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PROPERTY-LEVEL CAUSATION?

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Philosophers of science have recently shown great interest in *property-level causation*, the relation reported by sentences like:

(1) Smoking causes heart attacks.

Property-level causation contrasts with singular causation, what is reported by sentences like:

(2) John's smoking caused his heart attack.

One puzzling thing about sentences like (1) is that they may be true even though there are apparent counterinstances to the corresponding universal generalization. For example, (1) is true even though there are many smokers whose smoking never causes a single heart attack.

There has been surprising agreement about property-level causation. Many have defended some version of the *unanimity theory*, a probabilistic theory requiring roughly that (property-level) causes raise the probability of their effects in specified test situations. In the first section of this paper, I present one version of the unanimity theory and several straightforward objections. The remaining sections are more adventurous. They question the standard assumption made innocently in my opening paragraph: that sentences like (1) are relational sentences, that they have the form '*F* causes *G*' where 'causes' is a two-place predicate expressing property-level causation. By questioning that assumption, I thereby question the appropriateness of the unanimity theorists' investigation. I argue that property-level causation should not be a central topic in the philosophy of science. Included in my criticism will be the sketch of a positive theory that does some of the work intended for the unanimity theory.

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1. OBJECTIONS TO THE UNANIMITY THEORY

The probability function used in the unanimity theory is a *general-case* probability function — one relating properties, not propositions or events. For example, (3) reports a general-case probability:

(3) The probability of a smoker coughing is 3%.

We can represent it as:

(3a) Pr (Cx/Sx) = 3%.

(I shall use obvious abbreviations throughout; e.g., 'Cx' for 'x coughs' and 'Sx' for 'x smokes'. The appendix is a list of my abbreviations.) General-case probabilities stand in important relationships to *frequencies*. The frequency of *Gs* in *Fs* is the proportion of *Fs* that are *Gs*. Some have tried either to identify probabilities with frequencies or to give some modal interpretation of probability in terms of frequencies. I shall leave it open how the probability function should be interpreted, at least for now. Once the framework for investigating sentences like (1) is reworked in sections two and three below, I shall discuss the appropriateness of a modal probability function.

The *locus classicus* of the unanimity theory is Nancy Cartwright's (1979) article. Her account maintains roughly that *F* causes *G* if and only if *F* raises the probability of *G* in every *causally homogeneous test situation* for *F* causing *G*; where *T* is a causally homogeneous test situation for *F* causing *G* if and only if *T* is a maximal conjunction of properties (or their negations) that cause or prevent *G*, but are not caused by *F*. (*F raises* the probability of *G* in *T* if and only if $Pr(Gx/Fx \;\&\; Tx)$ is greater than $Pr(Gx/Tx)$.) This account is circular — it invokes property-level causation in the specification of the test situations. The circularity, however, does not undermine all the interest of the account. It still places certain restrictions on the relationship between property-level causation and probability (cf., Lewis 1986, p. 177). Though there are many variations on Cartwright's original proposal (e.g., Eells and Sober 1983, Eells 1986, and Cartwright 1989), I shall stick to one initially plausible, yet relatively simple, rendition (cf., Skyrms 1980, p. 108):

> *F* causes *G* if and only if (i) *F does not lower* the probability of *G* in *any* causally homogenous test situations for *F* causing *G*, and (ii) *F raises* the probability of *G* in *at least one* causally homogeneous test situation for *F* causing *G*.

I shall henceforth refer to the preceding account as *the unanimity theory*.

One attraction of the unanimity theory is that it avoids *the problem of epiphenomena*. Suppose that *H* causes *F*, *H* causes *G*, but *F* does not cause *G*. Though there is reason to expect *F* to raise the probability of *G* (simpliciter), the unanimity theory requires that *F* raise the probability of *G* in at least one causally homogeneous test situation for *F* causing *G*. Since *H* causes *G* (and is not an effect of *F*), each such situation includes either *H* or ~*H*. Then, since *H* screens off the expected influence of *F*, there is no reason to expect *F* to raise the probability of *G* in *any* of these situations. Thus, the unanimity theory does not have the untoward consequence that *F* causes *G*. The theory is, however, subject to some simple counterexamples involving temporal direction, properties raising their own probability, and effects raising the probability of the cause (cf., Carroll 1988, p. 311, and Davis 1988, p. 143 and p. 149). These problems usually are not considered to be very serious, because, if one is willing to exclude the possibility of simultaneous property-level causation, they can all be avoided by adding a necessary condition requiring that the putative cause "begin" before the putative effect.[1]

The literature spawned by Cartwright's paper (and earlier work on probability and causation) has produced three different sorts of more damaging counterexamples to the unanimity theory. The counterexamples, which are discussed in this first section, lead nicely to an even more serious objection to be raised in section two. In addition, the ease with which these cases are handled by my alternative theory to be sketched in section three supports that theory.

a. *Non-unanimity*

There are two related, controversial, examples that lead to problems for the unanimity theory.[2] The first is a case of interaction (Cartwright 1979, p. 428). It is initially tempting to think that ingesting acid poison causes death and that ingesting alkaline poison causes death. But, if ingesting alkaline poison causes death, then — according to the unanimity theory — ingesting alkaline poison must be included in some of the causally homogeneous test situations for the ingestion of acid poison causing death. Since ingesting acid poison lowers the probability of death in situations including ingesting alkaline poison, the unanimity theory has the consequence that ingesting acid poison does not cause death. I take this to be at least a minor problem. As I said, it is at least initially very tempting to accept both that ingesting acid poison causes death and that ingesting alkaline poison causes death (cf., Otte 1985, p. 114).[3]

John Dupré (1984, p. 172) describes a similar case that is even more trouble for the unanimity theory:

> Suppose that scientists employed by the tobacco industry were to discover some rare physiological condition the beneficiaries of which were less likely to get lung cancer if they smoked than if they didn't. Contrary to what the orthodox analysis implies, I do not think they would thereby have discovered that smoking did not, after all, cause lung cancer.

For the case Dupré describes, there is an initial intuition that smoking causes lung cancer, one that is even stronger than the intuition that ingesting acid poison (or ingesting alkaline poison) causes death. Yet, since having the rare physiological condition prevents lung cancer, having this condition belongs in some of the causally homogeneous test situations, and smoking lowers the probability of lung cancer in those situations. So, according to the unanimity theory, smoking does not cause lung cancer.

These two cases do not provide *absolutely* decisive objections to the unanimity theory. The intuitions needed for the objection could be challenged. I believe — but not very strongly — that smoking causes lung cancer. I believe — but even less strongly — that ingesting acid poison causes death and that ingesting alkaline poison causes death. What may ultimately be going on is that property-level causal sentences are *context-dependent*.[4] There clearly are many ordinary contexts in which we would accept as true the sentences 'Ingesting acid poison causes death', 'Ingesting alkaline poison causes death', and 'Smoking causes lung cancer'. There are other, less ordinary, contexts in which we would deny those same sentences. Intuitions may waver about the acid/alkali case and Dupré's case, because the present context may not be sufficiently developed. Thus, if this context-dependence exists, it explains the controversial nature of these cases and the lack of strength that may attend intuitions.

b. *Probabilistic sufficiency*

There are several counterexamples to the unanimity theory in which at least one property is *probabilistically sufficient* for another. Many result from a pair of cases discussed by Richard Otte (1981, p. 180).[5] In the first case, we suppose that we have a chain of probabilistically necessary and sufficient causes: H causes F and F causes G. In the second case, we have a probabilistically necessary and sufficient common cause: H causes F, H causes G, and F does not cause G.

In the causal chain case, the unanimity theory has the correct verdict. Because H causes G, each of the relevant causally homogeneous test situations includes either H or $\sim H$. F does not change the probability of G in test situations where H is present, because H is sufficient for F. Let T be any one of the remaining test situations. Since T includes $\sim H$, and since H is necessary for G, the probability of G in T is zero. Because H is also necessary for F, and since T includes $\sim H$, the conjunctive property F and T is probabilistically unexemplifiable. Usually, then, convention dictates that $\Pr(Gx/Fx \ \& \ Tx)$ is one.[6] At first, this looks promising. F does raise the probability of G in T from zero to one, and hence the unanimity theory has the desired consequence that F causes G. But ultimately, this is problematic. There is nothing special about the relationship between F *and* G that leads to the increase in probability. The increase results because of the relationship between F *and* H.

Here are two examples exploiting this feature of the unanimity theory. The first is Otte's common cause case. For exactly the same reason that the unanimity theory has the correct consequence that F causes G in the causal chain case, it has the incorrect consequence that F causes G in the common cause case. The second example is similar. Suppose that H causes G, that H is necessary and sufficient for F, and that F does not cause G. Then, rather than supposing that H is necessary and sufficient for G as we did in Otte's cases, we need only suppose that there is at least one relevant causally homogeneous test situation including $\sim H$ such that the probability of G in T is less than one. Again, either H or $\sim H$ is a member of every test situation. In those situations including H, F does not change the probability of G because H is sufficient for F. In those situations including $\sim H$, F makes the probability of G one. Since there is at least one situation including $\sim H$ in which the probability of G is less than one, the unanimity theory has the untoward consequence that F causes G.

One common response to counterexamples involving probabilistic sufficiency construes the unanimity theory not as an account of property-level causation, but as an account of *probabilistic* property-level causation. But, whatever interest this response might have for other counterexamples, it does not speak to the problems raised here. In the two cases just presented, *F does not probabilistically cause G*. Construed as an account of probabilistic property-level causation, the unanimity theory implies mistakenly that *F does probabilistically cause G*. By the way, I should point out that, unlike the objections presented in subsections (a) and (c), those presented in this subsection do depend on the specific version of the unanimity theory under consideration. Some of the many other versions are immune to these two counterexamples. Other versions, however, are troubled by other cases involving probabilistic sufficiency. For a more exhaustive look at versions of the unanimity theory and problems involving probabilistic sufficiency, see my (forthcoming) article.

c. *Properties of distinct individuals*

Notice that property-level causation is sometimes between properties typically instantiated by *distinct* individuals. For example:

(4) Dumping sewage causes pollution.

This sentence relates properties typically instantiated by distinct individuals in that it is ordinarily not the dumper of sewage that is polluted. Sentence (4) contrasts with sentence (1), which is always treated as if it were the sentence 'Smoking causes *having* a heart attack', and so is taken to relate the property of smoking and the property of

having a heart attack. These properties are typically instantiated by a *single* individual in that it is ordinarily the smoker who has the heart attack. There are also sentences relating properties instantiated sometimes by distinct individuals, sometimes by a single individual:

(5) Smoking causes coughing.

For some reason, philosophers of science overlook these sentences. They present an obvious problem for the unanimity theory.[7]

The unanimity theory has the unintuitive consequence that dumping sewage does not cause pollution. That is because dumping sewage does not raise the probability of being polluted. Dumping sewage raises the probability of *other* things in the environment being polluted, but not the probability of a dumper of sewage being polluted. Sentence (5) presents a slightly different problem. Here, it is plausible to think that the unanimity theory has the intuitive consequence — smoking does raise the probability of coughing. But, it gives the intuitive consequence for the wrong reason. According to the unanimity theory, it is only a smoker's coughing that is relevant to the fact that smoking causes coughing when, in reality, both the smoker's coughing *and* the coughing of others should be relevant.

I suspect that this relatively simple problem was overlooked by philosophers of science because many sentences relating properties typically instantiated by distinct individuals appear to be paraphrasable as sentences relating properties that are often instantiated by a single individual. Sentence (1) is a good example. It most naturally is taken to relate the property of smoking and the property of *being* a heart attack, but — as I said — it has always been treated as if it related the property of smoking and the property of *having* a heart attack. Sentence (4) does not, at least not readily, admit even of such an apparent paraphrase. I should point out that there is a drastic revision of the unanimity theory that deals with the problem presented by properties of distinct individuals.[8] It invokes singular causation, and lets singular causation do nearly all the work. That, I think, is the real significance of the problem presented by properties of distinct individuals. It forces us at least to acknowledge that singular causation plays a significant role in our understanding of property-level causation. As a matter of fact, it has led me to an even a stronger conclusion: *that there is no relation of property-level causation.*

2. IS THERE PROPERTY-LEVEL CAUSATION?

My criticisms to this point have been from within the framework established by unanimity theorists. Among other things, the appropriateness and the importance of the investigation have been taken for granted. I now want to raise a more serious criticism. I shall argue that property-level causation may be an inappropriate topic of investigation and that it is at least a relatively unimportant topic. Property-level causation should not be a major issue in the philosophy of science.

To this end, notice the similarities between sentences taken to report property-level causation and *generic sentences*.[9] Generic sentences include sentences like:

(6) Rabbits have tails.

(7) Dogs bark.

(8) Sunspots cause electrical disturbances.

We are usually prepared to accept generic sentences as true even though aware of apparent counterinstances. We are prepared to accept (6)—(8) as true though aware that some rabbits are born without tails, that there are dogs that never bark, and that some sunspots do not cause any electrical disturbances.

Of course, it is sentence (8) that is most similar to the sentences I have so far taken to report property-level causation. The only obvious difference is that it begins with a plural noun phrase (and includes the corresponding plural form of the verb). The sentences so far taken to report property-level causation begin with nominalizations. I focus on sentences beginning with nominalizations, in part, because those are the sentences most frequently discussed by unanimity theorists. Nominalization sentences also tend to permit the most natural and most plausible application of the unanimity theory, because sentences using noun phrases in the cause and effect position are naturally taken to relate properties of distinct individuals.

I doubt that unanimity theorists would object to my considering

sentences like (8). For one thing, thinking their investigation to be one in the philosophy of science, they understandably have not been overly concerned about minor variations in grammar. For another, sentences beginning with plural noun phrases have at times been considered in the unanimity literature right alongside nominalization sentences.[10] So, in considering sentences like (8), I doubt that I have changed or expanded the topic in any objectionable way. More importantly, there is good reason to think that the two sorts of sentences deserve one treatment. As sentence (1) indicates, causal sentences sometimes mix nominalizations and noun phrases. When the difference is important, I shall refer to sentences like (8), which include only plural noun phrases in the cause and the effect positions, as *generic causal sentences*. Sentences like (1) or (5), which include a nominalization in either the cause or effect position, will be taken to be *nominalization causal sentences*.

We could think of (8) as a relational sentence, as relating the property of being a sunspot and the property of being an electrical disturbance. This relational treatment, however, has some odd consequences when it is applied to other generic sentences. According to the relational treatment, sentence (6) reports a property-level having relation between the property of being a rabbit and the property of being a tail. That is odd because, while rabbits do have tails, in no sense does the property of being a rabbit *have* the property of being a tail. It is also not clear what the corresponding suggestion would be for sentence (7). Apparently, it would hold that (7) attributes the property-level property of barking to the ordinary property of being a dog. Again, this is odd because, while dogs bark, there does not seem to be a sense in which the property of being a dog *barks*. The relational treatment also has the surprising consequence that sentences (6)—(8) have none of the same semantic components.

Other proposals about the form of generic sentences have some attractions. Here is one example. It will help to make a point about property-level causation, and it will also help to motivate a more plausible proposal to be advanced in the next section. The present proposal takes all generic sentences to be stylistic variations on universally quantified sentences, sentences typically beginning with the words 'all' or 'every'. According to this proposal, sentence (6) is equivalent to the sentence 'All rabbits have tails'. Then, sentences (6) and (7) should be represented:

(6a) $(\forall x)(Rx \supset (\exists y)(Ty \& Hxy))$

(7a) $(\forall x)(Dx \supset Bx)$.

Sentence (8) could be symbolized in a manner similar to (6):

(8a) $(\forall x)(Ux \supset (\exists y)(Ey \& Cxy))$.

Though flawed, this proposal is instructive. If it were correct and could be extended to nominalization causal sentences and any other sentences that might be taken to express property-level causation, it would show in a dramatic fashion how the investigation of property-level causation is a mistake. According to the proposal, sentence (8) is not a relational sentence. In fact, it includes no component expressing property-level causation. It does include a predicate expressing singular causation, but that is the only thing causal about (8). So, according to this proposal, an investigation of the fact that sunspots cause electrical disturbances is not an investigation of a new kind of causation. If the proposal extended to nominalization causal sentences, then sentence (1) would not be relational. It would not include a causal component other than the component expressing singular causation. So, an investigation of the fact that smoking causes heart attacks would not be an investigation of a new kind of causation. If the proposal extended to all sentences that might plausibly be taken to express property-level causation, then in an important sense *there would be no such thing as property-level causation.* Investigations of property-level causation would be inappropriate.

There would still be some point to asking what makes it the case that sunspots cause electrical disturbances and what makes it the case that smoking causes heart attacks. It is just that these questions would no longer appropriately be asked by philosophers of science. They would appropriately be asked by philosophers of language or linguists investigating the finer points of universal quantification. My point is that there would be nothing to be learned about *causation* from asking

what makes it the case that sunspots cause electrical disturbances or that smoking causes heart attacks, except what could be learned much more directly from an investigation of singular causation.

As a matter of fact, I doubt that the proposal being considered is correct. At least on occasion, we treat generic sentences and universally quantified sentences differently. If I say 'All dogs bark' and am challenged by the report that Fido has never barked, I am likely to restrict the quantifier explicitly by saying that I meant that all *normal* dogs bark or, perhaps, that I meant that all dogs *that I have encountered* bark. But, if I say 'Dogs bark' and am given the same challenge, I am permitted an alternative response. I can simply point out that I did not say that *all* dogs bark. There are also some generics that we would be hard pressed to construe as universally quantified; e.g., 'Dogs are on the lawn' (Carlson 1980, p. 2). As I said above, this proposal treating generic sentences as universally quantified sentences is primarily intended to motivate a more plausible proposal. In the next section of the paper, I outline a new proposal about generic sentences and discuss its application to nominalization causal sentences. If it is correct, it has the same strong implications about the appropriateness of the investigation of property-level causation.

Before outlining my proposal, I want to point out that, even if it does not get things quite right, we should not return too quickly to the relational treatment of generic causal sentences or nominalization causal sentences. There are many sentences using the word 'cause' whose form is difficult to state; for example: 'Sunspots normally cause electrical disturbances' and 'Sunspots usually cause electrical disturbances'. These sentences resist inquiry in much the same way that generic causal sentences and nominalization causal sentences do, but that prompts no one to think that there is a relation of *normal causation* or that there is a relation of *usual causation*. The tip-off is that there are many similar sentences that have nothing to do with causation; sentences like: 'Rabbits normally have tails' and 'Rabbits usually have tails'. Analogously, the similarities between generic causal sentences like (8) and ordinary generic sentences like (6) — sentences that have nothing to do with causation — counts heavily against the relational treatment of generic causal sentences. There are also sentences similar to nominalization causal sentences having little to do with causation, sentences like:

(9) Chewing gum is healthier than smoking.

These similarities count heavily against a relational treatment of nominalization causal sentences.

Furthermore, my criticism does not wholly depend on my establishing that generic causal sentences and nominalization causal sentences are not relational sentences. If such sentences really are relational sentences, we should still doubt the *importance* of an investigation of property-level causation. I guess that such an investigation would then be *appropriate* — there would be a property-level causal relation. But that is about all that could be said for such an investigation. Notice that if (8) is a relational sentence then it is a good bet that (6) is also relational. If (5) is a relational sentence, then it is a good bet that (9) is too. We would then have to admit that there is a property-level having relation and a property-level being-healthier-than relation. That, however, would not prompt investigations of these two relations. There would be little that is interesting about these relations beyond what is interesting about their corresponding singular relations. Analogously, we should doubt the importance of an investigation of property-level causation. Even if there is such a relation, whatever is interesting about property-level causation is pretty much exhausted by what is interesting about singular causation. That no doubt is why the most promising theories of property-level causation have been those letting singular causation do nearly all the work.[11]

3. AN ALTERNATIVE

Here I outline a proposal about generic sentences, including generic causal sentences. After discussing some of the attractions of my theory, I discuss extending it to nominalization causal sentences. Then, at the end of this section, I point out an important difference between my theory and some versions of the unanimity theory. That will permit a concluding observation about a confusion common to discussions in metaphysics and the philosophy of science.

a. *The generic conditional*

I suggest taking all generic sentences to be conditional sentences of an unusual sort. Let us introduce a variable binding operator, '$\Rightarrow$', on pairs of open sentences with the same free variables.[12] Then, our generic sentences, sentences (6)—(8), could be taken to have the following forms respectively:

(6b) $Rx \Rightarrow (\exists y)(Ty \,\&\, Hxy)$

(7b) $Dx \Rightarrow Bx$

(8b) $Ux \Rightarrow (\exists y)(Ey \,\&\, Cxy)$.

There are obviously some similarities between this proposal and the earlier proposal treating generics as universally quantified sentences. There are also some important differences.

The appeal of this second proposal about logical form partly turns on what sort of analysis can be given for the generic conditional. For the central cases, those in which the frequency of *G*s in *F*s (i.e., $Fr(Gx/Fx)$) exists,[13] I suggest:

(GC) $Fx \Rightarrow Gx$ if and only if $Fr(Gx/Fx)$ is high.

By way of illustration, consider sentence (7). According to (GC), dogs bark if and only if the frequency of barkers in dogs is high. Symbolically:

$Dx \Rightarrow Bx$ if and only if $Fr(Bx/Dx)$ is high.

Now, consider sentence (8). According to (GC), sunspots cause electrical disturbance if and only if the frequency of *causers* of some electrical disturbance in sunspots is high. Symbolically:

$Ux \Rightarrow (\exists y)(Ey \,\&\, Cxy)$ if and only if $Fr((\exists y)(Ey \,\&\, Cxy)/Ux)$ is high.

One thing to keep in mind is that (GC) is in no way an analysis of causation. In the preceding biconditional, the predicate expressing singular causation occurs in both the left-hand and right-hand sides.

In addition to advancing (GC), I want to hold that ordinary generic sentences are context-dependent. Indeed, I think that sentences of the form 'Fr(*Gx*/*Fx*) is high' and generic sentences of the form '*Fx* ⇒ *Gx*' are sensitive to context in just the same way. For example, suppose that the frequency of barkers in dogs is 80%. Then, in many contexts, the sentence 'Fr(Bx/Dx) is high' is true. My hypothesis is that, in those same contexts, 'Dx ⇒ Bx' is also true. In other more demanding contexts, 'Fr(Bx/Dx) is high' is false. In such contexts, 'Dx ⇒ Bx' is also false. There is an upper and a lower bound on the context-dependence of generic conditional sentences: (i) if the frequency of *Gs* in *Fs* is zero, then '*Fx* ⇒ *Gx*' is false in all contexts; and (ii) if the frequency of *Gs* in *Fs* is one, then '*Fx* ⇒ *Gx*' is true in all contexts.

b. *Advantages*

Let us consider some advantages of my proposal. As I have not extended it to nominalization causal sentences, I have to change the examples that presented problems for the unanimity theory slightly. These changes are incidental. Nominalization causal sentences bring in complications that are relatively superficial. Though superficial, they can disguise the attractive features of (GC).

Consider a case of epiphenomena. Suppose sunspots cause electrical disturbances located on Earth and that sunspots cause electrical disturbances located on Mars. On my proposal, the sentences 'Sunspots cause electrical disturbances located on Earth' and 'Sunspots cause electrical disturbances located on Mars' can be rendered respectively:

(10) $Ux \Rightarrow (\exists y)((Ey \,\&\, Lye) \,\&\, Cxy)$

(11) $Ux \Rightarrow (\exists y)((Ey \,\&\, Lym) \,\&\, Cxy)$

Then, according to (GC), that sunspots cause electrical disturbances on Earth implies that the frequency of causers of electrical disturbances located on Earth in sunspots,

$$Fr((\exists y)((Ey \,\&\, Lye) \,\&\, Cxy)/Ux),$$

is high. Similarly, that sunspots cause electrical disturbances located on Mars implies that the frequency of causers of electrical disturbances located on Mars in sunspots,

$$Fr((\exists y)((Ey \,\&\, Lym) \,\&\, Cxy)/Ux),$$

is high. That these two frequencies are high gives us no reason to expect the frequency of causers of electrical disturbances on Mars in electrical disturbances on Earth,

$$Fr((\exists y)((Ey \,\&\, Lym) \,\&\, Cxy)/(Ex \,\&\, Lxe)),$$

to be high. So, that sunspots cause electrical disturbances on Earth and that sunspots cause electrical disturbances on Mars do not lead to the conclusion that electrical disturbances located on Earth cause electrical disturbances located on Mars. (GC) avoids obvious problems with epiphenomena.

My approach also handles cases like the acid/alkali case and Dupré's case. In both these cases, there is a causal sentence that we have at least some initial inclination to accept as true. It was pretty clear that we would accept each of these sentences as true in some contexts. Well, consider the acid/alkali example. When acid poisons are ingested, they often cause some death — the frequency of causers of a death in acid poisons is well above zero. So, in some contexts, the sentence 'The frequency of causers of a death in acid poisons is high' is true. In such contexts, the sentence 'Acid poisons cause death' is also true. Analogous considerations apply to the sentence 'Alkaline poisons cause death' and, for Dupré's case, the sentence 'Cigarettes cause lung cancer'.

The counterexamples to the unanimity theory involving probabilistic sufficiency turned on the role a third property played in the test situation. Of course, the presence of some third property is irrelevant to my model. Whether '*Fx* ⇒ (∃y)(*Gy* & Cxy)' is true only depends on a statistical relationship between the open sentences '*Fx*' and '(∃y)(*Gy* & Cxy)'. Incidentally, the trivial counterexamples to the unanimity theory involving temporal direction, properties raising their own probability, and effects raising the probability of the cause are all avoided by (GC) without any additional necessary conditions. These problems are nullified because (GC) gives singular causation a role in the analysis of generic causal facts.

c. *Nominalizations*

That nearly completes my look at the advantages of (GC). (I discuss one further feature of (GC), its invoking frequencies instead of modal probabilities, in subsection (d).) These advantages support the hypothesis that generic causal sentences are generic conditional sentences. It is worth noting that this hypothesis may be true even if I am mistaken about the analysis of the generic conditional.[14] Logical form is one thing, analysis another. In the present subsection, I discuss nominalization causal sentences. There are, unfortunately, some difficult questions regarding the logical form of *singular* causal sentences that muddy the waters surrounding nominalization causal sentences. Though nominalization causal sentences arguably include the generic conditional, it is not clear how best to represent *the other* parts of nominalization causal sentences.

Consider sentence (8) again. It is a generic causal sentence. Representing sentence (8) as (8b) incorporates a natural assumption about the logical form of corresponding singular causal sentences. (8b) includes the predicate 'x is a sunspot', the predicate 'x is an electrical disturbance', and a two-place predicate expressing singular causation. That is not surprising. It is just what one would expect given the traditional story about corresponding singular causal sentences like:

(12) The sunspot caused the electrical disturbance.

Representing (8) as (8b) incorporates the assumption that (12) contains a two-place predicate relating two events. The events — the sunspot and the electrical disturbance — are picked out by two definite descriptions. The definite descriptions include the predicate 'x is a sunspot' and the predicate 'x is an electrical disturbance', respectively. This is all quite natural, just what one would expect.

Were nominalization causal sentences treated the same way, similar assumptions would have to be made about nominalization causal sentences and their corresponding singular causal sentences. Then, (5) should be represented:

$$Mx \Rightarrow (\exists y)(Oy \,\&\, Cxy).$$

Here, 'Mx' is the predicate 'x is *a* smoking' and 'Ox' is the predicate 'x is *a* coughing'. That suggests that a corresponding singular causal sentence, like:

(13) John's smoking caused his coughing,

uses the predicates 'x is a smoking' and 'x is a coughing' as part of definite descriptions picking out two events: John's smoking and John's coughing. Basically, if nominalization causal sentences were treated on a par with generic causal sentences, sentence (5) would be treated as if it were the sentence 'Smokings cause coughings'.

Though that story is somewhat tempting, there is a more natural position regarding (13), which also suggests a different story about (5). It begins with the observation that (13) is equivalent to (14):

(14) John coughed because he smoked.

(14) is naturally taken to be non-relational, to be accurately represented with the sentential connective '. . . because - - -'. By letting '- - - C . . .' abbreviate '. . . because - - -', (14) can be symbolized as:

$$SjCCj.$$

On this treatment, (13) includes the ordinary predicates 'x smokes' and 'x coughs'. This treatment of (13) is more natural because the alternative maintains that (13) includes the odd predicates 'x is *a* smoking' and 'x is *a* coughing'. Those predicates occur infrequently and unnaturally in English. I doubt that they are used either in sentence (13) or in sentence (5).

If that is the correct story about (13), then sentence (5) must somehow include the connective '. . . because - - -', the predicate 'x smokes', and the predicate 'x coughs' along with the generic conditional. Here is one defensible suggestion:

$$Sx \Rightarrow (\exists y)(SxCCy).$$

What is messy about this suggestion is that the antecedent occurs again in the consequent. That is mandated by the assumption that, in sentences like (13), singular causation is expressed by a sentential connective. This proposal about sentence (5), when combined with (GC), has the consequence that smoking causes coughing if and only if the frequency, in smokers, of things whose smoking causes some coughing is high.

While this position on sentence (5) is appealing, it raises some difficult questions about the form of singular causal sentences. What, for example, is the relationship between singular causal sentences like (12) and singular causal sentences like (13)? It is most natural to take the former sentences as each containing a two-place predicate and the latter as each containing a sentential connective. But is one form more basic? Are there two singular causal concepts or just one? And, what of mixed sentences? How, for example, should we represent sentence (1)? How should we represent corresponding singular causal sentences like (2)? These are all difficult questions, which I shall not try to answer here.

In any case, we should have learned a lesson about property-level causation. These very difficult questions turn on questions about the logical form of singular causal sentences. They do not present any challenge — at least no obvious challenge — to my hypothesis that generic causal sentences and nominalization causal sentences are generic conditional sentences. If my hypothesis is correct (and can be extended to other sentences that might be taken to express property-level causation), then the investigation of property-level causation is a mistake. That conclusion follows in just the same way that it does from the proposal of section two, the proposal treating generic sentences as universally quantified sentences. If my hypothesis is correct, then the correct renderings of generic causal sentences and nominalization causal sentences, no matter how we answer the remaining questions about the form of singular causal sentences, include nothing expressing property-level causation.

d. *Frequencies versus probabilities*

To conclude this section, I want to comment on an important difference between (GC) and the unanimity theory, at least the unanimity theory as it is understood by some (e.g., Eells and Sober 1983, p. 36, and Cartwright 1989, p. 35). My comments will permit a final observation about a confusion common to discussions in metaphysics and the philosophy of science, a confusion that may explain some of the undue

interest shown property-level causation. The difference involves (GC)'s use of the frequency function rather than some more modal probability function.

A modal probability function is sometimes used in the analysis of property-level causation because some worry that frequencies can be misleading. If there are only five sunspots and, by accident, not one of them causes an electrical disturbance, then the frequency of causers of an electrical disturbance in sunspots is zero. So, according to (GC), it is not the case that sunspots cause electrical disturbances. Some apparently think that this is a mistake, claiming that sunspots might still cause electrical disturbances even if, by accident, no sunspots cause an electrical disturbance. Were (GC) to use some more modal probability function, like a propensity function or a hypothetical frequency function, that conclusion might be avoided. Similarly, if the only people that happen to smoke have the rare physiological condition described by Dupré and no lung cancer results, then (GC) implies that it is not the case that smoking causes lung cancer. Again, some apparently think that this is a mistake.

I strongly disagree. (GC) gives the correct consequence about both of the cases just described. In a case in which there are five sunspots and not one causes an electrical disturbance, it seems to me clear that it is not the case that sunspots cause electrical disturbances. After all, there are sunspots and *not one* causes an electrical disturbance. In a situation in which only people with that rare physiological condition smoke and no lung cancer results, it seems to me clear that it is not the case that smoking causes lung cancer. After all, there are people who smoke and *no one's* smoking causes lung cancer. The frequency function is perfectly appropriate.

Here is another way of making basically the same point. The frequency function belongs in (GC), because there are many *accidentally true* generics. Suppose, for example, that there are exactly three coins in my pocket and each is a nickel. Then, it is true that *coins in my pocket are nickels.* That generic proposition follows trivially from the proposition that *all coins in my pocket are nickels.* It would be inappropriate to include a more modal probability function in its analysis. There can also be accidentally true generic causal propositions: if there are only five sunspots and by accident each caused a tidal wave, then it would be accidentally true that sunspots cause tidal waves. Similarly, there can be accidentally true nominalization causal sentences: if all the people that happen to smoke have that rare physiological condition and all live a longer life as a result, then it would be accidentally true that smoking causes longer life. As stated, (GC) has these implications. It correctly implies about these cases that sunspots cause tidal waves and that smoking causes longer life.

Though it is ultimately untenable, there is a compromise position that may tempt some. It maintains that generic sentences are ambiguous, that generic sentences admit of a modal and a non-modal reading. The compromise position does not need to choose between frequency and a more modal probability concept. It maintains that, on the non-modal reading, generic sentences express generic conditionals and are subject to something like (GC). On the modal reading, generic sentences have a richer form, expressing what we might call *modal generic conditionals*. The modal generic conditional, then, gets analyzed using a modal probability function. As I said, this compromise is untenable. In fact, it is not even very tempting. It has the consequence that the sentence 'Coins in my pocket are nickels', while true on a non-modal reading, admits of a modal reading on which it is false. That is a mistake. There is no legitimate reading of that sentence on which it is false — not if there are exactly three coins in my pocket and each is a nickel, not if *all* the coins in my pocket are nickels.

We do need to recognize that some generics have interesting properties over and above their truth. If it were accidentally true that sunspots cause tidal waves, then it surely would not be a good explanation of the fact that such and such a sunspot caused such and such a tidal wave simply to say that sunspots cause tidal waves. That generic would be true but not suitably explanatory. Similarly, generic sentences can be true but not good action-guiding principles. In the variation on Dupré's example, it is true that smoking causes longer life but that is a terrible action-guiding principle. It may be that what unanimity theorists — especially those insisting on a modal probability function — were really after was not an account of what makes it true that smoking causes heart attacks. Instead, they may have been after an account of what makes that proposition true *and* have those other interesting properties, an account of what makes the proposition that smoking causes heart attacks true *and* explanatory *and* a good action-guiding principle. If that was the unanimity theorists' true goal, then they had identified an interesting and important topic. But that is not the topic they professed to be investigating: the topic of property-level causation. That is not even the topic that, by my lights, they turned out to be investigating: the generic conditional. That is not a topic that can be investigated simply by asking what makes it *true* that smoking causes heart attacks.

An account of the difference between accidentally true generics and the more useful generics would be a remarkable achievement in the philosophy of science. My analysis, (GC), says nothing about that difference. (GC) solves no great problem in the philosophy of science, nor would any plausible account of what makes it true that smoking causes heart attacks. That is exactly the point I was trying to make in section two. That, incidentally, also is why I am somewhat optimistic about (GC), at least more optimistic than I am about most analyses. The history of philosophy has made it painfully obvious that only relatively uninteresting analyses have any chance of success.

4. LAWS AND LAWHOOD

Unanimity theorists make a mistake analogous to a mistake that is commonly made about *laws of nature*. Many philosophers mistakenly think that the central issue regarding laws of nature is whether laws are universally quantified material conditionals. (Sometimes this is put a little differently: the issue is often thought to turn on whether laws are *regularities*.) That is, many mistakenly think that the central issue regarding laws of nature turns on what makes laws true. In their investigations, these philosophers typically point out that there are many true universally quantified material conditionals that are not laws. From there, they conclude that no law is a universally quantified material conditional. They maintain, instead, that all laws are relations between universals or that all laws include some modal connective.[15]

Suppose, as may be the case, that it is a law that all signals have speeds less than or equal to the speed of light. Also suppose that it just so happens the fastest that any raven has ever traveled, or will ever travel, is exactly thirty meters per second. Then, consider these generalizations:

(15) All ravens have speeds less than 31 meters per second.

(16) All signals have speeds less than 300,000,001 meters per second.

What (15) says is *true, but not a law*. Since the speed of light is less than 300,000,001 meters per second, what (16) says is *both true and a law*. Certainly, there are some differences between the logical form of (15) and the logical form of (16): (15) quantifies over ravens instead of signals, and also cites a much slower speed. But it would be an absurd position that treated (15) and (16) as *otherwise* having different logical forms, by maintaining, for example, that (15) expresses a universally quantified material conditional and that (16) expresses a universally quantified modal conditional. Such a position absurdly suggests that the logical form of sentence (16) is influenced by its being a law that no signals travel faster than the speed of light. On the contrary, the logical form of all sentences is determined by much more mundane and unsophisticated facts, not by matters of science.[16]

The central issue regarding laws of nature is not whether laws are universally quantified material conditionals. Obviously, some laws are universally quantified *indicative* conditionals. Whether they are also universally quantified material conditionals is a legitimate and interesting question. This, however, is not a central question in metaphysics or philosophy of science. It is an issue better left for philosophers of language and linguists. The key issue in metaphysics and the philosophy of science concerns *lawhood* — the property of being a law of nature. Metaphysicians and philosophers of science should be asking not what makes laws of nature true, but what makes them laws of nature. They should ask not what makes it *true* that no signals travel faster than the speed of light, but what makes it *a law* that no signals travel faster than the speed of light.[17]

Seeing the central issue about laws as an issue about what makes laws true is analogous to one mistake made by unanimity theorists that insist on a modal probability function in their account of property-level causation. They want to analyze property-level causation using a modal probability function just as some have wanted to analyze laws using a modal connective. Their position crumbles when faced with property-level causal propositions that are accidentally true, propositions expressed by sentences that have essentially the same logical form as their non-accidental kin. There is no more difference regarding their logical form and analysis than there is regarding (15) and (16).

The difference between accidentally true generics and more useful generics is interesting. This difference is roughly the difference between accidentally true universal generalizations and universal laws, roughly the difference between (15) and (16). So, I hypothesize that the difference between accidentally true generics and more useful generics is the difference between accidentally true generics and *generic laws*. If this hypothesis were correct, then an investigation of the difference between accidentally true generics and the more useful generics should be part of an investigation of lawhood. Unfortunately, my hypothesis may be a bit strong. I am not sure that there really are or could be generic laws. Generic sentences may be too informal to express laws of nature. Even so, it at least seems that a promising way — perhaps the most promising way — of investigating the difference between accidentally true generics and more useful generics is via an investigation of lawhood.

5. CONCLUSIONS

Let me conclude by summarizing the primary conclusions of sections two through four in a sentence: The interest of property-level causation as a topic in the philosophy of science is exhausted by the interest of two more traditional topics. Its interest is mostly exhausted by the interest of singular causation. That is the conclusion of section two and the first three subsections of section three, where I argue that the only thing causal about so-called property-level causal sentences is a component expressing singular causation. Whatever other interest the topic of property-level causation might have as a topic in the philosophy of science is exhausted by the interest of lawhood. That is the conclusion of the argument begun in the last subsection of section three and concluded in section four. Lawhood, like singular causation, is an important topic in the philosophy of science.[18]

APPENDIX

Bx: x barks
Cx: x coughs
Cxy: x causes y
Dx: x is a dog
Ex: x is an electrical disturbance
Hxy: x has y
Lxy: x is located on y

e: Earth
m: Mars
j: John

Mx: x is a smoking
Ox: x is a coughing
Rx: x is a rabbit
Sx: x smokes
Tx: x is a tail
Ux: x is a sunspot

NOTES

[1] The properties related by property-level causation are usually assumed to be *temporally-indexed* properties; e.g., smoking at noon yesterday. So, it does makes sense to speak of temporal relations between the properties. When no confusion will result, I shall continue to ignore the temporal indices.

[2] There is a third closely related case described by Germund Hesslow (1976). Also see Otte (1985, p. 120), Eells (1987, p. 236), (1988a, p. 99) and (1988b, p. 113); Cartwright (1988a, p. 86), (1988b), and (1989, p. 99); and finally Cartwright and Dupré (1988).

[3] As Ellery Eells (1988c, p. 194) points out, the problem is initially more serious then I let on. He shows that, as long as ingesting acid poison and ingesting alkaline poison have the same causal role (and the symmetry of the situation dictates that they do), the unanimity theory leads to a contradiction. But, as Eells also points out, there are (non-circular) versions of the unanimity theory that avoid this further problem.

[4] For more on context-dependence, see Lewis (1983a, pp. 233—249). DeRose (forthcoming) and Unger (1986) advance very plausible discussions of the context-dependence of epistemological sentences, especially sentences using the verb 'to know'.

[5] Also see Sober (1984, pp. 289—290). Otte raises his examples as counterexamples to Patrick Suppes' (1970) probabilistic theory, understood as a theory of singular causation.

[6] If we adopt the other common convention that $\Pr(Gx/Fx \ \& \ Tx)$ is undefined, then the causal chain case is a counterexample to the unanimity theory.

[7] I first raised this problem in my (1988) article. Unfortunately, there are several confusions in that article.

[8] The drastic revision is this: F causes G if and only if (i) for every causally homogeneous test situation T, $\Pr((\exists y)(Cxy \ \& \ Gy)/Fx \ \& \ Tx)$ is greater than or equal to $\Pr((\exists y)(Cxy \ \& \ Gy)/Tx)$, and (ii), for at least one causally homogeneous situation T, $\Pr((\exists y)(Cxy \ \& \ Gy)/Fx \ \& \ Tx)$ is greater than $\Pr((\exists y)(Cxy \ \& \ Gy)/Tx)$. 'Cxy' expresses singular causation.

[9] The connection between generic sentences and so-called property-level causal sentences was suggested to me by Roy Sorensen's "Process Vagueness" (1990).

[10] (8) comes from Wayne Davis' article (1988, p. 148). Cartwright and Dupré (1988) even take the appropriate locution for analysis to be '*P*s probabilistically cause *Q*s'.

[11] I have in mind the version of the unanimity theory presented in note eight, and the position suggested quickly by Davis taking property-level causal statements to be "vague quantifications of singular causal statements" (1988, p. 147).

[12] Ernest Adams (1988) suggests this position on logical form. He goes on to offer a treatment of generic conditionals that is quite different from the position I sketch.

[13] $\mathrm{Fr}(Gx/Fx)$ does not exist if and only if either (i) there are no *F*s or (ii) there are infinitely many *F*s. When there are no *F*s, I am inclined to accept '$Fx \Rightarrow Gx$' as vacuously true. I am not sure what it is best to say about the infinite case.

[14] Gregory Carlson's *Reference to Kinds in English* (1980) is a fruitful source of examples. He gives some examples that do not conform well to my position. These include 'Dogs are common' (p. 2) and 'Whiskey bottles come in three sizes' (p. 45). I do not think, however, that they present a serious problem. The latter pretty clearly is elliptical for 'Whiskey bottles come in one of three sizes'. The former, I hope, can be paraphrased as something like 'Dogs are nearby'.

[15] David Armstrong (1983) and John Pollock (1984) are two of many that make this mistake. I (1987) am just as guilty. David Lewis (1983b, 1986, and elsewhere) is one of the few that have consistently avoided the error.

[16] Philosophers faced with this problem are likely to invoke the distinction between *basic* and *non-basic* laws. They will revise their original claims to hold either that all basic laws are relations between universals or that all basic laws include some modal connective. They will claim that the proposition that all signals travel at speeds less than or equal to the speed of light is only a non-basic law. In response, I would like to know what the basic law is that entails this supposedly non-basic law. I suspect that there will either be accidentally true propositions of that same form, or that there are *no* (ordinary) natural language sentences that could plausibly be taken to have that form. Furthermore, such a response to my challenge is disingenuous. There is no class of natural language sentences whose truth conditions these philosophers set out to investigate. Instead, they want to know the essential difference between laws and non-laws. It is a bit of a mystery how they end up with a conclusion about the logical form of sentences that express laws.

[17] That is the better question to ask, but do not expect much of a answer. I argue that no very interesting analysis of lawhood is possible in "The Humean Tradition" (1990).

[18] A version of this paper was read at the City University of New York Graduate Center. My views on property-level causation have evolved drastically over the last few years. That evolution was encouraged by suggestions and criticisms made by many people. Special thanks are owed an anonymous referee for *Philosophical Studies*, Keith DeRose, Julia Driver, Jerry Katz, John Pollock, Stephen Schiffer, Roy Sorensen, and Peter Unger.

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THE MIRACULOUS CONCEPTION OF COUNTERFACTUALS*

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How are we to deal with a counter-to-fact assumption like this: Suppose George Bush had lost in his 1988 bid for the presidency of the U.S. On one popular point of view, to answer this question one must imagine a possible world which, at least up until about 1988, is a copy of the actual world. But one is to further imagine that sometime not too long before the selections of that year, the world is miraculously jarred from its actual course so that Bush loses. Still, after this lone miraculous occurrence, the imagined world develops in accordance with the actual laws of nature. Now, on the view I want to describe, what *would* be true given the above counterfactual assumption is just what *is* true at such miraculous possible worlds. Call any such view a "miracle theory of counterfactuals".

A number of miracle theories of counterfactuals have been proposed which at least roughly respect the intuitions of the above paragraph. The most influential of these is David Lewis's theory developed in his (1973), (1979), and (1986). Frank Jackson's (1977) is another example. Thomason and Gupta's (1980) should probably also be counted as a miracle theory. But since the publication of these articles, there has been a rush of criticism of the miracle theory: Nute (1980), Pollock (1981 and 1984), Bennett (1984), and Horwich (1987). All these authors have proposed anti-miracle theories of counterfactuals. Now, it is the purpose of this article to argue that such non-miraculous accounts fail. I will pay special attention to the theory proposed (independently) by Nute and Bennett, as that theory has been most influential (section 1 and 2). But I will also try to indicate how my argument cuts against the other authors (section 3).

As I see it, the failures of these anti-miracle theories have to do with a subtlety in the laws of nature, viz., that the laws allow the spontaneous generation of, e.g., pages of coherent English text, in a process of

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