Nomic Relations and the Dissolution of the Raven-paradox[1]

Abstract: A raven-type paradox is generated by the co-existence of two statements that are logically but not confirmationally equivalent. I argue that, in order for such a paradox to occur, the statements in question must read as having nomic force. Otherwise they end up being confirmationally equivalent. This is because "accidental" (nomically innocent) generalizations are not confirmed by their instances, so that two accidental generalizations are vacuously identical in respect of their confirmational properties. But, as I attempt to show, once we expose the nomic content of the two statements in question, they turn out *not* to be logically equivalent on any delineation of the concept of a nomic connection. So Hempel's paradox can be dealt with within the framework of classical logic, and without sacrificing our any of our intuitions regarding confirmation (in particular, our pre-theoretic intuition – denied by Hempel, among others -- that the existence of a red carpet fiber does *not* confirm "copper conducts electricity" or "all ravens are black").

I. (*) "all ravens are black"

is logically equivalent with

(**) "all non-black things are non-ravens."

Logical equivalence guarantees confirmational equivalence: if two hypotheses H1 and H2 are logically equivalent, then any given piece of evidence confirms H1 exactly as much as it confirms H2. (**) is confirmed by pink trousers and white pianos. But (*) is *not* confirmed by such things. So we have two statements that are logically but not confirmationally equivalent. A paradox.[2]

Some philosophers bite the bullet and say that pink trousers and white pianos *do* confirm (*) as much as they confirm (**). Others deny this, and try to solve the paradox through the construction of non-standard logics – logics in which (*) and (**) are *not* logically equivalent and which therefore accommodate the confirmational differences between them. A number of solutions combining features of both these proposals have been proposed. These solutions are drastic. It is hard to believe that pink pianos provide positive support for (*). And it is *ad hoc* to invent a whole new system of logic to deal with this one puzzle. (That would be like an accountant creating a new system of arithmetic to accommodate a bookkeeping error.) So, understandably, none of the aforementioned solutions has met with universal acceptance. I would thus like to propose a different approach.

II. The sentence:

(AC) "all the coins in Smith's pocket are quarters"

is said to express an "accidental generalization". The sentence:

(*)"all ravens are black"

does *not* express an accidental generalization. (*) is to the effect that, if a thing is a raven, that provides some kind of nomic basis (though, obviously, one that is extremely far from being sufficient) for its being black. So (*) affirms the existence of a nomic connection between two properties. We might say that it expresses a "nomic generalization".

There is an important difference between accidental and nomic generalizations. The latter do, while the former do not, receive confirmation from their instances. If I pull a quarter out of my pocket, that gives me no reason to believe that the next coin I pull out will be a quarter. The next coin I pull out could just as well be a dime or a nickel. So (AC) is not confirmed by its instances.[3]

But if I see a raven and it is black, that *does* give some reason to believe that the next raven I see will be black. Unlike (AC), (*) *is* confirmed by its instances.

Now consider the statement:

(CA) If a thing is not a quarter, it is not a coin in Smith's pocket.

Like (AC), (CA) expresses an accidental generalization, at least on its most natural reading. So, by reasoning exactly similar to that just given, non-quarters that are not coins in my pocket are no confirmation of (CA). (CA) is not confirmed by its instances.

(AC) and (CA) are logically equivalent. They are also confirmationally equivalent. (AC) is not confirmed by quarters drawn from my pocket. Nor is it confirmed by coins that are not quarters that are not in my pocket. (CA) is not confirmed by coins that are not quarters that are not in my pocket. Nor is it confirmed by quarters drawn from my pocket. There is nothing that confirms the one hypothesis more than the other, since there is nothing that confirms either.

Consequently, no raven-type paradox arises in connection (CA). Because (CA) and (AC) lack nomic force, neither is confirmed by its instances. That prevents them from being confirmationally different. That in turn prevents the occurrence of a raven-type paradox. For such a paradox to occur, we need two statements that are logically equivalent and confirmationally *non*-equivalent. (CA) and (AC), at least when they are read as devoid of nomic content, are logically *and* confirmationally equivalent.

Before moving on, we should deal with a possible worry:

> Imagine the following scenario. Every time my friend Smith pulls a coin out of his pocket, it is a quarter. This happens unfailingly for twenty years: I have never seen him pull a coin out of his pocket that was *not* a quarter. On the basis of this information, I surely have some reason to believe that the next coin he pulls out of his pocket will be a quarter. So surely the coin-withdrawals that I witness *do* provide for the statement that there are no coins other than quarters in Smith's pockets. So I don't see why (AC) is different from (*) in this respect.

In the case described, the statement "there are never any coins other than quarters in Smith's pockets" is *not* an accidental generalization, and it *does* have nomic content. In the case in question, what you come to believe is precisely that there is some kind of

principled connection between being a coin in Smith's pocket, on the one hand, and being a quarter, on the other. You come to believe that Smith's policy is never to have coins other than quarters in his pockets (because, perhaps, when he has to feed the meter or do laundry, he doesn't want to deal with the frustration of rummaging through useless nickels and dimes), or that he is the victim of a long-running practical joke. In any case, what you come to believe is *precisely* that the situation in question is not happenstance. Of course, it is not a *law of nature* that any coin in Smith's pocket must be a quarter. But that doesn't mean that no nomic connection is at work. It is not a law of nature that, whenever you flip the switch, the light turns on. But there is obviously a nomic connection at work. Flipping the switch *causes* the light to turn on: the first event provides the nomic basis for the second. There is a principled, nomic relation between the first event and the second. Similarly, if Smith's mission in life is to make sure that there are never any coins in his pocket that are not quarters, or if Smith's roommate wants nothing more than to steal all coins other than quarters from Smith's pocket, then there will be a causal mechanism ensuring that the property of being a coin in Smith's pocket is co-instantiated with the property of being a quarter. There will be a nomic, principled relation at work.

Like any other "all"-statement,

(AC) "all the coins in Smith's pocket are quarters"

is capable of two readings. On one of them, it is to the effect that there is some kind of *connection* between being a coin in Smith's pocket, on the one hand, and being a quarter, on the other.

There is another possible reading of (AC). On this reading, it is to the effect that every coin in Smith's pocket just happens to be a quarter, the concomitance being purely "accidental".

On the *first* reading, (AC) clearly receives support from its instances. The proposition that there is a *principled* relationship between the property of being a coin in Smith's pocket and the property of being a quarter is one that *is* supported by each instance of a coin in Smith's pocket that is a quarter.

On the second reading, (AC) is *not* capable of such confirmation. On that reading, (AC) has no nomic content, and makes a purely numerical statement. If there really is no principled connection between the property of being a coin in Smith's pocket and the property of being a quarter, then *ex hypothesi* each case of a quarter being withdrawn from Smith's pocket must be considered to be entirely independent of each other such case. In that case, tautologously, we cannot use those past cases as a basis for a prediction regarding future cases. In thinking otherwise, one would be guilty of the so-called "gambler's fallacy."

Past data is confirmationally inert except in so far as it suggests the operation of mechanisms that can be counted on to continue. So past data can confirm a hypothesis only if that hypothesis has nomic content – only if it is to the effect that the correlation in question has a basis in law. Statements like (AC) are thus capable of confirmation only when they are given a nomic reading. Really this is a truism. To give (AC) a nomic reading just *is* to take it to say that the concomitance in question is rooted in the kind of mechanism that warrants our making predictions on the basis of past information. To give

(AC) a non-nomic reading is to read it as *not* saying that the concomitance in question has any such basis. So a non-nomic reading is, practically by definition, one that doesn't warrant prediction and, therefore, doesn't allow confirmation. To sum up, it turns out to be a truism that genuinely accidental generalizations do not receive confirmation from their instances.[4]

If (*) and (**) both lacked nomic force, then they would both be incapable of being confirmed by their instances. Consequently, they would be equally incapable of confirmation by their instances. In that case, they could not be confirmationally different, and there would be no paradox. There is a paradox only because at least one of those two statements has nomic force – only because at least one of them affirms the existence of a nomic connection between two properties. Of course, if one of them has nomic force, both must have nomic force if they are to be logically equivalent. After all, if P affirms a nomic connection and Q does not, then P and Q are not true in the same models, and are therefore not logically equivalent. So if (**) is to be logically equivalent with (*), then we must see it as making a nomic statement.

So read in the way that is relevant to our inquiry, (*) is to the effect that:

($*_N$) If a thing is a raven, that provides a nomic basis for its being black.

So if (**) is to be logically equivalent with (*), then we must see (**) as being to the effect that:

($**_N$) If a thing is non-black, that provides a nomic basis for its being a non-raven.

The question now is: Are ($*_N$) and ($**_N$) logically equivalent? If not, then there is no paradox: for the paradox in question to arise, we need ($*_N$) and ($**_N$) to be confirmationally non-equivalent while being logically equivalent.

I will now argue that, in fact, ($*_N$) and ($**_N$) are *not* logically equivalent. For reasons previously discussed, their non-equivalence prevents the paradox in question from being generated.

III. There are different kinds of nomic relations. The most obvious examples of nomic relations are *causal* relations. Consider the statement:

(#) Anything[5] that drinks arsenic at time t is dead by time t*.

This is a true statement (at least for certain values of t and t*), and it is obviously not an accidental generalization. There is a nomic connection between drinking arsenic at time t and being dead by time t*. This nomic connection is causal: drinking arsenic *causes* death. So the nomic content implicit in (#) is given by the statement:

($\#_C$) Drinking arsenic at t causes death at t*.

Some nomic relations that seem *not* to be causal actually turn out to be causal. Consider the proposition:

(PF) Pinewood floats.

(PF) is not an accidental generalization. It is, in fact, a natural law -- albeit a very derivative one. The law in question is given by a *causal* statement:

(PFC) If something is pinewood, that is causally sufficient for its floating when placed in water.

Let $P_1 \ldots P_n$ be the properties individuative of pinewood. It is pretty clear that, where at least some of these properties are concerned, a thing's having those properties prevents it from sinking when placed in water. In other words, a thing's having those properties causes it to float. So the law embodied in (PF) is actually a causal law, even though (PF) does not initially appear to be a causal statement.

At least arguably, not all nomic relations are causal. Consider the statement:

(WO) "all water has oxygen in it".

(WO) is not an "accidental generalization". It expresses a principled relationship. But that relation is not causal. Being composed of water doesn't *cause* a thing to be composed of oxygen, and being composed of oxygen doesn't *cause* a thing to be composed of water. The relation in question is not one of causation, but of *constitution.* For something to be water is (inter alia) for its constituent molecules to be composed of oxygen atoms.[6]

IV. It is time to take stock. Let O be an arbitrary object, and let phi and psi be arbitrary properties. We've considered two ways that O's having phi might provide a nomic basis for its having psi. There may be a *causal* relation between O's having phi and its having psi. Or there may be a relation of *constitution.* If a thing has the property of drinking large quantities of arsenic at time t, that *causes* it to have the property of being dead at t*. If a thing has the micro-structure characteristic of pinewood, that *causes* it to float when placed in water. If something is made of water, that does not *cause* it to be composed of oxygen atoms: its being composed of water *consists* in its having such a composition.

Are there nomic connections that don't involve relations of causation or of constitution? Some new terminology will help us answer this question. Drinking arsenic at time t is one thing. Dying at time t* is another. Since they happen at separate times, and possibly separate places, the one event is not in any sense an ingredient of the other. So we might say that a thing's drinking arsenic does not *consist* in its dying, and that its dying does not *consist* in its drinking arsenic.

Let us now answer the question posed a moment ago. Suppose that a thing's having phi does not consist, even in part, in its having psi. So a thing's having phi is one thing, and its having psi is separate. They happen at different times or different places or both. We are thus dealing with distinct states of affairs – states of affairs such that neither is a component, proper or improper, of the other.

Given this, suppose that there is some nomic connection requiring a thing to have psi if it has psi. That connection must plainly be *causal.* Given any two distinct states of affairs, any law requiring the existence of the one, given the existence of the other, is *ipso facto* causal. A causal relation just *is* something that requires the existence of one state of affairs, given the existence of some other state of affairs. So it is a truism, or at least follows from truisms, that under the circumstance described, a thing's having phi must be *causally* related to its having psi.[1]

Now suppose that there is no causal relation between a thing's having phi and its having psi, but that there nonetheless *is* some kind of nomic connection: a connection that demands the existence of the one, given the existence of the other. If a thing's having phi were *distinct* from its having psi, then for reasons we've seen, any nomic connection of the kind described would be *causal.* So if there is to be a non-causal, nomic connection between the two, that must involve a thing's having phi *not* being distinct from its having psi – the one state of affairs must be a constituent of the other.

It seems to be a truism, or at least to follow from truisms, that any nomic relations between a thing's having one property and its having another must either be *causal* or must lie in the fact that possession of the one property is *constitutive* (at least in part) of possession of the other. Nomic relations are relations of causation or of constitution.

V. Now we can begin to close the argument. We saw that each of (*) and (**) must be given a nomic reading if there is to be a raven-paradox. On such a reading, (*) is to the effect that there is some kind nomic relation between a thing's being a raven and its being black. As we've just seen, such a relation would be one either of causality or of constitution.

Suppose that the relation is one causality. In that case, the nomic relation in question would be given by a story like the following. The class of ravens forms a natural kind. Let $R_1 \ldots R_n$ be the properties individuative of this kind. Where some subset of these properties is concerned, if a thing has the properties in this subset, that causes it to grow black feathers. If a thing has certain genotypic properties distinctive of ravens, that is a cause of its growing black feathers (at some early point in its life – perhaps before it hatches).

Now suppose that the nomic relation between a thing's being a raven and its being black *is* not causal. In that case, the nomic relation in question would be given by a story like the following. Supposing that $R_1 \ldots R_n$ are the properties individuative of this kind, there is some i such that R_i *is* the property of being black.[7]

We saw that, if there is to be a paradox, then (**) must be given a nomic reading – otherwise (*) and (**) will not be logically equivalent. There are two possibilities. The nomic connection can one of causality or of constitution. If the connection is one of causality, then (**) is to the effect that there is a *causal* relation between being non-black and non a non-raven. If the connection is one of constitution, then (**) is to the effect that for something to be a non-raven just *is* (inter alia) for it to be black, just for something to composed of water *is* (inter alia) for it to be composed of oxygen.

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[1] This doesn't mean that instances of phi cause there to be instances of psi (or vice versa). It could there, for some third property chi, it is instances chi that produces both instances of phi and of psi. But, in this case, the relationship between instances of phi and of psi, though not itself one of causation, would nonetheless be causal: the concomitance of phi's and psi's would have to be explained causally (though not as a causal relationship between phi's and psi's).

Given these points, it is clear why, on the relevant readings, (*) and (**) cannot be logically equivalent. Suppose we give causal readings to (*) and (**). In that case, (*) would be to the effect that:

($*_C$) Being a raven (having the genotype characteristic of ravens) *causes* a thing to be black (to grow black feathers).

And (**) would be to the effect that:

($**_C$) Being non-black *causes* a thing to be a non-raven.

($*_C$) and ($**_C$) are *not* logically equivalent. There are logically possible worlds, or models, in which a thing's having the genotype distinctive of ravens *causes* it to have black feathers, but where being non-black doesn't *cause* things to be non-ravens. An illustration may be in order. In the actual world, ($**_C$) is false. My shirt is non-black (it is green). But its being green did not *cause* it to be a non-raven; it never was, and was never going to be, a raven; nothing had to prevent it from becoming a raven, or make it stop being a non-raven. By contrast, ($*_C$) may well be true; in any case, it is an empirical question whether it is true or not. And given only that ($**_C$) is false, it cannot be *deduced* that ($*_C$); given the falsity of ($**_C$), it remains an open empirical question whether ($*_C$) is true or not. So ($*_C$) and ($**_C$) are not logically equivalent.

So, read causally, (*) and (**) are not logically equivalent, and there is no raven-paradox. What about if we give them the other possible reading? In that case, (*) would be to the effect that:

($*_K$) A thing's being a raven *consists in* (among other things) its being black (just as a thing's being composed of water consist in, among other things, its being composed of oxygen atoms).

And (**) would be to the effect that:

($**_K$) A thing's being non-black *consists in* (among other things) its being a non-raven.

There is an obvious difference between ($*_K$) and ($**_K$). ($*_K$) is meaningful. In fact, it is true. But ($**_K$) seems to be false. Intuitively, it seems false to say that that a thing's being non-black *consists* in its not being a raven. Of course, it may be that all non-black things *are* non-ravens. It may even be that this is necessarily the case. But it still seems wrong to say that being non-black *consists in* being a non-raven.

Let us try to be more explicit about the logic underlying these intuitions. One wants to say that being non-black is not *about* being a non-raven: rather, it is *about* having a surface that doesn't absorb certain wavelengths of light; or perhaps it is about looking a certain way in certain lighting conditions. If you want to say what it is for something to be black, you don't mention the fact that it is not a raven; from an explanatory viewpoint, being non-black is not "about" being a non-raven. By contrast, if you want to say what

water is, you *do* mention the fact that it contains oxygen. Being water is "about" (inter alia) being composed of oxygen atoms; if you want to say what it is for something to be water, you talk about oxygen atoms (and hydrogen atoms).

Evidently, the relation of "consisting in", in the relevant sense, is one that holds between x and y when there is an explanatory relation between them. ($*_K$) says (among other things) that there is an explanatorily significant connection between the property of being water, on the one hand, and the property of being composed of oxygen, on the other. The words "consist in" mark the presence of an explanatorily significant relation. The alleged relation does exist, and that is why ($*_K$) is true.

The categories *non-raven* and *non-black* are not explanatorily significant ones, at least not in remotely the same sense as the categories *raven* and *black*. Given only the information that something is *not* a raven, or that it is *not* black, our best theories don't really tell you anything about it. They leave it open whether it is a blue diamond, a green iguana, a point in space, or a prime number. That information puts no predictively significant constraints on what that thing might be. But given only that that something is a raven, or that it is black, our theories have an enormous amount to say – about its bone structure, its physiology, its microstructure, its reproductive mechanisms, and so on.

The categories *non-raven* and *non-black* are explanatorily bankrupt. *x is a non-raven* isn't explanatorily significant. Neither *x is non-black.* But *x is a raven* and *x is black* are replete with explanatory content.

For this reason, ($*_K$) and ($**_K$) are not logically equivalent. For ($**_K$) to be true, the categories *non-raven* and *non-black* would have to be explanatorily significant. There are obviously possible worlds (our world is one of them) in which the categories *raven* and *black* are explanatorily significant, but where the categories *non-raven* and *non-black* are not. This means that there are possible worlds where ($*_K$) is true and ($**_K$) is not. So ($*_K$) and ($**_K$) are not true in exactly the same models and are therefore not logically equivalent.

There (infinitely many) other paradoxes of the type just discussed. But exactly similar considerations dissolve them.

VI. I would like to end by considering a possible objection to our analysis:

Your analysis involves the claim that all nomic relations are either causal or constitutive. This is a very strong claim – one whose truth might well be doubted and therefore cannot be presupposed. And your argument is therefore shaky, at best, so far as it depends on it.

My argument is easily shown not, ultimately, to depend on the truth of the assumption in question (even though, to be sure, my use of that assumption did facilitate the exposition of my argument). My argument depends only on the assumption that statements such as

(PF) *pinewood floats* and (*) *all ravens are black* – non-accidental universal generalizations, in other words -- have nomic content of some kind or other.

We have argued that, when it is taken to express a natural law (or, in any case, some kind of principled, as opposed to merely accidental, generalization), (PF) has for at least part of its content the proposition:

(PF1) something's being pinewood provides some kind of nomic basis for its being something that floats

In light of this, consider the statement:

(PF2) If something doesn't float, then it isn't pinewood.

If (PF2) is read as having no nomic content, then it clearly isn't logically equivalent with (PF1) or therefore with the relevant reading of (PF). If (PF2) *is* read as saying that:

(PF3) Something's not being something that floats provides some kind of nomic basis for its not being pinewood,

then (PF2) is *not* logically equivalent with (PF) (on the relevant disambiguation of the latter) and, moreover, is a highly dubious statement. (For reasons given earlier, it is hard to see how x's *not* being something that float could provide a *nomic* basis for x's *not* being pinewood.) It is true that, as we presented it, our argument involves the assumption that all causal relations are either causal or constitutive; and it may also true that this is a strong and doubtful claim. But all we need for our argument to go through is the claim that statements like (PF) and (*) (and *metal expands when heated* and *copper conducts electricity*…) have some kind of nomic content. This is not an unreason able claim: it is not unreasonable to hold that *metal expands when heated* involve some kind of commitment to the position that a thing's being metal provides some kind of nomic, or at least principled, basis for its expanding when heated. Further, it is uncontroversial that, if *metal expands when heated* is read in this way, it is not logically equivalent with either *a thing's not expanding when heated provides some kind of nomic basis for its not being metal* or with any statement that *lacks* nomic content. Once this last point is granted, it straightforwardly follows that, read in the relevant way, *metal expands when heated* is not logically equivalent with *things that don't expand when heated are non-metals.* The same thing *mutatis mutandis* would seem to hold for any other pair of statements whose co-existence generates a raven-type paradox (e.g. *for all x, if x is pinewood, then x floats*/*for all x, if x doesn't float, then x isn't pinewood*). And therewith the Raven-paradox vanishes.

References

Ayer, Alfred Jules. (1972) *Probability and Evidence.* New York: Columbia University Press.
Cohen, Jonathan (1989) *The Philosophy of Induction and Probability*, Clarendon Press: Oxford.

Hempel, Carl. G. (1945a) *Studies in Logic and Confirmation.* Mind 54, 1-26.
Hempel, Carl. G. (1945b) *Studies in Logic and Confirmation. II.* Mind 54, 97-121.
Hempel, Carl G. (1966) *Philosophy of Natural Science.* Englewood Cliffs: Prentice-Hall.
Falletta, Nicholas. (1983) *The Paradoxicon: a Collection of Contradictory Challenges, Problematical Puzzles, and Impossible Illustrations*.
Gardner, Martin (1973) *Mathematical Puzzles and Diversions*, Penguin Books.
Kuipers, Theo. (2000). *From Instrumentalism to Constructive Realism. On Some Relations between Confirmation, Empirical Progress, and Truth Approximation.* Dordrecht, the Netherlands: Kluwer.
Leavitt, F. (1996). "Resolving Hempel's Raven Paradox." Philosophical Inquiry 18, nos 3/4: 116.
Goodman, Nelson. (1954). *Fact, Fiction, and Forecast.* Cambridge: Harvard University Press.
Mackie, J.L. (1977). *The Cement of the Universe.* Oxford: Clarendon Press.
Maher, P. (1999). "Inductive Logic and the Raven Paradox". *Philosophy of Science* 66: 50-70.
Quine, Willard van Orman. (1969). "Natural Kinds". In *Ontological Relativity and Other Essays*. New York: Columbia University Press.
Sainsbury R. M. (1997) *Paradoxes*, (2nd Ed.) Cambridge University Press.
Scheffler, Israel (1981) *The Anatomy of Inquiry.* Indianapolis: Hackett.
Trusted, Jennifer (1979) *The Logic of Scientific Inference*, The MacMillan Press Ltd.

[1] I'd like to thank Ernan McMullen and Theo Kuipers for their fruitful comments on earlier drafts of this paper.

[2] Of course, Carl. Hempel (1945a, 1945b) discovered the paradox. The paradox has been re-articulated many times, sometimes with interesting twists. (See Maher 1999). Hempel bit the bullet, saying that one *does* confirm (R1) by encountering non-black non-ravens. An intuitively more plausible view is proposed by Quine (1969). (My solution here has some vague affinities with Quine's view.) Some sharp -- in fact, devastating -- criticisms of the views prevailing during his time, including Quine's, is given by Ayer (1971). Scheffler (1981) admirably reviews all the major solutions prevailing at the time of his writing. Most solutions propose that (R1) and (R2) are, indeed, equivalent. See Schlesinger (1974), Trusted (1979), Cohen (1989), Leavitt (1996), Sainsbury (1997), Maher (1999).

There are views that try to destroy the alleged equivalence between (R1) and (R2). But these views always resort to non-classical logics. (See Sylvan and Nola (1991)).So in effect these views *do* concede that, within a classical framework, (R1) and (R2) are indeed, equivalent. So these views presuppose that (R1) and (R2) *are* equivalent, if only within a classical framework: otherwise non-standard logics wouldn't be invoked to block the equivalence.

These are all worthy views. For reasons of space I cannot review them all here. But what I can say is that, since they all presuppose a certain equivalence between (R1) and (R2), they are hobbled at the outset. Again, I grant that on *a* legitimate reading, (R1) and (R2) are, within the framework of classical logic, logically equivalent. But "all" statements are not always so transparent in terms of their content. And this is a case where the nuances of the word "all" are relevant. I submit that once we make these nuances explicit, we will find that *even within a classical framework*, what is said (or at least meant or insinuated) by (R1) and (R2) is not equivalent.

[3] Hempel (1966).

[4] Of course, Hume denied that there are nomic relations. (Or, what is the same, he said that nomic relations just *are* chance concomitances.) But Hume also said that the past is no basis for prediction. Hume was being consistent. *If* Hume's analysis of natural law is correct – if laws are *de facto* constant conjunctions – then every new event is a fresh roll of the dice; and one would be guilty of a version of the so-called gambler's fallacy if one were to make predictions about future dice-rolls on the basis of past ones.

[5] The quantifier is subject to implicit restrictions. There may be Martians that can drink arsenic without dying.

[6] It might be said that the connection between something's being water and its being composed of oxygen is not *nomic* – that it is better described some other way. Perhaps the term "nomic" should be reserved for contingent relations.

In my view, such a position would prejudge many important questions about the relation between nomic and metaphysical necessity – about the grounds of nomic necessity itself. A number of propositions that we intuitively regard as nomic are not contingent. If we removed all non-contingent propositions from scientific theory, it would be very difficult to organize what was left over. Non-contingent propositions, such as (WO), are such an integral part of the theories that describe natural law that it would be artificial to deny that they had nomic status.

Kripke (1972) describes the relation expressed by (WO) as "metaphysical". There is no metaphysically possible world where water doesn't consist (in part) of oxygen. I agree with Kripke. But it doesn't necessarily follow that metaphysically necessary relations are not also nomic. As a matter of simple fact, they often serve an explanatory function similar to that of principles that are *plainly* nomic. In the third lecture of *Naming and Necessity*, Kripke himself suggests that, in some cases, nomic relations might be *necessary* in the strictest sense. So I don't think I am completely off-base in describing the relation between the property of being water, on the one hand, and the property of being composed of oxygen, on the other, as "nomic".

[7] For the record, I am fairly certain that the *causal* story is the right one. The relation between being a raven and being black is not like the relation between being water and being composed of oxygen atoms. The first relation, unlike the second, seems to be contingent, even though it is a principled one. We could genetically engineer white or green ravens. This would involve tinkering with the causal mechanisms mediating between the properties distinctive of ravens, on the one hand, and their phenotypic expression, on the other.