What Accounts for the Paradox in Goodman's Paradox. The Neglect of the Functional Character of Natural Laws as the Reason for the Paradox*

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Abstract

Essential for the concept of the law of nature is not only spatio-temporal *universality*, but also *functionality* in the sense of the dependency on physical conditions of natural entities. In the following it is explained in detail that just the neglect of this functional property is to be understood as the *real reason for the occurrence of the Goodman paradox* – with the consequence, that the behavior of things seems to be completely at the mercy of change of unique unrepeatable temporal points. It is exactly this (mis-)understanding that also generated the induction problem. From the *intrinsic connection* between universality and functionality, however, – that is my claim – the *ontological* consequence of a nature results, for which lawfulness is coupled to essentially functionally defined time sequences – thereby implying a *potentiality dimension* of nature, too. These considerations are explained in the following six points:

1. Introduction
2. The Goodman Paradox
3. Concerning Attempts at Solutions of Goodman's Paradox
4. Goodman's Neglect of the Functionality Aspect
5. Function-related Determinations
6. Relationship between Universality and Functionality

1. Introduction

There are two main elements in the concept of *natural law*: on the one hand, the claim of *universal*, i.e. overall spatio-temporal *validity*, which in nature corresponds to the character of spatio-temporal *uniformity*; on the other hand, the *functional character* of natural phenomena, which results from their *dependence on specific conditions* and thus represents something like a *dimension of possibility or potentiality* of natural being. Both moments – universality and functionality[1] on the le-

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[1] From a formal point of view it has to be considered, that according to the doubled respect of universality and functionality *two forms of inductive generalization* have to be distinguished. As an example the law of gravitation is considered: On the one hand, there is the all-statement: "The conditional structure formulated in the law of gravity exists *at all places and at all times*' (universality); on the other hand, there is also an all-statement, but of the form: 'The conditional structure formulated in the law of gravity exists *for all distances* between two given masses' (functionality). The difference is obvious: In the first case the all-operator refers to *different* world regions and times (universality), in the second case however to different distances in *the same* world region and time (functionality).

While the empiricist oriented theory of science did not consider the first-mentioned way of generalization to be legitimate, i.e. the aspect of universality, because of the limitations of experien-

vel of description or uniformity and potentiality as characters of nature itself – obviously belong together essentially. In the mathematical formulation of the laws of nature this is expressed in the fact that they take the form of *universal functional laws*, which are indeed of paramount importance for science.

It is all the more surprising that the analytical theory of science has in fact made the moment of universality of the laws of nature a central theme, but has practically completely omitted *functionality*.[2] This is undoubtedly also connected with the fact that it has primarily considered *qualitative* statements of the kind: 'All swans are white', 'All emeralds are green', 'All metals are conductive', etc.[3] Since this is not specifically justified, one can only speculate about the motives. For the normal type of science theorist, unfamiliarity with scientific practice should be ruled out as well as a rejection of the mathematical form of science. A possible reason is the simple predicate logical formalizability of qualitative law-like statements. Of course, the concept of function can be formalized as well, admittedly with considerable additional effort. Howsoever – one must conclude that the aspect of functionality is basically not considered central.

Now, functionality, as already mentioned, refers to dependency on conditions and thus to the potentiality or dispositional character of natural entities. In connection with the problem of theoretical and dispositional concepts, this character has been discussed by the analytical philosophy of science, but, as can be seen, with a defensive tendency, as it were, i.e. with the intention of getting rid of the question, which in an empirical attitude remains aporetic.

The fact, however, that it has serious consequences for the concept of the law of nature, if the character of functionality is suppressed and the law concept thereby is reduced to the moment of universality, is to be demonstrated in the following at the example of the so-called *Goodman paradox*, which is to be considered and analyzed therefore now in more detail. As will be shown, a *paradox* indeed arises precisely because the functional character of natural laws is neglected.

2. The Goodman Paradox

Goodman's considerations[4] tie in with Hume's critique of the concept of causality: According to Hume, our ideas of causality and natural lawfulness are based solely on the experience of regularities of natural events, which subjectively leads to the formation of a habit of expecting such regularities in the future. The fact that subjective expectations of this kind cannot guarantee anything for the objective course of nature leads to the *induction problem*. However, this does not prevent scientists from inductively deducing future events from past experience. The fact that copper so far has always proved to be conductive is expected to be the case in

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ce, the second form of generalization, concerning the functional character of the laws of nature, should not be less suspect from an empiricist perspective because always only *singular* measuring points can be determined empirically – in the example: individual values of the gravitational force for the respective distances of the masses – while the functional law includes *all* values of force for *all* distances: This, too, is a form of universality, here in the sense of completeness, which as such can never be achieved by experience.

[2] See for example Hempel (1974); Hempel indeed mostly chooses quantitative functional laws as examples, without, however, thematizing the functional character; see also Nagel, E. (1961); Nagel lists the functional laws only as one type among others, see 77 f.

[3] Properly understood, qualitative provisions are also based on functional structures. For example, emeralds are probably green under 'normal conditions', but at high temperatures and pressures they (presumably) change their color – howsoever: According to the basic dependence on conditions of all natural entities these inevitably own functional character.

[4] Goodman, N. (1975).

the future as well, in other words: 'Conductive' is considered a 'law-like' predicate, i.e. one that entitles to induction and can thus be 'continued' into the future – naturally with the reservation of Hume that this method is only founded on *past regularities* and is therefore only hypothetical for the future. But in the practice of science (and also in our everyday actions) this procedure is common and efficient.[5]

Goodman adopts Hume's approach without questioning it in principle.[6] When he nevertheless criticizes Hume's interpretation, this is directed against his understanding of *regularities*, which he considers too undifferentiated: Hume's view that "regularities produce habits generated in experience, to expect something" is to be overlooking the fact that this can *not be generally* asserted, namely since "some regularities produce such habits, but others do not; that predictions based on certain regularities are justified, but not if they are based on others", (Goodman 1975, p. 107). Goodman explains this by means of drastic examples, which, in order to have a clearly defined starting point, will first be given here: "The fact that a given piece of copper conducts the electric current increases the credibility of statements that other pieces of copper conduct the current, and this confirms the hypothesis that all copper conducts the current. But the fact that a certain man who is now in this room is a third son does not increase the credibility of statements that other men who are now in the room are also third sons, and thus does not confirm the hypothesis that all men who are now in the room are third sons. But in both cases our hypothesis is a generalization of the data statement. The difference is that in the first case the hypothesis is a *law-like* statement, while in the second case it is just a random general statement ... Obviously we have to look for a possibility to distinguish law-like from random statements" (Goodman 1975, p. 97). "Hume's most modern successors," so Goodman, "have recognized and treated this problem just as little as he himself" (p. 108), namely the question under which conditions regularities *entitle* to induction and when not. Goodman calls this "the new riddle of induction" (p. 97).

Another striking example illustrates Goodman's problem in terms of time: "Every word you have heard me speak here preceded the last sentence of this lecture, but that does not, I hope, raise the expectation that every word you will hear will precede this sentence" (Goodman 1975, p. 107). Here again, the underlying regularity is problematic: Indeed, *all* the words of that lecture have *in common the characteristic* that they precede the last sentence of it. But why can we not conclude from this that this applies to all words of the lecturer, while the analogous conclusion in the case of the conductive copper pieces is correct? – a certainly surprising, but nevertheless legitimate question that demands a clear answer, although it is astonishing that this question has not been asked by empiricism itself or by its critics.

The whole paradox of Goodman's question becomes apparent in the well-known *emerald example*: The fact that green emeralds are repeatedly observed supports the hypothesis that all emeralds are green. This is the normal induction procedure practiced by science. Goodman now defines a very artificial predicate by stating that something should be called *gred* if it turns out to be green when examined before time t_0 or red when examined after time t_0 (Goodman 1975, p. 98). Notice that according to this definition it is gred all the time before *and* after (from) t_0. For the induction the following situation results: The observation of green emeralds *before* t_0 supports the hypothesis that all emeralds are gred according to the definition of 'gred'. *After* t_0 this would mean that all emeralds are red, with other words: The

[5] The not unjustified criticism of such an 'inductivist' understanding of empirical science, as pointed out by Popper, for example, can be left out of consideration here, because the following is not primarily concerned with an adequate concept of science, but with clarifying the concept of 'regularity'.

[6] On the criticism of Hume's position see Wandschneider, D. (1986), pp. 131–142.

observation of many *green* emeralds before t_0 accordingly justifies the expectation that after t_0 only emeralds are found that are *not green* – a truly paradoxical form of induction, which obviously is not permissible in this form: A predicate like 'gred' is indeed based on a 'regularity', which is similar to the abnormal one as in the previous examples. Such a predicate, so Goodman, cannot be a 'law-like' predicate. Such can only be a predicate, which can be "justifiably continued", i.e. inductively transferred from past to future cases (Goodman 1975, p. 119; see also p. 110 ff).

3. Concerning Attempts at Solutions of Goodman's Paradox

The 'new riddle of induction' that becomes visible here has especially put the *inductivist view*, as it was advocated by R. Carnap, into distress. For this reason alone, Goodman's paradox has repeatedly been the subject of intense discussion. The numerous *attempts to solve* the paradox proposed in this context have, however, remained unsatisfactory – in the following I would like to mention only a few points. If Goodman's paradox is taken into consideration here once again, it is primarily because, as already mentioned, it demonstrates that the concept of natural law cannot be reduced to the moment of universality and that paradox arises precisely because the other moment, that of *functionality*, is suppressed. But first some short hints to various proposals for solutions:[7]

It is interesting to note that non-law-like predicates à la Goodman are defined by reference to individual places, times, objects, events, so that it is obvious to look for this as the reason of the non-continuability of such predicates.[8] Kutschera, on the other hand, just refers to predicates of this kind like 'arctic', 'earthly', etc. (1972, I, p. 146). Thus, so Kutschera, it can be asserted, for example, that nitrogen is gaseous under the conditions of the earthly atmosphere: an obviously law-like hypothesis, although it refers to the singular object 'earth'. This objection will be discussed later.

The criticism of M. Hesse,[9] referred to by Kutschera, that the mixed use of non-law-like and law-like predicates in the context of physical theories leads to incompatibilities is self-evident, because it basically only repeats the doctrine of Goodman's paradox: that predicates like 'gred' have paradoxical consequences in comparison with 'normal' law-like predicates. By the way, the distinguishability of law-like and non-law-like predicates is here already assumed, while the solution of the paradox requires a *criterion* for it.

Goodman's own approach is also not very convincing. Law-like predicates are 'continueable' predicates according to Goodman's usage of language (see above), but do we also have criteria for continueability? Goodman says (with reference to 'green' and 'gred') that one has to "consider the balance of the previous continuations of the two predicates. With 'green', which can refer to older and much more numerous continuations than 'gred', it turns out more impressive. The predicate 'green', so we want to say, is much better *anchored* than the predicate 'gred'" (Goodman 1975, p. 121). Kutschera rightly points here to the merely pragmatic-historical character of the 'anchoring' of a predicate, which thus cannot be a *justification* for the continuability of predicates. And what applies to newly introduced law-like predicates, which are not yet linguistically anchored at the beginning – quite apart from the problems of making the anchoring balance comprehensible at all (Kutschera 1972, I, p. 149 ff)? According to Kutschera, this approach to a solution must therefore also be considered "hopeless" (1972, I, p. 155).

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[7] See the detailed description in Kutschera (1972), Vol. I, p. 141 ff.

[8] See e.g. Carnap, R. (1952/53), p. 311–318 and Will, U. (1985), p. 40 ff.

[9] Kutschera (1972), I, p. 148.

Kutschera's conclusion is extremely skeptical: "In its new [sc. Goodman's] garment, the old Hume's riddle has lost hardly any of its significance.From the discussion about Goodman's paradox one can safely conclude that at present there is no promising idea for a general solution of the problem in the sense of a general criterion for inducibility and interchangeability,[10] and with a high probability that there is no such general solution" (I, p. 158 f.)

After all, Kutschera himself attempts to "understand the origin and validity of the assumptions of interchangeability somewhat better" (1972, I, p. 159). He argues that the basic predicates of our language are from the outset linked to assumptions of inducibility, i.e. they *must* be treated as law-like predicates if they are to be *understandable* and learnable at all (I, p. 160). Such inducibility assumptions would thus have an "a priori" character, namely as "conditions of our understanding of language" (I, p. 160). Seen in light, this also contains the *ontological* statement that the assumption of a *law-like* nature is inevitable[11] – undoubtedly an interesting consequence of Kutscher's thinking. Admittedly, by the linguistic-relativistic restriction that inducibility assumptions are "not invariant to a change of the reference language" (I, p. 160), Kutschera subsequently robs this idea of its punch line: In one language, 'green', in the other language, however, a predicate like 'gred' is to be regarded as law-like (I, p. 160 f.). One is probably not mistaken in the assumption that a completely different, paradoxical world then belonged to the latter language.

As already mentioned, the Goodman construction still is to be critically reviewed in the following, because in the science-theoretical discussion of the problem, so it seems, a central point, namely the functionality aspect of natural laws, is overlooked.

4. Goodman's Neglect of the Functionality Aspect

Let's look at the emerald example for simplicity's sake. What is immediately striking here is the *reference to time* in the definition of 'gred'. Is it responsible for the non-law-like character of the predicate? Well, there are also laws of nature which contain time determinations, namely laws of motion and process, so that the occurrence of a time determination does not exclude per se lawfulness. Is this case given in Goodman's example?

This corresponds to the fact, that t_0 is a single, historical moment, which is unrepeatable as such. Thus a fact related to t_0 indeed cannot be generalized: because t_0 is historically fixed in its unrepeatability, which of course does not apply to the points of time occurring in a process law.

To illustrate the difference, let us consider the example of a bullet trajectory, t_0 being approximately the point in time when the trajectory reaches its highest point before it drops again. However, this is not a unique, immovably fixed historical point in time, but occurs in exactly the same way *again and again* during such ballistic movements. It is therefore a time determination generally connected with this process and in this sense *generalizable*.

On the other hand, a commitment to a *historically unique* point in time exists if, to consider a counter-example, certain tax benefits are only granted up to a certain date t_0. It would be absurd to consider this possibility of tax concession as generalizable, because this would miss the *sense* of the time specification, which implies a *limitation* and thus non-continuability. Nevertheless: Don't we also have here the

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[10] The concept of event interchangeability going back to B. de Finetti essentially means the independence of events from the time of their respective occurrence, which is obviously not the case for non-continuable predicates like "gred".

[11] For this also Wandschneider (1986).

more general Goodman problem, which is related to the concept of *regularity*: Aren't the tax cases before t_0 altogether similar in that they fall under that concession? Why should we not assume that the tax concession will also be granted in the future *despite this regularity*? Why is this regularity not continuable? Of course, because t_0 is an unrepeatable moment, which as such has the character of a border where something stops. But is it then allowed to speak of a 'regularity' at all? To clarify these questions, the relation between regularity and temporality is to be considered more closely.

'Regularity' has in any case also the *temporal* sense, that a certain fact is realized regularly again and again, and thus appears in the same manner at different times. The state of affairs can be of a temporal or non-temporal nature. 'S is green' contains e.g. no determination of time, but of course can be realized in the same way at different times and thus have the character of a regularity. But what is valid for specific *temporal* facts – think of the mentioned examples of a movement on the one hand and a tax-privilege with time limitation on the other hand? If the identical repeatability in time belongs to the concept of a regularity, so it is only possible to speak of a regularity concerning a state of affairs, if this can occur *at different times basically again and again in the same way with these time determinations*. So such a repeatability of the time determinations excludes each form of historical singularity, as it is given for instance in the case of a temporally limited tax benefit.

This clarifies, I think, how to judge the 'regularities' pointed out by Goodman and why they do not entitle to induction: The fact, that an object is gred, represents due to the reference to t_0 contained in the definition of 'gred' indeed a temporal fact; but as far as t_0 is a historically unique point in time, the gred state cannot be a regularity in the sense of a temporal fact, which can optionally be repeated in time. And exactly because of this reason 'gred' does not allow an inductive continuation into the future and thus is not a law-like predicate.

Goodman and his successors have been mislead by the fact, that before t_0 repeatedly states are realized, which are *similar* in the way, that they occur before t_0, so that this 'pre- t_0-occurrence' *seems* to have the character of a regularity. But the developed considerations make clear, why this is not the case: 'pre- t_0-occurrence' as a *temporal* fact could only be a regularity, if the essential time determination t_0 could be repeated identically in time, which, as intended, is not true; neither in the other Goodman example of the lecture, whose words are similar in the fact, that they precede the last sentence of this lecture; nor in the case of the tax benefit, which is granted for all tax cases before a certain point of time, but not beyond that: Therewith each time is referred to a *unique* point in time, so that there can be no temporal fact that is optionally identically repeatable.

What is to be understood more closely by a temporal fact which can be repeated identically in time, can be explained again by the example of the trajectory of a bullet: Such a movement is obviously a repeatable temporal fact, insofar as the time determinations can be assigned to corresponding *movement phases*, i.e. with a similar repetition of the movement also its characteristic time course is reproduced identically. The trajectory first rises, reaches its highest point at a certain time t_0, and then falls back again. In this respect, it is strictly speaking not reasonable to say that the bullet trajectory reaches its maximum *at time* t_0. More correctly it has to be said, that it reaches this maximum *after a certain duration of flight* t_0 (calculated from the time of firing), in other words: In a repeatable time determination the time counting does not start at the birth of Christ, but as it were again and again anew, namely when the underlying repeatable temporal fact, i.e. a certain typical motion process, at all any form of a determined process, starts anew. The determination of time here is not the general, historical time, but has something to do with the process itself, i.e.

with the time function of the law of process. In this sense I would like to speak briefly of a *function-related* time determination, and with this wording it can be said that a function-related time determination is a repeatable, i.e. *generalizable* time determination. Function related time determinations represent as it were 'phases' of a law of progression with a characteristic time function.

If these considerations are applied analogously to *place determinations*, then that other Goodman example also loses its seemingly paradoxical meaning: that a man in this room is a third son does not justify the expectation that all men in this room are third sons: because and insofar there is normally *no functional relationship* between a room and the characteristic of being a third son. A common room and the men in it usually do not form a functional system, even if such a thing remains conceivable in principle.[12]

5. Function-related Determinations

Functional determinations, as they are recognized here as essential for the property of generalizability, reflect specific behavioral laws of a system, thus having their reason in its *function*. Considered in *this* way, Goodman's concept of the *anchoring* of a predicate could be connected with a good sense: Not the frequency, with which this was used so far as a law-like predicate, is decisive – here indeed would be to ask, with which right a predicate then is introduced for the *first time* as law-like –, but rather the circumstance, that it is usable *according to its functional sense* for the characterization of time-repeatable processes of the same kind: 'anchoring' thus not in the usage of language, but in the functional fact, to which the usage of language refers. In this respect, the concept of 'anchoring' probably means something correct – exactly what has been called here the *generalizability of function-related determinations* – without, however, adequately explicating this state of affairs.

The already mentioned view that the reference to contingent, individual-unique points in time, places, objects, events is to be understood as the actual reason for the occurrence of Goodman's paradox on the one hand seems so applicable. On the other hand it is important to see, that such cases remain untouched, which concern individual predicates like 'earthly', 'arctic' etc., as long as they are used in the sense of function-related and therefore generalizable predicates. How appearance can deceive in this respect may be demonstrated by the example of the predicate 'earthly', which obviously refers to the individual object 'earth' and seems to exclude a law-like usage in this respect. But a sentence already stated above of the kind: 'In the earthly atmosphere nitrogen is gaseous' is, scientifically understood, not a statement about an individual fact, but is to say, that nitrogen is always gaseous under conditions of the type of the earthly atmosphere. Here the behavior of nitrogen under certain conditions is formulated, which in turn are characterized by recourse to an unique object (earth). These conditions, however are not inextricably bound to earth, they can basicly also be realized otherwhere and at a different time and therefore are generalizable. 'Earthly' is thus only used as an an exemplification of a function-related determination, which as such can be generalized.

Here the question must arise: If generalizability (in the sense of inductive continuability) excludes the reference to actual unique determinations, and such a reference is clearly given in the case of the predicate 'gred' – why then could the impres-

[12] In hotels (before each room had tv) there were occasionally rooms for the various television programs: In this case, therefore, there was (by convention) indeed a functional assignment of rooms and the people who wanted to watch a particular program.

sion of a *paradox* arise in this respect at all? Now, gred does indeed refer to the unique, unrepeatable time t_0, which means a time limit (similar to the case of the tax allowance, which is no longer granted after t_0). At the same time, however, gred is defined in such a way that it *seems to remain unaffected* by this time limit: Something is gred *for all* times, if it is green before t_0 *or* red after (from) t_0: Although the definition of 'gred' refers to an individual, unrepeatable point in time t_0, the fulfillment of this predicate – due to the clever 'overarching' definition using 'or' – does not seem to include a time limit. This only becomes visible, if the fulfillment of the predicate 'gred' has to be checked in the execution of induction and for this purpose the defining conditions ('green' or 'red') have to be considered: That these are different at different times means for induction, that at different times different things are to expect, while the actual sense of induction is to expect the same thing at different times. This immanent contradiction in the predicate 'gred', which on the one hand includes a temporal limitation by its reference to a unique point in time t_0, but nevertheless reaches beyond t_0 by its definition, is what has led to the idea of a *paradox* here, or in other words: The fact that the *time-spanning identity of a predicate* like 'gred' nevertheless *excludes a time-spanning identity of the state of affairs* characterized by it (before or after t_0) probably represents the actual scandalon from Goodman's point of view.

At the same time, it reflects an understanding of natural lawfulness that is onesidedly oriented towards *qualitative* law-like statements: Emeralds have always been green and will continue to be green in the future. So the only characteristic of natural law seems to be the property of *identity*. The time-bridging meaning of 'gred' seems to correspond to this on the one hand, but on the other hand not, as it involves *non-identity* ('green' before t_0 or 'red' after t_0), which, in the sense of qualitative natural laws, would be equivalent to the breaking of lawfulness: 'Gred' corresponds to and contradicts this understanding of natural lawfulness in equal measure.

An additional irritation in this context results from the correct intuition that non-identity is not to be necessarily understood as incompatible with natural lawfulness, as far as it includes also *functionality* and thus *change* of state, as e.g. temporal laws of progression show. The fact that changing states follow each other in a determinate way is characteristic for a process law, thus it does not imply a breaking of lawfulness. The temporally changing states represent a moment of non-identity, which is nevertheless compatible with time-invariant identity: not as a negation of the change, but on the one hand as the identical functional law of change underlying the change, and on the other hand, as has become clear in the example of the trajectory of the projectile, as an identical repetition of the overall change itself at another time (i.e. as a renewed instantiation of the functional law) – it will soon become clear that both are intrinsically connected. This is exactly what is meant by the concept of the regularity of a process. Under the aspect of the concept of function, the non-identity of temporally different states in terms of their lawfulness needs not to be irritating. But then time determinations like t_0 would not be seen as singular marks but as function-related, repeatable determinations which as such are basicly generalizable.[13]

In the form of Goodman's paradox, we are dealing, as it were, with two interlocking aporias: On the one hand, the time-spanning identity of the predicate 'gred' seems paradoxical, because it nevertheless includes non-identity of the facts characterized by it. On the other hand, non-identity, as explained, is compatible with natu-

[13] Precisely this point has often been completely overlooked in Goodman-critiques, which rightly name the reference to time in 'gred' as the reason for the paradox; as an example for many, see Barker/Achinstein (1974).

ral lawfulness – namely in the sense of function-related determinations – but this case is not given here, because the singular, historically unique time determination t_0 in the definition of 'gred' does not fit to it. This doubly paradoxical character of 'gred', as has been shown, is ultimately based on a misdefinition of the relationship between identity and non-identity in the concept of natural lawfulness, which in turn is mainly connected with the neglect of its *functional character*: This is the revenge for the fact that scientific-theoretical analysis has limited itself to *qualitative* statements of the kind: 'emeralds are green' and has basically ignored the *quantitative-functional* aspect of natural lawfulness.[14]

Please note: In the Goodman framework defined here it was a matter of delimiting predicates that were 'continuable' in time and in this sense inductively generalizable, i.e. 'law-like', from the non-generalizable predicates constructed by Goodman and to find a criterion for this distinction. Only such a structural distinction was intended here. The *fundamental ontological problem* of an inherently lawful nature thus is of course in no way decided. The result achieved so far only says: Predicates that can be generalized inductively are equivalent to function-related determinations. The *induction problem* itself, i.e. the deeper-lying empiricist problem of the spatio-temporal universal validity of natural laws, is not the actual topic here.

Nevertheless, the mentioned result already contains indications for a more adequate than the empiricist understanding of natural laws and induction: The fact that the natural being has a functional character also means that its behavior depends on *physical conditions* and not on *pure time*. The fact that copper conducts electricity is based on the electron configuration of its crystal structure and, for this very reason, has nothing to do with any date in time, and it is precisely for this reason that copper has not only been conductive in the past, but will continue to be so in the future. The natural being 'hangs', as it were, in the net of its conditions; it exists only by virtue of these conditions. But this then also means: Always – whenever – its conditions are given, it is itself likewise realized, in other words: If the context of conditions is in this way constitutive for the natural being, then its constitution cannot be affected by time purely as such; it has a temporally universal character or behaves lawfully. The doubt about the possibility of time-bridging laws of nature – the *induction problem* – stems, seen in this light, from a fetishization of the abstract temporal change with simultaneous neglect of the functional character and thus of the condition-dependency of natural being.[15]

6. Relationship between Universality and Functionality

Without going into further detail here, it is clear that the concept of natural law cannot be adequately grasped if the aspect of functionality remains unconsidered, in other words: Lawfulness cannot be reduced to one of the two moments of natural law stated above, its spatio-temporal universality. The example of Goodman's paradox shows in a particularly drastic way that even the *meaning* of law-like universality – since this is what the question of inductive generalizability aims at – is decisively misunderstood as long as the functional character of natural law is not taken into account. This leads to the assumption that *universality and functionality* are not independent of each other, but are *moments essentially belonging together of the natural-scientific concept of lawfulness*. If this is so, then the question of the *relationship* between universality and functionality must also be asked.

This question shall not be investigated in detail here, just a short note: In the

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[14] For this see footnote 3.

[15] For this see Wandschneider (1986) and Wandschneider (1998), pp. 369–382.

previous paragraph it was already mentioned that a function-related time determination is, strictly speaking, a *duration*, mathematically: a time interval – in the example of the trajectory of a bullet, for example, it is a time interval, calculated from the time of firing. Mathematically, we are dealing with functions $f(t–t_0)$, which depend on time *differences* $t–t_0$. If the projectile is fired, under otherwise identical conditions, at a later time t_0', which is shifted by the amount τ of time, the function

$$f(t'– t_0') = f((t+\tau)–(t_0+\tau)) = f(t–t_0)$$

and thus exactly the same time dependence as before the time shift, in short: function related time determinations are mathematical time *differences*, which as such are *invariant to shifts in time*. Analogously can be argued concerning function related space determinations. Accordingly functionalities depending on function related space and time determinations are invariant to shifts in space and time, and this *invariance* is nothing else than the mathematical formulation of its *spatio-temporal universal* character.

The simple example shows that the two moments of natural lawfulness highlighted above – universality and functionality – are by no means independent of each other. Rather, the functionality of natural lawfulness implicitly includes its spatio-temporal universality, and vice versa: Without reference to the functionality of the law of nature, no statement about its universality is possible. It is therefore not surprising that the neglect of the functional aspect in the context of analytical philosophy of science has increased the notorious difficulties of empiricism with respect to the universality of natural laws almost into the paradox, as has become clear, for example, from the appearance of Goodman's aporia.

The two moments of natural law on the descriptive level – universality and functionality – correspond, however, as already noted at the beginning, on the ontological level, to the moments of uniformity and potentiality as characteristics of nature itself. The developed argumentation, according to which universality and functionality intrinsically belong together, has a direct *natural-ontological consequence*: If nature behaves uniformly, i.e. in the sense of universal laws of function, then *potentiality* is an essential part of its being. Indeed, the functional character of the laws of nature expresses that being natural is what it is, always *depending on conditions*, and that means: it contains possibilities, dispositions, which are realized under specific conditions.[16] Biological evolution, which brings to light, as it were, immanent possibilities of natural being, is in this respect a grandiose example staged by nature itself; another is technology.

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[16] A simple example to illustrate what is meant: Iron becomes increasingly plastically deformable with rising temperature: an immanent disposition of iron, the realization of which depends on the respective temperature.

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