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The Dretske–Tooley–Armstrong theory of natural laws and the inference problem

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Abstract   *In this article I intend to show that the inference problem, one of the main objections raised against the anti-Humean theory of natural laws defended by Dretske, Tooley and Armstrong ("DTA theory" for short), can be successfully answered. First, I argue that a proper solution should meet two essential requirements that the proposals made by the DTA theorists do not satisfy. Then I state a solution to the inference problem that assumes a local immanentistic view of universals, a partial definition of the nomic necessitation relation as a relation of existential dependence, and a principle constraining multiple occupancy. I also argue that my solution meets the two requirements. Finally, I deal with non-standard laws such as exclusion laws, causal laws and laws involving spatiotemporal parameters.*

In an initial, general approach, the inference thesis holds that it is part of our concept of natural law that "A" can be inferred from the law statement "It is a natural law that A". When a deterministic and exceptionless law statement is taken, the inference thesis holds that the law statement entails its corresponding regularity statement. In this way, from the law statement:

(1) It is a law that all Fs are Gs

the following regularity statement can be inferred:

(2) All Fs are Gs.

In fact, the inference thesis is commonly introduced by requiring the existence of this inferential link connecting this kind of law statement and its corresponding regularity statement. It should be stressed that the notion of inference or entailment we have appealed to should not be understood in the strict sense of *logical* inference or entailment but in a wider sense. The step from (1) to (2) is intended to be a conceptual or analytical one.[1]

Philosophers such as Dretske, Tooley and Armstrong have defended what has been called a "necessitarian" or anti-Humean conception of natural laws, as opposed to regularitivist or Humean theories that hold that laws are regularities of a certain kind. According to the Dretske–Tooley–Armstrong theory of natural laws ("DTA theory", henceforth), (1)'s truth involves the existence of two universals, F and G, and a second-order relation, N, usually called "necessitation relation", so that what makes (1) true is the fact that F is related to G by N (or that F necessitates G).[2] However, Hochberg, Lewis and van Fraassen counter that the DTA theorist is faced with the

inference problem.[3] Roughly sketched, the problem is that the inference from (1) to (2) cannot be warranted if what makes (1) true is the fact that F is related to G by N. The general reason these authors afford is that in the analysis advanced by the DTA theorist, (1) deals with universals, whilst (2) turns on particulars. As (1) and (2) deal with different kinds of things, some added premise which elucidates the connection that is held to exist between both kinds of things will be needed in order to infer (2) from (1).

Hence, what the DTA theorist must offer in order to preserve the inference in his analysis is some premise, or set of premises, that guarantees the analytical step from:

(1*) F necessitates G

to:

(2) All Fs are Gs.

This premise will connect certain facts that concern certain kinds of entities, F and G, with certain facts that concern another kind of entities, the corresponding instantiations of F and G: namely, a premise such as:

(*) For any particular a, if F necessitates G and a is F, then a is G.

As far as the problem is that of furnishing (*) as a conceptual truth, it can be described in a general way as the problem of warranting how, from the obtaining of certain facts (that F necessitates G and that a is F), the obtaining of another fact (that a is G) can be conceptually inferred which is at least not totally identical to either of these facts or, obviously, to the conjunction of the two. Moreover, the DTA theorist must provide some explanation for the problem of why (*) should be accepted.

In Section 1, two different objections, both termed "inference problem", are disentangled. The first objection holds that it is not prima facie possible that the DTA theory preserves the inference from laws to their corresponding regularities, whereas the second maintains that, even if the inference is preserved, this is only due to an ad hoc principle which cannot be reasonably explained by the DTA theory. In Section 2, I make explicit the principle on which the first objection is based, distinguishing between a weak and a strong version of it. I then argue that the weak version does not suffice to ground the first objection and that the strong version is not plausible on the view of mereological and determinate/determinable relations. The first objection is rebutted; the answer to the second objection is the business of Section 3. There, I advance a different, original way of solving the inference problem, which assumes a local immanentistic view of universals, a partial definition of the nomic necessitation relation as a relation of existential dependence and a principle constraining multiple occupancy. I then argue that my solution meets two essential requirements that the other proposals made by the DTA theorists do not satisfy. Finally, Section 4 deals with non-standard laws such as exclusion laws, causal laws and laws involving spatiotemporal parameters.

1. The inference problem and some proposed solutions

Two related objections, both labelled "the inference problem", have been raised against the DTA theory. Although these objections are manifestly different when they are specified carefully, it is none the less true that they have seldom been clearly distinguished; indeed, they have even been confused or mixed, as in van Fraassen (1989). The source of each objection is what I call respectively "the validation requirement" and "the explanatory requirement". Since the inference thesis is a correction criterion for

theories of natural laws, whatever makes law statements true, it must at least preserve the corresponding inference *and* ought also to explain the nature of this inference. Any theory of natural laws is expected to furnish the completing true premise that allows us to pass from (1) to (2) in a logically valid way. This is the validation requirement. But, besides that, it is to be desired that the completing premises should be justified by the theory in question in such a way that not only is the inference preserved, but its nature is also explained. This is the explanatory requirement. The validation objection, which we will develop and rebut in the next section, holds that the DTA theory is unable to *preserve* the inference no matter which particular development gives full content to the theory. The explanatory objection asserts that even if there are no overriding prima facie reasons for allowing the disavowal of the possibility of preserving the inference, the DTA theory cannot successfully *account for* the nature of this inference; hence the inference will be preserved by means of a postulate and will be left *unexplained* by the theory. My answer to this second objection will be given in the third section, after my own solution to the problem has been developed in full. Then I will argue that the tenets on which my solution depends have grounds which are independent of the inference problem.

For reasons of space, I cannot present a complete, deep account of the attempts on the part of DTA theorists to solve the inference problem, though a brief survey is mandatory. In the first proposals, the DTA theorists merely *affirm* that their truthmaker for law statements guarantees the inference, without adding any further premise (Dretske, 1977; Tooley, 1977; Armstrong, 1983). Thus, they meet neither the validation requirement nor the explanatory requirement. In later works, they differ as to the kind of solution that should be given.

Armstrong (1993) tries to solve the problem through a double identification. Firstly, he identifies the singular causal relation with the general causal relation. Secondly, he identifies the nomic necessitation relation with the general causal relation. Thus, the nomic necessitation relation is identified with the singular causal relation. Although I cannot discuss these matters here, I find both identifications troublesome and, as van Fraassen and Carroll correctly argue, they are insufficient for solving the inference problem.[4] In addition, Armstrong's position (Armstrong, 1997) on the inference problem does not seem to me to be particularly illuminating; in my view, the solution he advances there presents the same serious difficulties as his earlier ones and, besides, it depends on an identification of universals with types of states of affairs that I find problematic.

Tooley's solution is just a solution by postulate; he partially characterizes his nomic necessitation relation as a relation that satisfies the inference thesis (Tooley, 1987). However, although this move apparently satisfies the validation requirement,[5] it plainly fails to satisfy the explanatory requirement. Tooley himself tries to ground the inference on what he calls his "speculative theory" (Tooley, 1987, pp. 110–112) but as Sider (1992) shows, his sketchy remarks are insufficient, or even misguided—his use of the part relation is a case in point (see Pagès, 1998).

Finally, we should mention Fuhrman's attempt to solve the inference problem from his theory of laws that resorts to tropes instead of universals.[6] Although Fuhrman accomplishes his goal of preserving the inference meeting the two requirements, I think that there are two main reasons for being unsatisfied with his solution to the problem: his commitment to natural *possibilia* which is essential for his solution to work, and the rigid pattern of his solution, which makes it extremely unclear how to extend it to cover other kinds of laws, such as exclusion laws or laws involving different particulars or temporal parameters.

My proposal for a solution to the inference problem, which I develop in full in the third section, will mainly depend on a particular conception of universals and their instantiations which assumes a local immanentistic view for universals and a partial analysis for the nomic necessitation relation, N, as a relation of existential dependence. On my view, universals and their instantiations are related by the same existential dependence relation that holds between determinables and their determinates. Thus: (i) if a universal exists at a certain region, then one of its instantiations must exist at that region.[7] And conversely: (ii) if some instantiation of any universal exists at a certain region, then that universal must exist at that region. Besides, N will be partially analysed in such a way that: (iii) if N holds between any two universals F and G, then if F exists at some region, then G also exists at that same region. A rough approach to my solution is as follows. Assume that F is related to G by N and that a is F at region s. Then F exists at s—by (ii). Thus, G must exist as s—by (iii). Then, by (i), there is some b such that b is G at s. A further principle constraining multiple occupancy grants that a is G. As I will argue, my solution meets both the validation and the explanatory requirements.

2. On the possibility of preserving the inference

Hochberg (1981, adapting an old argument from Bergmann, 1949), Lewis (1983), and van Fraassen (1989) advance arguments of the first kind considered. The analytical validity of sentence (⋆), these philosophers hold, cannot be established. This impossibility is grounded on the metaphysical principle of independence which holds that there cannot be any necessary connections between different existences. Hence, it is argued that there cannot be any modal link which connects the fact that F necessitates G and the fact that a is F to the fact that a is G, since they are three different facts. There is, however, an easy answer to this objection, even granting the truth of the principle. It merely consists in asserting that the facts involved in (⋆) are not strictly different though they are not totally identical either; it is simply a case of partial identity. These facts have something in common—and hence are partially identical—in virtue of the relation holding between universals and their exemplifications. For instance, in Armstrong's theory of universals, universals are conceived as constituents, though not parts, of their exemplifications.

None the less, there is a stronger version of the principle of independence that is not subject to this reply: the principle of independence for *non-totally* identical entities.[8] This principle holds that there cannot be necessary connections between non-totally identical entities. If this principle is accepted, then even granting that universals and their exemplifications are non-totally different entities, since the universal realist holds that universals are not to be totally identical to their exemplifications,[9] the DTA theory would necessarily fail in its aim of preserving a logical connection between the required sentences, for their content is explained as involving partially different entities.

However, the stronger principle seems to be harder to accept than its weaker predecessor. Indeed, unlike the weaker principle, the new one is subject to counterexamples. We will now see two sorts of cases that on our view are true counterexamples to the stronger version of the independence principle. On the one side, we shall consider entities related by the part/whole relation; on the other, cases of the determinable/determinate relation.

Notice, first, that some properties of parts are transferred to the whole. Heterogeneity is a case in point. The inference

(I)
a is (a proper) part of B
a is heterogeneous
…
B is heterogeneous

is analytically valid.[10] The fact that heterogeneity transfers from proper parts to their whole, as shown by (I)'s analytical validity, infringes the independence principle for non-totally identical entities, since proper parts are not totally identical to the whole they make up.

Another more interesting case for our purposes can be advanced as an exception to the independence principle for non-fully identical entities, and it involves any two properties which can be subsumed under the determinate/determinable relation. Let us say that a set of properties, D, is a set of determinates for a certain determinable property, P, if and only if the following conditions are fulfilled:

(i) Necessarily, if any particular instantiates any property belonging to D, then it also instantiates the determinable P.
(ii) Necessarily, if any particular instantiates the determinable P, then it also instantiates one property belonging to D.

The set of colours and the property of being coloured, or the set of shapes and the property of having shape, satisfy these conditions. The first condition requires that if *a* is, let us say, red, then *a* is coloured, whereas the second condition has it that if any particular object is coloured, then it has one particular colour. Hence, condition (i) guarantees the existence of an analytic modal connection between the instantiation of any determinate and the instantiation of the corresponding determinable. Thus, it can be inferred from the fact that a certain particular, *a*, is indigo that *a* is blue, and that *a* is coloured from the fact that *a* is blue. Though not logically valid, these inferences are analytically valid in the sense specified. Notice that the following sentences are completing premises for the second inference:

(a) Blueness is a colour.
(b) For any object *x*, *x* is coloured if and only if *x* has a property which has the property of being a colour.
(c) For any object *x*, *x* is blue if and only if *x* has blueness.[11]

Now, in the light of these reflections it seems plausible to conclude that both the entities related by mereological relations and the entities that are in determinate/determinable relations constitute two different kinds of true counterinstance to the independence principle for non-totally identical entities. Thus, so far we have rebutted the main objection against the prima facie plausibility of granting (*). However, the DTA theorist must still explain how the inference is preserved in his theory. It is important in this connection to show that the relations between determinable/determinate pairs and universal/instantiation pairs are similar. Granted, it cannot be said that universals and their instantiations satisfy axioms (i) and (ii), for it is assumed in these axioms that they can be satisfied only by instantiable entities, which instantiations are not. However, we shall see now that at a more abstract level a close link between the two sorts of entity pair can be found, under the assumption of local immanentism.

What is commonly called "the immanentistic thesis for universals" can be interpreted in two different ways. First, there is a global sense of immanentism according to

which for any universal to exist in any possible world it must have some instance in that possible world. This the weaker sense of the immanentistic thesis; the stronger one, the local sense, is committed to attaching location facts to universals such as those ascribed by Armstrong: universals exist wherever their instances exist and only there. It is this local sense that will be relevant to our considerations.[12]

It is true of some determinables that if they exist at a certain region, then there is one of their determinates that exists at that region. Given our technical usage of "existing at a region"[13] and our assumption of local immanentism, this means that if one of these determinables fully occupies a region, then there is one of its determinates that fully occupies that region. I will call determinables of this kind "totally filled determinables". Having mass, being totally of a certain colour and being totally of a certain density are totally filled determinables, but being coloured and having density are not. However, facts concerning non-totally filled determinables are supervenient on facts concerning totally filled determinables, while the reverse is not true; hence, the latter determinables are more basic than the former. An object, x, can be coloured by having two proper parts, a and b, instantiating two different determinate colours, but this fact depends on—and is explained by—two different facts involving only totally filled determinables; namely, the fact that a is totally of a certain colour and the fact that b is also of a certain colour. However, these two different facts concerning a and b which involve totally filled determinables do not supervene on the fact that x is coloured, for x could be coloured by having three differently coloured proper parts.

Notice in the first place that if we assume the local immanentistic thesis for universals, then axioms (i) and (ii) (which describe the relations between determinates and determinables) can be rewritten as follows:

(DET) A property, P, is a totally filled determinable for a set of properties, D, if and only if the following conditions are satisfied:
(i) Necessarily: for any spatiotemporal region, s, if some property in D exists at s, then P exists at s,
(ii) Necessarily: for any spatiotemporal region, s, if P exists at s, then there is one property in D that exists at s.

Observe also that (DET) falls under the following pattern:

(DEP) An entity, f, is related by R to any of the entities in class E if and only if the following conditions are satisfied:
(i) Necessarily: for any spatiotemporal region, s, if any e in E exists at s, then f exists at s,
(ii) Necessarily: for any spatiotemporal region, s, if f exists at s, then there is one entity in E that exists at s.

We call the last definition (DEP) because it describes a dependence relation, R, holding between the entities that satisfy it. It should be noted that if the local immanentistic conception of universals is to be accepted, then any universal is related by R to any of its exemplifications, as any totally filled determinable is to any of its determinates. In fact, this would be an insightful way of specifying the local immanentistic conception of universals. It should be understood, then, that totally filled determinable/determinate pairs and universal/instantiation pairs have something in common: both are related by the same kind of dependence relation. As we will see in the next section, the fact that universals and their instantiations are related by the dependence relation R plays a crucial role in my solution to the inference problem.

3. A solution to the inference problem

In this section I will develop my own solution to the inference problem, which I hope is free from the objections that have been raised against other proposals. The solution, which assumes that what makes (1) true is the fact that F is related to G by the necessitation relation N, involves three main tenets: the thesis that any universal and the class of its instantiations are related by R, the relation described in (DEP); a principle which constrains multiple occupancy, and a partial analysis of the necessitation relation, N, as a relation of existential dependence.

First, the following principle subsumes the relation between universals and their instantiations under (DEP):

> (D) All pairs of entities consisting of any universal and the class of its instantiations satisfy pattern (DEP).

As we have already noted, embracing (D) commits us to the thesis of local immanentism. Notice, in the first place, that (D) explicitly ascribes spatiotemporal location to universals, though in fact this attribution was already present in the very notion that (DEP) applies to the converse of the determination relation, which was defined to hold only between universals. It can be said that local immanentism is not required here. It is true that it is not enough to assume global immanentism to be able to hold (D), but local immanentism as it has been characterized here appears to be too strong, for to hold (D) one must assume that universals are present wherever their instances are, but it does not seem to be required that they are completely present wherever their instances are. In this way, a distinction can be made between weak and strong local immanentism, the former requiring that for any possible world universals are present (at least partially) in that world wherever their instances are, the latter holding that they are completely present in that world wherever their instances are. Let us state their corresponding principles:

> (WLI) For any possible world, w, and any n-adic universal, U, U exists at w if and only if at w: there is a spatiotemporal region, r, such that there exist n particulars at r, $x_1, \ldots x_n$, such that at w: $x_1, \ldots x_n$ exemplify (in this order) U at r. Then U (at least partially) exists at r at that world w.

> (SLI) For any possible world, w, and any n-adic universal, U, U exists at w if and only if at w: there is a spatiotemporal region, r, such that there exist n particulars at r, $x_1, \ldots x_n$, such that at w: $x_1, \ldots x_n$ exemplify (in this order) U at r. Then U exists totally at r at that world w.

Now our idea can be expressed by saying that (D) is committed to weak local immanentism (WLI).[14]

The second ingredient is the following principle which places some restrictions on multiple occupancy:

> (P) For any concrete particulars, x, y, and any spatiotemporal region r: if x exists at r and y exists at r, then for any natural property, F, (x is F at r if and only if y is F at r).

This principle allows two different particulars to share a spatiotemporal region only if they instantiate the same natural properties at that region. More will be said on this principle once we have stated our solution to the inference problem.

The last ingredient that is needed to solve the inference problem for standard law

statements like (1) consists of a partial analysis of the relation of necessitation, N, which partially constructs it as a relation of existential dependence between universals:

(Nec) If F is related to G by N, then: for any spatiotemporal region, r, if F exists at r, then G exists at r.

Some remarks are in order here. (Nec) just tries to make explicit part of the intuitive content that a relation called "necessitation relation" is intended to have; in this sense, it is conceived as a relation of existential dependence that holds between the related terms, a pair of universals. It is precisely the fact that the necessitation relation entails an existential dependence that allows the use of (DEP) to licence the inference, for (DEP) just describes existential dependences in a double route, from instantiations to universals and from universals to instantiations. Notice also that no natural necessity operator is involved in this solution, and there is no need at all to postulate *possibilia*.[15] Finally, this solution does not assume any particular version of (strong) local immanentism such as Armstrong's theory of laws as universal states of affairs though it is compatible with such a theory.

Let us see now how these ingredients allow us to solve the inference problem. Let us suppose that:

(1) F is related to G by N,

and also that:

(2) At s: a is F.

Now, given (2), by (D) and (DEP), (i):

(3) F exists at s.

Then, by (1) and (Nec):

(4) G exists at s.

Now, by (D) and (DEP), (ii):

(5) There is one instantiation of G, e, such that e exists at s.

But then there is some concrete particular, b, such that:

(6) At s: b is G.

And we know by (2) and (6) that:

(7) a exists at s and b exists at s.[16]

Then, by (6), (7) and (P):

(8) At s: a is G.

Something should be said at this point to ground our choice of principle (P). It could be thought, for instance, that our derivation would have been more simple if we had used a principle of unique occupancy as the following:

(C) For any concrete particulars, x, y, if there is a spatiotemporal region r such that (x exists at r and y exists at r), then $x = y$.

It has been argued, however, that principle (C) is subject to counterinstances. Consider an artist who moulds a statue from a pre-existing piece of clay and assume that the artist,

unsatisfied with the result, destroys the statue, dividing the original chunk of clay in several pieces. Let us call the statue "Andrea" and the piece of clay "Clay". Andrea and Clay share the spatiotemporal region that Andrea occupies throughout its existence, but Andrea $\neq$ Clay. This clearly falsifies principle (C). Unique occupancy can still be saved from the former counterinstance by appealing to temporal stages, as the following principle shows:

(C⋆) For any concrete particulars, x, y, if there is some spatiotemporal region r such that (x exists at r and y exists at r), then there is exactly one z existing at r, and z is a common temporal stage of x and y.

Notice that to solve the inference problem it does not suffice to substitute (C⋆) by (P), for another principle is required to connect the instantiation of properties by persistent entities with the instantiation of properties by their temporal stages. The next principle will do for this purpose:

(P⋆) For any persistent concrete particular, x, any spatiotemporal region, r, and any natural property, F: x is F at r if and only if there is a temporal part z of x existing at r such that z is F at r.[17]

However, I do not think that there is any need to commit ourselves to the thesis that constitution is identity to solve the inference problem. Even if the relation holding between the statue and the piece of clay is the relation of constitution rather than the identity relation, it does not seem to me that these particulars preclude us from inferring (8) from (6). The reason is that although the statue and the piece of clay are said not to bear the same *modal* properties, they still must bear the same *natural* properties, i.e. those properties which are referred to in law statements. Their having different modal properties just means that they differ in terms of which natural properties are essential to each of them. For example, wherever they share a spatiotemporal region, both share the natural property of having a shape S at that region, and their differing in terms of modal properties just means that the natural property of having a certain shape S is essential to the statue, but not to the piece of clay. But then, if the only particulars that can share a spatiotemporal region by occupying it totally are particulars related by the relation of constitution, then as those particulars must share all their natural properties they do not prevent our granting (8) from (6), for it is assumed that F and G are natural properties. I think that this argument grounds my principle (P), which has a crucial role in my derivation.[18]

So far, my defence of principle (P). Now, I will discuss some objections that might be raised against my solution. In the first place, it could be argued that it is an ad hoc solution, and, hence, that it fails to meet the explanatory requirement. Here is what I think makes a solution to a problem an ad hoc solution. Any theory intends to cover some phenomena. Some unexplained phenomena can force a revision of the original theory and some new postulates are added to it in order to solve the problem. I think that the addition of new postulates constitutes an ad hoc solution to the problem only if the new postulates are strongly dependent on the solution itself because they have no independent grounds or they do not cohere with the theoretical background in which the problem arises. However, I do not think that this is the case with my solution to the inference problem. My solution depends on three main elements: a partial analysis of the necessitation relation, a local immanentistic conception of universals and the principle (P) that constrains multiple occupancy. I think that there are general reasons that go beyond the inference problem and that ground both the local immanentistic

conception of universals and the constriction on multiple occupancy. Some of the reasons favouring immanentism are mainly epistemological and are given by Armstrong in several works. (See, for instance, Armstrong, 1978, I, pp. 128–132, 1997, pp. 41–43.) Moreover, reasons for principle (P) which are independent of the inference problem have been given above.

However, the following reply could be made:

But none of your reasons for defining N as a spatiotemporal existential dependence relation are independent of the inference problem. You have defined N in that way just in order to ensure that the inference from (1) to (2) is warranted.

True enough, but I do not think that this is a legitimate objection. Different kind of law statements will call for different kinds of nomic relations. Universal law statements like (1) will call for the nomic necessitation relation N, whereas exclusion law statements ("It is a law that no F is G") will call for the exclusion nomic relation. In the same way, saying that law statements are made true by world regularities does not commit the Humean to saying that any kind of world regularity makes true any kind of law statement. Different kinds of regularities will make true different kinds of law state-ments. In this case, universal law statements will call for universal world regularities, whereas exclusion law statements will call for exclusion world regularities. Besides, even if we stick to universal law statements it must be noticed that they can impose very different constrictions on the spatiotemporal relations that are said to hold between the antecedent fact and the consequent fact. Universal law statements which are used paradigmatically in the discussion of the inference problem require that the antecedent fact and the consequent fact should hold at the same spatiotemporal region. But there are other kinds of universal law statement which differ as to these constrictions. Consider, for instance this pair of statements, which will be accounted for in the last section:

(L) It is a law that for any particular x, if x is F at time t, then there is a particular, y, such that y is G at time $t + \delta$.
(L*) It is a law that for any particular x, if x is F at time t, x is G at time $t + \delta$.

In the regularity theory different kinds of regularities (imposing different spatiotemporal constrictions) are required to account for the truth of these law statements, and these regularities are also different from the regularity which is supposed to make true (1). In the same way, I hold that different kinds of nomic necessitation relations are required to deal with each of these kinds of universal law statements, and my appeal to spatiotemporal regions in the definition (Nec) was made to satisfy this requirement.

The very point of my definition (Nec) is that it grants the inference to the regularity without the forbidden appeal to the instances of the universals involved in the law statement. Besides, my appeal to spatiotemporal regions is legitimate as it is made within an immanentistic theory of universals. Since this theory provides independent motivation for the notion that universals have spatiotemporal location, it is perfectly intelligible that there be regularities connecting their locations, as (Nec) holds.

These remarks are connected to the question of why my solution is better than Tooley's solution by postulate.[19] I think that my considerations on the objection based on the independence principle in Section 2 tell us why Tooley's solution is insufficient. Note that the acceptance of Tooley's definition amounts to the acceptance of the validity of sentence ($\star$). Although we have argued that the reasons given against the

prima facie plausibility of (⋆) are not conclusive, I think that they still impose certain conditions that should be fulfilled if the prima facie plausibility of (⋆) is to be guaranteed. First, if the weak version of the independence principle is not to count against (⋆), universals cannot be completely different from their instantiations. Hence, the same condition must hold if Tooley's definition is to be accepted. Second, and more important, all exceptions that count against the strong version of the independence principle are pairs of entities that are related by dependence relations. Thus, it can be argued that if Tooley's definition is to be accepted then universals should be dependent on their instantiations.

Since Tooley's universals are independent entities, this argument does not lead us to accept his definition in his transcendental theoretical background; hence we can conclude that Tooley's solution does not even meet the validation requirement. However, this argument does not preclude accepting Tooley's definition in an immanentistic theoretical background in which universals are dependent entities. In fact, we have prima facie reasons to accept the definition in that immanentistic background, so we have prima facie reasons to think that a solution by postulate that assumes that universals are dependent entities at least satisfies the validation requirement. We can conclude that a solution by postulate that assumes an immanentistic background is better than Tooley's solution.

None the less, I think that something more is needed to satisfy the explanatory requirement. For, what kind of explanation is available to a proponent of this better solution? He can say that the validity of (⋆) is guaranteed by a definition which is grounded on the fact that universals are entities which existentially depend on their instantiations, and we know of other cases of existential dependent entities some of whose traits can be transferred to the entities they existentially depend on. However, a crucial question remains unanswered: why should the nomic necessitation relation be transferred from universals to their instantiations just because there is an existential dependence relation that holds between these two kinds of entities? I think that my solution gives an explanatory answer to this question. As we have seen, the necessitation relation must be transferred from universals to their instantiations because it is (partially) understood as a relation of spatiotemporal existential dependence between universals, and universals are entities whose existence and location are dependent on the existence and location of their instantiations.

4. Non-standard law statements

Besides the advantages of this solution for the inference problem, we should add that it is easily extended to cover other types of laws. Take, for instance, an exclusion law statement such as:

(EL) It is a law that all Fs are not G.

A truthmaker for (EL) should include a nomic relation, different from the necessitation relation partially defined by (Nec); let us say an "exclusion relation", E. Now, in order to preserve the inference from (EL) to the corresponding regularity that all Fs are not Gs, we can partially define E as a relation that satisfies:

(Exc) If F is related to G by E, then: for any spatiotemporal region, r, if F exists at r then G does not exist at r.

With both this partial analysis of the nomic relation of exclusion and thesis (D) at hand it is an easy matter to derive from (EL) the corresponding regularity. Let us assume that:

(1) F is related to G by E

and that:

(2) At s: a is F.

Then, by (D) and (DEP), (i)

(3) F exists at s.

By (Exc):

(4) G does not exist at s.

Now, by (4), (D) and (DEP), (ii), it follows that:

(5) At s nothing exists that is an instantiation of G.

Hence,

(6) At s: a is not G.

In inferring that all Fs are Gs from the relational nomic fact involving the necessitation relation, N, we had to appeal to (P); note that this is not the case here. The resort to (P) is now unnecessary because of the nature of the regularity involved. Notice that the regularity associated to the necessitation relation, N, states that, for any particular instantiating the antecedent property, that *same* particular *also* instantiates the consequent property. (Nec) only guarantees that the consequent property must be instantiated at exactly the same region as the antecedent property is instantiated, but this is not enough to warrant that the same particular is involved in both instantiations. In exclusion regularities—for all F, that F is not G—there is still the same particular involved in the antecedent and the consequent, but the consequent makes no claim that that particular must exemplify the consequent property.[20]

On the other hand, other regularities can involve different particulars located in different spatiotemporal regions. This is the case of simple formal schemes of causal laws such as:

(LC) It is a (causal) law that for all x, if x is F then there is a y such that y is G.

In this case, inferences involving the corresponding regularities do not require the principle (P), as is the case when dealing with exclusion laws. Besides, unlike exclusion laws, (LC) does not need local immanentism in any version thereof; global immanentism is good enough. As we have characterized it, global immanentism holds that:

(GI) For any possible world, w, and any n-adic universal, U, U exists at w if and only if there exist n particulars $x_1, \ldots, x_n$ at w such that $x_1, \ldots, x_n$ exemplify (in this order) U at w.

If there is no constriction on the particulars involved in the regularity nor any kind of condition posed on their location, then it seems even easier to preserve the inference from (LC) to its corresponding regularity (i.e. for all x, if x is F then there is a y such that y is G) than it was in our original case. First, as we have pointed out, there is no need for any appeal to the principle (P), nor to local immanentism; our purpose is

equally well served just calling on global immanentism. But, second, we are now allowed to dispense with thesis (D) which holds that the exemplification relation and the determination relation are both instances of the same kind of dependence relation, that is described by (DEP). Once we have substituted global immanentism for local immanentism, the partial definition of the nomic necessitation relation, $N^\star$, involved in (LC) should be consistently different from the definition of N, so we drop the spatiotemporal reference that appears in (Nec):

(Nec*) If F is related to G by $N^\star$, then (if F exists, then G exists).[21]

Now, suppose that F $N^\star$-necessitates G, and take a, an arbitrary F. By (GI), F exists. Then, by (Nec*), G exists. Hence, by (GI), there must be some particular, y, such that y is G.

Notice that if these considerations are correct, then there must be two different nomic relations respectively associated to the different types of laws expressed by "It is a law that all Fs are Gs" and "It is a (causal) law that for all x that has F there is a y that has G". On the other hand, however, the change of assumptions made there rather obeys an economy criterion; of course it is possible to preserve the inference from "It is a (causal) law that for all x that has F there is a y that has G" to its corresponding regularity given (Nec*) and the same auxiliary premise used in the first type of law, but that premise is stronger than needed.[22]

It should be noted too that (LC) is an oversimplified pattern of causal law statement; some more realistic patterns include information about the spatiotemporal relations holding between the antecedent fact and the consequent fact. Consider, for example, the following simple schematic case:

(L) It is a law that for any particular x, if x is F at time t, then there is a particular, y, such that y is G at time $t + \delta$.

In this instance, it is part of the content of the law statement that the consequent fact must occur after a certain temporal interval whose value is δ. This case can be subsumed under the following pattern of law statement:

(LC$'$) It is a (causal) law that for any particular x, and any spatiotemporal region r, if x is F at r, then there is a particular, y, and a spatiotemporal region, s, such that y is G at s and $s = V(r)$.

(Here, "V" designates a spatiotemporal variation function; that is, a function which takes spatiotemporal locations as arguments and assigns to them other spatiotemporal locations.) To account for these laws we should incorporate the nomically fixed spatiotemporal variations into the nomic relations, specifying them in the partial definition. In fact, we will not define just one more sophisticated nomic relation, but a family of them, each member of the family being associated to a distinct variation function, V. Thus, for any variation function, V, we partially define its associated nomic necessitation relation as follows:

(Nec$_V$) F is related to G by N_V only if for any spatiotemporal region r: if F exists at region r, G exists at region $V(r)$.

It should now be obvious that (Nec$_V$) and (D) jointly allow us to infer from (LC$'$) the corresponding regularity. In this case, the principle (P) is also unnecessary. Notice too that this device can easily be extended to successfully cover exclusion laws involving different locations.[23]

Some concluding remarks are in order. We have seen how to solve the inference problem for standard law statements by holding a partial analysis of the nomic necessitation relation that explains it as an existential dependence relation between universals, the thesis of weak local immanentism, and a principle constricting multiple occupancy. We have also explained how to treat a wide range of non-standard law statements. Besides, our solution seems overtly superior to those advocated by Armstrong, Tooley or Fuhrman, for no claim for *possibilia* is made, no ad hoc postulate is stated, the solution covers a fairly wide range of laws, and the inference from laws to regularities is not merely preserved but its nature successfully explained.[24]

Notes

1. Let us introduce some definitions to clarify these notions. Let us say, first, that an argument, A, is *analytically valid* if and only if A is logically valid or can be transformed into a logically valid argument by being completed by sentences that (totally or partially) describe the meaning of the non-logical terms involved in the premises of A. Consequently, we shall understand that a set of sentences $\{A_1, \dots, A_n\}$ *analytically entails* a sentence A if and only if the argument which has $A_1, \dots, A_n$ as premises and A as a conclusion is analytically valid.

   Now, let us consider the argument:
   Peter and John are brothers
   ...
   Peter and John are siblings

   This argument is not logically valid, but it is analytically valid: it becomes logically valid once the premise is added that all brothers are siblings and once this premise is suitably regimented. Note that the premise partially describes the meaning of "brother".
2. Cf. Dretske (1977), Tooley (1977, 1987), and Armstrong (1983). Although each of these three philosophers has his own theory of natural laws there is a common core which is substantive. In fact, many critics formulate their objections against this common core. In particular, the inference problem is sometimes advanced against the general view shared by Dretske, Tooley, and Armstrong. I introduce the inference problem for this common core in this preliminary section for expository reasons.
3. Cf. Hochberg (1981), Lewis (1983), and van Fraassen (1989). The label "inference problem" is taken from van Fraassen.
4. Van Fraassen (1993) and Carroll (1994). Armstrong's identifications fall short of satisfying the validation or the explanatory requirement.
5. But see my comments at the end of Section 3.
6. In spite of the vicinity between universals and tropes, Fuhrman's theory is not to be considered as a DTA theory. See Fuhrman (1991).
7. In this paper, I will use the expression "exists at region *s*" in a technical sense, as entailing that if any entity exists at a region, then it fully occupies that region. It is important to keep this in mind especially in my argument in the third section which purports to solve the inference problem.
8. Although this version is not actually held by any of the critics mentioned in the previous paragraph.
9. There appears to be one possible exception to this assertion. A theory of universals which conceives particulars as mere bundles of universals should identify any particular instantiating just one universal with the universal itself. But it seems to me that this odd result should count against the bundle theory. Though we will not deal with the bundle theory in this paper, there are strong general reasons against it. For instance, Armstrong (1978, I, pp. 91–97) argues that the bundle theory is committed to the principle of the identity of indiscernibles which is subject to counterinstances.
10. Notice that (I) can be transformed into a logically valid argument if the following completing premises are added:

    (a) an entity is heterogeneous if and only if it has two parts which are intrinsically discernible,
    (a) any part of any part of any entity is part of that entity.

    The first premise expresses the meaning of the term that designates the allegedly transferable property, heterogeneity, whereas the second one just partially describes the meaning of the relational predicate "is part of", reporting that the designated relation is a transitive relation.

11. Besides these inferences from determinates to determinables, other inferences can be found from determinables to determinates. For instance, if any property is a determinable for another property, and the second property is a determinable for a third property, then the first property is a determinable for the third.

12. Notice also that it seems clear that the first sense does not entail the second, though the second obviously entails the first. Notice that the fact that the existence of a certain entity depends on the existence of other entities does not necessarily imply that the first entity is to be *located* wherever those entities on which it depends are located. In fact, it is not even the case that the dependent entity must have location at all.

13. See n. 7.

14. In any case, I do not really think that this last distinction is substantive. Notice that universals are commonly required in the explanation of natural similarities of concrete particulars and it does not seem consistent with that to hold that universals are divided entities. The similarity between two white things is explained by the fact that both things exemplify the same universal, whiteness, which, if weak local immanentism is true, amounts to saying that the same universal is present in both locations. But then, if strong local immanentism is not true, it is not exactly the same thing that is present in both locations and so it now seems quite mysterious that the two particulars can be exactly similar.

15. This is not committed to the idea that there is no need for modal components in the analysis (even partial) of the nomic necessitation relation. That is, it is perfectly possible that other traits will be used in its characterization which include modal notions with the purpose of covering some other aspects that laws are supposed to have. For instance, such a trait could be called for in the explanation of how laws support counterfactuals. For an argument that it is not necessary to insert modal notions in the analysis of the nomic relation to account for the counterfactual supporting problem, see Pagès (1997).

16. We should recall that, in our technical usage, existence at a region entails existence at any proper part of that region. Similarly, the instantiation of a property by a particular at a region is intended as entailing that the particular fully occupies that region.

17. There is, however, an important difficulty concerning principle (C⋆). It has been argued that there are particulars that share all their spatiotemporal regions but are still not identical. We have just to think of the statue and the piece of clay as being created at the same time and destroyed at the same time. It appears that in this new situation Andrea and Clay occupy the same spatiotemporal region, and hence the defender of (C⋆) must hold that there is just one concrete particular involved; that is, Andrea should be identical to Clay. The problem for this position is that Andrea and Clay seem to have different modal properties. For instance, Andrea could have survived the amputation of one of its fingers, but Clay could not. Or Clay could have survived squashing, but Andrea could not. Now, taking for granted that different properties make for different particulars, as Leibniz's Indiscernibility Principle holds, Andrea should be different from Clay, contrary to what any holder of (C⋆) must say.

    Although I will not dwell on these matters here, a brief appraisal must be given. I would favour a way out for the defender of (C⋆) along the lines proposed by Lewis. (Cf. Lewis, 1971.) Lewis's kind of answer is based on the idea that modal predications are sensitive not merely to the referent of the singular terms to which they are applied, but also to certain sortal terms associated to them. A statement consisting of a modal predication, like "Andrea could have survived the amputation of one of its fingers", is true if there is a possible world where certain facts hold, facts relative to a certain particular that we fix by means of individuation criteria at least partially determined by the sortal term associated to the singular term referring to the particular. Substitution of coreferring singular terms fails when coreferential terms are associated to different sortal terms which generate different transworld individuation criteria.

18. A referee of this journal has pointed out that it seems to be metaphysically possible that two entirely different entities, not sharing the same natural properties, be located at the same place. He or she proposes considering a possible world in which things of kind F and things of kind G do not causally interact (in which an F-thing with a collision course with a G-thing would pass right through each other). If this is a metaphysical possibility, then it is also a counterinstance to (P). I am not sure that this is even a conceptual possibility: ghosts, for instance, are like this and it is not clear to me that it is a conceptual possibility that ghosts have natural properties. In any case, even if it is a metaphysical possibility, it is reasonable not to think that it is also a physical possibility (as the referee acknowledges). Hence, the actual natural laws at least would be covered by our theory.

19. We should recall that Tooley's solution by postulate consists merely in partially identifying through a theoretical definition the nomic necessitation relation as a relation such that whenever it holds between any two universals, then any instance of the first universal is an instance of the second universal.

20. We should bear in mind that we are presupposing that "F" and "G" designate genuine universals. General reasons for avoiding negative universals notwithstanding, there is no need at all to require them to account for the applying of the predicate "no-G" to particulars under the assumption that G is a true universal.

21. Though we have dispensed with (DEP), there is still a kind of dependence relation associated to global immanentism. We can define it as follows:

> (DEP*) For any entity, *f*, and for any class of entities, E, *f* is related by R to any of the entities of class E if and only if:
> (i) Necessarily: if any *e* in E exists, then *f* exists,
> (ii) Necessarily: if *f* exists, then there is one *e* in E such that *e* exists.

As we did in the case of (DEP), we can now state a principle which holds that any pair consisting of a universal and the class of their instantiations can be subsumed under (DEP*):

> (D*) All pairs of entities consisting in any universal and the class of its instantiations satisfy pattern (DEP*).

22. To see why the auxiliary premise for the first type of law—(D), which in turn implies local immanentism—suffices to solve the inference problem for the second type, note that any version of local immanentism, strong or weak, implies global immanentism.

23. However, a problem remains: how to treat those laws involving nomic connections between facts relative to the same particular at different times. We have in mind laws such as those expressed by the following law statement:

> (L′) It is a law that for any particular *x* and any spatiotemporal region *r*, if *x* is F at *r*, then *x* is G at V(*r*).

(Here, "V" again designates a location variation function.) It may be instructive to contrast (L′) with the standard law statement (1). It must be observed that there seems to be no way of constructing a law which involves the regularity embedded in (L′) just by relating universals, despite our successful treatment of (1). The problem with (L′) is that the particular that has to exemplify both the antecedent and the consequent property must be one and the same particular, as happened with (1), but—unlike (1)—it is equally true that the temporal location of the particular involved in both sides of the conditional is no longer maintained in (L′). And notice that the crucial trait in (1) was that the antecedent fact and the consequent fact occupied the same spatiotemporal region, which made it possible to guarantee that the antecedent particular and the consequent particular were one and the same particular by merely appealing to the principle (P). Now, when confronted with the parallel task concerning (L′), the lack of identity in the spatiotemporal regions occupied by the antecedent and the consequent facts rules out the possibility of appealing to the principle (P). I think that a proper treatment of these cases requires the postulate of formal relations holding between particular states of affairs, which report on matters concerning the identity of the particulars involved in those states. For reasons of space I merely state the problem.

24.

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