Technology and Goodman's Paradox*

Ingemar Nordin†

Goodman's paradox gives rise to a cluster of problems, problems that are in need of different answers. I will discuss some variants of the grue hypothesis applied to the technological context. One conclusion in this paper is that there is room for rational decisions, and that solutions to the paradoxes in technology can be found in the practical choice situation.

1. Introduction. A much-discussed problem within philosophy of science is the so-called grue paradox—originally formulated in Goodman [1955] 1965. It goes like this. Suppose we have a long series of observations about the color of emeralds. Every observation so far has shown that they are green when held in normal white light. A very natural hypothesis that comes to mind is H_1: 'All emeralds are green'. But suppose that a scientist comes to think of an entirely new color property and proposes an alternative hypothesis, H_2: 'All emeralds are grue'. The predicate 'grue' stands for 'being green up to the time point t, and blue thereafter', where t is some specific time point in the future. The grue predicate is clearly quite artificial and arbitrary. Our intuition is that there is absolutely no reason whatsoever for believing that emeralds are grue and not green. But the frustrating thing is that there seems to be just as much inductive support for believing in H_2 as in H_1. They cannot both be true, but all the inductive evidence supporting H_1 also supports H_2. This seems to be a reductio ad absurdum argument against inductivism.

Within a falsificationist philosophy of science Goodman's original problem of developing a theory of confirmation does not have to arise since its methodology is not directed towards making confirmations of beliefs at all. A possible position is to remain skeptical to all theories, corroborated or not. The falsificationist does not have to accept any theory as true or probable. But as soon as our ambition is to *act* on the basis on

*Received April 2008.

†To contact the author, please write to: Department of Medical and Health Sciences, Linköping University, SE-581 83 Linköping, Sweden; e-mail: ingemar.nordin@liu.se.

Philosophy of Science, 76 (July 2009) pp. 345–354. 0031-8248/2009/7603-0005$10.00
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https://doi.org/10.1086/649809 Published online by Cambridge University Press

some theory then it could be argued that the problem cannot be dismissed as easily. Since we do have to act, it seems unavoidable that we also have to make a positive choice of sorts. Hence, inductivists and falsificationist face the same problem, sometimes called the Pragmatic Problem of Induction.[1] In a scientific choice situation the falsificationist may argue that since there is no good reason to believe in any theory, or prediction, we should simply refrain from choosing or believing, and stay skeptical. The only choice one should do is negative; to discard refuted theories. But in the practical problem situation we have to act even if there is no good reason to believe that a positive choice of a technique will lead to the wanted effect. (As I see it, we do not actually have to believe, or trust, anything in order to act efficiently. Indeed, I do not see why it should be practically necessary to even trust or believe that our chosen technique is working. Trust is one thing and the necessity to sometimes apply a technique promptly and without hesitation is another.) The question is, is there room for a rational, positive choice anyway? It has been suggested that even if one cannot make a rational choice of which *theories* are to be believed, there is room for a rational, noninductive, choice of which *techniques* to use (Nordin 2006). That argument tries to show why it is more rational to prefer a technique that has been shown to work to a technique that has not been shown to work. I will return to this argument shortly.

However, Goodman's paradox deals with a situation where two hypotheses are equally corroborated. Translating this to the practical problem situation, where inductivists and falsificationists face the same urgency to make a positive choice of techniques, there is no obvious rational solution. Suppose there are two techniques T_1 and T_2. The first is based on, and will only work tomorrow, if the hypothesis that emeralds are green is true. And T_2 is based on, and will only work tomorrow, if the grue hypothesis is true. Suppose someone claims that he has as good reasons to use T_2 as to use T_1 because T_2 is just as likely to be successful as T_1. There are as many corroborating observations for his basic hypothesis as it is for the one T_1 is based on. What arguments are there really for preferring the 'green' technique to the 'grue' one? In order to solve Goodman's paradox—applied to the pragmatic problem of choosing techniques—further exploration (and exploitation) of the practical problem situation is necessary.

2. Techniques and Corroboration. Before we come to the original grue paradox there are some preliminaries to deal with. Let me start with the

1. This discussion arose in connection with Wesley Salmon's (1981) criticism of Popper. See also Miller 1994, 20–21, for an account of the debate.

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distinction between theory and technique. The former is of course a linguistic entity that is capable of having a truth value, while the latter is capable of being more or less functional with respect to an intended effect.[2] A technique can be defined as a repeatable procedure (sometimes involving a tool or a machine) with a specified effect aiming at solving a practical problem. For each technique, T, we may formulate a corresponding hypothesis $H(T)$: 'T works'. This is the commonly held hypothesis that is tested when T is tested. If the technique T is said to be 'corroborated' then I interpret that as $H(T)$ is corroborated. It should be noted, however, that $H(T)$ is not an explanatory hypothesis; the aim of testing it is not to achieve a better understanding of our world but to solve a practical problem.

However, from a purely logical point of view we are of course free to formulate any kind of hypothesis we like. Therefore we are free to formulate a grue-like hypothesis for T like $H'(T)$: 'T works until t, but does not work thereafter'.[3] Suppose t is tomorrow. Then all the observations that has corroborated $H(T)$ so far also corroborates $H'(T)$. Both the original grue hypothesis and our own $H'(T)$ are 'unnatural' in the sense that they are counter to our intuition (for example, we do not usually view time as such as a causal factor). And they may not be very helpful either in science or in technology. But, as far as we know, they may be true nevertheless.

What does the corroboration of $H'(T)$ show? Well, from a falsificationist point of view 'corroboration' is not to be equated with 'justification', or 'support', of what is going to happen in the future. The corroboration of T does not show that we are inductively justified in believing that T will work tomorrow. If we accept the arguments behind the grue paradox and the skeptical view of induction, then we are as little justified in believing that T will work tomorrow as we are in believing that it will not. We cannot justify a choice between two corroborated but incompatible hypotheses concerning the same technique. At the same time, is not that exactly what we have to do if we are going to act at all?

3. The Role of Corroboration. But to choose between hypotheses of this kind is not quite the relevant choice to make. If we are going to solve a

2. For a description of the concept of functionality, as well as its relation to usefulness, see Nordin 1989. It is necessary to specify the intended effect when talking about functionality since there are always many various effects of a technique.

3. There are similarities here with the concept of 'counter induction', introduced by Salmon 1957. Since my aim is not to justify induction, or to show the difficulties with inductive principles, but to explore the relevance of Goodman's paradox in relation to the choice of techniques, I will not enter that discussion here.

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practical problem with the help of some technique our choice is not between two *hypotheses* concerning the same technique but rather to choose between two, or more, available but different *techniques*. And if there is a difference of degree of corroboration between these techniques (i.e., between hypotheses that they work) there may be a ground for making a rational choice.

According to the skeptic, corroborating evidence for a technique does not prove that it will work in the future, or that it will most probably work. The problem of induction does not disappear in the technological context. But corroborating observations can still be used as a ground for a rational choice in a practical choice situation without involving any principle of induction. In a practical choice situation you first of all always have to choose *something*. Even the choice not to act is a choice of action in a sense since that choice also has consequences. Often you also have more than one option and you can compare those options. Some of the options are perhaps corroborated by previous tests and others are less so or not at all.

Suppose that you have two techniques, T_1 and T_2, to choose between. Both have an intended effect, E, that would help you to solve the practical problem at hand. The technique T_1 is well corroborated, that is, it has withstood previous tests and produced E in those situations. T_2 has not been tested at all, or it has not worked very well when tested. What does the corroboration of T_1 show? Well, it shows at least one thing, namely, that the *skeptical* hypothesis concerning T_1 that *it does not work at all (or cannot work) in any situation*, is false. Because T_1 did in fact work at one time and in one situation. On the other hand, total skepticism towards T_2 is still possible. That means that you have a reason to doubt T_1 less than T_2. You have no reason to trust T_1 but there is still a small but important epistemological difference between the techniques.[4]

Given that there is no justification for our beliefs about the future, there is nothing to be said with certainty about the future working of techniques. The corroborated T_1 may work, or it may not. The uncorroborated (or less corroborated) T_2 may work, or it may not. But since there is practical necessities to choose we should use the only epistemological distinction there is (i.e., our reasons for being less doubtful) and prefer T_1 to T_2. The only alternative to this would be clearly irrational, namely, to prefer the technique concerning which we have no reason to be less skeptical.

4. The Need for Positive Guides. A further characteristic of the practical decision situation is the need for a positive guide for action, that is, we

4. This argument is further elaborated in Nordin 2006, 235–237.

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need rules like 'use the technique x!'. Negative guides such as 'refrain from using technique y!' are not sufficient. The reason is that in every practical choice situation there are not just one or two options. There are an infinite number of possibilities; perhaps some that have been negatively tested, perhaps one or two that have been corroborated and always an infinite number that have not been tested at all. Suppose you contract an illness that you are unfamiliar with. You are alone in the jungle. Since you do not have any doctor or hospital conveniently at hand, you try your own methods: berries of different colors, roots and whatnot. Some of these 'techniques' make you worse, but the bright red berries make you feel better. So you decide to keep on eating the bright red berries and stop eating the other stuff. But you haven't tried *all* the alternative stuff. Would it not be just as rational to start eating new things: black berries, herbs, insects, and so on? Or why not try a variant of the red berries: eating red berries and having bloodletting at the same time? Or, eating red berries and praying? Or, eating red berries and standing on one leg? Anything that has not been tried is possible. But this would lead us to inaction instead of action. That is not rational. Besides an infinite number of possibilities not eliminated we need something positive to go on. It is rational to choose what has given us an admittedly small but positive guide for action.

It might be objected that since T_1 is just as likely not to work as to work, why should we trust such an uncertain technique at all? The answer is that we have no good reason to 'trust' *anything*. For every technique, including T_2, a corresponding grue hypothesis may be formulated. If we should feel inclined to discard T_1 because it may not work tomorrow, then we would have to do the same with all the techniques in the world. And if trust in a technique would be necessary for action, then we could not act at all. But this option is not practically possible.

One can further illustrate the distinction between justification of a belief about the future and corroboration of a technique by the following 'paradox'. For T_1 we have the normal $H(T_1)$ and the grue-like hypothesis $H'(T_1)$. For T_2 we have $H(T_2)$ and $H'(T_2)$. Suppose now, as before, that T_1 is the most corroborated of the two. This seems to imply (still under the assumption that the arguments behind the grue paradox are accepted) that $H'(T_1)$ is *more* corroborated than $H'(T_2)$. Therefore it seems that the prediction that T_1 will not work tomorrow is better corroborated than the prediction that T_2 will not work, that is, that we have less reason to doubt the malfunctioning of T_2 than the malfunctioning of T_1! This is strange, at least until we remind ourselves of what $H'(T_1)$ and $H'(T_2)$ stand for. They are not just predictions about what will happen. They also state what has been the case, namely, that the technique in question *has* worked. $H'(T_2)$ includes the statement that T_2 has worked in the past, and

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$H'(T_1)$ includes the statement that T_1 has worked in the past. Clearly, we have a reason to be less skeptical about the latter than the former.

In a practical problem situation I believe that hypotheses like $H'(T_1)$ and $H'(T_2)$ are simply irrelevant. I have said that the practical problem situation includes the necessity to act. I also claim that finding a rational solution to the practical problem includes the problem of finding a positive guide for action. The choice is not between inaction (which is out of the question) and an irrational positive choice (anything that has not been 'falsified' will do). We can make a rational positive choice of a technique here. However, $H'(T_1)$ and $H'(T_2)$ do not give us any positive guidance for action, only for inaction. Suppose T_1 stands for the technique of eating red berries against the illness in the jungle and the untried T_2 stands for eating black berries. Then the grue-like hypotheses concerning them only tell us to refrain from eating red or black berries after time t. Nothing else. So, if we are looking for a positive guidance of action, the fact that $H'(T_1)$, with its gloomy prediction, happens to be corroborated is beside the point.

For the same reason, other hypotheses concerning T that happen to be tested at the same time are of less importance. For instance, the hypothesis $H(T_1\&T_2)$, where T_2 is an untested technique, is corroborated if T_1 is corroborated. But that corroborated hypothesis does not help us make a practical choice, and it certainly does not make T_2 a corroborated possibility.

This whole business of formulating strange hypotheses about techniques seems to be very far from the practical problem situation. Why is that? One reason is that we are after positive guides, not primarily negative guides. Another reason is that when we talk about 'corroboration' of a technique we mean observations of a technique's functioning, that is, that the intended effect has occurred. The concept of functionality must refer to a given effect E, and this effect has to occur in order to corroborate the functionality of a technique. But a *hypothesis* about a technique may well be corroborated by the *absence* of an effect! Suppose the technique T_3 has been tested without success. Construct the following hypothesis $H''(T_3)$: 'The technique $T_3(E)$ does not work until time t but will work after that'. Then we see that H'' has been corroborated by the absence of the effect E so far. In this case, it could be argued that H'' provides us with a kind of guide for what we should do after t, since it promises that T_3 will have an effect tomorrow. Still, the *technique* $T_3(E)$ has not been corroborated. On the contrary, it has failed so far. The hypothesis H'' may well be true, but it is not useful. Perhaps we could say that $H''(T_3)$ has been corroborated with respect to its truth value but not with respect to its usefulness. There is a difference between corroborating the truths

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of hypotheses and corroborating the functionality of techniques or of practical guides.

5. Back to Goodman's Paradox. So far I have used what I see as the logic of the practical choice situation to discard some grue-like hypotheses as irrelevant. However, not all such cases may be dismissed as irrelevant in a pragmatic choice situation. For example, it could be argued that the Problem of Induction as such is irrelevant in a pragmatic context. Why not just assume, for practical reasons, that the world is uniform, and that if a technique has worked yesterday it will probably also work tomorrow? After all, it is not the business of technology to dwell on matters of metaphysics! But the grue paradox also shows how problematic such an assumption is. It makes it clear that this assumption is pretty unhelpful. Of course we may assume that the world is uniform, but it still leaves the question in *what way* it is uniform. After all, the world of emeralds may be uniformly green or uniformly grue. Translating this to the technological context the assumption of uniformity is of little help as soon as we ask ourselves whether the present situation is the same as before. Maybe it is, maybe it is not. It all depends on in what way the world is uniform. And since hardly any techniques work in all possible situations (for all people, at all temperatures, in space as well as on earth, etc.) we are left with the very real problem of not knowing what will happen even if we knew that the world is uniform. Nor is it obvious what relevance corroborating observations have for making a rational choice. To illustrate this problem, let me sketch a somewhat less artificial example than what we have dealt with so far.

The grue paradox is an instance of theories that are underdetermined by data; it is always possible to construct two or more theories that are inconsistent with each other but that are consistent with the same set of observations. Suppose that the theories in question are classical Newtonian optics and gravitation on the one hand and the general theory of relativity (GR) on the other. Suppose also that the year is 1918 and that no crucial experiment exists that has shown that one of them is incompatible with any data known so far. However, the theories give rise to different predictions concerning how much the light from a distant star will bend as it sweeps close by the sun in 1919 when the next solar eclipse will take place. Suppose further that someone plans to construct one of two different techniques based on the theories such that $T_n(E)$ will work in the experiment in 1919 if and only if the Newtonian prediction occurs and $T_e(E)$ will work in that experiment if and only if the Einsteinian prediction occurs. In this case the choice is primarily a question of which of the two theories we ought to use for constructing a technique. We really

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do want to accomplish the effect E in 1919 and we have two serious alternatives regarding how to do that. Which shall we choose?

Is there any given answer to this question? Given the premises, only one technique will work in 1919 and there is no way in 1918 to distinguish empirically between the theories. But since we have to choose and both techniques may work as far as we know, neither option seems to be a bad one. If we only have one choice, why not just flip a coin?

I think that from a technological point of view scientific theories should be treated as tools; as instruments for construction of techniques. And they should be evaluated with respect to their functionality and usefulness as such tools and not with respect to their truth or falsity, just as was done in the case of techniques above. This means that an instrumentalist interpretation of scientific theories is appropriate in the practical choice situation.[5] In principle GR could have been used and tested as a tool for a couple of years before 1919. But actually this was not the case in 1918. GR *was* a new theory and no technique had yet been based on it and tested. Nor would there have been any point in basing a technique on it, since Newton's theory was simpler and had worked very well. Newton's theory had been used by engineers and others for over 200 years in various tasks of calculation. It was well corroborated as a working tool within technology. In accordance with the arguments given above concerning techniques and positive guides I would say that the rational choice would be to choose the technique that was based on Newtonian physics. There would have been a reason for being less doubtful about that theory *as a practical tool* than GR.[6]

It is true that GR, as a descriptive theory, could explain why Newton's theory had been successful so far. But the new theory was not corroborated as a tool since it had not been used for construction or for solving any practical problems. Hence it was GR that had to prove itself as a superior instrument by being corroborated in situations where its predictions made a difference in the practical results. Therefore T_n is a better choice than T_e.

Viewing theories as tools and applying my previous arguments con-

5. It is common that instrumentalists interpret theories as predictive instruments. But we have to be clear about that it is not the truth and falsity of the predictions that are important in technology but the view of theories as instruments. We are only interested in their functionality and usefulness, not in what they happen to say about the world. However, I do not propose an instrumentalist view in the scientific context. In science realism is appropriate. Otherwise there would be no distinction between science and technology.

6. Miller (1994, 35) reaches a similar position with respect to new hypotheses in science. However, his argument is based on the Popperian criterion of science and differs from mine here.

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cerning the practical choice situation we can also deal with the original grue hypothesis. Suppose you have the problem of buying the right tiepin for your tie for the party tomorrow. You want a green jewel on it to match the tie.[7] So, should you buy an emerald pin under the assumption that emeralds are green or should you choose some other alternative (it is taken for granted that the alternative is based on a proper positive guide for action)? The two hypotheses concerning the nature of emeralds torture your mind. Then you remember that you have tried emeralds many times before and succeeded in getting the right match of colors. Of course there is no way to know which hypothesis is true. But since you have based your previous actions on the first hypothesis you have corroborated that hypothesis as a tool. The logic of pragmatism makes the conservative choice the most rational.

This argument against the grue hypothesis is based on the fact that it is a latecomer, invented as it was by Goodman only 50 years ago. What would be the case if it were older than the green hypothesis? Or suppose that the young Newton had created GR, but that some physicist 200 years later discovered that a mechanics based on Euclidian space and time would be much simpler (although it involves the introduction of the 'occult' force of gravitation) and fitting the observed facts just as well? It would not be possible to perform a crucial experiment to see if the newcomer was a better alternative than the old and established one until 1919.

There can be a number of reasons why these possibilities are extremely unlikely, or even absurd. But my conclusion would be the same. If a theory has proved itself a successful guide or tool for practical action, why should all untried alternatives be looked upon as equal or better alternatives when we are facing a new crucial situation? After the introduction of the new theory we can indeed see that it would not have mattered if we had used the old or the new theory up till now. But since their predictions about the future (or about the new situation) are completely uncertain, a difference in the actual elimination of reasons for doubt is all we have. The importance of viewing theories as tools, and not as descriptions, is evident when the grue hypothesis is discussed in a technological context. Our intuition is to discard it as absurd and to blame the artificial and unnatural predicate involved. But if it is viewed as a pure tool then we have to ignore its meaning and just use it as an algorithm for calculating outcomes of various actions. The hypothesis being regarded as such a tool there is no other criterion by which to evaluate our grounds for skepticism but its corroborating data. And if there are reasons of that kind to be less skeptical about the grue tool than the green tool,

7. I have borrowed this example from Miller 2006, 129–130.

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then we should stick to the former. In this sense it is similar to the situation in the jungle where we stick to red berries just because we happened to try them first.

Finally it must be said that there may still be cases where we cannot make any rational choices or discard any of the options as irrelevant. For example, there may be cases where we have two or more equally corroborated techniques to choose between, and where we do not know which one will be the most functional in the new situation in front of us. The options are equally good or bad in that respect. But we will have to try one of them anyway. So, we flip a coin. That is what we sometimes have to live with.

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