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Capacities, universality and singularity

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Capacities, Universality, and Singularity*

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In this paper I criticize Cartwright's analysis of capacities and offer an alternative analysis. I argue that Cartwright's attempt to connect capacities to her condition *CC* fails because individuals can exercise capacities only in certain contexts. My own analysis emphasizes three features of capacities: 1) Capacities belong to individuals; 2) Capacities are typically not metaphysically fundamental properties of individuals, but can be explained by referring to structural properties of individuals; and 3) Laws are best understood as ascriptions of capacities.

In a recently published précis (Cartwright 1995), Nancy Cartwright describes her book, *Nature's Capacities and their Measurement* (Cartwright 1989, hereafter NCM), as an apology for the role of causality in modern science, and particularly for the role of irreducibly singular causal facts. According to Cartwright, causal capacities of individuals are metaphysically fundamental, and much of the business of science is to measure these capacities.

Although I am sympathetic to Cartwright's causal realism and to her emphasis on singular causes, I think that there are a number of tensions and ambiguities in her account of capacities. The first two sections of this paper discuss Cartwright's account. The first section discusses her view of the relationship between capacities and so-called contextual unanimity conditions. The second examines her view of the relationship between capacities and laws. In the third section I offer an alternative account of capacities which eliminates some difficulties with

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Cartwright's account. My account accords capacities a less exalted metaphysical status than does hers and also suggests that the distinction between singularist and generalist accounts of causation is less stark than is commonly supposed.

1. Capacities and Contextual Unanimity. Several commentators (Maudlin 1993, Morrison 1995) have noticed a tension in Cartwright's account of capacities: On the one hand, capacities are said to exhibit themselves case by case, and the fact that a capacity does not manifest itself on an occasion does not necessarily impugn that capacity; on the other hand, Cartwright distinguishes capacities from causal laws precisely in virtue of a capacity's putative universality or invariance. Capacities *always* increase the probabilities of their effects. As Margaret Morrison puts it: "The reason capacities are cited as superior to causal laws is that they are not context-dependent; rather they are universalizable, holding not just in cases where all other things are equal but in mixed circumstances as well" (Morrison 1995, 163).

To see what grounds Morrison's and my concern we must discuss Cartwright's condition *CC*. *CC* is not a *definition* of a capacity or even of a cause. Rather, it is an inference license. It tells you under what conditions you may infer on the basis of probabilities that property C causes property E:

> *CC*: C causes E iff $P(E/C \pm F_1 \pm \ldots \pm F_n) > P(E/\neg C \pm F_1 \pm \ldots \pm F_n)$ where $\{F_1, \ldots, F_n, C\}$ is a complete causal set for E (NCM 56).

The notation $F_1 \pm \ldots \pm F_n$ is meant to indicate the presence or absence of causally relevant factors $F_1, \ldots, F_n$. Thus *CC* is best construed as a universally quantified statement: C causes E iff for every combinatorial combination of the presence or absence of causally relevant factors F, the probability of E given C and those factors is greater than the probability of E given the $\neg C$ and those factors. It demands that a cause raise the probability of its effect in all causally differentiated contexts.

As stated, CC is a condition that no putative cause can meet. It must be modified to restrict from the set of Fs any causes intermediate between C and E. Otherwise, since proximal causes screen off distal causes, nothing will ever qualify as a cause. A more serious concern involves the applicability of *CC* as a test condition. As Cartwright remarks:

> The practical difficulties with [*CC*] are conspicuous. The conditioning factors $F_1, \ldots, F_n$ must include every single factor, other

> than *C* itself, that either causes or prevents *E*, otherwise the criterion will be useless. (NCM, 56)

Much of Chapter Two of NCM is devoted to showing how one can, without full knowledge of the *F*s, apply *CC* to determine if a factor *C* really is a cause of *E*. There are some serious difficulties here, but I shall not address them. Rather I will consider the relationship between causes as characterized by *CC* and capacities.

The idea behind *CC* (which appears for the first time in Cartwright 1979) is not unique to Cartwright. It is a species of what Cartwright and Dupré call "contextual unanimity conditions." In addition to Cartwright, versions of contextual unanimity accounts of causation have been defended by Skyrms (1980), Humphreys (1989) and Eells (1991).[1] Contextual unanimity conditions are probabilistic analogs of sufficiency conditions. Causes need not be sufficient for their effects, but they must raise the probability of their effects across all contexts.

Cartwright thinks there is an intimate connection between capacities and condition *CC*, although she never explains their exact relationship. The closest she gets is this:

> A property carries its capacities with it, from situation to situation. . . . [*C*]apacities are much like essences. . . . What I have been trying to show here is that [the concept of a capacity] is a concept with just this peculiar kind of strength that is marked out by the universal quantifier in Principle *CC*. (NCM, 146)

We can spell out the connection more explicitly as follows: Capacities are properties of properties (cf. NCM, 140). Reading the cause *C* in condition *CC* as a property, say that *C* has the capacity to produce *E* just in case the relation *CC* obtains between *C* and *E*. This characterization should not be seen as a definition of capacity because Cartwright explicitly does not want to *define* causality statistically, and, given CC's reference to causally relevant factors, such a definition would be circular. It does however provide a test condition for capacities. Cartwright believes capacities are more fundamental than causal laws because, on her construal of causal law, causal laws are *ceteris paribus* and population-relative (NCM, 141).

The difficulty with this characterization of capacities is that it does not square with the fact that capacities may only manifest themselves on occasion. Consider the capacity that aspirin has to alleviate headaches. It would seem that the fact that aspirins relieve headaches only

1. For criticisms of contextual unanimity, some of which parallel those I will offer, see Dupré 1993 and Woodward 1993.

on occasion undermines the claim that aspirins have the invariant capacity to relieve headaches. Using the capacity of aspirins to relieve headaches as a central example, I shall consider three possible responses to this difficulty: appeal to chance, appeal to counteracting capacities and appeal to interactive effects. The first two strategies work in some cases (though not plausibly in the aspirin case), but are not generally applicable. The last strategy seems to me to be the correct one for the aspirin case, but accepting it requires renunciation of contextual unanimity.

1.1 Chance. Cartwright could try to solve her difficulty by appealing to chance. *CC* is a probabilistic condition. All that it says is that for *C* to have the capacity to cause *E, C* must increase the probability of *E* across all homogeneous partitions of other causal factors. So perhaps on the occasions in which aspirin doesn't relieve my headache, it still did increase the probability that my headache would go away. For certain kinds of capacities this strategy is entirely appropriate. Consider the capacity of a sample of uranium to emit an alpha particle within some time interval: in some instances it exercises this capacity, and in others not. We would not say in these latter instances that the uranium sample did not have the capacity to emit an alpha particle. The presence of a uranium sample always increases the probability of an alpha particle emission. Whether the event actually happens is a matter of objective chance.

In the case of aspirins, however, appeal to objective chance is *ad hoc*. Whether aspirin will be effective in stopping headaches will most likely depend upon the presence or absence of other factors. For instance, there could be some kind of chemical inhibitor of aspirin action in the stomach of the individual taking the aspirin. On such an occasion, the aspirin would not even raise the probability of its effect. While variation in aspirin efficacy may depend in some part on objective chance, there are good reasons to believe that not all of this variation can be so explained.

1.2 Counteracting Capacities. Another way to explain the variation in the effectiveness of the putatively invariant capacities is to appeal to the presence or absence of counteracting capacities. *CC* says that if *C* has the capacity to produce *E,* it must increase the probability of *E* across contexts, but nothing about *CC* implies that there might not be other properties *C'* with counteracting capacities. Let us consider how this might apply to the case of the aspirins. To do so, let us ignore probabilistic examples and consider a hypothetical deterministic model of aspirin action. Suppose headaches are caused by insufficient levels of some chemical H in the bloodstream. A person has a headache just in case $H <$ constant b. Suppose that without any screaming children or aspirin, the level of $H = b$, and that each aspirin increases the amount of H in the bloodstream by a, while each screaming child S decreases H by the same value (if $H > 0$) (and that there are no other factors which decrease H). Our model of the relations between S, A and H would be $H = \max(b + aA - aS, 0)$. If this model were correct, aspirin would invariantly increase H, and would always tend to eliminate headaches when present, i.e., when $H < b$. But aspirins would not actually relieve headaches when the number of screaming children exceed the number of aspirins taken.

Although I have applied this approach to a case in which the counteracting capacities belong to distinct properties, the same strategy can handle what Cartwright calls "dual" or "mixed" capacities—cases where a property has the capacity both to prevent and to bring about an effect. The most frequently discussed example of this in the literature is a dual capacity of birth control pills with respect to thrombosis. The same property (being a birth control pill) has the capacity to produce thrombosis (because women taking the Pill are more likely to get thrombosis than those not taking the Pill) and to prevent it (because women who are pregnant are more likely to get thrombosis). Cartwright's explains the lack of unanimity in the effect of the Pill by saying that each capacity operates, but in opposite directions.

The difficulty with appeal to counteracting capacities, as with appeal to objective chances, is that there is little reason to believe that all or even most capacities work in this way. If there are aspirin inhibitors of the kind discussed previously, it would disqualify any linear model of counteracting capacities. This point is perhaps clearer in the thrombosis case. Taking the Pill is not invariably a preventative of thrombosis, because the Pill only acts to prevent pregnancy in cases in which there otherwise would have been a pregnancy. So women who take the Pill but who are not sexually active (or who have infertile partners, etc.) will not receive any of the positive side effects of the Pill in preventing thrombosis.

Cartwright is sensitive to this kind of problem. In fact it provides one of her main arguments for a singularist approach. To meet this difficulty Cartwright adds a condition $*$ to CC. It is a condition on the partitioning of a population which must be met to test the causal law 'C causes E':

> $*$Each test population of individuals for the law 'C causes E' must be homogeneous with respect to some complete set of Es causes (other than C). However, some individuals may have been causally

> influenced and altered by *C* itself; just these individuals should be reassigned to populations according to the value they would have had in the absence of *C*s influence (NCM, 96).

Condition ∗ implies that whether *C* causes *E* is a question that can only be asked relative to a population, and in particular relative to the actual causal stories of the individuals in the population. Birth control pills will prevent thrombosis only in populations where women would otherwise have gotten pregnant.

While I think that Cartwright is correct that whether *C*s cause *E*s can only be answered relative to a population, by amending *CC* to *CC*∗ she gives up on contextual unanimity. *C*s cause *E*s in one population but not in another. So long as *CC*∗ is construed only as a license for inferring causal laws, this should be acceptable to Cartwright, since she explicitly adopts Eell's position that causal laws are three place relations between causes, effects and populations (NCM, 144). However, it does not sit well with the supposed universality of capacities.[2]

While the counteracting capacity story doesn't work well for the capacities of aspirin or birth control pills, it may work for some more basic capacities. Consider for instance whether the earth's gravitational field has the capacity to cause my computer to fall to the ground. The capacity is not manifested right now, as my computer is securely sitting on a table three feet above the ground. However, according to the standard explanation given in elementary physics, the force is still acting on the computer. The fact that the computer is not accelerating towards the ground is explained by the fact that there is a proportional upward force being exerted on the computer by the table. One's model of the counteracting capacities at work here is structurally analogous to the model of the counteracting capacities operating on *H* that I discussed above, but in this case we have reason to believe that the account is true.

This story about the forces of classical mechanics is a very nice one, because it allows one to reconcile contextual unanimity with the fact that capacities do not always manifest themselves in observable outcomes. Ironically, if forces in classical mechanics provides a paradigmatic example of capacities, then there appears to be a lot of truth in fundamental laws of physics which Cartwright has famously accused of lying (cf. Maudlin 1993). In her previous book Cartwright argued that component forces acting on a body are not real:

2. Cartwright still regards *CC** as a contextual unanimity condition. She remarks: [C]ausal laws are to be relativized to particular test situations. Yet the initial formula—either *CC* or *CC** quantifies over *all* test conditions" (NCM, 145). Given that *CC** appears to be an inference rule for causal laws, it is hard to reconcile these two claims.

> The vector addition story is, I admit, a nice one. But it is just a metaphor. *We* add forces (or the numbers that represent forces) when we do calculations. Nature does not 'add' forces. For the 'component' forces are not really there, in any but a metaphorical sense, to be added. (Cartwright 1983, 59)

Cartwright's claim about the metaphorical character of the components was motivated by a particular strong empiricism, but if component forces represent the exercise of metaphysically fundamental capacities, then it would seem unlikely she should treat their reality as metaphorical. The laws of physics can't lie if capacity claims tell the truth.

1.3 Interactions. The last route to reconciling the putative universality of capacities with the capriciousness of their manifestation is to appeal to interactions between one capacity and another. Cartwright, replying to Morrison's concern about the universality of capacities remarks:

> [O]ur central usage of tendency terms supposes the association of tendencies with properties or structures (e.g., the ascription of the capacity to relieve headaches to medicaments with the chemical structure of aspirin) need not be universal; it may hold only across certain regimes or domains. But within the domain in which the claim of association can be regarded as true, the tendency when appropriately triggered will always operate unless there is a good physical reason why not (e.g., interaction, which is a physical process that is independently identifiable in most material situations). (Cartwright 1995b, 179–180)

In a footnote to this passage Cartwright distinguishes interactions from cases like vector addition of forces in classical mechanics where "rules of composition" apply. Thus, this case is distinguished from cases of counteracting capacities discussed in the previous section.

As a description of "our central usage of tendency terms" (or capacity terms), Cartwright's caveats that capacities only work in appropriate domains and only in the absence of interactions seems correct. But if Cartwright really accepts this view of capacities, she cannot consistently maintain that capacities satisfy *CC* or any other contextual unanimity condition. *CC* demands that *C* raise the probability of *E* across all partitions of a population with respect to any combination of causally relevant factors F_i. This demand is inconsistent with either the domain specificity of capacities or with the caveat about interactions.

I think that the right way to go here is to accept that *CC* need not be met for a property *C* to have the capacity to produce *E*. However, if we are to make Cartwright's suggestion work we need to say something about what constitutes an interaction. Cartwright discusses the problem of interactions in Chapter Four of NCM. As she rightly points out, statistical definitions of interactions are such that they will trivialize claims about capacities. The basic idea of such characterizations is that two exogenous variables are independent just in case each variable contributes the same amount to the expected value of the endogenous variable, regardless of the value of the other variable. Alternatively one can say that if two exogenous variables are independent, their contributions to an effect can be written as separate terms of a linear combination. But, if any failure of independence constitutes an interaction,

> [t]he claim that one can expect the relationship between *x* and *z* to be the same no matter what the level of *y* is, except in cases where *x* and *y* interact, now says no more than this: you can expect the relationship to be the same except where it is different. (NCM, 165)

It is for this reason that Cartwright emphasizes that an interaction must be "a physical process . . . [which is] independently identifiable" (Cartwright 1995b, 180). As Cartwright concedes (NCM, 166), the problem of giving a non-statistical characterization of interaction is a daunting one, but I think she is correct that ultimately we can do so, and to do so we must appeal to physical theory.[3]

It is of course possible to maintain a contextual unanimity approach by demanding of capacities that they operate invariantly, regardless of what other conditions obtain. This is in the spirit of Mill's view of tendencies (as Morrison points out) and in Mill's arguments for what Humphreys calls the unconditionality requirement. The staunchest defense of this approach can be found in Humphreys 1989. Humphreys argues that a putative cause which fails to raise the probability of its effect in all circumstances is not a cause, but only part of a cause (Humphreys 1989, 73). One must include in the cause as many factors as is necessary to ensure genuine contextual unanimity. Humphreys has various reasons for adopting this metaphysical position, but the cost of doing so is quite high. For one thing, it parts ways with ordinary and scientific usage, because we typically call many things causes which are, on Humphreys' account, only parts of causes. More importantly in

3. Salmon has tried to do just this in (Salmon 1984), and his motivations, like those of Cartwright, stem from the conviction that statistical characterizations will not do. Salmon's appeal to physical theory is partially hidden by his use of counterfactuals. His revised theory (Salmon 1994) is much more explicit in appealing to physical theory in order to characterize the notion of a causal interaction.

connection with Cartwright, Humphreys' requirement divorces causes and capacities from measurement. The factors that we typically measure are not completely invariant.[4]

Cartwright cannot have it both ways. She could accept the full blown consequences of contextual unanimity as Humphreys does, but in doing so, she would leave measurement and scientific practice behind, and she would have to give up claims like the one that aspirin has the capacity to stop headaches. Alternatively she could give up the contextual unanimity condition. This is the approach Dupré (1993) favors (for some of the same reasons I have suggested) and I think Cartwright ultimately leans this way as well. However, apart from *CC*, Cartwright has given us no characterization of what we should take capacities to be.

2. Cartwright on Capacities and Laws. One of Cartwright's goals in developing an account of capacities is to argue that laws are of less metaphysical and methodological significance to science than is commonly supposed. In this section I would like to examine what Cartwright takes to be the relationship between laws and capacities, and consider whether she meets this goal.

Cartwright initially proposes that laws are descriptions of capacities:

> It is the singular fact that matters to the causal law because that is what causal laws are about. The generic claims of science are not reports of regularities, but rather ascriptions of capacities, capacities to make things happen, case by case. (NCM, 2–3)

But later she suggests that capacity claims are more fundamental than laws:

> The claim I am going to develop . . . is that the concept of general *sui generis* causal truths . . . separates naturally into two distinct concepts, one at a far higher level of generality than the other: at the lower we have the concept of a causal law; at the higher, the concept of capacity. I speak of levels of generality, but it would be more accurate to speak of levels of modality. . . . (NCM, 142)

There is a tension between the first and second passages. On the one hand descriptions of capacities have a modal character, and it is thus natural to call such descriptions laws. On the other hand, there is another class of lawlike statements which Cartwright sees as describing metaphysically less fundamental features of the world. The difficulty is primarily verbal. Cartwright isolates two kinds of lawlike claims, law claims and capacity claims, but chooses to reserve the term 'causal law'

4. See Woodward 1994 and Glennan 1997 for further discussion of Humphreys' position.

only for the former, weaker kind. This weaker kind is the sort of population-relative law claim that has been discussed by Eells. Cartwright does not explain her reasons for adopting this usage, but clearly one reason is to give an account of the kinds of laws one gets out of proper applications of causal modeling techniques.

According to Cartwright, "what makes the causal law true that *C* causes *E* in [population] T is not the increase in probability of *E* with *C* in T, but rather the fact that in T some Cs do regularly cause Es" (NCM, 144–145). These sorts of laws are what Woodward (1993) has called 'causal role claims'. They are descriptions of how capacities of the various individuals in a population combine to produce certain effects. Note that in different contexts the same sentence may be taken either as a causal law statement or as a capacity claim. For instance, 'Birth control pills prevent thrombosis' may be taken as an ascription of a capacity to the Pill, or as a description of the causal role of the Pill in a particular population. Taken in the second sense, the sentence could be false even if the Pill has the capacity to prevent thrombosis. This would be the case, for instance, if the population in question had no sexually active women, in which case the Pill could not act to prevent thrombosis, since it only does so by preventing pregnancy.

Cartwright's restriction of the term 'law' to population claims is unfortunate, because it overstates the difference between her position and that of philosophers who accept non-Humean accounts of laws of nature. The examples of laws of nature typically cited by philosophers are fundamental physical laws, e.g., Coulomb's law or the law of universal gravitation. These laws are not causal laws in Cartwright's sense because they are not generalizations about populations, but are rather what she calls capacity claims.

Cartwright tries to distinguish laws from capacity claims on the basis of modal strength. Capacity claims are, on her view, stronger than law claims, because individuals carry capacities "from situation to situation" (NCM, 145). As we have seen, however, if Cartwright wants to hold on to claims such as the one that aspirins have the capacity to relieve headaches, she must back off from this universal claim. The capacity will raise the probabilities of its effect in many situations but not in all. Capacities are robust but they are not generally universally invariant. Consequently the difference between capacity claims and causal law claims (in Cartwright's sense of causal law) is not primarily a distinction in modal strength. The difference is that causal laws are about properties of populations, whereas capacity claims are about properties of individuals. Capacity claims are more fundamental because the properties of the population derive from the properties of individuals.[5]

5. By making this claim, I am not supporting theses like methodological individualism

I shall not, in the remainder of this paper, be concerned with causal laws in the population-relative sense. I will therefore take the term 'law' to refer to those sorts of generalizations which Cartwright has claimed are ascriptions of capacities, including the more typical examples of 'laws of nature'. If laws are best understood in this way, has Cartwright really shown that laws are less fundamental than capacities? In one sense, yes: laws, on this view, are descriptions of capacities, and the description is secondary to the thing described. On the other hand, laws in this sense are no more local or context dependent than capacities; the relation is not between truths of different generality, but between a description and the thing described.

3. A New Account of Capacities. I have tried in the previous sections to make two claims plausible: first, the fact that a something has a capacity to cause E does not require that it increase the probability of E in all contexts. Second, many laws can be understood as ascriptions of capacities. In concluding this paper, I will offer an alternative account of capacities and their relations to laws which will do justice to these two claims.

3.1 The Logic of Capacity Claims. What kinds of things do we ascribe capacities to? Capacities are sometimes ascribed to individuals. For instance my computer has the capacity to transmit faxes. At other times we ascribe capacities to types. For instance, aspirins have the capacity to relieve headaches. This latter usage suggests that capacities are properties of properties—a view that Cartwright adopts:

> [A]spirins—because of being aspirins—can cure headaches. The troublesome phrase 'because of being aspirins' is put there to indicate that the claim is meant to express a fact about properties and not about individuals: the property of being an aspirin carries with it the capacity to cure headaches. (NCM, 140)

I think, however, that taking capacities as properties of properties is not the best course, because it seems inconsistent with Cartwright's (and my own) commitment to the primacy of singular causes. If capacities are causal powers, then we want them to belong to individuals. The correct understanding of the claim that "aspirins—because of being aspirins—can cure headaches" is that *individual* aspirins, in virtue of having the property of being aspirins, have another property, the capacity to cure headache. Capacities therefore are properties which

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in the social sciences. Irreducible properties of collectives can be accommodated within this singularist perspective by treating collectives as complex individuals.

individuals have in virtue of having certain other properties. Assertions about capacities of properties should be understood as generalizations about a class of individuals having a certain property.

Capacities are properties, but of what kind? I think they are analogous to functional properties, because they are characterized in terms of their ability to do something. Functional properties are properties which an individual has in virtue of playing a certain causal role. Capacities are similar, except that we attribute capacities to individuals so long as they *could* play certain causal roles. Whether that capacity is manifested depends upon whether the individual having that capacity is placed in the appropriate context. For instance, a piece of iron pipe has the capacity to carry sewage water, but whether it ever exercises this capacity depends upon whether it is ever embedded in an appropriate context, e.g., the plumbing system of a house. A second sense in which a capacity is merely potential is that in some cases capacities may only exercise themselves with a certain probability, even supposing the entities having the capacity are placed in a context where that capacity may be exercised. So for instance, we think that metal detectors in airports have the capacity to detect weapons that are carried through them, even though the detectors will sometimes fail in their detection. This is a different case than one in which the metal detector is never put in a context where it could play this causal role.[6]

3.2 Fundamental and Structural Capacities. That an individual has a certain capacity, i.e., can play a certain causal role, is not typically a basic fact about that individual. In most cases, the individual involved is complex, and it is something about the structural properties of the individual which gives it the capacities it has. Cartwright tells us that aspirins have the capacity to cure headaches because of their property of being an aspirin. But talk of the property of being an aspirin is just shorthand . An aspirin is a complex individual, and the property that makes an individual an aspirin is surely its chemical structure (or certain features of that structure). On the other hand, there are some capacities which do not derive from an individual's structural properties. For instance, an electron has the capacity to accelerate another

6. Note that the distinction between these two kinds of failures to exercise a capacity might disappear under a more detailed specification of the circumstances. It might be, for instance, that the detector's failure to uncover a certain weapon had to do with the particular composition of the weapon, and that actually the detector did not have the capacity to detect weapons of this type. The only way to guarantee that one has an instance of a truly probabilistically exercised capacity would be to choose a capacity that explicitly depended upon objectively indeterministic events such as alpha particle emissions.

charged body. There is here nothing more to say about what gives an electron this capacity—it is a brute fact about electrons. The difference between these two sorts of capacities is a deep one: some capacities are basic, while others depend upon the properties and arrangement of the individual's parts. I shall call capacities of the first kind *fundamental* and capacities of the second kind *structural*.

Structural capacities are *mechanically explicable*. By this I mean that capacities of individuals are exercised via some sort of mechanism whose structure depends upon the structure of the individual having the capacity. In a case involving capacities to detect events or processes, it is natural to speak of the individual having the capacity as being a mechanism. I take a mechanism to be a complex system which produces a characteristic behavior in virtue of its parts interacting according to causal laws.[7] For instance, my radio has the capacity to detect radio signals and convert them into sounds. To understand why it has this capacity one needs to understand what its parts are, what nomological relations obtain between the parts, etc. (I have chosen an artifact as an example of a mechanism because it is perhaps clearest to see, but mechanisms need not be artifacts.) In other cases of mechanically explicable capacities, calling the individual with the capacity a mechanism would be rather forced. For instance, the aspirin itself is not a mechanism for relieving headaches. There is, however, a characteristic mechanism by which aspirin exercises this capacity. This mechanism extends beyond the boundaries of an aspirin itself, for one must describe how aspirin is ingested and distributed through the bloodstream, and the biochemical mechanism by which it interacts with cells to produce the dilation of capillaries which leads to the relief of, among other things, headaches.

Fundamental capacities are not generally mechanically explicable. If one considers the capacity of an electron to repel another electron, this is just a brute fact. However, there are capacities which are fundamental, in the sense that they do not depend upon the structure of the individual having the capacity, but which are mechanically explicable. This fact follows simply from the fact that things have capacities in virtue of potential causal roles, and with enough ingenuity one can find a way to give an individual just about any causal role. For instance, one could presumably create a Rube Goldberg mechanism in which the repulsive force of a single electron played a causal role in the det-

7. See Glennan 1996 for a detailed analysis of the notion of mechanism and of mechanical explicability. I argue that all causally related events, except events at the most fundamental level of physics are connected by mechanisms, and thus that the existence of a mechanism is the constituitive feature of non-fundamental causal relations.

onation of a bomb. Thus, the electron would have the capacity to detonate a bomb. This capacity, however, would be mechanically explicable. Still, the most basic of the fundamental capacities—those expressed by fundamental physical laws—are not mechanically explicable.

3.3 Capacities and Reliability. In the first section of this paper I argued that the presence of an individual with a capacity to produce *E* does not invariably increase the probability of *E*, and that for this reason we should abandon the idea that capacities can be characterized by unanimity conditions like *CC*. Nonetheless, I think that *CC* and contextual unanimity conditions are motivated by a fundamentally sound intuition—capacities are, as Cartwright sometimes says, 'stable' or, as Woodward (1992, 1993) puts it, 'invariant'. An individual carries a capacity with it from context to context. Cartwright's error was to make the overly strong demand of universality. Stability and invariance come in degrees.

We should distinguish two kinds of conditions in which capacities fail to operate. First, in order for a capacity to operate it must be put in a context where that capacity could be exercised. Recall that capacities are a kind of potential functional property. A water pipe has the capacity to carry water even if it is not actually contained in a system where it performs that function. Similarly, the Pill cannot exercise its capacity to prevent thrombosis (via preventing pregnancy) unless it is taken by women who are sexually active.

Even if an individual is situated in a context in which it normally could operate, in certain of these contexts other conditions will obtain which will prevent the exercise of the capacity. The reason for this is that there are mechanisms by which the structural properties which give an individual the capacity in question go about producing or contributing to the effect, and mechanisms can break. A few examples will illustrate this:

First consider the capacity of acid to cause a person's death. First of all, to exercise this potential function, the acid must be ingested by a person. Given that this is the context, there is a characteristic mechanism by which this capacity would operate. Presumably the chemical structure of acids is such that they damage the lining of the stomach and intestines, causing hemorrhaging and eventually death. Suppose however that there is in the stomach an appropriate quantity of an alkali. The alkali would interact with the acid, neutralizing the chemical effect. Inserting alkali into the stomach causes a breakdown of the mechanism by which acid causes death.

Another example is the capacity of a spring, rubber band or other elastic material to resist deformation and hence, e.g., to move an object attached to one end. This capacity is described by some variant of Hooke's law, where the elastic material exerts a restoring force $f = -kx$ proportional to its displacement x from its rest state. Hooke's law applies to a wide variety of media, though each different kind of medium will have a different value of k. For the sake of definiteness suppose we are considering a spring attached on one end to a fixed object and on the other to a small mass, so that as the spring expands and contracts, the mass travels back and forth over a nearly frictionless surface. The capacity of the spring to move the weight is characterized by the strength of the restoring force which is under suitable conditions proportional to the amount of displacement. The reason that we must add the caveat "under suitable conditions" is that the relationship described by Hooke's law will fail to hold if the spring is extended too far. Just how far is too much depends upon the exact characteristics of the spring. There is a mechanism which explains why the spring behaves as it does. The parts of the mechanisms are the constituent molecules in the spring and the reason that the spring resists deformation as it does has to do with the electrostatic forces between the molecules. When the spring is stretched too much, the nature of the intermolecular bonds are altered.

In a passage quoted previously (Cartwright 1995b, 180), Cartwright responds to Morrison's claims about the supposed universality of capacities by indicating that they only operate if (a) they are appropriately triggered, (b) they are within their domain or regime of application, and (c) they are not prevented from operating by a physical interaction. Condition (a) corresponds to my requirement that the capacity be placed in a context where it can operate; condition (b) corresponds to breakdowns like that in my Hooke's law example; and condition (c) corresponds to breakdowns like that in the acid example. Thus it appears that the analysis of the conditions under which capacities fail to be exercised follows closely what Cartwright says in her response to Morrison, though as I argued in the above discussion it amounts to giving up *CC*.

Once one abandons *CC*, it turns out that strictly speaking just about anything has the capacity to do (or contribute to) anything else. Roughly, any individual which could be part of a mechanism or process which ultimately leads to the occurrence of some event has the capacity to cause that event. For instance, the same piece of iron pipe discussed above also has the capacity to kill someone, because it could with the right (or wrong) owner be employed as a murder weapon. The same pipe might also have the capacity to save the president's life, because it could be that the pipe could somehow find its way into the president's arms at precisely the moment at which an assassin fires a bullet at him, and that the pipe could deflect the bullet from its trajectory towards the president's heart, thus preventing his death.

While in principle the pipe does have this capacity, in practice our capacity attributions are guided by the degree to which a capacity is robust or invariant. The capacity of the pipe to save the president's life is extremely fragile: a lot of very special circumstances (circumstances which we have no reason to expect will obtain) would have to come to pass in order for this capacity of the pipe every to be exercised. The degree to which we are inclined to attribute a capacity to a thing can be described in terms of the three conditions mentioned above: First, for a capacity to be robust, the individual bearing that capacity should possibly (perhaps even frequently) come to be situated in a context where it can act (or be triggered). Second, the mechanism by which the capacity is exercised should be resistant to breakdown in a fairly wide domain. Third, the kinds of interactions which could prevent the exercise of a capacity should be fairly rare.

So far we have considered only mechanically explicable capacities. A different story has to be told about fundamental capacities that are mechanically inexplicable. Our account of failures of invariance for mechanically explicable capacities appeals to breakdown conditions for associated mechanisms. In the case of mechanically inexplicable capacities, like the capacity of an electron discussed above, there is no mechanism—the electron's capacities are just a brute fact. Of course, the electron's capacities might not manifest themselves. For instance, there might be another electron positioned in such a way that the fields of the two electrons cancel each other out, but this is a case of a counteracting capacity of the sort discussed previously. Given that there are not mechanisms to break down it is not surprising that it is in the realm of fundamental physical law that one finds the greatest degree of invariance.[8]

One important difference between the characterization of capacities that I have given here and the account Cartwright gives in terms of

8. As Woodward (1992) points out, even our deepest theories have certain restrictions on their domain of application. For instance, he notes, that laws about gravitation derived from general relativity break down at very small distances where one has to account for quantum gravity effects. My own intuition is that this kind of failure of invariance is different from those based upon breakdowns of mechanisms. Where fundamental physical theories such as general relativity theory and quantum mechanics have limits on their domain of application and areas where their predictions conflict, we are inclined to see this as a defect of the theories involved. In cases like that of Hooke's law, we have a theoretical account of the mechanism producing the lawful behavior which yields an account of why the boundary conditions obtain.

contextual unanimity is that I have made no mention of probabilities. This is because capacities belong to individuals, and the probabilistic apparatus behind *CC* is meant to measure features of populations. Cartwright's condition *CC* is really meant to tell us whether in a certain population a factor *C* has invariantly increased the probability of an effect *E*. Whether this is going to be the case depends upon the population. The probabilities are generated by partitioning the population by causally relevant factors and collecting statistics. It is not clear at all how to apply this to the individual case. To understand individual capacities, we must understand the structural properties of the individual in question and understand whether and under what conditions those structural features contribute to the bringing about of some effect. There are some cases in which the capacities of individuals will be truly probabilistic, in the sense that whether a capacity is exercised or the strength of the capacity may depend upon objectively indeterministic events. If this is the case then single-case probabilities will show up (interpreted as propensities) in our descriptions of the mechanisms which give the individual its probabilistic capacity. But genuine objective probabilities are, as I have argued elsewhere (Glennan 1997), hard to find, and there is no reason to believe that the differences between individuals within a population are due to differences in the outcome of objectively chancy events.

3.4 Laws as Capacity Ascriptions. I would like now to reconsider Cartwright's proposal that laws are capacity ascriptions in light of my proposed analysis of capacities. To say that laws are capacity ascriptions is to say that laws are descriptions of the actual or potential behavior of individuals. It is the individuals that are doing the acting. The capacity ascription account of laws should be contrasted with two other accounts, Humean (or anti-realist) accounts and the Armstrong-Dretske-Tooley account of laws as relations between universals. The view differs from the Humean view because it supposes that laws are not descriptions of actually occurent regularities, but rather of capacities which may not manifest themselves. The difference between the capacity ascription account and the universalist account is that on the capacity account there is no transcendental relation between properties that *governs* the behavior of individuals. The individuals are doing the acting, and the laws are just descriptions of what they do or tend to do. Woodward, who explicitly has defended the capacity ascription account of laws over a universalist account emphasizes that the capacity account squares better with the *ceteris paribus* character of laws than does the universalist one:

> [A]n account of laws which relies on notions like invariance and stability seems to fit naturally with the idea . . . that laws are abstract (and often highly idealized) descriptions of capacities and dispositions characteristic of particular objects or systems, rather than descriptions of special relations between universals. There is nothing mysterious about the idea that a sample of gas might possess the sort of stable disposition described by the ideal gas law under a certain range of circumstances, but that this disposition should break down or behave differently under other circumstances (e.g., under extreme pressures). By contrast, if the ideal gas law describes or is made true by a relationship between transcendent universals, it is arguably less natural to expect that this relationship should hold in some circumstances, but not others. (Woodward 1992, 205)

The point is that if we see laws as abstract descriptions of the behavior of individuals and if we take the behavior to be produced by mechanisms involving the structural features of the particular individual as well as features of that individual's context, it is easy to see (a) why the behavior of individuals will only approximately conform to the predictions of the law, (b) why the behavior of different individuals will differ, and (c) why sometimes the law will fail to apply to some individuals. Each of these features follows from the fact that laws are just descriptions of the behavior of individuals, and that individuals differ both in internal structure and external circumstances.

The capacity ascription view of laws also shows that one cannot, as is often supposed, treat the objects in the universe and the laws that govern the universe as independent categories. There aren't possible worlds where all of the objects are the same but the laws are all different because what the laws are depend upon configurations of particular individuals. Consider for instance Mendel's second law. This law says roughly that during the process of gamete formation, in which one member of a gene pair is taken from each locus, the choice at one locus is independent of the choices at other loci. This law is really just a description of how a particular type of mechanism behaves. The reason that it applies to most organisms on earth is that most such organisms have, in the respects relevant to meiosis, similar cellular structure and reproductive mechanisms. Furthermore, the circumstances under which the law fails to apply (most notably where the loci in question are located near together on the same chromosome) are also fixed by the mechanism. If the actual particulars of our cellular reproductive systems were even slightly different, e.g., if there were fewer chromosomes and if crossing-over was more rare, then Mendel's second law would fail to be even approximately true. Changing the particulars changes the mechanisms, which changes the laws.

One might suspect that the dependence of law on particulars is a special feature of Mendel's Second Law and similar laws which describe the behavior of very specific mechanisms. I would, however, argue that any law ascribing what I have called a structural capacity is of this kind. Woodward's example of the ideal gas law illustrates this point. The ideal gas law is, as Woodward suggests, a description "of particular objects or systems". Whether this law provides an adequate description of a certain system depends upon whether the particular parts of the system (e.g., the gas molecules and the enclosing vessel) are configured within certain constraints. While these constraints are certainly looser than those associated with Mendel's second law—many more physical systems satisfy the former than the latter—the difference is only one of degree.

It is not so clear whether the arguments for the capacity ascription view of laws work for fundamental laws. While one can certainly view, e.g., Maxwell's equations, as ascribing fundamental capacities to individuals, in this case one cannot appeal to the sort of arguments Woodward offers to prefer a capacity account over a universalist one.[9] The reasons (a–c above) offered in favor of the capacity ascription view for non-fundamental laws do not apply here. Electrons, for instance, do not appear to behave in approximately the same manner, but in exactly the same manner. Again, laws of this kind don't appear to break down in the same way in which, e.g., the ideal gas law does. While it is true that actual applications of fundamental laws do involve approximation and limits on domains of applicability (see note 8), it is at least conceivable that one might find fundamental laws that are precise and exceptionless. Were this circumstance to obtain, then I think that the distinction between the singularist and the universalist account would lose its empirical content. If one had a law relating properties of one individual to properties of another individual, and all pairs of individuals having these properties behaved exactly as the law prescribed, then it seems that no true distinction could be drawn between the claim that the individuals are acting as they are because of their intrinsic capacities, and the view that they are acting in virtue of a relation between universals. While I think that to "explain" this law

9. There are some fundamental laws which are difficult to construe as claims about capacities. Conservation laws and symmetry principles don't seem to fit, nor do laws like Newton's second law, which seem to me to describe ways in which various capacities are composed. Cartwright (1995a, 155, note 1) goes further. She, for instance, explicitly argues that Newton's second law is a capacity ascription.

by reference to a relation between universals is to replace one mystery with another, much the same thing can be said about "explaining" the law by reference to brute capacities of the individuals.

3.5 The Metaphysics of Capacities. In the introduction to NCM, Cartwright remarks:

> The point of this book is to argue that we must admit capacities, and my hope is that once we have them we can do away with laws. Capacities will do more for us at a smaller metaphysical price. (NCM, 8)

Whether we have to admit capacities, and whether we can do away with laws depends a great deal on how we understand 'admitting' and 'doing away with'. If the capacity ascription view of laws is correct, we can do away with laws in one sense. We don't have to think that there are two metaphysical categories—particular facts and general laws. On the other hand, laws will never leave us, for they are the instruments we use to characterize capacities. But what of capacities? What sort of metaphysical commitments do we need to license our use of capacities?

If capacity claims are analogous to causal role claims, then we need not think that the usefulness of capacity talk implies that capacities are a new metaphysical kind. When we ascribe a capacity to something, we say what it can do. But the capacity claim is just a placeholder, a kind of dispositional property. We expect an account of what properties of the individual give it that capacity. Smoking causes cancer—this is a capacity claim. But the explanation does not stop here. We want to know what it is about smoking that causes cancer—we want to know what the relevant properties of cigarette smoke are and we want to know the mechanism by which instances of these properties cause cancer. There are, as I have indicated, some capacities for which we cannot give any further explanation—those capacities typically described by fundamental physical law. These sorts of capacities do demand an ineliminable place in our ontology, but this is not big news metaphysically.

I think the more novel and enduring aspect of Cartwright's advocacy of capacities over laws has to do with her analysis of laws as capacity ascriptions. If her analysis is, as I have argued, correct, then it gives further weight to a singularist approach to causation. Causal laws are idealized descriptions; what actually happens depends upon the properties of the individuals involved.

While I agree with Cartwright that we must adopt a singularist approach to causation, there are nonetheless a number of respects in which, even within this approach, causation is general. Let me mention a few of these respects: First of all, capacities of individuals are stable or invariant, and for that reason they are appropriately described by lawful generalizations. As we have seen in our discussion of *CC*, these laws are not completely general—they are idealizations and are true only ceteris paribus. Nonetheless, it is an important contingent fact about our world that there are many features of it which are stable and may be described by lawful generalizations.[10] Second, even if the set of causal factors which lead to the effect are peculiar and are never actually repeated in the world, the claim that this set of factors caused the effect is "counterfactually general," because if a sufficiently similar set of causal factors were to arise, the same kind of effect would occur (or supposing that the relation between the set of factors and the effect is indeterministic, the increase in probability of the effect would be the same). The truth of this counterfactual depends upon the stability of the capacities involved in producing the effect. This stability is expressed by the fact that the capacities involved in the production of the effect can be described by laws (which of course support counterfactuals). A third sense in which causation is general is that often large classes of individuals have similar kinds of capacities, and hence can be described by the same idealized lawful generalizations. Thus, for instance, one can make idealized lawful ceteris paribus generalizations about meiotic and mitotic processes that apply to a very wide class of individuals (here cells), because all the members of this class have similar structures which give them similar capacities. Finally, the particular mechanisms which realize a capacity comprise systems of parts connected by laws (though, as I have indicated, except in the case of fundamental laws, the connecting laws will be mechanically explicable) (cf. Glennan 1996).

While I have joined Cartwright in adopting a singularist view of causation, I hope these remarks have shown that to lay too much emphasis on this fact is to forget the important role of causal generalizations. We should not become too distracted by the metaphysical issue, because it tends to obscure from view the rich interplay of singular and general aspects in our practices of causal explanation and inference.

REFERENCES

Cartwright, N. (1979) "Causal Laws and Effective Strategies", *Noûs* 13: 419–437.

———. (1983), *How the Laws of Physics Lie.* Oxford: Clarendon Press.

———. (1989), *Nature's Capacities and their Measurement.* Oxford: Clarendon Press.

———. (1995), "Précis of *Nature's Capacities and Their Measurement*", *Philosophy and Phenomenological Research* 55: 153–161.

10. See, however, Heathcote and Armstrong 1991, who argue Kripke-style that the connection between laws and causes is *a posteriori* but necessary.

———. (1995b), "Reply to Eells, Humphreys and Morrison", *Philosophy and Phenomenological Research* 55: 177–187.

Dupré, J. (1993), *The Disorder of Things: Metaphysical Foundations of the Disunity of Science*. Cambridge, MA: Harvard University Press.

Eells, E. (1991), *Probabilistic Causality*. Cambridge: Cambridge University Press.

Glennan, S. (1996), "Mechanisms and the Nature of Causation", *Erkenntnis* 44: 49–71.

———. (1997), "Probable Causes and the Distinction between Subjective and Objective Chance", *Noûs* 31:496–519.

Heathcote, A. and D. Armstrong (1991), "Causes and Laws", *Noûs* 25: 63–73.

Humphreys, P. (1989), *The Chances of Explanation.* Princeton: Princeton University Press.

Maudlin, T. (1993), "Review of *Nature's Capacities and their Measurement*", *Journal of Philosophy* 90: 599–603.

Morrison, M. (1995), "Capacities, Tendencies and the Problem of Singular Causes", *Philosophy and Phenomenological Research* 55: 163–168.

Salmon, W. (1984), *Scientific Explanation and the Causal Structure of the World.* Princeton: Princeton University Press.

———. (1994), "Causality without Counterfactuals", *Philosophy of Science* 61: 297–312.

Skyrms, B. (1980), *Causal Necessity*. New Haven: Yale University Press.

Woodward, J. (1992), "Realism about Laws", *Erkenntnis* 36: 181–218.

———. (1993), "Capacities and Invariance", in J. Earman, A. Janis, G. Massey and N. Rescher (eds.), *Philosophical Problems of the Internal and External Worlds: Essays on the Philosophy of Adolf Grünbaum*. Pittsburgh: University of Pittsburgh Press, pp. 000–000.

———. (1994), "Review of Paul Humphreys' *The Chances of Explanation*", *British Journal of Philosophy of Science* 45: 353–374.