Necessitarianism and Dispositions

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In this paper, I argue in favor of necessitarianism, the view that dispositions, when stimulated, necessitate their manifestations. After introducing and clarifying what necessitarianism does and does not amount to, I provide reasons to support the view that dispositions once stimulated necessitate their manifestations according to the stimulating conditions and the relevant properties at stake. In this framework, I will propose a principle of causal relevance and some conditions for the possibility of interference that allow us to avoid the use of *ceteris paribus* clauses. I then defend necessitarianism from recent attacks raised by, among others, Mumford and Anjum, noting that the antecedent strengthening test is a test for causal relevance that raises no difficulties for necessitarianism.

Keywords: dispositions, properties, necessitarianism, modality, antecedent strengthening.

1. The question

Dispositional properties manifest their effects in specific stimulating conditions or in interaction with partners. Classic examples in the philosophical and scientific literature are solubility and fragility. Something is soluble if, when immersed in a liquid, it dissolves; similarly, fragility is manifested if something shatters when struck. We are all acquainted with these kinds of properties, which are not confined to the physical world, but also found in the psychological world, such as when we consider someone irascible who is quick to react if provoked. The crucial issue is the strength of the relation between the stimulating conditions S and the manifestation M of a dispositional property D. Take a delicate glass, hit it with a hammer: will it *necessarily* shatter or rather will it *typically* shatter? What happens when a dispositional property is not manifested or is prevented from manifesting itself, as when we wrap the glass in bubble wrap? The importance of these questions derives from our need to understand how strongly change and stability cleave together or, better, how strong the stability we can find in change is. Many authors think that the relation between the manifestation of a disposition and its stimulating condition is one of easing (Vetter 2015) or of habitual doing (Fara 2005) or a *sui generis* modality between possibility and necessity (Mumford and Anjum 2011), surely not one of necessitation.

One way to address the "modality status" of these properties is to resort to *ceteris paribus* clauses: this allows us to sidestep the apparently endless exceptions that may interfere or prevent the manifestation of a disposition. Basically, by using *ceteris paribus* clauses, a disposition is analysed into a conditional sentence of the form "if object O is given stimulus S it will manifest M *ceteris paribus*". Gabriele Contessa

(2013), in a thoughtful paper, has argued that it is possible to provide such a conditional analysis using a non-circular specification of the proper conditions in which a disposition is manifested. My aim in this paper is to follow Contessa's line of reasoning, setting conditions under which we can reduce the number of the *ceteris paribus* clauses from a given law or conditional statement to eventually eliminate them altogether, thus supporting the idea that stimulated dispositions necessitate their manifestations. This result can be achieved by clarifying which relevant properties are at stake when the conditional manifestation of a dispositional property is set.

In what follows, I will state the necessitarian view in general, then I will advance my own view on how necessitarianism could be improved; finally, I will argue that the antecedent strengthening test proposed by Stephen Mumford and Rani Anjum (2001) against necessitarianism is a test for causal relevance rather than a test for the modal force of dispositional properties, and should be used as a method to eliminate the *ceteris paribus* clauses. My purpose here is to argue that an object having a disposition will *necessarily* manifest it in the proper circumstances or under the proper stimulation, and in so arguing I will take Mumford and Anjum to be my main opponents.

2. Necessitarianism

The necessitarian view has been stated in different ways by different authors. Brian Ellis argues that everything with disposition D that undergoes stimulus S (or that has contact with a powerful partner such that stimulus S is produced) will necessarily manifest M, as in:

1) $\forall$xNec. ((Dx & Sx) → Mx) (Ellis 2001: 286)

Alexander Bird, for his part, has argued that (reading $D_{(S,M)}x$ as x has the Disposition to manifest M under stimulus S) from:

"i) $\Box$ ($D_{(S,M)}x \leftrightarrow Sx \Box\!\!\rightarrow Mx$) and

ii) $\Box$ ($Px \rightarrow D_{(S,M)}x$) we can derive:

iii) $\forall x$ ((Px & Sx) → Mx)"[1]

but that, given the possibility of interference in the manifestation of the disposition, i) is false, and we must add a *ceteris paribus* clause, to conclude:

2) $\forall x$ (*ceteris paribus* (Dx & Sx) → Mx)) (Bird 2007: 59-60, renumbered).

[1] This line should have been $\Box \forall x$ ((Px & Sx) → Mx), a thesis that Bird states on p. 48, but he develops this only for fundamental properties.

To put Bird's argument into words: If (i) necessarily, *x* is disposed D to manifest M in response to stimulus S if and only if when stimulated it manifests M,[2] and (ii) necessarily, if *x* has property P then it is essentially disposed to yield M if stimulated S, then (iii) for all *x*, if *x* has property P and is stimulated S, then it manifests M. However, since the manifestation of all dispositions – excluding the fundamental ones – can be interfered with, it is crucial to add the *ceteris paribus* clause (2). The views put forward by Ellis and Bird are, in fact, similar. Both views take the relation between the stimulated disposition and its manifestation to be a necessary one or to invariably occur *ceteris paribus*, and they derive the laws of nature from such relations: the tighter the relations, the stronger the laws. In Bird's view, because hidden interferences are absent only at the most fundamental level of reality, it is only at this level that these relations are necessary. At this level, then, we can dispense with *ceteris paribus* clauses, and the laws built on these fundamental relations are necessary. So, thesis 2 holds for all properties; for properties at the most fundamental level, Bird's view holds in its stronger form as in *iii*.[3] Can we defend the necessitarian view not just at the fundamental level but at all levels? It is the purpose of this paper to reply in the affirmative and to find a way to pinpoint which properties determine the possible interferences that force one to add the *ceteris paribus* clause, so to dispense with the *ceteris paribus* clause even at a non-fundamental level.

Before diving into this problem, though, it is important to make clear what necessitarianism *doesn't* say. In arguing that dispositions should be analysed according to a *sui generis* modality, one weaker than necessity but stronger than mere possibility, Mumford and Anjum (2011a, 2011b) criticize necessitarianism, showing the defensibility of these four claims:

3) $\sim(DMa \rightarrow \Box Ma)$ (Dispositions don't always manifest);

4) $DMa \rightarrow \sim\Box Ma$ (Dispositions can always be prevented);

5) $\sim(\Box Ma \rightarrow DMa)$ (Cases of necessity are not always cases of dispositionality);

6) $\Box Ma \rightarrow \sim DMa$ (Cases of necessity are never cases of dispositionality) (Mumford and Anjum 2011b: 386).

Taking 3 as an example, with M being *shattering,* Mumford and Anjum's thesis can be read thus: it is not the case that if *a* has the disposition to shatter (*a* is fragile) then it

[2] The $\Box\rightarrow$ symbolizes the subjunctive / counterfactual conditional, as in Lewis (1973).

[3] On the issue of dispositions, powers, and laws, see Kistler (2012.

necessarily shatters.[4] Now, leaving aside that Mumford and Anjum do not mention stimuli, a problem with their attack on necessitarianism is that they take properties rather than relations to be necessary. Necessitarianism, however, takes *relations* to be necessary, not properties.[5]

Consider claim 3: placing the modal operator on properties rather than on relations is tantamount to committing the "modal scope fallacy", which consists in failing to recognize that the scope of the necessity operator is on the *consequence* relation (the whole conditional) rather than solely on the *consequent* of the entailment. As Sider puts it, "the distinction between $\phi \rightarrow \Box\psi$ and $\Box(\phi \rightarrow \psi)$ is called the distinction between the 'necessity of the consequent' and the 'necessity of the consequence'" (Sider 2010: 176). What bearing does such a misreading have on this matter?

If the necessitarian view is taken to hinge on the presence of necessary properties, this makes the dispositional view somewhat self-defeating. In this regard, Mumford and Anjum themselves say, "A necessarily manifesting property looks to be, if anything is, a categorical property, and this rules out the case of a disposition involving manifestation" (Anjum & Mumford 2011b: 387). A categorical property is a property that depends on the local laws of nature for its interactions with the world. It is a property that keeps itself to itself, to paraphrase Armstrong (1997: 80).[6] If a property necessarily manifests itself, this means it has no dependence on any stimuli or conditions. If necessitarianism were so interpreted, it would entail that there are no unmanifested dispositions. If there were no unmanifested dispositions, there would be no dispositions at all, because dependence on the presence of a condition or a stimulus for manifestation is part of what it means to be a disposition. True, some authors (e.g. Vetter 2015) deny that dispositions necessarily request stimuli, but they do not deny that dispositions necessarily fail to always manifest. Consequently, the only interpretation compatible with the theses endorsed by Ellis and Bird is to take the modal operator as

[4] The other cases show that dispositions can always be prevented (4); that cases of necessity are not always cases of dispositionality (5) and that cases of necessity are never cases of dispositionality (6). The last one, as Mumford and Anjum recognize, is the most difficult to argue for.

[5] See Ingthorsson (2013) for an interesting analysis on how to conceive of dispositions in this respect.

[6] Black (2000) argues that categorical properties are causally inert. Hutteman (2007) has also argued that dispositions can be taken as continuously manifesting dispositions, but not as necessarily manifesting. I am assuming that the distinction between categorical and dispositional properties is accepted. For a general review see Choi and Fara (2012). For arguments against the distinction, see Martin (2008) and Heil (2003).

applying to the consequence relation. To make a case against necessitarianism, the proper formulation of those theses might be[7]:

3*) $\sim\Box\forall x\,(D_{(S,M)}x \rightarrow (Sx \rightarrow Mx))$;

4*) $\forall x\,\Diamond\,(D_{(S,M)}x \,\&\, Sx \rightarrow \sim Mx)$;

and analogously for 5 and 6, whose appropriate formulation should have been:

5*) $\Diamond\forall x\,(Mx \rightarrow \sim (D_{(S,M)}x \,\&\, Sx))$

6*) $\forall x\,\Box\,((Sx \rightarrow Mx) \rightarrow \sim D_{(S,M)}x)$.

Having dispelled these possible misunderstandings, let us go back to the main problem: can we do without *ceteris paribus* clauses in the analysis of dispositions?

3. "Dispositions can always be prevented"

Ceteris paribus clauses are the technical solution for bracketing all the possible ways in which a dispositional property might not manifest itself once the proper conditions obtain or once it has been stimulated. But how metaphysically deep are these clauses intended to be? On the one hand, Mumford and Anjum (2011a: 76) say, "If two tokens of the same dispositions were placed in identical contexts – identical in every causally relevant respect for that disposition – they would produce identical manifestations". So, as Markus Schrenk underlines (2016: 76), "there is a sense of necessity that Mumford and Anjum acknowledge" because identity of contexts can be interpreted, as Schrenk interprets them, as identity of worlds. On the other hand, they argue that there is no need to move from this to the stronger claim that identical manifestations are *necessitated* by the same dispositions. A case in point is that of indeterministic dispositions, such as radioactive decay. We know that two identical tokens of radioactive material placed in identical circumstances may differ in their manifestations, in that one may decay at some time *t* while the other may not. To what extent should we take this as a problem for necessitarianism? The necessitarianist can have two possible responses: to bite the bullet and accept that indeterminism and necessitation are not compatible with each other, and that one must conditionally limit necessitarianism to deterministic phenomena; or to argue that this argument is not compelling: let's see this second thread. In decay phenomena, besides the instability of the atomic nuclei, time is the crucial factor. However, time differs across the various occurrences of decay

[7] I have re-written the theses in analogy with Bird's notation, having D as disposition, S as stimulus and M as manifestation. Even if the formulations proposed are more appropriate than those proposed by Mumford and Anjum, I am not committing myself to all of them.

phenomena: so, there is no way to claim that the entailment "given an amount of time *x,* this particle will decay" fails, because – given indeterminism - the antecedent cannot be established in a rigorous and stable way. Why choose *x* to be 10,000 years as opposed to 10,001? If there is no principled way to set the antecedent, there is no way to be clear about the truth-conditions of the entailment. Necessitarianism is still alive.

Setting aside the issue of indeterministic phenomena, the main argument Mumford and Anjum enlist against necessitarianism is that "the possibility of prevention [in the sense of both negative and positive interference] leaves no room for any kind of necessity in causal production" (2011a: 53). This argument, which is based on ideas brought into play by Antony Eagle (2009) and Schrenk (2010a), aims at deterministic, not indeterministic dispositions.

In arguing that deterministic dispositions can always be prevented, does "always" have an implicit modal force?[8] For one may immediately raise the question: if disposition D can always be prevented, is this tantamount to saying that D can necessarily be prevented? This would be a necessitarian thesis in disguise, one in which a meta-anti-disposition is ready to be triggered if the disposition is correctly stimulated. Mumford and Anjum may rebut that "always" is not modal. A more plausible reading is the following: if disposition D occurs along with an activating power, then in any case there is the possibility that a preventer may block its manifestation.[9] Basically, preventers of D can be as varied as we like, so that whenever D is stimulated, there will be some preventer or another that interferes with its manifestation.[10] In this case, the apparent endlessness of the preventers is sufficient in Mumford and Anjum's eyes to block any necessitation relation that might lead from stimulus to manifestation given any disposition. It is time to see how necessitarianism addresses this difficulty.

4. Necessity

Necessitarianism allows us to deal with the co-occurrence of mutability and stability in this world, without assuming that this is simply a matter of regularity or counterfactual dependence. For if regularity were the norm, deviant cases could be analysed as infrequent cases, possibly due to interfering factors. Then we would still have

[8] Eagle (2009: 20) takes "always" to be a temporal analogue to alethic necessity.

[9] This interpretation can be formalized as follows: For all *x*, if *x* is disposed D and is stimulated S, there is a possible *y* such that *y* is a preventer P such to block the manifestation M of *x*, that is: $\forall x \exists y$ (D*x* & S*x* $\rightarrow \Diamond$ (P*y* & ~M*x*)).

[10] Various interferences are possible, including finks, masks and antidotes. I will consider them below, putting positive masking aside.

interfering factors, without being clear about what kind of reliability we could attribute to the regularity of the events. Perhaps the reliability of the causal relations is a function of the number of deviant cases. But then we would be left with further questions: what makes deviant cases deviant? Can we obtain deviant cases regularly? It seems to me that these questions point to the fact that we are not looking for a statistical solution; rather, we want to know *why* the deviance occurred, what went wrong in the structure of the relation understood as causal. This question is also left unanswered by the idea that causal relations are nothing but counterfactual dependences. For we may record that for some events *c* and *e*, had *c* not happened, *e* would not have happened either. But counterfactual dependence relies on factual dependence, and it is not possible to generalize from factual dependence to counterfactual dependence unless we assume that there are *types* of events that establish relations robust enough to support the counterfactuals. In such a case, though, we are left with the question: how modally robust are these relations? Consequently, a commitment regarding the modal force of such relations is needed anyway.

So-called *Dispositional essentialism* came to the rescue by coupling Aristotelian essentialism, the view that entities have some properties essentially – as part of their nature – with the dispositional view, according to which properties are ultimately irreducible dispositions that determine the way entities causally interact with each other (cfr. Schrenk 2016). The very nature of a property, then, is to confer on its bearers the causal powers they manifest (Shoemaker 1980). These causal powers can be appreciated in interaction with other causal partners (Ingthorsson 2002; Heil 2012). With dispositional essentialism, necessitarianism comes as part of the bundle: if entities have their properties essentially, this means that they have these properties necessarily. If such properties are *individuated* by the causal powers they confer, these powers are necessary as well. Thus, dispositional essentialism sees the causal relations determined by these properties as necessary, which is the main tenet of necessitarianism.

A disposition D is essentially individuated by its causal relations, defined as the kind of manifestation/ output it produces given the activating power/input it encounters. Being so individuated, disposition D wouldn't be the property it is unless it engaged in those relations. However, if either the acting powers or the manifestations of a disposition are interfered with, the disposition is consequently also interfered with. If a disposition is interfered with, there is a sense in which we can say that it is not the original disposition we are talking about anymore, because the input/ output relations

have changed. However, one may want to resist this conclusion. The way out is either to say that a property cannot be essentially or necessarily characterized by its causal relations, thus renouncing dispositional essentialism, or to say that the stimulating or triggering conditions of the disposition were different from those that hold in similar cases when the expected manifestation occurs. It is this second path that I want to explore.

Let us consider the manifestation M of a disposition D by some stimulation S (for instance, the striking of a fragile glass) as a causal relation. The causal relation $S_D \Rightarrow M_D$ can be depicted as involving one or more powers P_1, P_2, … P_n, that belong either to the stimulus or to the object or both the dispositional partners (e.g.: the structure of the glass, the magnitude of the mass striking it, its momentum, etc.). The necessitation relation in force between S and M holds in virtue of all the powers involved. We cannot have a change in the causal relation $S_D \Rightarrow M_D$ without a change in one or more of the powers of that causal relation. Therefore, to interfere with the necessitation brought by S on the bearer of D such that this bearer will manifest M, a preventer must interfere with one or more of the powers at play.[11] That is, for something to qualify as an interferer with disposition D it must have the right kind of causal powers and to a sufficient degree.

S and M, the essential features of disposition D, are events, each having one or more constitutive powers (following Kim's view of events – Kim 1976) as brought about by one or more bearers. So the relation is that S (in virtue of its powers P_{1S}, P_{2S}, … P_{nS}) causes M (i.e. its powers P_{1M}, P_{2M}, … P_{nM}), and for something to qualify as a preventer of such a relation it must interfere either with some member of the first set or with some member of the second set or with one or more members of both sets. So, the apparently endless ways in which a causal relation can be interfered with[12] are a function of the powers involved in the relation. And the powers involved are not endless, because the *relata* are actual events.[13] In this way, both the stimulus or trigger and the manifestation

[11] The relation between disposition and powers as described here is parallel to another distinction, originally proposed by Borghini and Williams (2007). These two authors distinguish between *dispositions* and *dispositional properties*. "Disposition", they argue, is a generic place-holder for a certain kind of relation (e.g. solubility); "dispositional properties" are those fine-grained causal relations that determine the way in which, for instance, salt is soluble in water and not in alcohol while iodine is the opposite. I prefer to use "powers" instead of "dispositional properties" to avoid confusion between "dispositions" and "dispositional properties".

[12] See Armstrong (1983: 149) and Contessa (2013: 404) for concerns in this regard.

[13] An alternative argument on this point could be the following: the more specific D is, the fewer the Ps that can be realizable robustly. Take D to be the disposition to be scratched ("scratchability"). If *x* is a sapphire (a variety of corundum) then only a diamond can scratch it. Therefore, any candidate for preventing the sapphire from being scratched must impede the physical contact between the two;

are taken as maximal state, that is, states maximally specified and such that any change in any part of them determines a different causal relation.

To illustrate this point, imagine a simplified world.[14] In this world, there is only one object O, having disposition D, by the interaction of power P, pertaining to O, and power Q which, by triggering P, determines manifestation M. It is only by acting on either P or Q or both that D can be prevented from manifesting M. A fink would prevent Q from interacting with P, a mask would modify the way in which P and Q interact, an antidote would constitute an early-acting anti-Q, preempting Q's interaction with P, and a mimic would be some non-D Object manifesting M. Excluding the case of the mimic, which violates the example by adding something, it is only by acting on either P or Q that interference can occur. And the action on P or Q must amount to something incompatible with the way in which P or Q interact. Clearly, if we add a further power, say K, the interferer may also interact with it, but the point is that to have causal effects, the interferer must interact with the causal relations at stake. So any interferer must interact with the fundamental powers involved in the causal relation. One general principle that can be established to define this interaction is the principle of causal relevance. I define it as follows:

Causal Relevance: Property P is causally relevant to relation R if and only if variations in the value/ magnitude of P result in variations in the value/ magnitude of R.

The null condition of this principle is that in which variations of P do not result in variations in R; in such a case P isn't causally relevant to R.[15] If any variation in P results in some variation in R then P is causally relevant, but its relevance could be due to other and co-occurring properties. If there is a *correlation* between the magnitude of P and the magnitude of R then P is crucially relevant to R. For instance, if variations in P are linearly/ logarithmically/ *x*-ly correlated with variations in R, then P is a fundamentally relevant property for relation R. Notice that the correlation can be very complicated, as is the case for temperature and conductivity in superconductivity, but if

otherwise it will fail to prevent the power of diamond to scratch sapphire. Consider the fragility of glass. The shattering of the glass can be prevented by anything that blocks the direct application of a force $\geq n$ for n taken as the value sufficient to overcome the bonding relations in the lattice structure of the sample of glass under consideration. As we know there are many ways to prevent this before or after contact is made (Contessa 2013). However, in every case the preventers must interfere with this fundamental property. Vetter (2015) argues against this view, but I cannot enter this discussion here.

[14] Here I am imagining a condition parallel Bird's fundamental level.

[15] A threshold effect may be obtained, that is, one in which insufficient variations in a (relevant) P do not result in any variation in R.

it can be tracked then its relevance holds. Once this principle has been established, causal interactions, as those in which interferers play a role, can be better understood. Let us define more generally the conditions for interaction, conditions that interferers as well should meet:

Interaction by I with disposition D of object O occurs iff:

1) P_1, P_2, … P_n are all and the only powers involved in O's stimulation/ association with the causal partner during time interval t_1-t_2;
2) *I*, at time interval t_1-t_2, exemplifies either P_1 or P_2 or … or P_n;
3) The presence of *I* results in a modification in the value (vector/scalar) of one or more powers P_1, P_2, … P_n exemplified after t_2.

What these conditions say is that the only way in which it is possible to interfere with a disposition D is by having properties that are causally relevant for the $S_D \Rightarrow M_D$ relation to obtain, and that are present in sufficient proportion. Basically, the *P*s specified in these conditions implement the principle of causal relevance by showing: 1) that we must look at the relevant powers; 2) that the interferer must be causally relevant, and 3) that that interferer is what determines some causal effect as expressed in the principle of causal relevance. It is important to note that condition 3 differs according to the type of interferer at stake, for there might be cases in which an interferer causes an all-or-nothing prevention or a proportionality effect (a venom antidote). These conditions cannot be changed without changing the relation as well. They should be considered as a comprehensive whole. One may ask, how can we distinguish between interferers and the causal partners of D? We can't: an interferer is simply an unexpected causal partner of D, one that wasn't intended to be at stake. Basically, every entity that may manifest powers P_1, P_2, … P_n is a potential causal partner for D, that may interact with it. I think most of the discussion has been vitiated by the thought that there is a crisp and clear distinction between ideal conditions and interferences. Every causal relation, among which dispositions manifestations belong, sets its own condition. This point makes it evident that necessitarianism implicitly endorses another principle, one that I will name after Hobbes:[16]

[16] I attribute this principle to Hobbes with reference to several passages in his dialogue with Bramhall in *Liberty and Necessity*: "If there be a necessity that an action shall be done or that any effect shall be brought to pass, it does not therefore follow that there is nothing necessarily required as a means to bring

Hobbes' Principle: All the relevant powers involved in a causal relation are necessary for it to obtain.

Hobbes' principle states that a causal relation is individuated by all its relevant powers, those that make the relation what it is. Thus, my defence of necessitarianism depends on accepting the principle of causal relevance, the conditions for it to operate and Hobbes' principle. Therefore, necessity applies to maximally specified relations.[17] Modifying any of the conditions would bring about a different relation because different powers would be at stake. Schrenk stresses this point, saying, "metaphysical necessity is discrete: that two specific properties or event types … are necessarily linked together … has no bearing whatsoever on the instantiations and correlations of any other properties or event types even if they are very much [a]like" (Schrenk 2010a: 732). Committing to the necessity of the relation $S_D \Rightarrow M_D$ doesn't commit one to the necessity of the relation $S^*_D \Rightarrow M_D$, where S and S* are similar to each other. If it is the case that $S^*_D \Rightarrow M_D$, that doesn't mean that there is some flexibility in how M can be caused: rather, it shows that necessity applies to the many ways a disposition may manifest itself and that what differentiates S from S* is some power irrelevant for the causal relation at stake (cfr. Vetter 2015; Schrenk 2016: 278, n. 59). Finally, notice that this is compatible with a disposition never manifesting itself: that it remains a potentiality indicates that the proper stimuli/conditions have never been manifested. Necessity, then, holds for the various relations as set by the relevant causal conditions at stake. One criticism must be considered now: the anti-necessitarianism of Mumford and Anjum.

5. Against necessitarianism: the test of antecedent strengthening

Mumford and Anjum's conviction that necessitarianism about dispositions fails is based on the idea that "any causal process can be interfered with or prevented by the introduction of some additional factor." This concern has afflicted many philosophers in their attempts to provide either analyses of the semantics of dispositional properties or metaphysical descriptions of their structure (see for instance, Vetter 2015, Choi 2012,

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it to pass", and also "… this consequence, if the effect shall necessarily come to pass then it shall come to pass without its cause, is a false one …" Thomas Hobbes, Vere Chappell 1999: 26.

[17] There is a further semantic reason (a Kripkean one) for accepting this principle: we extrapolate from the original condition in which the stimulus brought about the manifestation; this connection entails all the properties in which the conditional was formulated.

Fara 2005, Molnar 2003, Manley and Wasserman 2011, McKitrick 2003, Yates 2013, Contessa 2013, and Cross 2011 for a review).

Instead of trying to repair the definition or provide better analyses, Mumford and Anjum propose to implement a test for checking the modal force of dispositions. This test, which finds its roots in Goodman (1954) and has been revived by Eagle (2009) and Schrenk (2010a; 2010b), is described as follows: "The idea is that if causation involves any kind of necessity, it should survive the test of antecedent strengthening." (M&A 2011a: 56) The antecedent strengthening test (A-S test, henceforth) is intended to apply to conditionals, and works as follows: if the semantic value of a conditional remains unchanged for any consistent expansion of its antecedent, then the conditional holds necessarily. The test is the application of the idea that necessity is, as Schrenk (2010a) puts it, *monotonic*, that is, that no additional factor can change the outcome of a necessary relation.

The test is formally written as follows:

If A necessitates B, then:
if A plus ϕ, for any ϕ, then B (M&A 2011a: 57)

According to these authors, "in case of genuine necessity, where A necessitates B, no new information or extra premise can prevent B if A is the case" (Ivi).[18] Identity statements are examples of genuine necessity, and in such cases the test doesn't fail. However, the test fails for every case of causation. Therefore, causation is not a necessary relation.[19] Let us see the test at work in these two cases.

Identity: take A and B to be "This is water" and "This is H_2O" respectively. This engenders the following identity relation, in conditional form, "If this is water then it is H_2O", a statement that remains true for every value of ϕ, such as "If this is water and Madonna is a man then it is H_2O". So, if identity is involved, the relation between A and B is one of necessitation.

Causation: take A to be "the match is struck" and B as "it lights." The conditional "If the match is struck it lights" is made false for many ϕs, such as "the match is wet,"

[18] Here, Mumford and Anjum seem inclined to consider the proper interpretation of necessitarianism, in which it is the relation that is necessary, not the *relata*. This would show that they have been drifting between two different understandings of necessitarianism.

[19] Lowe (2014) has protested that the logic behind the strengthening test can be rejected if other, different systems of logic are adopted.

"there is no oxygen", and so forth. Therefore, if causation is involved the relation between A and B is not one of necessitation.

Can necessitarianism bear out this test? In the rest of this paper I shall argue that 1) there could be constraints on the conditions for applying the test; 2) if these conditions are properly applied, the test can be accepted by the necessitarian, since it constitutes a test for causal relevance rather than a test for the modal force of dispositional properties.

6. Applying the test

6.1 The case of identity

As we have seen, the test is applied to both identity and causal relations. However, in many cases both causation and identity are involved. Take A and B as in the first example and let ϕ be "poured into alcohol". Then we have "If this is water and it is poured into alcohol then it is H_2O". Now, this is empirically false if "it" is taken to be the actual mix of water and alcohol. On the other hand, if the proper reading of "it" amounts to the same reference of "this", the conditional is fine, but surely for semantic reasons more than for empirical ones, for no one can refer to the molecules of water dispersed in the mix, nor would anyone want to say that this reference is an ideal one. The cases of causation and identity are problematic in a second way. Beyond the usual sense (water = H_2O), there is a sense of identity Mumford and Anjum (2011a: 3-4) consider: a property is identical to a cluster of causal powers. If this is the case, the conjunction of all the causal powers that are part of the identity of a property should withstand the test. Consider the following:

A= this is spherical;
B= this is disposed to roll straight on an inclined plane.

By assuming that the tendency to roll straight on an inclined plane is one of the conjunct of the identity conditions of the property of being spherical, Mumford and Anjum stress that spherical objects can be prevented from rolling straight: "a soap bubble sticks to the surface, a bowling ball may have a weight in one side that causes it to roll in a curved line, …". The reason these balls do not roll straight is that they have one (or more) countervailing powers ϕ acting on them. Having observed this, the further step that I think we should take is to ask ourselves: how ready are we to omit the tendency to roll straight on a plane from the identity conditions of *sphericality* to

account for countervailing dispositions? In identifying what *x* is, we can either describe *x*'s constitutive elements or what *x* does, where this second identification may be deducible from the first. If what *x* does runs against what *x* is, rather than revising the identity conditions of *x*, the sphere in our case, I think we should isolate the countervailing powers that determine its anomalous behaviour, because it is these that interfere with the essential conditions that individuate what *x*, a sphere, is. Otherwise, rolling or not rolling straight are just equal possibilities and we should not expect anything from a sphere in terms of rolling paths notwithstanding geometrical analysis to the contrary.

Basically, since both identity and causation are involved, we should understand that in the case described by Mumford and Anjum we are considering not just the geometrical property of the sphere, but a *mass sphere*, in which every point of equivalent mass is equidistant from the centre, i.e. an object of homogeneous stratification; and what we have in mind when we consider *rolling* are conditions of friction within a certain range. In the case of a curve-rolling sphere, then, we would say that the object is not a sphere all the way through, and it is the not-homogeneous stratification that necessitates the curved path it takes (assuming the plane to be perfect, of course). In saying that something is a sphere, then, we are, in accordance with Hobbes' Principle, grouping together several properties, some geometrical, others physical. The fact that we encounter a violation in its expected causal path doesn't imply that we should abandon its identifying properties and their necessitating effects. Rather, it shows that the A-S test is to be understood as the way in which attempts to isolate interfering factors are devised and formulated. Basically, identifying a property with a set of dispositions does not obligate one to give up its identity because of vagaries in the conditional analysis of the property itself; rather, it forces to recognize that the necessitation relation holds according to the conditions at stake.[20]

If one is not willing to abandon the identity of properties with their set of causal powers, then one reconsiders the significance and the role of the A-S test as a method for distinguishing cases of identity from cases of causality. Countervailing powers should be considered along the lines that I will suggest for causation, as causally relevant powers for manifesting the property of being spherical. Let us examine how to consider dispositional causal relations with respect to the A-S test.

[20] For a critical assessment of this point, see Marmodoro (2015).

6.2 The case of causality

Consider the match manifesting its disposition to light once struck. According to the A-S test, there is no necessitation: taking ϕ as "the oxygen is missing" determines the failure of the conditional – "if the match is struck it lights." But what is exactly revealed by such a case? The causal relation under discussion holds for all those cases in which the value of ϕ is something like "it is in my left hand," "the match is coloured blue," and so forth. However, we do not consider these to be cases that support the necessity of the relation, and the reason is that the truth of conditional strengthened by these clauses just shows the causal *irrelevance* of the presumed interferer. Indeed, no variation in the hand holding the match or in the colour of the match results in any variation in the flammability of the match. The case of the missing oxygen is one in which an event *similar* to the one described in the unstrengthen condition is occurring, one that doesn't guarantee for the manifestation of the disposition. However, the property is causally relevant, because the manifestation is affected. Two options are at stake in this regard. First, as we saw, necessity is discrete, so similarity in the antecedent *per se* is no guarantee of similarity in manifestation (*pace* Hume). *A fortiori*, if we end up with dissimilar manifestations, we may well guess that the cause wasn't similar after all. Second, as a matter of fact, the two stimulating events – a striking in the presence of oxygen and a striking in its absence – are not compossible. The missing oxygen is not compossible with the conditions holding in the successful case.[21] Now, it is a standard view that a counterfactual is vacuously true if the antecedent is empty, contradictory or impossible.[22] The case of the missing oxygen determines an impossible antecedent, because it sets two not compossible states. Hence, it makes the conditional vacuously true. Let me expand on this problem.

It is coherent with the necessitarian thesis to claim that if A necessitates B, then A&ϕ necessitates B. The problem is whether A *excludes* ϕ, that is, if they are compossible or not: the match cannot be struck in the presence and in the absence of oxygen, at least not in an empirically reasonable sense. If ϕ individuates a condition which is not

[21] Clearly, other conditions might be made explicit (the match not being wet, no wind blowing), but this is exactly what is part of any scientific enterprise: finding out the relevant properties for any given interaction.

[22] This is also used as a constraint for non-monotonic reasoning. See Meyer & Veltman (2007: 1021). Basically, adding an extra premise in a counterfactual of the form A□→B is not allowed, if it is the case that the antecedent A and the extra premise S are such that A □→~S is true and A □→S is false. In the remaining case, strengthening A with S is valid. On vacuous truth and compossibility see Lewis (1973).

compossible with A, the necessitation relation holds vacuously. If this is the case, then strengthening cannot be accomplished for any ϕ.

Here is a further analogy that illustrates how to interpret the A-S test in conjunction with Causal Relevance and the Hobbes' Principle. Take A to be "These two blocks of the same mass are placed, one on each dish of this pair of scales" and B to be "This pair of scales is at equilibrium". So, the relation is: "It is necessary that if these two blocks of the same mass are placed, one on each dish of a pair of scales, this pair of scales will be at equilibrium". Now, if ϕ is "an extra block is placed on one of the scales" the consequent is obviously false. What is revealed by such falsity?

On the one hand, we could see this as direct evidence that the pair of scales is functioning properly. Vice versa, if the scales had remained at equilibrium once the extra block was added, we would instead have evidence that either there was some malfunction of the scales / the presence of a *safe block* - which prevented them from moving - or that the mass is causally irrelevant for the functioning of the scales. Once the first two hypotheses are discarded, in this case the A-S test shows that mass is at least one causally relevant property of the scales disposition to balance, because variations in the magnitude of P (different masses placed on the two dishes) will result in variations in the magnitude of R (the balance of the scales). Being the mass a relevant property in the relation, we get that the first event, the antecedent in the conditional, should be interpreted as saying "These two blocks of the same mass, *and only these two*, are placed, one on each dish, on this pair of scales." This is an application of Hobbes' Principle, that states that all relevant properties are necessary for any given causal relation, in the light of the principle of causal relevance, that sets which properties are salient for the relation at stake. That is, we build the pair of scales so that they are at equilibrium when and only when two blocks of the same mass are properly placed, one on each of the two dishes.[23] If this is the case, placing an extra block on one of the dishes is incompatible with the antecedent and makes it contradictory. Consequently, the antecedent being contradictory, the conditional becomes vacuously true. It is important to note that the compossibility condition should be applied at the level of powers, as mentioned in conditions 1 and 2 in the interaction analysis given above.[24]

[23] I am thinking here of the manipulability view of causation as in Menzies and Price (1993).

[24] One may wonder whether my speaking of *com-possibility* is circular, given the modal character of the notion. I think that the proper reading of that notion is along the lines given by the following principle:

The A-S test thus has the merit of making the causally relevant properties apparent and clear, but not of showing the non-necessity of the conditionals. So, in setting the conditional, we refer to the structural or underlying powers that make the phenomenal properties of the disposition possible under some conditions, as stressed by John Heil (2012: 123 et passim) in his argument concerning networks of causal powers. If a match lights when struck, the counterfactual analysis of this observed disposition picks out the necessitating condition(s), independent of our knowledge of them. I may come to know, *a posteriori*, what these conditions are, perhaps measuring the causal relevance of the fundamental powers at stake, but the conditional is set metaphysically, not epistemically. Our ignorance of the underlying powers involved doesn't entail an open set of sufficient conditions. It is the purpose of science, after all, to specify which factors and conditions are causally relevant and which are not. This point has been expressed by Schrenk (2010a, 2010b), who has stressed that: "the fact that we, epistemically and/or semantically can't get a good grip on these conditions […] does neither mean that these conditions do, ontologically, not exist nor that a less demanding, maybe benignly circular, yet still informative characterization (as opposed to a strictly reductive analysis) of dispositions can be given." (Schrenk 2010b: 174-5).

So the necessitarian has no difficulties with the A-S test, because its presumed violations are just ways to make the causally relevant properties explicit. There are as many necessitation relations as the conditions in which a causal relation occurs. Our duty is to make those conditions explicit, and the A-S test is a way to point out what is causally relevant and when. In sum, the strengthening in the A-S test either adds a relevant but incompatible condition, making the conditional vacuously true, or it adds a compatible but irrelevant condition, leaving the conditional truth untouched.

CP: Two states/properties are compossible if and only if they do not compete for the same qualitative space.

For instance, being red and being yellow compete for the qualitative space *colour* as obtaining in the same time and location. You can't have something which is red and yellow at the very same time and in the very same spot (cfr. Lombard 1986; excluding the possibility of time travel). Properties, and states in general, completely saturate qualitative spaces. Now, there is nothing worryingly dispositional or modal in such a view. Saying that placing the extra block on the pair of scales is not compossible with nothing else being placed on the scales but the two mass-equivalent objects amounts to saying that the actual state of the scale having the extra block rules out the state of not having this extra block there. One state or property completely saturates the actual qualitative space. Therefore, no circularity is involved in appealing to the concept of com-possibility.

7. A survey of cases.

I have so far concerned myself with countering the attacks mounted by Mumford and Anjum against necessitarianism.[25] However, I still need to explain how necessitarians can deal with all the cases in which an interference occurs. In the literature on dispositions, these interferers have been classified into four main categories. In the following, I provide an analysis of each category and also provide an illustrative example.

Fink: (When the match is struck the surface on which it is struck becomes perfectly smooth): the interferer, the smoothness of the surface, is causally relevant for the occurring of the power *temperature for ignition*. In this case, the value at which the stimulus occurred wasn't sufficient for ignition. The necessity of the relation is untouched. If the smoothness of the surface is reduced, i.e. its abrasiveness is increased, the temperature for ignition will rise more quickly, thus resulting in a change in the relation that determines the ease with which the stimulus results in the manifestation of the disposition.

Mask: (Reducing – to zero – the oxygen present). One of the fundamental powers behind the relation is excluded, and a new necessitation is in order. (Consider: wrapping a glass masks its fragility: even if, say, the mass and momentum of the hitting hammer both remain the same, the resultant vector of force on the glass surface is only apparently similar: a hard hit results in a much reduced impact).

Antidote: (The Sulphur on the match head is mixed with a chemical that blocks its reaction with oxygen). One of the fundamental powers of S is tampered with in terms of the chain-reaction required for the match to be flammable, so S is not occurring. (This point also applies in the case of the boron rods described by Bird 1998).

Mimic: (A marble match lights thanks to a sorcerer). Many fundamental powers P_1, P_2, … P_n are added where originally there was none. This is tantamount to an interference with the dispositions that constitute the property of being a piece of marble.

This sensitivity to conditions can be better appreciated if we consider the nature of stimuli. What is a stimulus? Anjan Chakravartty (in conversation) has suggested we

[25] A different reply to Mumford and Anjum has been given by Williams (2014), who thinks that necessity is in force on precisely defined temporal parts of causal processes.

consider stimuli to be INUS conditions (Mackie 1965). An INUS condition has causal powers because some parts of it are necessary but insufficient against a context in which others are sufficient but unnecessary. So, a stimulus is not just a single precise entity, but a complex. This complex is not undifferentiated; there are elements in it that are more causally relevant than others, and such causal relevance varies according to the relation picked out by the causal relevance principle. This internal complexity is revealed by the way the stimulus interacts with a dispositional property. For instance, in phenomena such as radioactive decay, all states are equivalent stimuli for a given disposition. If, however, there is just one very particular state that must be exemplified for a disposition to occur, we have encountered an extremely specific disposition. These are the two extremes of a continuous spectrum. For many dispositions, as a matter of fact, there could be many states that can be taken to be stimuli: objects consisting of different materials can still result in the equilibrium of a pair of scales. What is crucial is the fundamental powers that are in play. The kind of material is causally irrelevant for the balancing of the scale.

8. A further concern

A source of concern could be the question: is all this *ad hoc*? It may seem that I am constructing an argument to spell out the *ceteris paribus* clause by saying that all the problematic cases are to be excluded from the very beginning. I think there is a clear line of defence here. The A-S test, I argue, is a common practice in science used to make apparent which properties are causally relevant for any given relation, to ensure well-controlled experiments. After all, well-controlled experiments aim to have perfectly repeatable results, which is the mundane side of necessity. If the hypothesis is that A necessitates B and this proves not to be the case, then the further hypothesis is that there is some hidden ϕ that is preventing B from occurring and this ϕ should be removed or explicitly considered in the experimental setting.[26]

Two famous cases come to the mind. The first is the discovery of background radiation by Arno Penzias and Robert Wilson, who were awarded the Nobel Prize in 1978. The other is the discovery of Neptune by Adams and Le Verrier. Let us consider the first case. The two scientists were trying to develop a zero-noise antenna at the Bell Laboratories. According to their calculations, the antenna they were building was

[26] Chakravartty takes *ceteris paribus* clause to be a "partial map of property relations", in Chakravartty (2003: 409)

supposed to be perfectly noiseless. However, there was a noise uniformly distributed in the environment. What was wrong?

The situation was as follows:

A = this antenna screens off any physical noise;

B = this antenna detects no noise.

$A \rightarrow B$

Yet, apparently, A was true, and B was false

Penzias and Wilson searched for any ϕ such that its presence would have explained the falsity of B. The ϕ had to be a noise that could not be filtered out. Inquiring with physicists they discovered that they were the first to listen to background radiation. The noise that they were recording wasn't a noise, but a signal: the signal of the Big Bang. The interfering factor was and would always be present and is now considered to be a stable interference. So, A *and* ϕ should have read: this antenna filters out any physical noise *and* there is a noise that cannot be filtered out. The conditional, then, having two non compossible conditions A and ϕ holds vacuously. Since it was not possible to avoid ϕ, we were forced to accept that it was not possible to have A. The context is part and parcel of the conditions in which any conditional with some modal force has to be interpreted.

Summing this up: if the original four theses envisaged by Mumford and Anjum were meant as an attack on necessitarianism, they fail; if they are intended to show that the modality behind dispositions is different from logical necessity than they can easily be accepted by necessitarianism as I have presented it. For necessitarianism holds that dispositions give rise to a form of natural necessity exemplified in patterns described in conditional terms.

9. A final point

There is a final point to be made. In a recent paper, Anjum and Mumford (2018) have argued that logic should follow our metaphysical intuitions, rather than having metaphysics enslaved to logic. They argue that propositional logic is well suited for a Humean metaphysical view, in which everything is disconnected. The limit of such a view can be appreciated, Mumford and Anjum continue, by observing the difficulties and insufficiency of Carnap's analysis of dispositional terms in *Testability and Meaning*

(Carnap 1936-7). And one of the paradoxical and senseless consequences of adopting classical logic to analyse conditional statements is precisely that they are true given the falsity of the antecedent. Abandoning classical logic and re-defining conditional statements according to the dispositional view should be at the centre of the agenda. A new logic follows, or so they argue.

Now, it is not possible to enter this debate here; it suffices to note that necessitarianism addresses the issue of disconnectedness as well, and does so using the weapons of classical logic, without recourse to specially designed weapons. And there are already attempts being made in this direction: Boniolo et al. (2015) have argued that biochemical pathways can be viewed as deductive inferences, using the tools of classical logic. They have argued that chemical syntheses are context-sensitive, which makes non-monotonicity a desideratum in the context of classical logic. Above, I have attempted to show that the apparent collapse of the necessitation relation is due to specific contextual settings. It is therefore no wonder that necessitation doesn't hold in certain cases.[27] In sum, I think that necessitarianism doesn't require a change in logic because the connection issue at stake is not a matter of logic. Difficulties with contexts are not to be confused with difficulties with analyses.

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[27] Similarly, Iacona (2015) has argued that counterfactuals can be viewed as strict conditional, once the context is in sight, a move that parallels what I am arguing here on the necessitation relation.

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