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ARTICLE

Induction and Natural Necessities

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Abstract Some philosophers who believe that there are necessary connections in nature take it that an advantage of their commitment is that the problem of induction is solved. This paper aims to offer a comprehensive refutation of the arguments necessitarians use to show that if natural necessities are posited, then there is no problem of induction. In section 2, two models of natural necessity are presented. The "Contingent Natural Necessity" section examines David Armstrong's explanationist 'solution' to the problem of induction. The "Natural Necessity and IBE" section looks in detail into the claim that natural necessity is the best explanation of observed regularity. The "Dispositional Essentialism to the Rescue?" section moves on to Brian Ellis's dispositional essentialist 'solution'. The "Sankey's Helping Hand" section examines Howard Sankey's attempt to blend dispositional essentialism and explanationism.

Keywords Natural necessity · Induction · Laws · Inference to the best explanation · Armstrong · Ellis

1 Introduction

Some philosophers who believe that there are necessary connections in nature take it that an advantage of their commitment is that the problem of induction is solved. This belief is widespread and quite independent of how exactly natural necessity is understood, provided that it is taken to be a robust feature of the world. This paper aims to offer a comprehensive study of the arguments necessitarians use to show that if natural necessities are posited, there is no problem of induction. It will offer, what I hope they are, conclusive refutations of these arguments.

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As will be explained in Sect. 2, there are two models of natural necessity. Though the two models are importantly different, they both rely on the same strategy to 'solve' the problem of induction, viz., on the argument that positing relations of (contingent or metaphysical) necessitation is the best explanation of observed past regularities and at the same time the ground for the extendability of the regularity. Necessity plays the role of justifying a restriction of the number of possible futures to exactly those which are like the past. The paper will show that both ways to achieve this restriction fail; hence the problem of induction is not solved by inflating metaphysics.

Section 3 examines David Armstrong's explanationist 'solution' to the problem of induction by positing contingent necessitating relations among universals. Section 4 looks in detail into the claim that natural necessity is the best explanation of observed regularity. Section 5 moves on to Brian Ellis's dispositional essentialist 'solution'. Section 6 examines Howard Sankey's attempt to blend dispositional essentialism and explanationism.

It should be noted that I will not aim to offer an 'alternative' solution to the problem of induction. But it will transpire that since the problem of induction is an *epistemological* problem, viz., the rationality of an ampliative inference which bridges the gap between what has been observed so far and what will be observed in the future, it cannot be accounted for by inflating metaphysics—the answer to it, if any, has to be *epistemological*.

2 Two Models of Natural Necessity

There are two models of natural necessity available. The first takes it that there is a relation of necessitation between distinct properties which is, however, contingent: it might not have held between them; or it does not hold in other possible worlds in which exactly the same properties exist. This is the view made popular by David Armstrong (1983). The key idea is that, as a matter of contingent fact, there are (in the actual world) non-trivial relations of necessitation among distinct universals. These are *external* relations; they do not supervene on the intrinsic properties of the related universals; hence, they could vary independently of the intrinsic properties of them. Yet, they *do* obtain between the related universals in the actual world and necessitate their co-instantiation.

On this account of natural necessity, laws of nature are naturally necessary: they embody relations of necessitation among distinct properties. Given that there is a necessitating relation between property F and property G, it is claimed that unobserved instances of F have to be instances of G. Hence, there is no natural possibility that an unforeseen F will not be G (though there is a metaphysical possibility that it might not be; since the necessitating relation is *not* metaphysically necessary). It is then claimed that since there is a necessitating relation between F-ness and G-ness, all unobserved Fs (being instances of F) will be G (i.e., instances of G). The problem of induction, it is claimed, is solved: given natural necessity, there is no room for inductive scepticism.

The second model of natural necessity is stronger than the first. It is envisaged that there is a necessitating relation between distinct properties F and G such that it is metaphysically impossible that F is instantiated without G being instantiated. The key idea is that this necessitating relation is an *internal* relation, that is, it bilaterally supervenes on the intrinsic properties of the relata. Given that the relata (the related properties) are what they are, they must be so related—that is, there has to be a necessitating relation between them.

This view was made popular by Brian Ellis (2001). In its most challenging form it puts together two metaphysical theses. One is that properties have essences—that is, there are

certain characteristics that a property has in virtue of which it is the property it is. The other metaphysical thesis is that properties are powers—that is, they are active (or passive) and are individuated by their causal profile, i.e., by the effects they produce under certain circumstances. If these two (independent) theses are brought together, we have what has become known as *dispositional essentialism*, where the essences of properties are powers. It is then claimed that since it is part of the essence of F to bring about G, whenever F is instantiated, so will be G; not just in the actual world, but in all possible worlds. Here the necessitating relation implies that the problem of induction is not solved just for the actual world, but *for all possible worlds*. If there is a law connecting F and G such that this law is metaphysically necessary, then not merely unobserved but also possible Fs will be G.

Both models imply that metaphysics can solve (once and for all) the problem of induction. Perhaps there are different ways to formulate *the problem of induction*. Indeed, the history of the problem, which goes back to Aristotle, is long and variegated. But what matters for our purposes is that induction is the mode of inference that permits the extendability of an observed regularity. To say that we (are rationally entitled to) infer that All Fs are G on the basis that *so far* all Fs have been Gs is to say that we (are entitled to) infer that a fact with a temporal character (*so far*) can be extended to an atemporal fact (*Always—all*). Given this, what matters for our purposes is one significant feature of natural necessity: that natural necessity guarantees the extendability of an *observed* regularity. This key element of necessity goes back to Aristotle (cf. 1139b19–1139b35; 1991, p. 1799). Actually, precisely because Aristotle thought there *are* necessary connections among universals (in fact, he thought that the first principles of science have to be necessary truths which are not demonstrable), he also thought that induction faces no epistemological problem.[1]

3 Contingent Natural Necessity

On Armstrong's (1983) approach to laws of nature, a law-statement is typically written as N(F, G), meaning: *F-ness* necessitates *G-ness*, or *being F* necessitates *being G*. How is this supposed to solve the problem of induction?

For Armstrong, "the law involves some extra thing; some further state of affairs", meaning that N(F, G) is something over and above All Fs are G. He therefore argues as follows:

> The presence of this extra thing (…) serves, first, to explain why all the observed Fs are Gs, and, second, to entail that any unobserved Fs there are will be Gs. The postulation of the extra thing is a case of inference to the best explanation. It is rational to postulate what best explains the phenomena. Induction is thus rational, because it is a case of inference to the best explanation (1983, 55).

So the problem is supposed to be solved by an IBE; and it depends on it being the case that N(F, G)—the extra thing over and above All Fs are G—is the best explanation of the fact that *so far* All Fs have been G. But is this external relation of necessitation between F-ness and G-ness the best explanation? The N-relation is contingent—hence it might not have applied between F-ness and G-ness. How are we to understand this? It may mean either

[1] This is not the place to elaborate on Aristotle's views of induction. For more on this, and in particular for the connection between natural necessities and induction in the Middle Ages, see my (2015).

A: there is a possible world W1 in which there are F-ness and G-ness but no relation N between them, or
B: there is a possible world W2 in which there is a relation of necessitation N among F-ness and G-ness, but this relation has a temporal limit.

On option B, N(F, G) 'binds' F-ness and G-ness up to some time *t* and fails to bind them after *t*. N(F, G), in other words, is a temporally indexed universal.

If N(F, G) is contingent, then there must be W2 worlds. And the question is: how can we force it to be the case that the actual world is not like W2? Given the available evidence, the world we live in might be W2!

The answer to this worry should be something like this. The claim 'the world we live in in such that N(F, G) holds atemporally' is the best explanation of the available evidence (the regularity *so far*). But why is this so? Recall that N(F, G) is something *over and above* All Fs are G—an "extra thing" as Armstrong put it. But, there is nothing in *N* itself which guarantees that it might not cease to hold between F-ness and G-ness in the future. The fact that F-ness and G-ness are universals does not, in and of itself, dictate that the relation of nomic necessitation between them will hold for ever. The universals might not change, but their *external* relations need not be timeless. Armstrong disagrees. He says:

> The universals F and G are exactly the same things at their different instantiations. They cannot dissolve into different F-ness and G-ness at different places or times: if they do, we are not dealing with unitary universals, that is, with universals. As a result there can be no question of their being related in a certain way at one place and time, yet not being related in that way elsewhere (1983, 79).

This sounds too rash to me. The universals need not change. But their *external* relations might. The external relations are not part of the identities of the universals. (If they were, the relation of necessitation would not be contingent). But then, G does not have to change if it ceases to be related to F; it just ceases to be related to F. Here is an example. Take the universal 'Smallpox' and its relation to universal 'Death'—before the smallpox vaccine and after the vaccine; or before the eradication of smallpox and after it. If anything, N(Smallpox-ness, Death-ness) is a law restricted to a cosmic epoch. The epoch it holds is characterized by *N*; but there is no such relation among Smallpox and Death any more, though the universals have not changed (even if smallpox has no instances now, it has had instances; it is simply no longer instantiated). Hence, there is nothing except brute fact that makes the contingent necessitating relation N(F, G) atemporal. Positing it offers no better explanation of *so far* All Fs are G than the claim that All Fs are G is a brute fact.

There is another reason why positing N(F, G) is problematic as the best explanation of the regularity *so far* All Fs have been G. This is that there is nothing in N(F, G) itself which makes it to entail that R: All Fs are G. R is not 'part' of N(F, G) in the way A is 'part' of 'A&B', as David Lewis (1999, 40) pointed out. How then can we get the regularities out of *N*? If N(F, G) is the case, then *N* should be such that, though it does not entail that All Fs are G, it *enforces* that F and G are (always) co-instantiated. But there is no clear understanding of how an external relation enforces the co-instantiation of its relata. It is perfectly possible that there is an *external* relation between F-ness and G-ness without it being the case that whenever F is instantiated, so is G. Here is an example: red colour is taken to stand in the relation 'being warmer than' to blue; but it does not follow that whenever red is instantiated, so is blue.

4 Natural Necessity and IBE

For the move to natural necessity via IBE to work it is important to think of IBE as a type of argument which is distinct from induction; for otherwise, the considered move will be question-begging. John Foster (1983) follows exactly this line when he contrasts 'extrapolative induction' to inference to the best explanation and claims that an appeal to IBE can ground the stronger conclusion that 'All Fs *must* be G', given that *so far* All Fs have been G. To be sure, IBE is an ampliative inference and there is an issue concerning its own justification. Since this is a central issue, I will briefly discuss it towards the end of the paper in Sect. 6. For the time being, let us assume that IBE is distinct from enumerative induction and see how far we can go.

Foster offers the following argument-type for commitment to necessary connections:

(A)
O: Gravitational behaviour of all bodies *so far*
Best explanation:
(NC) Necessary Connections: the gravitational behaviour of bodies is a matter of natural necessity.
NC entails U: All bodies always behave gravitationally
U entails O.

In this argument, the extendability of a regularity is (supposed to be) best explained by a necessary connection. As Foster put it, "The past regularity does indeed, by means of an explanatory inference, afford rational grounds for expecting its future continuation" (1983, 89).

However, there are two potential explanations of the *past* regularity.

E1: There is a necessary connection between (properties) F and G.
E2: There is a necessary connection between (properties) F and G *so far*.

If, for whatever reason, E2 is taken to be the best explanation of the past regularity *so far* All Fs have been G, then not only is it the case that (A) has not identified the best explanation of the past regularity; it also transpires that the move from the past regularity to the regularity, even when mediated by IBE, is inductive. It essentially depends on generalizing to *all time* the necessary connection between F and G *so far*. Hence, there is no 'solution' to the problem of induction.

But how could E2 be the best explanation? Helen Beebee (2011) has argued that there is no reason to think that E1 is a better explanation of the observed regularity than E2. She notes:

> (…) there is no reason to think that [E1] explains our observed regularity any better than [E2]. After all, in general, if E is the best explanation of $A\&B$, it doesn't follow that E is also the best explanation of A. So just because N(F, G) is the best explanation of the fact that *all* Fs are Gs—both observed and unobserved—it doesn't follow that it is the best explanation of the fact that all observed Fs are Gs. If all we are trying to explain is the fact that the observed Fs have been Gs, then the hypothesis that F and G have been necessarily connected so far is surely just as good a candidate explanation as is the hypothesis that F and G are timelessly necessarily connected (2011, 510).

Her claim is that when it comes to the *explanandum*, viz., that *so far* All Fs are Gs, it makes no difference if the *explanans* is E1 or E2, since the extra content of E1 (viz., the atemporal necessary connection) has no bearing on why *so far* All Fs are Gs. She then goes on to argue that a notion of time-limited necessity (encapsulated in E2) is coherent. And the main argument she uses for this claim is that we can imagine (conceive) that though F and G are related by the necessitating relation N, God could make it happen that they cease to be after some certain time t (cf. 2011, 512).

The appeal to God might be a rhetorical device, but the underlying point should be well-taken. The point is that it is certainly possible that natural necessities are time-indexed. And there is nothing in Armstrong's and Foster's approach to necessitation to block this possibility.

Eduardo Castro (2014) has taken issue with Beebee's claim that there is a stand-off between E1 and E2. Though E1 entails E2, Castro claims that E1 should not be taken to be the conjunction of two claims, viz., (E2): There is a necessary connection between (properties) F and G *so far* & (E1′): There will be a necessary connection between (properties) F and G *in the future*. But what exactly is the extra content of E1 over E2? He says that E1 unifies "all possible" E2s. The thought, I take it, is that explanations like E2 make a reference to time; hence there are as many temporally-indexed necessary connections between F and G as there are times. This proliferation of explanations—for each particular time that is present—is avoided by E1: a timeless necessary connection between F and G. Hence, Castro's thought is, E1 is a better explanation of the observed regularity than E2.

This kind of argument misconstrues the role of time in E2. It is not as if there are as many temporally limited necessary connections as there times. Rather, I take it that the point is that there are two accounts of necessity—one that takes it to be, by default, unrestricted and another which leaves it *open* that necessary connections have a 'best before' date. Let us call the first conception NC and the second NC_{bb}. NC_{bb} need not posit any *particular* time from which on a necessary connection fails to hold between two properties F and G. It simply takes it that necessary connections may break down and that they are not by default atemporal. On NC_{bb}, the existence of a necessary connection does not imply that there is no time from which on the connection fails to hold. If this move is allowed, the point is that there is nothing in (the properties) F and G *themselves* which makes it the case that if they are related by some kind of necessary connection, this is NC and *not* NC_{bb}. And this is enough to show that as far as the best explanation of an observed regularity between F and G goes, NC_{bb} is no worse that NC. Seen in this light, NC is simply an *alternative* to NC_{bb}.

In the next section I will offer an example from physics, related to the so-called 'critical point phenomena', as a potential model of NC_{bb}. For the time being, let us grant its possibility and note that in its light, the proper way to state the explanatory contrast is:

E1*: There is a NC between (properties) F and G.
E2*: There is a NC_{bb} between (properties) F and G.

The question then is: is there any substantial reason to prefer E1* to E2* as the better explanation of past regularity?

Castro (2014, 78) notes:

> $N(F, G)$ is independent of time. With $N(F, G)$ in mind, and given that $N(F, G) \rightarrow \forall x\ (Fx \rightarrow Gx)$, the timeless necessitarian explains *deductively* why all other observed ravens are black. Given that a is F and $\forall x\ (Fx \rightarrow Gx)$, a is G. Thus, the

> timeless necessitarian is not struck by new *FG*s. On the contrary, the time-limited necessitarian cannot take the deductive step.

As noted already it is far from clear that $\{N(F, G) \rightarrow \forall x\,(Fx \rightarrow Gx)\}$ is true. And if it is not, then the suggested deductive entailment fails. But suppose that it is true. Does the NC_{bb}-necessitarian have a difficulty in making the 'deductive step' to the *next instance FG*? Note that all the NC_{bb}-necessitarian is committed to is that the necessity that connects F and G is 'breakable'. It does not follow from this that, at *any* particular time, there is reason to believe that it is actually broken. In fact, the NC_{bb}-necessitarian is 'not struck by new *FGs*' provided there is no particular reason to take it that the NC_{bb} connection between (properties) F and G has actually been broken. Hence, though it is true that from NC_{bb}(F, G) and Fa it does not deductively follow that Ga because the time at which the necessity breaks might be just between our discovery that All Fs are G so far and the observation of the next F, unless there is reason to suspect that NC_{bb}(F, G) has actually been broken at this particular instance, the inference (though not strictly speaking deductive) can go through.[2]

Castro (2014, 78) also points out:

> (…) the time-limited necessitarian and the timeless necessitarian require different steps in reasoning. The time-limited necessitarian first makes an IBE step towards *Nt* (*F*, *G*) and then makes an illicit induction step towards *N*(*F*, *G*). However, the timeless necessitarian only makes an IBE step towards *N*(*F*, *G*), and hence, the conclusion—all *F*s are *G*s—is rationally supported. The point of this discussion is only concerned with the first step, as it is unreasonable to make an inference to the best explanation every time that, for example, a new black raven is observed.

Here again, there are no two steps involved in going for E2* as the best explanation of the observed regularity. There need be no further inductive generalization to NC!

With this in mind, let us go back to Foster's argument. There is nothing that forces us to prefer NC to NC_{bb} as the best explanation of the past regularity. So

(A')
O: Gravitational behaviour of all bodies *so far*
Best explanation:
(NC_{bb}) Necessary $Connections_{bb}$: the gravitational behaviour of bodies is a matter of natural $necessity_{bb}$.

Unlike NC, NC_{bb} does *not* entail U: All bodies *always* behave gravitationally. But this is not a problem because the *explanandum* is the regularity *so far*. Yet, one may wonder, does NC_{bb} entail the *explanandum* after all? It seems that if the relation between F and G is NC_{bb}, then it's not necessarily the case that *so far* All As have been B. For all we know, NC_{bb} might have been already broken.

In reply, it should be noted that the difference between NC and NC_{bb} is this:

NC: *So far* all Fs are G and it's not possible that there are Fs which are not G.
NC_{bb}: *So far* all Fs are G and it *is* possible that there are Fs which are not G.

Then, the difference between NC and NC_{bb} is about what is possible and what not, given the regularity so far. Then, NC_{bb} does entail the *explanandum*, viz., that *so far* all Fs are G. Hence, the issue is which and why is the better explanation of the *explanandum*: *so*

[2] Many thanks to an anonymous reader for pressing this point.

far all Fs are G. Arguably, NC_{bb} is as good an explanation as NC because the explanation is that NC_{bb} has *not* yet been broken (though it is possible that it might) which is more in tune with the fact that there is room for exceptions in inductive practices.

But suppose one is not satisfied with the reply just offered. Suppose the objection is that we should understand NC and NC_{bb} as being genuinely distinct. That is, suppose we do not follow the line above and take the content of NC_{bb} not to be: '*So far* all Fs are G and it *is* possible that there are Fs which are not G'. Now, if this move is made, then NC_{bb} does not entail the *explanandum*, viz., that *so far* all Fs are G. Then, the IBE (A') would be reformulated thus:

(A'')
O: Gravitational behaviour of all bodies *so far*
Best explanation:
(NC_{bb}) Necessary $Connections_{bb}$: the gravitational behaviour of bodies is a matter of $natural\ necessity_{bb}$ & NC_{bb} is not broken

This *conjunctive explanans* in (A'') is no less parsimonious than the alternative *explanans*: the gravitational behaviour of bodies is a matter of natural necessity NC. This is because NC may well be seen as stating the following: the gravitational behaviour of bodies is a matter of natural necessity & NC is unbreakeable. More generally, the issue is this. How can we best explain the fact that there regularities with no exceptions *so far*? One explanation is that there are NC in nature. The other is that there are NC_{bb} in nature. Seen this way, there is no explanatory advantage in positing NC, since for all regularities without exceptions so far, NC_{bb} *does* entail that the connection has not yet been broken.

The key issue is this: is NC or NC_{bb} the best way to understand necessary connections? NC_{bb} is more in tune with the intuition that induction might fail in other possible worlds; and that, though reliable, it is not infallible in the actual world either.

5 Dispositional Essentialism to the Rescue?

Ellis (2001) takes it that the necessity of laws of nature is grounded in the kind essences of things, where kind essences are those properties of a natural kind that are constitutive of it, that is those properties which the members of a kind cannot lack without ceasing to be members of this kind. As Ellis put it: the natural kind essences of things "are properties which no individual could lack, yet be a member of the kind to which reference has somehow been made" (2001, 11). Individuals (or processes, for Ellis) belong to natural kinds in virtue of their intrinsic natures. For Ellis, a natural kind K is a universal; its instances belong to the natural kind class C(K) associated with it. Kinds are sharply distinguished from each other: they are distinct and discontinuous. All and *only* things which belong to kind K have intrinsic nature ϕ. Hence, the members of a kind K are intrinsically identical to each other (vis-à-vis their kind-constitutive essential properties).

In this picture, laws of nature are metaphysically necessary because "they are all true in virtue of the essential properties of the natural kinds of things existing in the world" (2001, 33). Laws of nature do not relate universals externally. Rather the laws describe "the behavioral dispositions that things must have in virtue of being things of the natural kinds they are"; hence "they are necessary" (2001, 48). Here is Ellis's illustration of his view:

> To illustrate: If a and b are electrons, then it is necessarily true that they are negatively charged. And, necessarily, if a and b are negatively charged, they are

> intrinsically disposed to repel each other. Therefore, if a and b are electrons, it is necessarily true that they are intrinsically disposed to repel each other. It is therefore a necessary truth, not a contingent one, that electrons are intrinsically disposed to repel each other. The law that electrons are intrinsically disposed to repel each other is therefore true in all possible worlds. It is non-vacuously true in every possible world in which electrons exist.

Note that Ellis's essentialism is dispositional. What makes an entity what it is, is that it is disposed to behave in certain ways. He says: "A particle is a neutron if and only if it is disposed to behave as a neutron does. Its dispositional properties are of its essence" (2001, 117). He takes it that properties (though not all of them) are powers that confer certain dispositions for behaviour on their bearers. Properties are identified independently of laws and they are the truth-makers of law-statements. Since properties are universals and retain their identity in all possible worlds, the laws they give rise to must be the same in all possible worlds.

Ellis claims that this kind of metaphysics has an impact on the problem of induction. He (2001, 283) takes it that the problem of induction is generated by Humeanism:

> If one believes, as Hume did, that all events are loose and separate, then the problem of induction is probably insoluble. Anything could happen. However, if one thinks, as scientific essentialists do, that the laws of nature are immanent in the world, and depend on the essential natures of things, then there are strong constraints on what could possibly happen. Given these constraints, the problem of induction may well be soluble. For these constraints greatly strengthen the case for conceptual and theoretical conservatism, and rule out Goodmanesque inferences based on alternative descriptions of the world. This may not in itself solve the problem, but it significantly changes its nature.

The thought then is that essential modal properties restrict severely the number of all possible futures to just one: that which is exactly like what has happened in the past. Alternative descriptions of the world are excluded. What could possibly happen is what has happened given the (modally laden) kind-essences that there are in the world.

It is not entirely clear to me what exactly Ellis's argument vis-à-vis the problem of induction is. I take it to be that *if* kind essences are fixed, and given their modal nature, various patterns of necessary connections among objects, natural kinds and processes are fixed too. These are part of the identity of these entities and hence they remain invariant as long as these entities do not change.

Yet, I find it hard to see how there is *any* room for induction in this picture of the world. Identifying (fixing) the kind essences, that is the essential properties of the various objects in virtue of which they belong to kinds, cannot be—on this picture—an inductive matter. For if it were, the possibility would always be left open that these are not the essential properties or that they do not remain fixed over time. Hence, there must be some other way by means of which we (the scientists) come to identify the kind essences, which does not rest on generalizing on what has been observed in the past. The same goes for the laws of nature, of which Ellis says: "Laws are not things that exist in the world; they are things that are true of the world. (…) For the truth-makers for the relevant laws of nature are, we hold, just the fundamental dispositional properties" (2011, 128). If the truth-makers of laws are the modal kind-essences, once these properties have been identified so have the laws. Since identifying these properties is not a matter of induction, identifying the laws is not either. It is hard then to see whether there is any role left for induction in this world-view.

Indeed, Ellis (2001, 287) comes very close to accepting this, when he says:

> So, for an essentialist, the problem of induction has a rather different flavor. It is not a question of justifying the inference from" all observed As are Bs" to "all As are Bs." This inference would be justified automatically if we had good reason to believe that the As we had observed belonged to a natural kind and that the property of being a B was an essential property of the As. In that case, the problem would be rather to explain the failure of such an inference.

Ellis is right in pointing out that the critical matter is having *good reasons* to believe that the observed Fs belong to a natural kind and that they possess G essentially. Knowing that *so far* all Fs belong to a natural kind would require knowing that they share a kind-essence. If this were known, and if in addition, it was also known that all the Fs essentially possess G, we would thereby know, according to Ellis, that All Fs are G. But this kind of knowledge cannot be acquired inductively. In fact, it cannot *possibly* be acquired inductively on pain of circularity, since it is this kind of knowledge that is supposed to justify inductive extrapolations "automatically".

Unsurprisingly, we are in the ballpark of IBE again, conceived as a non-inductive method. But before I finally close off this option in Sect. 6, let me challenge the basic assumption that Ellis relies on. This is that if we knew that *so far* all Fs have kind-essence K and if we also knew that *so far* all Fs essentially possess G, then we could conclude that All Fs are G. Leaving the knowledge requirement aside, the argument is this.

(E)

So far all Fs have kind-essence K
So far all Fs are essentially G
Therefore, all Fs are G

No matter what we think of (E), it should be clear that it relies on an implicit assumption, viz.,

(EP): Essential properties are temporally invariant; or kind essences are immutable.

But (EP) can be challenged. It is perfectly conceivable that kind-essences have a 'best before' date. Beebee has already noted an option. She has claimed that it is conceivable that the essential properties themselves change. This, as she (2011, 522–3) noted, amounts to "wholesale changes in which natural kinds there are". As she put it:

> Perhaps, for example, the fundamental particles will start behaving in totally different ways. In that case, there will no longer be the kinds of fundamental particle that there previously were; there will be new kinds, with new dispositional essences, and the old kinds will have gone out of existence (or at any rate will no longer be instantiated).

On this possibility, there is no "guarantee that which natural kinds are instantiated remains constant over time". The weakness of this move is that it shifts the issue to the existence of new natural kinds. Can we challenge EP above without changing the natural kinds?

It is possible that essential properties have built-into best before dates (or better: best-before conditions); that is they are such that they have it *within themselves* that they change at some point or other. In fact, we can think of essences on the model of entirely natural phenomena which exhibit 'critical point' behavior. Ferromagnets, for instance, are easily magnetized. Yet, there is a saturation point in which the magnetization approaches a limit.

When a strong magnetic field is applied and then removed, the magnetization of a ferromagnetic material does not return to its original value—this phenomenon is called hysteresis. Similarly, when heated to a certain temperature, which is different for each material, the ferromagnetic materials cease to be magnetic. This temperature is called Curie point. The point here is *not* that magnetization is an essential property that may be lost (this may well be so; but I am not arguing for this). The point, rather, is that we can *conceive* of essential properties, whatever they are, as possibly possessing built-in Curie points. Hence, something whose essence is K is not necessarily K for ever. Therefore, if it is *possible* that there is something *analogous* to the Curie-point for essences in general, (EP) is false.[3]

An alternative way to look at this issue is to think of essences as being disjunctive: to possess essence K is to be an F-before-Currie point or to be G-after-Curie point. The essence does not change and yet it is not necessarily the case that something which is essentially F before t, will be essentially F after t.

Ellis seems aware of these difficulties and that is why he says that his argument above "may not in itself solve the problem" [of induction]. Elsewhere he makes the honest admission that "a solution to the problem of induction must ultimately be epistemological". I take this to imply that a solution to the problem cannot be purely (or even mainly) metaphysical, since the issue is exactly the grounds for accepting this metaphysical worldview—which might well be inductive. Ellis is right in stressing that "how we ought to reason about the world might well depend on what kind of world we think it is. For this will affect what we think the epistemic task is". What should be added is that for a solution to the problem of induction, it is not enough that the world is in a certain way but that we are *justified* (and in particular that we justified in a non-inductive way) to believe that it is in a certain way.[4]

Here again, Ellis seems aware of this problem. He says: "From the perspective of a scientific essentialist, all scientific inference is seen as depending ultimately, not just on observed regularities, but on what postulates about natural kinds are justifiable" (2001, 285). Though he does not elaborate on what these postulates are it appears from the context that he refers to various principles that ground essentialism—e.g., that there are kind-essences and that they are stable over time. And that is precisely the issue: can these postulates be justified in a non-ampliative way? If not, we have not solved the problem of induction.

If we have had independent (non-inductive) reasons to accept these postulates, it seems we would be home and dry (more or less). But we do not have such reasons; if anything these reasons will be empirical and broadly ampliative-inductive. Ellis has tried to find a helping hand in Howard Sankey's (1997) argument that "the world has a basic natural kinds structure, and that this is important because it gives substance to the idea that nature is uniform" (2001, 285).

[3] A natural reply by the necessitarian would be that essential properties cannot be lost or changed. I only claim that it is conceivable that it is part of the very nature of an entity to have its essential properties modified under certain circumstances.

[4] I am not assuming that externalism is wrong. But it is important to note that this metaphysical 'solution' to the problem of induction may work only if externalism is right.

6 Sankey's Helping Hand

Sankey (1997) capitalized on Hilary Kornblith's (1993) idea that an appeal to natural kinds makes inductive knowledge possible since "the clustering of properties" that makes a kind natural grounds the reliability of the inductive inference from the presence of some of these properties to the presence of others. But whereas Kornblith relies on Richard Boyd's view of natural kinds as homeostatic property clusters, Sankey accepts dispositional essentialism.

He therefore takes it that laws of nature are descriptions of behavioural patterns of things, which are grounded in the real inbuilt causal powers they possess, where the irreducible dispositional properties constitute "the real essences of natural kinds, possession of such powers is crucial to the identity of natural kinds" (1997, 246).

How is the problem of induction solved? For Sankey, the unobserved members of a kind share the essential properties of a kind. What, then, makes the inductive inference true is that the unobserved members of the kind "are all members of a natural kind all of whose members possess those properties essentially (1997, 240). More specifically, Sankey accepts the principle that nature is uniform, but couches it as follows: "the fundamental kinds of things which exist are natural kinds of things which possess the same essential properties". Hence, he argues, unobserved members of the kind "will possess the same properties as members of the kind which have already been observed". It is supposed to follow that

> (…) what makes it rational to make inductive predictions about objects which belong to kinds is simply that it is part of the nature of objects of a given kind to have certain properties (1997, 247–8).

Sankey makes an explicit use of IBE in his argument. He takes it that scientific essentialism, viz., the existence of natural kinds *with essential properties*, is the best explanation of the empirical success of science. He argues (1997, 249) as follows:

> (S-IBE)
> Science is successful.
> The existence of natural kinds is the best explanation of the success of science.
> Therefore there are natural kinds.

He thereby thinks that he avoids the issue of circularity in the justification of induction, since IBE is distinct from enumerative induction.

Note that though it can (and perhaps should) be accepted that the best explanation of the success of science is the existence of natural kinds in nature, it does not follow from it that these kinds are such that they have dispositional essences. Neither essentialism, nor dispositionalism (nor their conjunction) are ipso facto best explanations of the existence of natural kinds. Natural kinds can exist (as networks of objective similarities and differences) without having a dispositional kind-essence. Hence, the case for dispositional essentialism should be argued independently of S-IBE. It is not simply part of S-IBE.[5]

Let us consider a standard inductive argument:

[5] Tuomas Tahko (2015) has pointed out an interesting problem in formulating the very thesis of natural kind essentialism. Part of the problem (which is relevant to my argument so far) is the isotopic variation of chemical substances. This constitutes a challenge to micro-structural essentialism, which takes the *essential* properties of a substance to be fixed by their micro-structural properties. Isotopic variants are not necessarily the same chemical kind.

All observed Fs have been Gs
Therefore All Fs are Gs.

As noted already, for the scientific essentialist to be able to close the inductive gap, she will have to rely on an extra premise, viz., that the observed Fs form a natural kind such that it is part of the essence of the members of the kind to be G. In other words, she would need to interpolate the premise that 'It is the part of the essence of F-kind to be G'. But that's precisely a premise which needs an epistemological justification, as Ellis has already noted. And given the evidence we have, there is simply no way this can be justified non-inductively.

Though I will not argue for this point here, it is right to say that for induction to work reliably, no essences or necessary connections are needed. A clustering of properties which—as a matter of fact—go together, is enough. Induction might not work in other possible worlds—it is enough that it works in the actual world. So induction can be reliable even if natural necessity is denied.[6]

There is a last knot that needs to be tied: can we find solace in thinking that IBE is distinct from enumerative induction? Can we *really* avoid the problem of induction if we turn to IBE as the friends of natural necessities have typically done?[7]

IBE cannot bypass the problem of induction—since the problem concerns, at bottom, the very idea of an *ampliative* but rational method. As I have argued in detail in my (2002), the tension pointed out by sceptic philosophers is a general one between ampliation and epistemic warrant: ampliation does not carry its epistemically probative character on its sleeves. When ampliation (of whatever form) takes place, the output of the method can be false while its input is true. The following question then arises: what makes it the case that the method conveys epistemic warrant to the intended output rather than to any other output which is consistent with the input? No ampliative method can be epistemically probative in the sense in which a deductively valid argument is. (The sense being that *if the input (premises) of the inference are warranted, then the method guarantees that the output (conclusion) cannot be less warranted than the input*.) The question then is: can there be any other way in which a method can be epistemically probative? If the method is not such that the input excludes all but one output, in what sense does it confer any warrant on a certain output?

The sceptic points out that any attempt to strike a balance between ampliation and epistemic warrant is futile for the following reason. Given that ampliative methods will fail to satisfy the conditional italicized a few lines back, any alleged justification will have to base any differential epistemic treatment of outputs which are consistent with the input on some *substantive and contingent assumptions*, (e.g., that the world has a natural-kind structure, or that the world is governed by universal regularities, or that observable phenomena have unobservable causes, etc.). It is *these* substantive assumptions that will do all the work in conferring epistemic warrant on some output rather than another. But, the sceptic goes on, what else, other than ampliative reasoning itself, can possibly establish that these substantive and contingent assumptions are true of the world? Arguing in a circle, the sceptic notes, is inevitable and this simply means, he concludes, that the alleged balance between ampliation and epistemic warrant carries no rational compulsion with it.

I do not think the sceptic is right and I have argued against the view outlined above in my (1999, chapter 4 & 2002). But the key point now is that IBE does not ipso facto meet

[6] For some way to develop this argument, see Benjamin Smart (2013).

[7] I have discussed the relation between IBE and induction in detail in my (2002).

the sceptical challenge. It is subject to it no less than are other forms of ampliative reasoning. I conclude that attempts to use IBE on the basis that it is supposed to be on a different justificatory boat than induction are bound to fail. IBE needs defence against the sceptic no less than induction.

7 Conclusions

Ellis is optimistic that science has "now revealed many of the intrinsic properties and structures of the things that exist in nature, and we are now justifiably able to say what makes them the kinds of things they are and why they are disposed to behave and display the properties they do" (2001, 55). This optimism, the spirit of which I certainly share, raises an epistemological question: how can all these be known without relying on ampliative methods? Clearly they cannot. Even if one could solve the problem of induction by inflating metaphysics, the question would still be: on what grounds is this metaphysical view acceptable?

In what preceded, I argued that the various attempts made by the new necessitarians to ground the extendability of alleged necessary connections fail. It is perfectly conceivable and possible that necessary connections have a 'best before' date (or conditions); hence, they cannot be used to ground universal generalisations non-inductively. IBE cannot be of much help here since a) it is not the case that timeless necessary connections offer the best explanation of past regularities and b) IBE is itself an ampliative (and hence, broadly inductive) method which is in need for justification.

My closing remark is that none of what said above entails that the inductive sceptic wins! All that has been argued is that the sceptic cannot be beaten by inflating metaphysics and by positing necessary connections among properties and kinds.

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