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INTERFERING WITH NOMOLOGICAL NECESSITY

ABSTRACT

David Armstrong's law-maker, *nomological necessity* (N), is a second order relational universal that holds between state of affairs types, e.g., N(F, G). With only a small proviso, nomological necessity is supposed to instantiate as the causation of its second *relatum*, G, whenever its first *relatum*, F, instantiates.
In this paper, I will show that there is some friction within this theory when we consider that causal processes can be prevented and interfered with. The above mentioned proviso is supposed to handle these case but, so I argue, it fails to do so.

Keywords: Armstrong, laws of nature, causation, nomological necessity, prevention and interference, exceptions, *ceteris paribus*

Ca. 8,000 words without the appendix

NOMOLOGICAL NECESSITY AND ITS RELATION TO CAUSATION

Remember David Armstrong's theory of lawhood: a law of nature is identified with a second order relational universal, called "nomological necessity" (short: "N"), holding between universals. That is, *Fs are Gs* is a law *iff* N(F, G).[1]

What is *nomological necessitation*? Armstrong relates it closely to causation. Nomological necessity is, he claims, the relation-type of which singular causation is the token instantiation:

> Nomic connection can be understood as the sort of connection actually encountered in certain cases of singular causation. (Armstrong 1997: 232).

> Singular causation is no more than the instantiation of this type of relation in particular cases. When we experience singular causation, what we are experiencing is nomicity, law-instantiation. (Armstrong 1997: 227)

[1] To do full justice to Armstrong's theory I should say that laws are nomic/nomological relations between *state of affairs types* with the property involved being a universal. A *state of affairs type* is a gutted states of affairs. It is what 'a is F' becomes when we take away the object 'a' in abstraction: '_ is F'. In what follows I will nonetheless often speak of nomic necessity holding between universals for nothing hinges on that matter for the issue under concern here (cf. Armstrong 1997: 28-9).

Armstrong writes in later publications "C(F, G)" or "(_1 being F) *causes* (_2 being G)" (cf. Armstrong 1997: 230) rather than N(F, G) as a notation for the law-relation so that the close relation between nomological necessity and causation—the instantiation of necessity *just is* causation—is immediately obvious.

I aim to show in this paper that we have reasons to doubt that this direct identification can be made.[2] The Humean minded reader, who favours a regularity account of laws, might want to conclude that my arguments (if correct) amount to a *reductio* of Armstrong's account. This I would very much regret and I hope that one of the tentative suggestions I give for what else nomological necessity's instantiation could be instead of causation could be developed into a proper account in a natural sequel to this paper.

THE INFERENCE PROBLEM

My starting point is to ask how we get from the law, N(F, G), to the goings on in the world and especially the regularities we observe in nature. How does, if it does, N(F, G) entail $\forall x$ (Fx $\supset$ Gx)? Van Fraassen was the first to ask this question—"What information does the statement that one property necessitates another give us about what happens [...]?" (van Fraassen 1989: 96)—he called the related riddle the "inference

[2] One objection to Armstrong's theory goes like this: not all laws are causal laws—there are also the synchronic laws of co-existence like 'electrons have negative charge' or Pauli's exclusion principle, etc. How can, for those cases, N's instantiation be causation? Are electrons caused to be negatively charged? Although this is an interesting point in its own right (which Armstrong has acknowledged (cf., for example, (Armstrong 2004: 134)) it is not the subject of my paper. Rather, I aim to show that *even for the causal laws themselves causation cannot be N's instantiation.*

problem", and thought it would not be solvable for Armstrong (cf. van Fraassen's, 1989: 96ff; and also Armstrong 1997: 228).[3]

Yet, Armstrong gave a convincing answer to the inference problem along the following lines: F and G are universals and so is N. It holds as a second-order state of affairs between F and G: N(F, G). Now, if the universal F is instantiated so must be N simply because N(F, G) holds. Again: if N(F, G) holds N cannot but instantiate if F instantiates, N is *dragged along* by F (so to speak). The instantiation of N, however, "is the causality instantiated in the situation". Hence, the universal G must be tokened as well since it is *caused* by the F-token qua N's instantiation. Accordingly, any instantiated F causes a G and so, as a consequence, $\forall x (Fx \supset Gx)$. Therefore, N(F, G) does, indeed, ensure $\forall x (Fx \supset Gx)$ and "this would seem to solve the inference problem" (Armstrong 1997: 228).[4]

THE *IN*-FERENCE PROBLEM, LOGICALLY CONSTRUED

So far so good, but Armstrong denies that the entailment as sketched above goes through as easily as I made it seem: "The entailment actually holds only for the case where it is given that *nothing further interferes*." (Armstrong 1997: 230) And, for Armstrong, "it seems to be always possible that for any antecedent of a law there exists […] an [interfering factor] H" (Armstrong 1997: 231; my addendum in square brackets).

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[3] Van Fraassen (van Fraassen 1989: 96ff) confronted Armstrong with two problems, one being the *inference problem* as above, the other being the *identification problem*: what exactly is *nomological necessity*? I have given the *ontological part* of Armstrong's answer to the latter question already: nomological necessity's token-instantiation is causation, i.e., nomological necessity is, so to speak, causation's universal. This idea has not always been part of Armstrong's theory. As a matter of chronological fact, Armstrong has started to identify nomological necessity's instantiation with causation in this explicit form as direct answer to van Fraassen's identification challenge.
Note that the *identification problem* can also be interpreted in an *epistemic way*: how do epistemic subjects identify, i.e., *know about* or *perceive* nomological necessity? Armstrong's suggestion emerges already from the quotes given above but here's an even more explicit statement: "The Identification problem is solved via our *direct awareness*, in certain favorable cases, of causation in the token case." (Armstrong 1997: 228; my italics)

[4] I ignore here the difficulty that N, a *second order* relational universal, is supposed to have *token instantiations* (as causation) just like *first order* one-place universals have their tokens. In (Armstrong 1983: 96-99) we find a passage which defends the soundness of this stipulation.

Translated into talk about events and causation the story about interference is the (almost) truism that it is always possible to interfere with a causal process that relates (spatio-)temporally distinct events.

Taking these considerations into account, Armstrong distinguishes between "oaken" and "iron laws": N(F, G) is *iron* just in case there is, as a matter of fact, no physically possible interference. N(F, G) is an *oaken law* (in later publications Armstrong speaks of a "*defeasible law*") if there are possible interferers:

> We can [...] distinguish between two types of law. If F→G (with some probability) is a law, and if it is empirically possible (nomically possible) that there is a universal F&H, and if in these circumstances the probability of an outcome of type G is altered, then F→G by itself is a defeasible law. [...] It seems to be always possible that for any antecedent of a law there exists such an H. But it may not be empirically possible. If it is not empirically possible, then the law may be called an iron law. (Armstrong 1997: 231)

Now, when focussing on the *logics* or *semantics* of interferences the mere addition of a proviso clause to the entailment postulation—"The entailment actually holds only for the case where it is *given that nothing further interferes*"—might resolve any trouble one could have with the subject of oaken laws or interferences and, so, Van Fraassen's inference problem might still count as settled.[5]

Yet, the difficulties start (latest) when we aim to conceptualise within Armstrong's *metaphysical framework* what happens in such interference cases. Especially puzzling will be the question what happens in such cases to nomological necessity and its instantiation. This is the question I would like to address in this paper.

The difficulties I will unearth have not come to our attention yet because, or so I believe, Armstrong has tied the problem of *inter*-ference too closely to van Fraassen's problem of *in*-ference, i.e., he has treated preventions and interferences mostly in terms of *semantic issues* of *entailment* or *entailment provided that* rather than on *metaphysical grounds*.

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[5] I leave aside the vast literature on so called "*ceteris paribus* laws" that shows how controversial the issue of proviso clauses really is (but compare Author 2007a). Also, I will not question whether van Fraassen's problem is, in fact, solved. My aim is to show that whether or not the semantics of proviso clauses and the inference problem are resolvable we still encounter grave metaphysical problems. These problems are the focus of my paper.

Whether my guess is true or not, I am sure that Armstrong would support the enterprise to address these issues also from an ontological, not only from a logical point of view, for he says elsewhere (and in a slightly different context) that we should not be "concerned with true statements of law, but rather with the truthmakers of such statements." (Armstrong 2004: 127).

THE *INTER*-FERENCE PROBLEM, METAPHYSICALLY CONSTRUED

I turn, hence, to the ontological problem. In the case of interferences we encounter the following situation:

- There is the atemporal second order state of affairs (the law) that N(F, G).
- There is the first order state of affairs that, at a certain time and place <x, y, z, t>, something *a* is F.
- There is the interfering state of affairs at that time and place (or shortly afterwards) that *a* is also H.

However, or rather, consequently,

- we do not have, at t (or a short time afterwards), the state of affairs that *a* is G.[6]

The crucial question is, now: what happens to N? Does it instantiate together with F as it should if we follow the answer to van Fraassen's inference problem or not? The problem is that N's instantiation is supposed to be causation but causation demands success. In other words, without G occurring, N cannot be the causation of G: "we should deny that these are cases of causation […] no relation exists without its full complement of terms." (Armstrong 1997: 75)[7]

Consequently, interference cases, interpreted from within Armstrong's metaphysics, seem to be internally incoherent:

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[6] At most, G could come about *incidentally* because of other present and uninterfered with causes not involving F, for example, because of an uninterfered with N(K, G) incidentally operating at the same place and time. However, these *random coincidences* are unimportant for the present considerations.

[7] To be fair, it has to be said that Armstrong is in this quote not talking about interference cases but about probabilistic causation. Yet, the message that causation demands success is the same.

(1) If N(F, G) is a law then N instantiates whenever F instantiates (as answer to the inference problem).

(2) N's instantiation is causation, here: the causation of G (to answer the identification problem)

(3) There are cases of prevention where some interferer prevents G from coming about although F is instantiated (= there are oaken laws).

(4) Causation demands success.

Contradiction: you cannot have N instantiating as causation whenever F instantiates while its effect, G, does sometimes not come about.

Our task for the rest of the paper is to establish which of the four claims we had better drop in order to re-establish coherence without distorting too much Armstrong's original theory of laws of nature. While (1)-(3) are principally up for grabs I do believe that (4) should be left untouched: it is impossible for F to cause G (qua N's instantiation) and, yet, G does not happen (but see Fn. 8 if you have different intuitions).

Here are, then, ways in which (1)-(3) can be denied (*prima facie* at least):

(N1) N does not instantiate in cases of interference.

(N2) N does instantiate but not as causation (an alternative has to be given).[8]

(N3) No prevention is possible for real laws (= there are no interferences = there are no oaken laws).

There are two versions of negation 3:

(N3.1) The first law-*relatum* is not what it seemed to be. N(F, G) has never been the law; instead, it is the strict N(uninterfered-with-F, G).

(N3.2) The second law-*relatum* is not what it seemed to be. N(F, G) has never been the law; instead, all laws have the form of the strict N(F, D_G), where D_G is (merely) a disposition to bring about G.

What unifies negations (N2), (N3.1) and (N3.2) is that each one of them alters one of the three elements that make up Armstrong laws: (N2) changes N, (N3.1) alters F, and

[8] If you believe that (4) above *can* be denied (contra my and Armstrong's intuitions) then we are not, after all, in major disagreement, for we could treat our dispute as mere verbal and agree that my negation 2 (that N instantiates as something else) is your negation of 4. In other words, while you say that causation does not need success I say that you have something else rather than causation in mind which you happen to call "causation".

(N3.2) replaces G. What relates negations (N2) and (N3.2) is that they both introduce a dispositional element into the theory (this will become obvious only later).

In what follows, I will first have a look at (N1) and reject this option as inadequate. I then jump to (N3.1) which will turn out to be a far more profound alteration of Armstrong's theory than it might seem at first sight. Afterwards, I discuss the thematically linked N(2) and (N3.2). They, too, will not prove to be entirely satisfactory.

(N1) N DOES NOT INSTANTIATE IN CASES OF INTERFERENCE[9]

Although we can infer that Armstrong should not be sympathetic to (N1) (see Fn 9) we are, to my knowledge, left uncertain in his writings as to what happens to N in interference cases. The only statement tangentially touching this issue is ambiguous: "Wherever the antecedent state-of-affairs type is instantiated, then [...] it *must* (subject to an already signalled qualification) [...] *produce* the consequent affairs." (Armstrong 1997: 228; my italics)

This is ambivalent in so far as we are not explicitly told whether the "must produce subject to qualification" means either that N, *although instantiated*, fails to produce together with F the consequent if interference happens, or whether it fails to produce the consequent simply because it is *not even instantiated*.

Be that as it may, I will now assume that *N does not instantiate*. There is a strong and a weak reading of this option, (i) and (ii). In the strong reading, (i), it is the whole law that

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[9] Note that, disregarding the problems I will list below, endorsing (N1) seems to weaken Armstrong's general solution to van Fraassen's inference problem where it was crucial that F does or must drag N along because of N(F, G). It seems that the solution to van Fraassen is only convincing if F brings N with it *no matter what*. Taking this into account and considering a quote from *What is a law of Nature* should make clear from the outset that (N1) can't be our solution to the problem of interferences (I discuss (N1) nonetheless for the sake of completeness): "If F and G are related by a dyadic relation [N, that is] […] then it cannot be that they have this relation at one time or place yet lack it at another. The universals F and G are exactly the same things at their different instantiations […] If it holds in one instance then it holds in them all, because it is the one identical thing in all the instances." (Armstrong 1983: 79; my addendum in square brackets)
[(N1) is an absolute impossible solution for our problems if Armstrong follows Baxter and postulates that "the connections between universals involved in laws of nature are necessary rather than contingent" (Armstrong 2004: 136) for in this view N would be partially identical with F and G and so cannot be separated from them (cf. Armstrong 2004: 136).]

ceases to hold in cases of interference and if the law, i.e., N(F, G), ceases to hold, then, naturally, N does not instantiate when F does. It seems sometimes that Armstrong has this strong reading in mind:

> An interfering property, I, is one such that if x is F and is I, then *it is not a law that FIs are Gs.* (Armstrong 1983: 149; my italics)
>
> *This law* holds providing that 'nothing interferes' (Armstrong 1983: 148; my italics)

Yet, the strong reading is not very attractive. For a start, note that we should think of laws as being omni-temporal and omni-spatial state of affairs. They might vary across possible worlds, all right, but they should not change or vary within a world. Therefore, they also should not cease to hold because of interferers[10] for if we allow this possibility, then an interferer at a particular place and at a particular time would make N(F, G), which ties together *all* the Fs and Gs there are in space, cease to hold *everywhere*. In other words, an interferer here and now would cause all the actual F and G relations in the entire world to be loose and separate. A result we clearly cannot accept. Interference is local, lawhood is global. Reading (i) of (N1) is clearly unacceptable.

I turn to the weak reading, (ii), of the thesis that N is not tokened in cases where something interferes: while N(F, G) itself remains untouched, it's just that N does not instantiate locally where the interferer, H, is. Surely, this weak reading is only conceivable if *every* such H instantiation (or FH-instantiation) has this preventive power, or, more precisely, if the prevention itself is nomological, not magical or accidental. Armstrong

[10] Surprisingly, and, I think, contra to our intuitions concerning laws of nature, Armstrong *does* allow for the metaphysical possibility that laws change *even within an world.* He writes (at a place unrelated to interferences): "Why cannot a law of nature, if conceived of as the holding of a contingent relation between categorical universals, change? Why may it not be that F has the nomic relation G at one time, but later, since the connection is contingent, this relation lapses, perhaps succeeded by F's being related to H?" (Armstrong 1997: 257) and "It seems that I have to allow that contingent relations between universals can change." (Armstrong 1997: 258)
I have argued in (Author 2007a: 109ff) that Armstrong should, after all, not allow for this possibility because he would be in danger of losing the advantages his strong theory of laws has over regularity theories. Yet, in the present context, I only point out that even if we grant this general possibility of laws ceasing to hold it still does not help us for the case of interferers.

seems to agree (if not explicitly then implicitly) because he occasionally talks about "*the laws* involving the interfering conditions*"* (Armstrong 1983: 149, my italics).

Yet, how do we have to think of this *prevention law*? I concede that I have no good intuition how such a law would have to be formulated correctly but I will inspect one option in the hope that it exemplifies possible difficulties any formulation would encounter. If the questions and problems I will now list (but not tackle) are not decisive against (ii) they at least strongly suggest that this weak reading of option (N1) is metaphysically on shaky grounds.

Suppose, then, that the prevention law has the following general form: N(H∧F, prevention of N(F, G)'s instantiation). Here are three reasons why this leads into trouble: (a) Is '*the prevention of N(F, G)'s instantiation*' a universal? (b) Are '*preventions of'* negative state of affairs types? If so Armstrong can't accept them for he does not allow negative universals in his ontology. (c) There is a worrying iteration of Ns here: N(... , ... N ...). Is this allowed?

On the basis of these puzzles I reject also the weak reading of suggestion (N1) for no matter how you answer these three questions the resulting metaphysical picture is bound to become very contrived.

Excursus. One might be tempted, at this point, to introduce a further nomic relation next to N, namely *nomic exclusion* (cf. Tooley 1977: 676, 679). Yet, nomic exclusion, E, as originally conceived by Tooley, was meant to exclude G, not N, from coming about: E(H, *G*). That is, Tooley's original nomic exclusion would not exactly deliver what we were looking for above. But let us accept it as a new variant to deal with interference cases. We face new challenges. We have, for example, to ask how nomic exclusions, E, and nomic necessitations, N, interact when instantiated: suppose that we have N(F, G) but also E(H, G) where the latter means that Hs nomically exclude Gs. Also, suppose that Fa and Ha is the case. Are there laws mediating between instantiated

Ns and Es? Are Es stronger than Ns or do both come in various strengths? Nomic exclusion, E, would also face a new identification problem: could it's instances, exclusions, also be causations of a sort? Moreover, N's own instantiation can still not be causation for it still does not always lead to success. Finally, if we were solely interested in the correct Armstrong text exegesis then we could also add, as the ultimate reason against Tooley's nomic exclusion, that Armstrong himself rejects this option (cf. Armstrong 1983: 143ff). **End of excursus.**

I conclude that option (N1) is unacceptable in all its variants and derivatives.

(N3.1) N(F, G) IS NOT THE LAW; INSTEAD, THE STRICT N(UNINTERFERED-WITH-F, G) IS.

Maybe N(F, G) is not really the law we should be looking at in the first place (it has actually never been a law) but rather something like N(*uninterfered-with-F*, G). That is, our first *relatum*, F, is of a different nature than we have envisaged so far. Armstrong mentions this option explicitly elsewhere: "But cannot an oaken law [a law with possible interferences] always be represented, in principle at least, as an iron law [a law where no prevention is possible] by putting in all the negative qualifications?" (Armstrong 1983: 149; my addenda in square brackets). He gives an affirmative answer:

> Yes, in a way it can, provided that we bear in mind how wide the qualifications may be which are implied by the phrase 'in principle'. It could even be that the statement [...] would have to be of infinite length. (Armstrong 1983: 149)[11]

The idea behind (N3.1) is, again, to claim that the nomological state of affairs that constitutes the law has never been N(F, G) but rather something like N(uninterfered-

[11] Although I will now discuss this idea as a *prima facie* possibility it has to be noted that the way it is presented in Armstrong's quote is slightly at odds with the project he is generally engaged with. Let me explain. Instead of "cannot an oaken law always be *represented* as an iron law" the question should rather be: "is, what seemed to be an oaken law, not in reality an insufficiently well represented iron law?" or, again in other words, "are what we have called 'oaken laws' not only rough and ready incomplete approximations to the real laws"? After all, Armstrong's aim is to give a *metaphysical theory* of what laws of nature *are* and not how fallible epistemic subjects *represent* the laws. Therefore, if a so called "oaken law" can be "*represented*" as an iron law then the "oaken law" has never been a law in the first place. Rather, the, as yet, misrepresented or undiscovered iron law is the law.

with-F, G). If this strategy proves to be successful we have effectively denied entry (3) of the above multi-lemma: any causal process governed by real laws is such that there is no interference possible (in other words: there are no oaken laws).

Although this solution looks quite elegant it, too, has its difficulties. I will discuss four such problems, (i) to (iv). They all relate to the challenge to spell out what universals like *uninterfered-with-Fs* exactly are. On our way to a characterisation we will see that, in order to fulfil their required role, (i), uninterfered-with-Fs must be enormously complex, (ii), their instantiation must encompass spatio-temporally extended regions, (iii), they must be numerous, and, (iv), they must be really very numerous indeed. All this might count against the existence of these universals, or against the laws they figure in, or both.

(i) For a start, note that if uninterfered-with-Fs were something like $\neg H \wedge ... \wedge \neg I \wedge F$

we would be confronted with negative universals which are unacceptable for Armstrong's ontology. There could be a way to circumvent this problem: we might be able to stipulate that there is a positive, yet, complex, structural universal that, when instantiated, fixes the sum total of all (positive) states of affairs at least for a sufficiently large region in space so that interferers are excluded simply because such a complex state of affairs includes and fixes all there is and, by *fiat*, all there is simply has no interferer.

This will remind readers of Armstrong's *Truth and Truthmakers* of *totality facts* as truthmakers for general and negative truths (cf. Armstrong 2004: 68-82): the totality of first-order positive states of affairs plus the higher order state of affairs (the totality fact) that these are *all the first-order states of affairs* makes true certain general propositions and also negative statements about the first-order positive states of affairs. It is along these lines that I believe one could probably capture what uninterfered-with-Fs are. (I concede that this is a bit sketchy. Yet, since my aim is primarily to unearth the challenges for

Armstrong's theory and only secondarily to meet them I allow myself this sloppiness here.)

(ii) The required complex totality fact types have to be expanded in yet another dimension for we have not yet considered time: there are cases of late preventions where H comes about after F. In other words, while an F might have been instantiated without any interferer at t, it could be interfered with at $t+\Delta t$ where $t+\Delta t$ is still early enough to prevent G at t^* (with $t < t+\Delta t < t^*$).[12]

But never mind, we have already extended instantiations of Fs in space (in (i) above), so why not also in time? In response to late preventions, we can reply that when we talk loosely about uninterfered-with-Fs what we really mean is state of affairs types that instantiate as fairly large *four dimensional* event types. These 4D worms are temporally extended at least until an infinitely short time $\Delta\epsilon$ just before the instantiation of G.

(iii) Yet, even if we accept these four dimensional totality fact types as uninterfered with-Fs we are not at the end of the story for there is presumably more than one such type of super state of affairs that incorporate F and that leads to a G. That is, not only is the law's first *relatum* much more complex and encompassing than we thought, but what seemed to have been just one law, N(uninterfered-with-F, G), actually emerges as a cluster of a huge number of nomological relations each connecting one such super state of affairs type (including F) with G: Fs are Gs is a law *iff* {N(uninterfered-with-F*, G), N(uninterfered-with-F**, G), …}.

(iv) This law cluster has to grow even bigger. For note that, so far, we have made it seem as if prevention and interference is always and only an all or nothing matter: once there is an interference there is no G, otherwise G is fully instantiated. Yet, if G is a determinable property, there are cases of interferences that only alter the degree to which

[12] One can see the trouble with late interference also this way: if N's instantiation is meant to be causation it can't be instantiated as causation (of G) up until $t+\Delta t$, the time of interference, and then, having caused nothing, suddenly cease to be instantiated.

G is instantiated: there is partially dissolved sugar (because of supersaturated water); there are smouldering, yet not burning inflammables (in case of low oxygen levels); there are lower than expected accelerations (because of counteracting forces), etc. In short, although we might not have an instantiation of one of the many pure uninterfered-with-Fs (as in the set of (iii)) we might have an instantiation that deviates (slightly) from one of these ideal case in that it has some impurities. In such a case we might still get, as a result, an almost or impure G instantiation. These cases, however, are not yet members of our cluster which takes care only of the pure cases.

Why should we be concerned with impure cases at all? Because even impure cases are, presumably, thought to be law governed. They do not just so happen, i.e., the world is not loose and separate for those cases. Yet, their nomicity is, so far, not captured by the present cluster of laws because nomological necessity, N, holds *discretely* only between pure uninterfered-with-F cases and Gs. But an N that holds between uninterfered-with-Fs and Gs has simply no impact on impure F* and impure G* cases. So, if we want these impure cases to be nomological as well we have no choice but to incorporate also these cases into the cluster, that is, we claim that nomological relations hold also between impure (semi-interfered with) four dimensional state of affairs types and the according impure G* types. As a result, all types of interferences will have their very own nomological relations relating some super state of affairs type F* with some degree of G.

Suppose we managed to take care of (i) to (iv) in a satisfying way. Just how far have we departed from what was originally supposed to be a law of nature, namely a relation between simple, non-structural, and probably fundamental universals? We have made two major changes: (a) laws are, now, clusters of relations and not merely a single relation, (b) N does not relate atomic, local universals anymore (masses and charges, ... to forces or accelerations, ...) but hyper-complex four-dimensional structure types. Maybe this is a revision one could happily accept but it is certainly a radical change from the orthodox picture of lawhood, both Armstrongian and pre-theoretical.

This becomes even more obvious if we start to wonder what has exactly happened to the original simple universal F within these super state of affairs types: the original F seems now degraded to an *INUS* condition for the antecedents of members of the respective law cluster: an F becomes an *insufficient* but *necessary* part of an *unnecessary* but *sufficient* super state of affairs type which stands in the relation of nomic necessity to G (and similar for the semi-interfered-with-F*s and G*s). I take it that this is not quite what we have in mind when we say that it is a law that masses attract or that electrons repel each other.

We can also ask whether the role that N and its instantiation was supposed to play has changed. One thing is sure, there is no reason for N not to instantiate whenever the right hyper complex four-dimensional structure type instantiates. Yet, would we still call such an N instantiation "causation"? The trouble is not that its effect might not occur (for it definitely does) but that N's instantiation loses its locality. We are not any longer looking at a single object at a particular space-time point and a single universal, the former F, that causes G but, here, N's operation is spread out over four dimensional space-time-areas. N becomes a mysterious holistic global matter.[13]

So, hasn't (N3.1) it all wrong? Complexity should result from the (incidental) interplay of many individual nomological factors rather than nomicity arising only from complexity. We feel that it is the components that give rise to the whole and not the whole that leaves at best some secondary importance to the parts. It is, therefore, unlikely that (N3.1) is an acceptable amendment of Armstrong's theory of lawhood.

FIRST INTERMEDIATE CONCLUSION

Let me summarise. Armstrong's theory of laws of nature confronts us with difficulties when it comes to *interferences with* or *preventions of* law-governed causal

[13] Note that, as a consequence of N's being spread out and global, its instantiation's observability (i.e., causation's observability) could be at stake.

processes. N, the law maker, which holds as a second order relation between universals (for example, N(F, G)), is supposed to instantiate as causation (of G) whenever the first *relatum*, F, is instantiated. Yet, in prevention cases the effect G might not come about so that either (N1) also N should not instantiate (contra Armstrong's theory) or (N2) N's instantiation can't be causation, for causation demands success, or (N3) it is wrong in the first place to assume that N(F, G) is the law (rather, something else is, which is free from possible preventions).

We have, so far, tried to resolve the tension in Armstrong's theory by saying that N does, indeed, not instantiate in interference cases, (N1), and by reformulating the initial law so that interferences cannot cause trouble by *fiat*, (N3.1). Neither solution seemed entirely satisfying.

INTERLUDE: THE (FUNDAMENTAL) FORCE LAWS

There are two further possibilities left to discuss of how we could resolve the tension in Armstrong's theory. Both give back the individual, simple universals the power they had lost to the clusters of global states in (N3.1): we could, (N2), try to find a different kind of instantiation for N (instead of causation) that allows N to be unsuccessfully instantiated. In other words, we could be looking for an appropriate middle ground for N somewhere in between *not being instantiated* and *being instantiated as causation*. That is, we would search for a "softer" N that is *not quite causation* but *more than nothing*.

Alternatively, (N3.2), we could give G a new interpretation that would allow it to be instantiated *no matter what*, i.e., even in interference cases: N could strictly bestow on Fs *the potential to be or become G*. That is, rather than N(F, G) our laws could have the form N (F, D_G), where D_G is (merely) a disposition or potential to be or to become G.

Focussing our attention for a while on a special kind of law—the (fundamental) force laws—we get some inspiration for both (N2) and (N3.2). Armstrong himself takes

force laws as one of his prime examples when talking about laws with interferences. (In fact, I believe that force laws have been the model for the entire theory of nomological necessity but this is just a speculation.)

An important general feature we ordinarily associate with forces and which will come in handy for later purposes is that forces push to a certain degree in a specific direction whether or not they successfully accelerate the object they operate on. Provided no other forces are active success is guaranteed. If, however, other forces counteract we only get a smaller acceleration (or deformation) according to the resultant force (which might well be zero). Realism about component forces assumed, we can stipulate that forces are always instantiated whether or not they successfully bring about the respective acceleration. Note that the superposition of forces is well understood. Here, interference is quantifiable and calculable. In fact, every schoolgirl and -boy learns about the basic vector algebra of force addition. In other words, interference and overlap within the realm of forces poses no problem.

In the following discussions of (N2) and (N3.2), I will suppose that either N, nomological necessity, or G, the law's second *relatum* is, in the relevant sense, *like a force*. This idea seems to have some potential to solve the problem of interference (but, I fear, our high expectations will not be met).

(N2) N DOES INSTANTIATE BUT NOT AS CAUSATION

So, let N's instantiation (whenever F is instantiated) not be the causation of G but rather a kind of force or forceful push towards G. Only if there are no other such pushes or influences due to further features of the situation (the object being H as well as F, for example) will G really be brought about. Otherwise G is not (or only partially) instantiated.

Armstrong sympathises with this move. He believes that (provided my arguments are sound so far) N's instantiation could be a kind of *factor* of causation. The totality of

all factors operating at one place is, then, the causation in that instant. However, according to Armstrong, what the nature of these factors is still remains to be seen.[14] And, indeed, as shall be revealed now my reference to forces is at best metaphorical.

Here is why: for real forces we have a (vector) algebra readily available and, so, know exactly how to calculate the influence of interfering forces. Specifically, we know what it means for a force to be cancelled out by another force (both forces acting upon the same object with the same strength, yet, in exactly opposite directions).

Unfortunately, we do not have any such algebra or theory available for Ns. We could, of course, leave our theory at a metaphorical level and only hand-wavingly gesture at forces but I fear only a few metaphysicians would find that satisfying. Yet, once we start to form a theory we seem to face very similar problems to those we have already encountered in (N1) and our interlude on Tooley's theory which introduced nomic exclusion as a second nomological factor: presumably, the interaction of two different Ns—the one that F brings with it and the one the interferer H brings with it—is regular, even lawlike, and not just so happening. Consequently, we would need "a new N which gives the rule (law) for summing the factors" (Armstrong 2008)[15]. This is problematic for many reasons.

First, note that we are, then, confronted with a reiteration of nomicities: there are first level Ns, call them "N^1", which instantiate as force-like factors of causation and there are, additionally, second level Ns, call them "N^2", that mediate between those factors. Second, we would have to answer the question whether those second level N^2s form strict laws. If we cannot argue convincingly that they do we end up in an infinite regress (for we'd need mediating N^3s…). Third, van Fraassen's identification problem has its bite again: what is N^2?

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[14] Personal communication, February 2008.

[15] Personal communication, February 2008.

Now, in an Ockhamian mood you might want to deny that N^2 is a new N and postulate that $N^2=N^1=N$. This is not satisfying either, for if N^1 and N^2 are the same so are their instantiations. Yet, it seems odd to say that sometimes N instantiates as a factor of causation of events and sometimes as a mediator between those causal factors.

Maybe there is a way out of these difficulties but it seems that any solution has the taste of contrived speculative metaphysics. For the time being, I therefore reject also option (N2).

(N3.2) THE SECOND LAW-*RELATUM* IS NOT WHAT IT SEEMED TO BE. INSTEAD OF G WE HAVE THE DISPOSITION D_G

I am afraid, we do not gain much by transferring the force character from N into the second *relatum* and replace G in N(F, G) by the (maybe basic, unanalysable) power D_G to bring about G. In fact, we are merely shifting most of the metaphysical burdens N had to carry in (N2) onto G or, now, D_G.[16]

Here's first a description of the picture we get in (N3.2): just as in (N2), N itself instantiates whenever F does. However, contrary to (N2) here also D_G instantiates. Yet, D_G, while surely present whenever F is, is (merely) a dispositional property which, while present, does not have to manifest itself (i.e., D_G does not have to bring about G). Yet, what seems first to be a solution to the interference problem turns out, on closer inspection, to be a veiling strategy. Our problems have not disappeared, they merely hide under the cover of D_G.

Note the parallels to (N2) above: unless we leave the talk about the disposition or power D_G at a rather abstract level we must answer, also for dispositions just as much as

[16] Some philosophers have pointed out that the problem of interference and prevention is, in the guise of so called "*ceteris paribus laws*", also a grave problem for *regularity theories* of laws (cf. (Hüttemann 1998), (Lipton 1999), (Kistler 2003), and Cartwright in several of her publications, for example (Cartwright 1992)). In fact, some even claim that one can see regularity theories fail because of *ceteris paribus* laws. These philosophers offer dispositionalist accounts of laws of nature as an alternative where, just like in N(3.2), laws correlate properties with their powers to bring about events rather than that laws state event regularities. For an analysis of these accounts and why they are problematic see (Author 2007b).

for the N in (N2), what exactly happens in interference cases. Are there G-preventing as much as G-causing powers, i.e., D_{G-} versus D_{G+}? Is there a calculus telling us how to combine D_{G-} and D_{G+}? Are there laws governing the interplay of D_{G-} and D_{G+}?[17]

Finally, it has to be mentioned that Armstrong would rather not allow dispositions into his ontology: "We should not postulate any […] properties and relations (universals) save actual, or *categorical*, properties and relations" (Armstrong 1983: 8-9; my emphasis; cf. also Armstrong 1997: 261).

I acknowledge once again that giving a list of questions that have to be answered within a theory does not equal giving decisive arguments against that theory. Still, I believe we are in the same or a similar metaphysical predicament as in (N2). I therefore allow myself to reject also (N3.2).

SECOND INTERMEDIATE CONCLUSION

The starting point of our inquiry was to point out that there is some friction within Armstrong's theory of lawhood when it comes to interferences and preventions. On the one hand, Armstrong demands that if N(F, G) is a law then N instantiates as causation (of G) whenever F instantiates. However, he also concedes that there are cases of prevention where some interferer prevents G from coming about although F is instantiated. Yet, since causation demands success N cannot, pace Armstrong, instantiate as causation whenever F instantiates because its putative effect, G, does occasionally not come about.

We have tried to amend each of the premisses that together lead into this predicament: we have tried to bite the bullet and say that N does simply not instantiate in cases of interference, (N1), and we have tried to find an alternative for N's instantiation rather than causation, (N2). Neither option seemed promising. We have also tried, in (N3.1) and (N3.2) respectively, to change N's two *relata*, F and G, in order to exclude

[17] Here (N3.2) might have the advantage over (N2) in that it would not involve iterations of Ns.

possible interferences by the reinterpretation or reconstruction of the laws. Again, we were confronted with more questions than with solutions.

Is there another way out? Above, I have praised a particular kind of laws, the force laws, which, so it seems, can handle interferences with relative ease. In an appendix to this paper, I will focus on the force laws only and explore whether Armstrong's theory, when limited solely to these laws, draws a coherent picture. The main critique of Armstrong's laws ends here.

CONCLUSION

Preventions and interferences, where they are possible, cause problems for Armstrong's theory of laws of nature for it is not clear what nomological necessity's role is when an interference occurs.[18] I have explored several ways to handle this problem. All come with metaphysical burdens, some insurmountable, some probably very difficult to resolve.

I attached a proviso to my paper at the beginning which I wish to repeat: you might want to treat the arguments surrounding interferences as a *reductio* for the nomological necessity account of laws and so reject it altogether. However, if you turn Humean be aware: the problems of interferences and preventions are everything but easy to handle also for regularity views of laws.

Therefore, I would very much like to see that one of the rough sketches of amended theories, maybe along the lines of force laws as introduced in the appendix, could be turned into a success.

APPENDIX: FORCE LAWS TO THE RESCUE?

Armstrong writes regarding the law of gravitation and possible interferences:

[18] As I show in (Author, forthcoming), these difficulties are aggravated if, as for example some dispositional essentialists do, nomological necessity is replaced by metaphysical necessity.

> The gravitational laws give the gravitational forces holding between two bodies having certain masses and a certain distance from each other. It is not necessary that these forces cause the two bodies to move towards each other. There may be many other bodies also exerting gravitational force in the situation, not to mention other types of forces […] that may be operating. […] We can never rule out the possibility, mere possibility though it may be, that further forces […] could be added to the situation which would alter the behaviour of the particulars involved. (Armstrong 1997: 230-1)

How do we formalise the law of gravitation within Armstrong's original framework? The first sentence—"The gravitational laws give the gravitational forces holding between two bodies having certain masses and a certain distance from each other."—suggests that N holds between the structural state of affairs type "two bodies having certain masses, M_1 and M_2, and being at a certain distance, D, from each other" and the gravitational force, F_g. That is, the law of gravitation reads: $N(M_1 \wedge M_2 \wedge D, F_g)$. Note that this interpretation is akin to the general interpretation (N3.2) where we have replaced G by a disposition D_G to bring about G. Here, we have a force F_g which might or might not cause an acceleration A.

There is a second plausible interpretation of the force laws. It follows interpretation (N2) from above: the law of gravitation could also state that bodies accelerate with acceleration A towards each other if they have certain masses and are at a certain distance: $N(M_1 \wedge M_2 \wedge D, A)$. Where has the gravitational force gone in this picture? The answer is obvious when we compare to (N2): we identify N with the force. I will come later to this interpretation, call it "(Force 2)", and start first with $N(M_1 \wedge M_2 \wedge D, F_G)$, which I will refer to as "(Force 1)".

Needless to say, in (Force 1), all other force laws[19]—for example, Coulomb's law: $N(Q_1 \wedge Q_2 \wedge D, F_c)$—have to be interpreted in very much the same way. The great advantage of this interpretation is that we are able to claim that all those laws are *iron laws* in the sense that no interference is possible: that a massive particle might also be charged does

[19] If present physics is correct these are, next to the gravitational force, the electro-magnetic force and the weak and strong nuclear forces.

not take away the gravitational force. Rather, Coulomb's force acts as well but that does not annihilate the first force. Coulomb's force might enforce or reduce (even to zero) the gravitational force's *effect*, but it won't make the gravitational force itself disappear and it is this force, not the force's effect, which is the law's second *relatum*.

For forces, unlike any general D_G as in (N2), we have an algebra readily available that tells us the rule or law by which a multitude of overlapping and interfering forces will interact. As a consequence, we can hope to be able to add to the individual force laws, (i), a further law governing the interaction of a multitude of different forces, and, (ii), a law mediating between resultant forces and accelerations. The first law, (i), says that all individual forces operating on a certain body with mass M add up by means of vector addition: $N(F_1 \wedge ... \wedge F_n; F_T = \sum F_i)$ (the F_i being vectors).[20] The second, (ii), tells us that the so calculated total or resulting force, F_T, operating on an object with mass M causes it to accelerate with $A= F_T/M$, that is $N(F_T \wedge M, A=F_T/M)$. Note that both laws are perfectly strict and uninterferable: no matter what, the total force results from vector addition of all component forces and the acceleration of an object is certain considering the total force acting upon it (as long as F_T really remains the total force). In short, it looks as if, for the force laws, we get rid altogether of the problems of interferences and preventions. (So, item (3) in our original list of together incoherent claims can successfully be denied.)

Yet, there's one drawback for this interpretation (the discussion of which will smoothly lead to our second interpretation of the force laws, (Force 2)). N's instantiation is secured because there is no interference, yet, can it be conceived of as causation? Do masses and distances "cause" the forces between them? Do component forces "cause" resultant forces? If we have a conception of causation where causation is bringing about

[20] As in (N3.1) where we tried to amend the laws first *relatum*, F, we might have to talk about totality facts: $F_1 \wedge ... \wedge F_n$ have to be *all the forces there are*. This, I hope, would be reasonably unproblematic here because we have limited our inquiry to forces, i.e., there is really just one type of entity to be considered.

events then the notion of causation has to be stretched a little here. Note that Armstrong at times endorses such a push-and-pull intuition. Especially when he states that causation is observable he relies on this picture of causation:

> The dyadic predicate 'causes' is as much an observational predicate as any other predicate in our language, especially in such cases as our awareness of *pressure on our own body*. (Armstrong 1997: 228; my italics)

Also:

> The philosophically little-discussed perception of *pressure on our body*—in general *the action of force on our body*—is as directly perceived, I maintain, as anything else in our experience. (Armstrong 2004: 128; my italics)

Yet, if masses in a distance "cause" a force between them—as interpretation (Force 1), namely, $N(M_1 \wedge M_2 \wedge D, F_G)$ would have it—than this causation is not directly perceived as pressure on our body (or the action of a force on our body) for, simply, the force we might feel on our body is the force that is brought about but not the "force" that causes (or ensures) that force to be there.

When talking about the observability of causation Armstrong is, I believe, tacitly moving from interpretation (Force 1) to interpretation (Force 2), for remember that there N itself instantiates as (Newtonian) force: (Force 2) says that the proper formalisation of the law of gravitation within Armstrong's framework is: $N(M_1 \wedge M_2 \wedge D, A_G)$. That is to say that bodies accelerate with acceleration A_G towards each other if the two bodies have masses M_1 and M_2 and are at a distance D from each other. It is N's instantiation, namely a (gravitational) force, that brings this movement about (if no other force interferes).

Yet, while (Force 2) is more in line with Armstrong's claim that N's instantiation is directly observable as pressure on our body or, in general, the action of force on our body, it differs in other respects from Armstrong's original theory: if N's instantiation is a gravitational force (or an electromagnetic, weak or strong force) then N, the second order relational universal, instantiates as a *vectorial magnitude* with both a direction and a strength. Moreover, the strength of N's instantiation would be a function of N's *relata*.

These might be alterations that could be accommodated but there are also some consequences of (Force 2) which are harder to deal with.

The most pressing one is how we explain within (Force 2) the nomicity of force interactions. As pointed out in (Force 1), force interactions themselves are lawlike: they obey vector additions. Yet, if we consult the respective formulations of these interaction laws within Armstrong's theory (as in (Force 1)) we see the problem immediately: both $N(F_1 \wedge ... \wedge F_n;\ F_T = \sum F_i)$ and $N(F_T \wedge M,\ A=F_T/M)$ would confront us with iterated nomological necessities for note that forces, the F_is, really are N's instantiations. This leads ultimately to the unacceptable oddity that *forces force forces* to interact the way they do.[21]

I can only offer a fairly *ad hoc* solution to this riddle: maybe Armstrong could, at this point, claim that force interaction laws are *mere regularities*. When forces interact they do so according to vector additions as a matter of brute fact. No further nomological necessity involved. To ease the pain of this step, one could claim that the desired strong link in nature that binds the world together has been secured already with nomological necessity's primary force instantiation.[22]

Conclusion. When limited to force laws Armstrong's theory of laws of nature seems immune to problems arising from the possibility of interferences. This has largely to do with two facts about the force laws: (i) that there is a force if, for example, there are two

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[21] Note aside that there's also an issue about types and tokens here: nomological necessity is the type of which forces are the token. I.e., for the above laws I should have written: $N(N_1 \wedge ... \wedge N_n;\ F_T = \sum N_i)$ and $N(N_T \wedge M,\ A=N_T/M)$ which makes the trouble even more obvious.

[22] This regularity view about force interaction could somehow be seen as the projection of the following general story about laws and causation onto force laws: "One can accept the reality of singular causation, yet still be a Humean about causal *laws*. The operation of singular causation, one might maintain, is regular as a mere matter of fact. It is not an essential feature of causation. It could have been that from the same sort of cause, quite different effects follow on different occasions. That, however, does not in fact happen […] Perhaps this was the position held by Elizabeth Anscombe (1975). Causes are singular, but regularities in *what causes what* are mere regularities." (Armstrong 2004: 130)
I somehow happen to sympathise with this general picture. Unfortunately, Armstrong ends the above quote saying: "I should like to see this halfway position fully worked out, but *it makes an unsatisfying impression*." (ibd., my italics)

masses in a distance, is uninterferably true. (ii) While one can the interfere with the action of a force (namely by counteracting with a second force) these counteractions are well understood: for forces we have an algebra available that enables us to calculate the effect of interfering forces precisely. Still, both Armstrongian interpretations of the physical force laws, namely (Force 1) and (Force 2), were not free from difficulties.

Moreover, once we start transcending the force laws again we have at least two more challenges to meet: (i) forces and force laws are not *en vogue* in present day physics; (ii) not all physical laws are force laws and, maybe, not all laws are physical laws.

To (i). Even if we suppose that we can make one of the two interpretations, (Force 1) or (Force 2), work we would have to deal with the allegation that forces are no longer respectable entities in the physical sciences. On the contrary, it occasionally seems that modern physics has abandoned talk about forces entirely. In macroscopic physics energy-based accounts (Lagrangians and Hamiltonians) replace forces, in the General Theory of Relativity geometry replaces forces, and quantum phenomena are best described in terms of probabilistic functions of initial conditions. Forces, one might radically conclude, have been deleted from scientific ontology. Like phlogiston they have had their day. If so, the rug is pulled out from under our feet: an Armstrongian account of force laws would be as useful as an Armstrongian account of phlogiston.

There's no space to say much in support of forces here but I would like to point out that there is a growing community of philosophers who defend forces against this kind of reduction (cf. (Bigelow et al. 1988) and (Wilson 2007)). So, maybe, there is justifiable hope that forces can be rescued from phlogiston's fate.

To (ii). Where do the force laws stand in the larger scheme of things? It is true that I have, in this section, intentionally limited our attention to the force laws so this question is, in a way, unfair. Yet, ultimately it will have to be ask. We could try to seek refuge in a radical reductionism: we could claim that every other (causal) law (ideally also including

laws from the special sciences) supervenes on the fundamental force laws so that the problem of N and other frustrations dissolves. Yet, whether this is a viable strategy is more than controversial.

In the light of (i) and (ii) and the problems (Force 1) and (Force 2) inherently have the question "Force laws to the rescue?" is likely to receive a negative answer. this is regrettable, for I believe that with the force laws we came closest to a solution of the problem of interferences with nomological necessity. Maybe the force laws are still a good starting point for the formulation of a future sound theory.

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