves. This result favors the component-forces view over Fodor's, at least insofar as one is convinced by extant criticisms of Fodor's way of handling absolute exceptions.[50]

Turn now to an increasingly popular view that grounds laws of nature in dispositions.[51] As this dispositions-based approach is sometimes developed, it resembles the component-forces view in certain important respects. Consider Peter Lipton's account of the role of dispositions in *c.p.* laws:

> Instead of seeing a cp law as a description of what happens when there are no interfering forces, the suggestion is that we see some cp laws as descriptions of one force that is present even in situations where many other forces are in play, and even if there is no situation where the first force acts alone.[52]

Dispositions so described sound much like our component forces. Nevertheless, the component-forces view has at least three significant advantages over the dispositions-based approach.

First, the component-forces view preserves a plausible distinction between *c.p.* laws and strict laws. Unless there is only one physical force acting in the universe, at least some, perhaps even all, of the laws of fundamental physics fit Lipton's description of *c.p.* laws; these laws involve forces that are "present even in situations where many other forces are in play," and it is plausible that, in fact, some such forces rarely or never act alone. It is not as plausible, though, that the law-statements of fundamental physics refer to properties sometimes instantiated in systems wherein component forces do not combine in their normal fashion. Thus, although Lipton's criterion classifies many fundamental laws as *c.p.* laws, the component-forces view gets things right: it explains what appears to be a genuine difference between the laws of fundamental physics, all strict, and even the most reliable special-science laws.[53]

Second, the component-forces view is not subject to any version of the *virtus dormativa* objection,[54] which seems to apply in a straightforward way to a dispositions-based view. If it is constitutive of disposition *D* that it cause effect *E* under conditions *C*, then it is metaphysically necessary that *D* cause *E* in *C* if *D* is instantiated in *C*. In any given case where conditions *C* obtain, then, if *D* does not cause *E*, *D* was not present (and could not have been, assuming *C* and not-*E* are held fixed). Advocates of a dispositions-based view might gladly embrace this result, but to many it seems a steep price to pay for causal explanation or causal relations.

The component-forces view has a third advantage over the dispositions-based approach, an advantage in simplicity that ramifies through debates about laws and dispositions. The component-forces view allows that properties' relations to each other are extrinsic to the properties themselves. On this view, the causal processes of the universe are ultimately governed by a system of nomic relations holding between properties, not by the natures of the properties themselves. In contrast, the dispositions-based view seems to entail a more extravagant picture. C. B. Martin introduces a bit of terminology that might be fruitfully applied here: on Martin's view dispositional properties have reciprocal disposition partners, other properties that trigger or inhibit the manifestation of the dispositions in question.[55] Our world is incredibly complex. Thus, for any given disposition, the full story of its reciprocal partners (and of the various conditions in which these partners are and are not manifestation-activating or inhibiting) is incredibly complicated. Where does all of this information reside? Not, on the dispositionalist account, in extrinsic relations between properties. If that were the case, the dispositional approach would be superfluous. If the interactive effects of various objects' dispositions were accounted for by external nomic relations holding between those dispositions, then no purpose would be served by the additional talk of dispositions (or capacities); a complex network of extrinsic relations between properties would suffice. The dispositionalist's remaining alternative is to see patterns of interaction and manifestation as functions of dispositional properties' intrinsic natures.[56] Each disposition must carry in itself a specification of how its instantiations interact with the various instantiations of other properties and combinations of properties.

A system of external nomic relations can, admittedly, seem extravagant. A metaphysical system in which each disposition carries information about all, or nearly all of the others, is, however, profligate by comparison.[57] Granted, if we consider only the simplest sorts of universe, the dispositions-based view appears to have an advantage over the component-forces view: in a universe with only two properties the dispositions-based approach requires *fewer* fundamental facts about interaction to be built into the structure of the universe. On the dispositionalist view, each property carries information about its effect when operating alone and its effect in combination with the other property – for a total of four nomic facts. On the component-forces view, five such facts are needed: each property must be connected to the causal influence it produces, and each possible combination of causal influences (excluding the noninstantiation of both properties) must be accounted for in the combinatorial law—two plus three equal five. In a universe of any significant degree of complexity, though, the number of nomic relations that must be represented on the dispositional model far outnumbers the total of those required by the component-forces view.[58] If there are four properties and one combinatorial law (and we assume an outcome must be represented for each possible combination of property instantiations), the component-forces view requires that there be nineteen fundamental nomic facts about the universe. Four laws connect antecedent-properties to the causal influences they produce; add the number of distinct subsets (excluding the empty set) of those four causal influences (each connected nomically to an outcome by our combinatorial law), i.e., fifteen, for a total of nineteen basic nomic connections. In contrast, the dispositional view requires thirty-two: each of the four dispositions contains, in its internal nature, facts about (1) its effect without any partners, (2) its effect with each of the other three singly, (3) its effect when combined with each of the three possible pairs of the other three; and (4) its effect when combined with the treble composed of the other three; these total eight, which must then be multiplied by four, for each disposition must represent the same number of facts at the risk of excluding duplicates *ad hoc*. As we consider universes of greater and greater complexity, this gap widens, and the more implausible the dispositions-based view appears.[59]

This consideration does not decide matters in favor of the component-forces view. To decide the issue would require a full inventory and weighting of the relative advantages and disadvantages of the component-forces and dispositions-based views. I hope, however, the preceding discussion provides a useful comparison of the two views in respect of their shared commitments and also insofar as their unique commitments differ in ontological implications; in this latter regard, it would seem that the component-forces view has the advantage of metaphysical economy, although an advantage that could, in principle, be outweighed by other disadvantages.

IV. The semantic problem and its epistemic consequences

Ceteris paribus law-statements seem to say that when certain conditions hold, A causes B; yet no one can specify the intended conditions—recall the open-ended list from Section I. This alone might not speak against the use of *c.p.* law-statements, for it must be granted that many legitimate assertions are incomplete in certain respects: "If a person tries to enumerate the integers, he will die before completing the job" contains the term 'the integers,' the reference of which is not, and cannot be, explicitly spelled out. In such a case, though, the *principle* determining reference is clear enough. In contrast, the unprincipled nature of the list of exceptions to a *c.p.* law suggests something untoward: that the incompleteness of *c.p.* law-statements results from the tautologous nature of their content; asserting "*c.p.*, $A \rightarrow B$" is to claim no more than that *A*s cause *B*s, except when they do not.[60] If this diagnosis is correct, *c.p.* law-statements are unfalsifiable and should be jettisoned from the empirical enterprise. They may have a semantics (always true), but not one that suits scientific laws.

Exacerbating the semantic problem is the great diversity—some would say inconsistency—in what is meant by tokens of '*ceteris paribus*'; this diversity has caused some authors to suspect that we have no clear and univocal idea of what it is for something to be a *c.p.* law.[61] Sometimes '*ceteris paribus*' seems to mean "if no other forces were present" and sometimes "if certain factors were present;"[62] and sometimes, as the term itself suggests, "across a range of otherwise similar cases." The single, overarching thought might be that '*ceteris paribus*' invokes idealization. Nonetheless, it is a different kind of idealization in different cases. It is one thing to imagine an isolated system upon which only a small number of forces are acting, but idealization of a different sort is involved when '*ceteris paribus*' qualifies such generalizations as "Cheetahs are fast" and "Rubber bands are elastic."[63] In these latter cases, idealization limits our consideration to normal or typical cases.

On the component-forces view, "*A* causes *B*, *ceteris paribus*" has clear content. It means "instantiations of *A* cause instantiations of *B*, but instantiations of *B* are governed by a combinatorial law that does not always hold."[64] There is no list of exceptional conditions, because there are no exceptions. In contrast, a combinatorial law can, in a sense, break down, but such breakdowns occur only when the combinatorial law of physics leads to an effect contrary to the one that would be determined by the combinatorial law of the special science in question.[65] Thus, '*ceteris paribus*' is univocal.

This approach to the semantics of *c.p.* law-statements helps to solve a problem Lipton raises in a different context, a problem that can be adapted to the present discussion so as to appear quite serious. In arguing for his dispositions-based view of *c.p.* laws, Lipton emphasizes the shortcomings of accounts put in terms of the occurrent instantiations of properties—'Humean' views, as they are often called. Among his other concerns, Lipton doubts the Humean can state *c.p.* laws in a convincing way, such that there are positive instances of them and not too many negative instances needing to be explained away. The obvious solution is to enumerate the various conditions under which both the antecedent- and consequent-properties of interest obtain. Pursuit of this strategy typically results in a new, wildly disjunctive antecedent: a list of cases where there are no influences that, speaking loosely, prevent the antecedent-property in our simple *c.p.* law from having its standard effect. Most of these unmanageable predicates are barred from Humean law-statements, though, the relevant prohibition being required for the more general purpose of distinguishing accidental generalizations from genuine laws.[66]

In contrast to the Humean, I have been taking laws to be contingent relations between properties or universals. Nevertheless, the problem for the

Humean might seem to arise in a different form for the component-forces view. It seems incredibly implausible that an unwieldy predicate of the sort at issue expresses a natural kind or property. Such a predicate must state, by inclusion or exclusion, all of the circumstances where a given special-science property causes its standard result. Thus, fully spelled-out, *c.p.* law-statements would appear to involve relations between ragtag collections of properties. Granted, one might allow conjunctive kinds onto one's list of properties that can participate in nomic relations; all the same, the antecedents at issue almost certainly state negative conditions and disjunctive conditions, and thus the properties supposedly picked out by these hodge-podge predicates are highly suspect as relata of natural laws.

The component-forces view neatly handles this problem. On the component-forces view, the conditions normally associated with a *c.p.* clause do not enter into the nomic relation asserted by the *c.p.* law-statement whose antecedent these conditions are thought to qualify; these conditions simply are not, and should not be, referred to by the antecedent of the law-statement. On the component forces view of *c.p.* laws, "*c.p.*, $A \rightarrow B$" asserts a nomic connection between property A and property B. When A is instantiated, A produces the apposite causal influence, in this case B.[67] The *c.p.* clause serves only to flag an important fact about B, *viz.*, that the combinatorial law having B as an antecedent-property sometimes does not hold; but there is no need to list conditions on A's nomic relation to B and thus no reason to think the antecedent-properties of *c.p.* laws are not natural kinds or properties. The status of the effect, B, may seem less clear, but I hold that causal influences are properties; if this is correct, a *c.p.* law's consequent-property is also the right sort of thing to be a relatum in a natural law.[68]

Although the component-forces-based semantics for *c.p.* laws has much to recommend it, the methods employed to test and confirm *c.p.* laws might suggest that any such unified semantics is mistaken. I argue, however, that the complexity of the epistemic problem does not infect the semantics of *c.p.* laws; in fact, the messy epistemic situation and the univocal component-forces semantics fit together naturally.

In order to justify a law-statement, *c.p.* or otherwise, we should like to isolate, as much as possible, the causal efficacy of the antecedent-property. We try experimentally (or, more generally, by observation and data analysis) to home in on its relation to instantiations of other properties. Were we in an epistemically ideal world, we could directly observe the effects of the antecedent-property's instantiations. In the actual world, the most appropriate methodology is fairly complex, as has been widely noted. It can involve eliminating other potential causal factors entirely, holding their values steady, or merely putting ourselves in a position to know their changing values (and the results of the changes in those values). Notice the common theme, however: we try to determine which properties produce which causal influences and how those causal influences combine.

On the component-forces view, many of the epistemic concerns about *c.p.* laws reappear as concerns about combinatorial laws in the special sciences. Consider, then, how we might attempt to identify the combinatorial law at work in a particular special science. In the initial stages, we would like to isolate the antecedent-property from the instantiation of other properties we think are likely to be causally relevant—on the assumption that when only one property from the relevant domain is instantiated, the combinatorial law in question simply maps the effect of that one causal influence onto an outcome. If this can be done independently for two properties from a given domain, we can begin to work out the logic of the combinatorial law at work (assuming there is some sort of logic—in the case of mental states, this logic might partly consist in compositional principles governing the combination of the repeatable components of content-bearing states and principles concerning the relation of these components to each other in, e.g., inference). We record the outcome of paired instantiations of our two properties in cases where we think no other factors are causally relevant. We then formulate an equation that factors the outcome of paired instantiations into what we have taken, on independent grounds, to be the contributions of each of the two properties in the cases when they acted alone.

The component-forces view adds a further twist. Special-science properties, by their nature, can be co-instantiated with limited ranges of physical properties. The property *running away*, for example, can be co-instantiated with only certain physical properties. Thus, once we have in hand reasonable hypotheses concerning (a) the effects of a variety of special-science properties acting alone and (b) the form of the combinatorial law, we can bracket the results of experiments or data analysis involving some systems—at least where we have sufficient knowledge of the physical laws in play. The idea is this. Regarding some systems at some times, we should be able to predict that, given the physical properties co-instantiated with antecedent properties of the relevant *c.p.* laws, those systems will instantiate physical properties inconsistent with the consequent-properties of the applicable special-science combinatorial law. As a result, those working in the special sciences should consider a further range of ways of "holding things equal:" researchers should be careful to identify (and bracket results from) systems in which the physical properties the system instantiate are likely to cause, via the combinatorial law of fundamental physics, outcomes that conflict with those properties yielded by the combinatorial law of the special science in question.

To cast this strategy in a slightly different and perhaps more illuminating light, consider it as a way of meeting the following kind of challenge: If it does not follow from "*P* is a combinatorial law" that *P*, how can we form a justified belief that *P* is a law? How could the observation that only sometimes *P* holds justify the belief that *P* is a combinatorial law? The strategy proposed above avoids this problem by exploiting three kinds of fact. First, there are circumstances in which the combinatorial law of a special science always holds—circumstances in which only one relevant force is present and in which the consequent-property of the combinatorial law does not "conflict" with the consequent-property of the combinatorial law of physics as applied to the systems in question. Second, proprietary properties of the special sciences (other than their component forces) are typically observable. Third, our understanding of the special-science properties in question justifies hypotheses concerning which physical properties could not be co-instantiated with which special-science properties. These facts ground a procedure of the following sort.

We observe instantiations of some property *M1* that is the antecedent-property of a *c.p.* law. We contrive to bring about circumstances such that *M1* causes, via the pertinent combinatorial law, instantiations of another observable special-science property *M2*. This process involves both (a) the explicit attempt to keep the system from instantiating other properties from the same special-science domain and (b) the bootstrapping inference that, if we can get *M1* to cause *M2* across a variety of circumstances, we are right in our estimation of which other special-science properties are likely to produce causal influences that combine with those produced by *M1* and which might thereby change the outcome, perhaps eventuating in the instantiation of some *M3* not identical to *M2*. The choices are also guided by hypotheses—based on our understanding of the special-science properties in question—of which physical systems are likely to preclude the instantiation of *M2*. The point of the process described thus far is to isolate *M1*'s effects, i.e., to make it the case that the combinatorial law is mapping only one causal influence—that produced by the instantiation of *M1*—onto the system's subsequent behavior, i.e., its instantiation of *M2*.

We should then carry out a similar procedure in respect of other special-science properties, so as to reach reasonably well-supported hypotheses concerning how the relevant combinatorial law of the relevant special science treats each of those properties when it is instantiated in isolation from other special-science properties of the same domain. Once we have in hand a substantial range of such (confirmed) hypotheses, we bring about the instantiation of pairs of the observable antecedent-properties to see what results. We compare these results to those established for individual properties, and as a result we can formulate some reasonable hypothesis concerning the form of the combinatorial law, as it applies to pairs of causal influences. In this way, we can build up knowledge of the combinatorial laws. As part of this process, we might also attempt to bring about conflicts between physical properties and special-science properties, as a way of testing our running hypotheses concerning which physical properties can be co-instantiated with which special-science properties.

The emerging picture explains the messiness of scientific methodology in terms of epistemic strategies motivated by the component-forces view. Such strategies, complex though they may be, follow naturally from the univocal component forces based semantics of *c.p.* law statements together with facts about the human epistemic situation. Furthermore, they seem to allow the justified inference of a combinatorial law in a world where that combinatorial law does not always hold—by focusing in the first instance on the limited range of circumstances in which we have reason to believe it does always hold.

Finally, consider a potential criticism of the component-forces view: that it fails to provide any philosophical payout. Once we have committed ourselves to the relation of secondary nomicity, the thinking might run, why should we bother with the apparatus of component forces and combinatorial laws? Why do we not simply understand *c.p.* laws in the traditional way—as connecting observable special-science property-instances, all talk of component-forces aside—and say that *c.p.* laws hold with secondary nomicity?

There are genuine advantages to shunting off the oddness of *c.p.* laws to the combinatorial laws of the special sciences. By doing so, the component-forces view respects the genuine physical phenomena of component forces and combinatorial principles compounding them, extending this framework to special-science properties and laws; it is likely that the universe exhibits general patterns across scientific domains, and thus this shared structure speaks in favor of the component-forces view. The component-forces view also solves some of the most important problems facing accounts of *c.p.* laws, including the problem of assigning plausible, nontautological meaning to *c.p.* law-statements and the problem of explaining how distinctively causal processes at the level of the special sciences can be consistent with a not-entirely-toothless version of physicalism. What is more, the component-forces view offers some advantages over prominent competing views; and it does so without simply moving elsewhere the bump in the rug. Having straightened out the semantics and the metaphysics of *c.p.* laws, a straightforward epistemological story suggests itself – even with regard to the combinatorial laws (where one might expect the bump to have migrated)—and the variety of methods used to investigate *c.p.* laws no longer seems mysterious. In the end, then, the component-forces view solves the outstanding semantic problem within a plausible metaphysical and scientific framework, and in doing so, helps to motivate and explain progress in the special sciences; this is payout a plenty.

Notes

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[2] A few words may be in order regarding terminology, usage, and theoretical assumptions. Laws hold independently of there being any expression of them. When laws are given linguistic or symbolic expression, it is by law-statements. Where this distinction is of importance, I am

careful to use the appropriate term. Also, it is commonly supposed that law-statements take the form of universally quantified conditionals. With one exception, this quantificational structure is irrelevant to present concerns; thus, I normally employ bare conditional forms, e.g., $A \rightarrow B$. Furthermore, although I shall be interested primarily in the *properties* related by natural law, it will be convenient to refer to these properties via the role they play in law-statements; thus, I use the terms 'antecedent-property of a law' and 'consequent-property of a law' to denote the properties related by the law in question. This talk of antecedent- and consequent-properties should be understood to apply *in principle*, i.e., as applying even if law-statements expressing the laws in question have not yet been formulated and even if humans never will, in fact, formulate such statements.

[3] For this general talk of causal influences, see Lewis Creary, "Causal Explanation and the Reality of Natural Component Forces," *Pacific Philosophical Quarterly* 62 (1981): 148-157; see also Evan Fales's suggestion as to how Armstrong might best account for *c.p.* laws (or something very much like them—the laws Armstrong labels 'oaken laws'), in "Are Causal Laws Contingent?" in K. Campbell, J. Bacon, and L. Reinhardt (eds.), *Ontology, Causality, and Mind: Essays in Honour of D.M. Armstrong* (Cambridge University Press, 1993), pp. 121-44, p. 139.

[4] Note that, despite the label, a combinatorial law can apply in a case where only one causal influence of the appropriate sort is present, mapping that single force onto the resulting behavior of the relevant system.

[5] Suppose a universe with no combinatorial laws, say, a universe with only two properties governed by one simple law of nature. How would the present view categorize this lone law? The straightforward solution is to add a third sufficient condition to the characterization of a strict law: a law is strict if it always holds and its consequent-property is subject to no combinatorial law. Note, however, that the distinction made in the text need not be exhaustive; below I consider laws that fall into neither category.

[6] See David Armstrong, *Universals and Scientific Realism*, vol. II: *A Theory of Universals* (London: Cambridge University Press, 1978); Fred Dretske, "Laws of Nature," *Philosophy of Science* 44 (1977): 248-68; Michael Tooley, "The Nature of Laws," *Canadian Journal of Philosophy* 7 (1977): 667-98.

[7] "New Work for a Theory of Universals," *Australasian Journal of Philosophy* (1983): 343-77, p. 367.

[8] See David Lewis, "How To Define Theoretical Terms," *Journal of Philosophy* 67 (1970): 427-46.

[9] See Bas van Fraassen, *Laws and Symmetry* (Oxford: Oxford University Press, 1989), pp. 38, 72-73.

[10] Note 35, below, contains a brief explanation of the way in which the component-forces view can be reconstructed in keeping with the semantic conception of theories under which, it is often thought, laws are dispensable. To the extent that such a reconstruction can be successfully fleshed out, the conditional nature of my argument is not as narrow as suggested in the main text.

[11] "You Can Fool Some of the People All of the Time, Everything Else Being Equal; Hedged Laws and Psychological Explanations," *Mind* 100 (1991): 19-34, p. 20.

[12] As a result, according to the component-forces view, *c.p.* laws themselves are exceptionless. Thus, there is no problem of inference, at least as that problem is sometimes understood. Van Fraassen (*op. cit.*, pp. 38-39) asks how it can be that "It is a law of nature that A" entails A. Regarding *c.p.* laws, this entailment holds for a straightforward reason: the laws, by their nature, guarantee that, at least in respect of the universes in which they hold, antecedent-properties of *c.p.* laws always cause instantiations of consequent-properties; at the very least, the laws determine universal causal relations between the properties involved. An inference problem of sorts remains for the combinatorial laws of the special sciences; "it is a law that special-science forces of domain D combine in such-and-such a manner" does not entail that special-science forces of D combine in such-and-such a manner. Nevertheless, given that some form of physicalism

appears true and that there are irreducible special-science domains, this is to be expected; in the sections to follow, I attempt to explain both how we might have epistemic warrant for believing specific combinatorial laws of special sciences and why it is natural to expect those laws to fail under certain circumstances.

[13] *Cf.* Marcello Guarini, "Horgan and Tienson on Ceteris Paribus Laws," *Philosophy of Science* 67 (June 2000): 301-15, p. 307.

[14] On some views of the laws of nature and of scientific domains, it is an interest-relative matter which domains exist and which laws govern them. Our practice of giving explanations certainly is interest-relative; which properties and laws we cite in an explanation depends on the context in which the explanation is given. Nevertheless, I assume that laws are objective (see note 2) and that if the laws are objective, there is a fact of the matter which forces cause a given event. Because of the interests of the parties involved, it might not be relevant to cite all of these forces in a given explanation of an event, but this in no way undermines the objective fact that those forces—no more, no fewer, no others—caused the event in question. Be that as it may, a reader who accepts the existence of any laws at all presumably has in hand a way of reconciling interest-relativity with the view that natural phenomena are governed by laws; it is hoped, then, that the component-forces view can be cast in some form amenable to that reconciliation. Again we see that a complete defense of the component-forces view requires a complete defense of (and theory of) laws of nature generally, a task beyond the scope of this paper.

[15] The priority and comprehensiveness of physics are secure, so long as everything that exists has physical properties, the combinatorial law of fundamental physics always holds, the noncombinatorial laws of physics always hold, and the consequent properties of both kinds of law are governed only by a combinatorial law that always holds – this presumably being limited to the combinatorial law of physics itself. The discussion to follow presupposes this minimal form of physicalism.

[16] See Robert D. Rupert, "Functionalism, Mental Causation, and the Problem of Metaphysically Necessary Effects," *Noûs* 40 (June, 2006): 256-83.

[17] See Lewis, "How To Define Theoretical Terms," Journal of Philosophy 67 (1970): 427-46.

[18] For more details, see Block, "Introduction: What is Functionalism," in Block (ed.), *Readings in the Philosophy of Psychology,* Volume one (Cambridge: Harvard University Press, 1980), pp. 171-84; Sydney Shoemaker, "Some Varieties of Functionalism," *Philosophical Topics* 12 (1981): 93-118; Lewis, "Psychophysical and Theoretical Identifications," *Australasian Journal of Philosophy* 50 (1972): 249-58.

[19] For ease of exposition, I shift freely between talk of states and properties; substantive issues lurk here, but nothing in the present discussion turns on a choice of states over properties or vice versa.

[20] Additionally, we should expect that, in the adapted Ramsey-sentence of a completed psychology, some O-predicates represent unobservable, internal states associated in the text with (some) I-predicates: the property of seeing the moon gives rise to a causal influence that combines with others to cause the instantiation of believing there to be a moon which combines with other influences to cause behavior, e.g., the utterance of "I believe the moon exists." Both the believing and the utterance are outputs, at one stage or another, of the combinatorial law. Thus, our best Ramsified characterization of causal influences in psychology might include statements identifying the referents of certain I-predicates with the referents of certain O-predicates (because some of the states being caused by the causal influences created by inputs are the same states that cause influences leading to observable output). Or, better yet, in the case of psychology, a more economical and perspicuous formulation of the adapted Ramsey-sentence might include three categories of antecedently understood predicates: one for input states, one for internal states, and one for output states. This is not offered as a general result in the philosophy of the special sciences. How many categories of predicates should appear in an adapted Ramsey-sentence is a matter to be determined separately for each special science.

[21] In this vicinity, one finds what I think is the most convincing solution to the identification problem (see van Fraassen, *op. cit.*, pp. 38-39, for the problem, and Tooley, *Causation*, p. 80, for a solution that employs the method of Ramsey-Lewis sentences to identify the relation of nomic necessitation that holds contingently between universals in cases of natural law).

[22] See, e.g., Paul Pietroski and Georges Rey, "When Other Things Aren't Equal: Saving *Ceteris Paribus* Laws from Vacuity," *The British Journal for the Philosophy of Science* 46 (1995): 81-110.

[23] Tooley, *Causation* (Oxford: Oxford University Press, 1987), pp. 81, 148.

[24] If secondary nomic necessitation seems to multiply forms of nomic relation beyond need, other closely related strategies are available. It may be that the nomic relation can be modified by a higher-order property *being weak* or *being nonfundamental*; in which case we might be able to do without a new form of basic nomic relation. Instead, we would advert to a compound property: instantiations of the standard nomic relations are co-present with instantiations of a property of nomic weakness, and thus there is instantiated a compound property, e.g., *weak nomic necessitation*. Unless, however, there is independent reason to include the higher-order property *being weak* (or *being nonfundamental*) in our ontology, the suggested strategy carries ontological commitments no less excessive than the approach advocated in the main text. Here my articulation of the component-forces view seems to rely indispensably on the view that laws are contingent relations between universals; a Lewisian translation must wait, however, for section II (see note 35).

[25] Mahmet Elgin and Eliot Sober note a complication; see "Cartwright on Explanation and Idealization," *Erkenntnis* 57 (2002): 441-50. If law-statements take the form of, or even merely entail, conditionals, then law-statements entail the contraposed form of those conditionals; but it is clear from the contraposed form that the laws in question *do* entail something about the parts of the universe where the properties at issue are not instantiated: if a law holds and its consequent-property is not instantiated in a given system, then its antecedent-property is not instantiated in that system. (*Cf.* Tooley, *Causation*, pp. 44-45.) Nevertheless, there is a clear sense (closely related to the one Elgin and Sober eventually identify) in which the laws of economics and psychology are moot when dealing with the parts of the universe in question. In a region of the universe in which, for example, no psychological properties are instantiated, there is no psychological effect to be causally explained. (Note that I have in mind cases where special-science properties are not instantiated at all, rather than cases where a special-science property has the value zero on some scale—see Jonathan Schaffer, "The Problem of Free Mass: Must Properties Cluster?" *Philosophy and Phenomenological Research* 66 (2003): 125-38, pp. 130-31.)

[26] Rooted largely in the work of Nancy Cartwright; see *How the Laws of Physics Lie* (Oxford: Oxford University Press, 1983) and *Nature's Capacities and Their Measurement* (Oxford: Oxford University Press, 1989); cf. Michael Morreau, "Other Things Being Equal," *Philosophical Studies* 96 (1999): 163-82, p. 163.

[27] Cartwright distinguishes between phenomenological and theoretical law-statements, taking the former to do a much better job of fitting observation; given, though, that all law-statements—phenomenological and theoretical—are, in Cartwright's sense, literally inaccurate, one might conclude that they all express *c.p.* laws.

[28] See Creary, *op. cit.*, pp. 150-51; Terence Horgan and John Tienson, *Connectionism and the Philosophy of Psychology* (Cambridge: MIT Press, 1996), p. 108; John Earman, John Roberts, and Sheldon Smith, "*Ceteris Paribus* Lost," *Erkenntnis* 57 (2002): 281-301, p. 287. For her part, Cartwright doubts the reality of component forces (those separate forces that are supposed to operate in concert to determine actual behavior), partly on the basis of the following concerns: (a) no statement about a component force accurately describes the phenomena; (b) which component forces are at work in any particular case is underdetermined by the phenomena; and (c) component forces are redundant—if they are assumed to be distinct from resultant forces, they are explanatorily superfluous (the resultant forces do the requisite causal-explanatory work). For cogent defenses of realism about component forces, see Creary, *op. cit.*; Malcolm

Forster, "Unification, Explanation, and the Composition of Causes in Newtonian Mechanics," *Studies in History and Philosophy of Science* 19 (1988): 55-101.

[29] Some authors have argued that the laws of physics predict nothing directly about the development of physical systems over time; see Earman and Roberts, "*Ceteris Paribus* There Is No Problem of the Provisos," *Synthese* 118 (1999): 439-78, p. 444; Earman et al., *op. cit.*, pp. 285-87; Smith, "Violated Laws, *Ceteris Paribus*, and Capacities," *Synthese* 130 (2002): 235-64. Their position may well ground a distinct and telling criticism of the messiness argument, but it raises issues beyond the scope of the present essay.

[30] On the problem of causal exclusion in the philosophy of mind, see Jaegwon Kim, *Mind in a Physical World: An Essay on the Mind-Body Problem and Mental Causation* (Cambridge: MIT Press, 1998); about the problem's application to the special sciences in general, see *ibid.*, chapters 3 and 4; Ned Block, "Do Causal Powers Drain Away?" *Philosophy and Phenomenological Research* 67 (2003): 133-50; Kim, "Blocking Causal Drainage and Other Maintenance Chores with Mental Causation," *Philosophy and Phenomenological Research* 67 (2003): 151-76.

[31] Cf. Lawrence Shapiro, *The Mind Incarnate* (Cambridge: MIT Press, 2004), p. 85.

[32] Some readers might object to the idea that a disjunctive construction could be comprised by a property, for only a symbolic entity can have a part with disjunctive form. This complication can be finessed, however. A disjunctive construction is a certain kind of collection of properties, instantiations of each of which satisfy the relevant disjunctive predicate. I offer no particularly enlightening positive account of how properties are to be collected disjunctively; I will only point out that insofar as one is willing to countenance compound properties, one should be equally willing to countenance the possibility of such "disjunctive" collections. A law of nature might hold that if properties P and Q are both instantiated in the same region of space-time, their instantiations cause an instantiation of the further property R; here the role of conjoined property instantiations constitutes no particular mystery, even though conjunction is a formal concept. Similarly, that special-science property Q is instantiated might entail that either a physical property R or a distinct physical property S is instantiated, even though disjunction is a formal concept.

[33] Here I follow Armstrong's reasoning in rejecting disjunctive universals (see *A Theory of Universals*), reasoning that rests on the Eleatic Principle, which applies to properties as much as to anything else. As Armstrong puts it, "Everything that exists makes a difference to the causal powers of something"—*A World of States of Affairs* (Cambridge: Cambridge University Press, 1997), p. 41; Kim (*Mind in a Physical World*, p. 119) has recently endorsed a similar principle, which he sometimes calls 'Alexander's dictum'—see *Supervenience and Mind: Selected Philosophical Essays* (Cambridge: Cambridge University Press, 1993), p. 348.

[34] The view on offer should also be distinguished from the view that higher-level properties are determinables of which certain physical properties are determinates; Stephen Yablo, "Mental Causation," *Philosophical Review* 101 (1992): 245-80. That a determinate is instantiated entails that its determinable is instantiated; on the view developed in the main text, it is not the case that the instantiation of a physical property that satisfies the disjunctive construction comprised by a special-science property Q entails the instantiation of Q.

[35] Now the component-forces view can be recast in terms of Lewis's theory of laws of nature. The set of axioms that strike the best balance of simplicity and strength will contain predicates referring to component forces in physics. This system will also contain axioms explicitly correlating psychological predicates with the range of physical predicates with which they can (or cannot) be co-instantiated. Given the anti-reductionist assumption in force, distinct axioms will represent the laws of the special sciences, including their combinatorial laws. Taken together the axioms will entail exclusive disjunctions pertaining to various particular situations: either psychological property *M2* is instantiated or physical predicates such-and-such hold (these predicates expressing the physical properties instantiation of which is inconsistent with the instantiation of *M2*). Thus, if the axioms entail that, in the situation at issue, the system of interest instantiates physical properties inconsistent with the instantiation of *M2*, then the

best system of laws will not simultaneously entail that the system of interest instantiates *M2*. In this way a Lewisian framework can accommodate my talk of conflict between combinatorial laws of physics and those of the special sciences.

Readers inclined toward the semantic conception of scientific theories (in contrast to Lewis's more syntactic approach) might wish to understand the component-forces view in terms of Hempel's problem of the provisos. Laws of mechanics make no predictions without provisos: the laws are satisfied by no contingent, empirical sub-structures absent an explicit proviso put in the language of the theory itself (e.g., a closure clause saying that no other forces are at work). Provisos are necessary, then, and combinatorial laws motivate the provisos made (at least with regard to theories involving special-force laws). In the case of *c.p.* laws, provisos would take an extra clause: such-and-such forces entail a given empirical substructure provided that there are no other forces at work and *provided that the laws of physics do not entail the instantiation of any of the following physical properties in the system in question* (where this is filled out by a list of the physical properties inconsistent with those that would be entailed by the combinatorial law in question even provided no other forces of the same special-science domain are acting on the system). For detailed discussion of the problem of the provisos, some of it put in terms of the semantic conception of theories, see Earman and Roberts, *op. cit.*

[36] The sufficiency thesis entailed by standard realization- and supervenience-based views can account for conflict between the combinatorial law of a special sciences and the combinatorial law of physics; but such views give rise to the problem of causal exclusion. It seems wasted effort to develop a theory of *c.p.* laws for special-science domains the properties of which are epiphenomenal.

[37] On the assumption that *M2*'s instantiation is not precluded by the laws of physics, *M1*'s instantiation entails the instantiation of some physical property or other from the disjunctive construction associated with *M2*. The instantiation of *some physical property or other from a given list* does not itself cause any effects, and thus, as noted above, the disjunctive list does not itself express a natural property. Thus, it is not the case that the instantiation of *M1* generates an exclusion problem via its causing of *M2* together with the latter's connection to *P2*.

[38] *Cf.* Derk Pereboom's attempted nonreductionist solution to the problem of causal exclusion in "Robust Nonreductive Materialism," *Journal of Philosophy* 99 (2002): 499-531. Pereboom argues that, although Kim's identification of mental and physical causes might solve the problem, it can be solved equally well by an account of mental properties according to which a mental property's causal powers are constituted by, but are not identical to, the causal powers of its realizing property. According to Pereboom, the constitution-based account does not differ from the identity-based account in any respect that would create competition between the two proposed causes—and thus Pereboom takes his account to be a nonreductivist competitor to Kim's reductionist view (*ibid.*, pp 505-6). Pereboom overlooks the most important difference, though: in the case of identity, there is only one cause, while on Pereboom's account there are two. Kim's identity-based account absolutely precludes competition, because competition requires more than one competitor, while Pereboom must establish that his two causes are not competitors. So far as I can tell, the antireductionist is better off eliminating competition by countenancing two causes and two effects, each of the causes responsible for a distinct effect.

[39] I acknowledge this possibility, but I do not give it much credence. I would bet that scientific research will, in the limit, uncover physical constraints on the instantiation of all special-science properties, even in cases where physical constraints do not follow from either our current conception or our everyday observation of those special-science properties. Here is one way this discovery might occur. Assume we have independent reason to believe that the combined causal influences produced by a certain number of observable psychological properties (involving, say, the hearing or seeing of certain things) cause the instantiation of mental property *M14*. We discover also that in certain cases those observable properties do not combine to cause *M14*. In such a case, we have reason to think the combinatorial law

of psychology fails, and the best explanation of this failure is that the various physical states coinstantiated with the psychological input properties caused the occurrence of a physical state that is outside the range associated with *M14*—in which case, instantiation of *M14* does, after all, entail the instantiation of some physical property or other from a limited range of physical properties. In response to such results, one could conceivably alter one's psychological theory, but we should not assume that this will always be as reasonable as, or more reasonable than, concluding that *M14* comprises a limited disjunctive construction of physical properties.

[40] Cf. David Chalmers's discussion of naturalistic dualism, in *The Conscious Mind: In Search of a Fundamental Theory* (Oxford: Oxford University Press, 1996), pp. 128, 169-70.

[41] Paul Bloom, *How Children Learn the Meanings of Words* (Cambridge: MIT Press, 2000).

[42] Such processes may have to work on much shorter time-scales as well, e.g., in the case of perception or the case of drugs that alter (or introduce) mental states.

[43] See, e.g., Robert D. Rupert, "The Best Test Theory of Extension: First Principle(s)," *Mind & Language* 14 (September 1999): 321-55.

[44] There could be oddball cases of causal competition, where, for example, a causal-historical process comes to fruition, causing the instantiation of a special-science property *S2*, at the same time as the instantiation of some special-science property *S1* causes the same instantiation of *S2*. This kind of case does not give rise to the deeply troubling problem of causal exclusion. It amounts to garden-variety causal overdetermination, as when many bullets kill a victim simultaneously (the killed person standing before a firing squad, for example – *cf*. D. Lewis, "Postscripts to 'Causation'," *Philosophical Papers*, Vol. II, [Oxford: Oxford University Press, 1986], pp. 172-213, at p. 194). The typical reaction to such cases is simply to admit that sometimes, because of unusual and contingent facts about the world, effects *are* overdetermined.

[45] The component-forces view and the proposed solution to the problem of causal exclusion are asymmetrically related in at least one important respect. The component-forces view needs an account of the relation between special-science properties and physical properties; the account offered in the present section fills the bill while allowing for what I think we should want in our special sciences: causal laws. As much of a boost as this discussion might provide to the component-forces view, the proposed solution to the problem of causal exclusion does not presuppose the component-forces view of *c.p.* laws, and thus has philosophical merits independent of its contribution to the component-forces view.

[46] "Making Mind Matter More," *Philosophical Topics* 17 (Spring, 1989): 59-79; reprinted in *A Theory of Content and Other Essays* (Cambridge: MIT Press, 1990), pp. 137-59 (page references are to the reprinted version).

[47] *Ibid*, p. 152.

[48] Fodor discusses absolute exceptions in a paper ("You Can Fool Some of the People All of the Time, Everything Else Being Equal; Hedged Laws and Psychological Explanations") primarily about the semantics of *c.p.* law-statements. Nevertheless, Fodor clearly believes that there are *c.p.* laws and thinks a semantics of *c.p.* law-statements should allow for the assertion of those laws; given this context, a semantics of *c.p.* law-statements is, indirectly, a theory of *c.p.* laws.

[49] "Ceteris Paribus Laws," *Mind* 100 (1991): 1-17, at pp. 7-9.

[50] Peter Mott, "Fodor and Ceteris Paribus Laws," *Mind* 101 (1992): 335-46; Ted Warfield, "Folk Psychological Ceteris Paribus Laws," *Philosophical Studies* 71 (1993): 99-112, pp. 109-10.

[51] See Peter Lipton, "All Else Being Equal," *Philosophy* 74 (1999): 155-68; Andreas Hüttemann, "Laws and Dispositions," *Philosophy of Science* 65 (March 1998): 121-35; Stephen Mumford, *Dispositions* (Cambridge: Cambridge University Press, 1998), chapter 10 (although in Mumford's case, accounting for laws amounts to eliminating them in favor of dispositions). Development of the dispositions-based approach to laws has been heavily influenced by Cartwright's capacities-based view; see *Nature's Capacities and Their Measurement*. Cartwright is often thought to hold that virtually all laws are *c.p.* laws (see, e.g., Morreau, *op. cit.*, p. 163). Given the way *c.p.* laws are typically characterized, Cartwright now rejects this way of

describing her view, while continuing to claim that most laws-statements, from physics to the special sciences, are of a piece: they make claims about capacities; see "In Favor of Laws That Are Not Ceteris Paribus after All," *Erkenntnis* 57 (2002): 425-39, p. 429.

[52] Lipton, *op. cit.*, p. 164. Compare Cartwright's view. She claims that "CP, smoking causes lung cancer" expresses the proposition that "Smoking has the capacity to cause lung cancer." According to Cartwright, the latter is of the same form as what are considered to be strict special-force laws: "it states a matter of fact that is either true or not . . . it has no *ceteris paribus* clause that needs filling in" ("In Favor of Laws That Are Not Ceteris Paribus after All," p. 430).

[53] Cartwright offers an account of this difference, an analogue of which is available to the defenders of dispositions. Cartwright claims that in physics, we have greater knowledge of the conditions under which the relevant capacities are exercised and how the simultaneous exercise of various capacities interact ("In Favor of Laws That Are Not Ceteris Paribus after All, p. 429). Although Cartwright may be correct about this, the differences she suggests are epistemic in nature and thus do not fully preserve the intuition being appealed to in the text: that there is some deep, not-merely-epistemic difference between the strict laws and *c.p.* laws.

[54] See Jonathan Cohen, "Colors, Functions, Realizers, and Roles," *Philosophical Topics*, in press; Rupert, "Functionalism, Mental Causation, and the Metaphysically Necessary Effects."

[55] C.B. Martin, "On the Need for Properties: The Road to Pythagoreanism and Back," *Synthese* 112 (1997): 193-231; for the terminology of "reciprocal disposition partners," see p. 201ff. Note that the criticisms made below of the dispositions-based approach do not speak directly to Martin's view; for he holds that properties themselves have a dual nature, each property being both categorical and dispositional. Evaluation of the dual-nature approach is beyond the scope of the present essay; for a survey and comparison of various leading views about dispositions, including Martin's, see Alexander Bird's dual review of Tim Crane (ed.), *Dispositions: A Debate* and Stephen Mumford, *Dispositions*, in *The British Journal for the Philosophy of Science* 52 (2001): 137-49.

[56] And note, dispositionalists often take it to be an advantage of their view that the causal relations into which a property enters are determined by the intrinsic nature of that property; see, e.g., Brian Ellis and Caroline Lierse, "Dispositional Essentialism," *Australasian Journal of Philosophy* 72 (1994): 27-45.

[57] Cf. Fales's complaint (*op. cit.*, pp. 139-40) against any view holding that all contingent nomic relations into which a universal enters are internal to it. Note that the present discussion presupposes an essentialist view of dispositions—i.e., that the effect of a given disposition is essential to it. Perhaps one could hold a dispositionalist view without being an essentialist about effects (even conditionalized effects). Nevertheless, it is not unfair to associate an essentialist view with Lipton, whose work was used to introduce the present discussion; for he takes at least some of a disposition's effects to be constitutive of the disposition itself (see "What good is an explanation?" in J. Cornwell (ed.), *Explanations: Styles of Explanation in Science* (Oxford: Oxford University Press, 2004), pp. 1-21, pp. 12-13). It is a further question whether one can be an essentialist about dispositions' effects while denying that the intrinsic natures of dispositions determine the causal relations between dispositions and their effects. It is unclear whether Lipton holds the latter position; but as argued in the text, it is also unclear what would be the motivation for offering a dispositional account of laws while denying that the natures of the dispositions determine their effects.

[58] This discussion raises the interesting issue of how properly to use a criterion of ontological simplicity to compare two views with different relative simplicity-rankings in different possible worlds.

[59] In calculating the number of nomic facts that must be built into a given universe, I have made two significant, simplifying assumptions. I have assumed that there is no essential ordering in the combination of forces. Thus, a combinatorial law represents only one nomic fact in representing the combination of the causal influences produced by properties P and Q, as opposed to two facts (one for each sequence of causal influences produced by P and Q).

Second, I have assumed that combinations with null values need not be separately represented as such. There need not be distinct combinatorial facts for each of the sequences $\{A, B\}$ and $\{A, B, \text{null}, \text{null}\}$, where A and B are the causal influences produced by P and Q, respectively. Note that these assumptions greatly reduce the number of nomic facts required by either model, but the assumptions do not favor either the dispositions-based view or the component-forces view. Without these simplifying assumptions, the number of nomic facts to be included in the more complex world considered in the text is 628 on the component-forces view and 1,476 on the dispositionalist view—again, many more on the dispositionalist view than on the component-forces view. (Here are the calculations. First for the component-forces view: begin with 4 nomic connections between properties and the causal forces they produce; then, given the assumption that the combinatorial law has four ordered "slots" to fill, there are 625 possible sequences of five values—each of the properties' causal influences plus the null value—in those four slots; finally, subtract 1, on the assumption that there need not be a nomic connection represented when all four places take the null value. Now for the dispositionalist view. To maintain parity with the preceding calculation, assume that a maximum of four dispositions can interact at a time. On this assumption, 369 facts must be represented by each of the four dispositions; this results from taking, for each disposition, the total number of possible sequences of five values [one being the null value] in four places—625—minus the number of sequences not containing that very disposition in any position, i.e., minus 256; here I assume that order must be represented but that a disposition need not represent a nomic outcome when that disposition does not itself appear in a sequence.)

Note that in the present section, I bracket the ontological baggage taken on in my discussion of the exclusion problem. There it was argued that special-science properties, by their nature, comprise information concerning the physical properties with which the special-science properties can be co-instantiated. Insofar as the position espoused in section II is meant to constitute part of the component-forces view, the present omission might be thought unfairly to favor the component-forces view over a dispositions-based one. This would be too hasty, however. The calculation done here does not take into account the relations between special-science properties and physical properties *on either view*. The dispositions-based view owes us an explanation of the relation between special-science dispositions and physical properties (or dispositions). Particularly if a dispositions-based view is anti-reductionist about the special sciences, it may well import as much or more ontological baggage as does the discussion of properties in section II. (It is an interesting question, and one I will leave open, whether on a Lewisian reconstruction of the component-forces view, the present point concerning comparative ontological simplicity holds.)

[60] Cf. Fodor, "You Can Fool Some of the People All of the Time, Everything Else Being Equal; Hedged Laws and Psychological Explanations," p. 22; Pietroski and Rey, *op. cit.*, p. 87.

[61] For a discussion of this variety of uses of '*ceteris paribus*', see Morreau, *op. cit.*; cf. James Woodward, "There Is No Such Thing as a *Ceteris Paribus* Law," *Erkenntnis* 57 (2002): 303-28, pp. 305-6.

[62] Cartwright observes that one should sometimes "read 'ceteris paribus' as 'other things being right' " (*How the Laws of Physics Lie*, p. 45).

[63] See Horgan and Tienson, *op. cit.*, chapter 7; Alice Drewery, "Dispositions and *Ceteris Paribus* Laws," *British Journal for the Philosophy of Science* 52 (2001): 723-33.

[64] This suggestion is not simply a more specific version of Morreau's ultimate solution. He proposes that '*Ceteris paribus*, *A*s cause *B*s' means something of the form 'If *p*, then *A*s cause *B*s'. On my view *A*'s causal contribution is not conditional upon anything. Note also that my semantic proposal—and the component-forces view more generally—is not offered as an analysis of the *concept* of a *c.p.* law, but rather as a claim about what makes true *c.p.* law-statements true.

[65] Pietroski and Rey's (*op. cit.*) semantics for *c.p.* laws demands an explanation in terms of independent factors whenever a true *c.p.* law fails to hold. For obvious reasons, I disagree

with this way of putting things: on the component-forces view, *c.p.* laws *never* fail to hold. Nevertheless, the present discussion overlaps with Pietroski and Rey's in the following way: when a combination of special-science forces does not eventuate in an expected outcome, the component-forces view entails the availability, in principle, of a certain kind of explanation: a derivation from the combinatorial law of fundamental physics showing that the physical properties to be instantiated in the system in question fall outside the range of physical properties that can be co-instantiated with the expected special-science outcome.

[66] Cf. Lipton, *op. cit.*, p. 161.

[67] Cf. Creary, *op. cit.*, p. 150.

[68] This suggests a response to a further concern raised by Lipton, the question of how an externalist semantics might apply to the antecedent terms in *c.p.* laws (*op. cit.*, pp. 167-68). On the component-forces view, the antecedent (and consequent) term of a given *c.p.* law-statement is a natural kind or property term; no unmanageable, disjunctive antecedents are required. Thus, the referents of these terms can, at least in principle, be fixed in accordance with an externalist semantics, e.g., the causal theory of reference; see Saul Kripke, *Naming and Necessity* (Cambridge: Harvard University Press, 1980); Hilary Putnam, "The Meaning of 'Meaning'," in *Mind, Language, and Reality: Philosophical Papers*, Vol. 2. (Cambridge: Cambridge University Press, 1975), pp. 215-71. In the case of causal influences—themselves natural kinds or properties—reference might be fixed via rigidified descriptions canonically given, for example, by the adapted Ramsey-Lewis sentences discussed in section I. Something much less robust might do, however, to fix the reference of terms for causal influences: "the force produced by special-science property *A*."