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**Creationism, Bayesian Confirmation, and the Problem of Demarcating
Science from Pseudo-science**

Gerhard Schurz (University of Duesseldorf)

1. Anthropic principle, creationism, and the demarcation problem

Although evolution theory was able to solve numerous riddles concerning the evolution of life and has thereby pushed back the influence of religious creationisms, scientists have found out in the last decades that the possibility of the evolution of higher forms of life rests on extremely improbable parameter settings of our planet, our solar system, and ultimately of our universe (Ward und Brownlee 2000, Smolin 1997). This improbable parameter settings includes facts such as that the earth is orbiting around the sun without that narrow temperature zone which allows for the existence of fluid water, that the earth's magnetic field stabilizes the earth's rotation axis and deflects potentially harmful cosmic radiation, that neighbouring planets like Jupiter shield the earth, at least partially, from the impact of comets, until to the fact already very small changes in the values of constants of nature would cause matter to become unstable, or would at least prevent the formation of stars in the universe. The consequences of these well confirmed facts for the ethical responsibility of men for our planet would deserve a consideration of its own. In this paper, however, I am interested in the quest for an explanation of these facts.

As part of the effort to explain this "improbability" of our world, and under the heading of the "anthropic principle", creationist explanations have received new

impetus these days, even in the domains of physics and cosmology (Barrow und Tipler 1988, Davies 1995). The anthropic principles says the following:

(AP) The parameter settings of our world are as improbable as they are, "because" we human beings (or other complex forms of life) can exist in this world.

Obviously this principle is ambiguous. The "because" can be understood in the weak sense of a mere *justification*, or in the strong sense of an explanation. In the justification sense the principle (AP) is harmless, because it merely says that we human beings could not exist if the parameter settings of our worlds were not as improbable as they are.¹ In contrast, the above-mentioned neo-creationist movement understand the "because" in the sense of an *explanation*, namely a *teleological* explanation (an explanation in the causal sense is impossible because the explanandum lies in the past of the explanans). The parameter settings of our world are in this understanding as improbable as they are *in order to* enable life to evolve – because there exists an intelligent creator that has purposively designed our world.

On this basis a series of neo-creationist attempts have been launched to rehabilitate creationism as a scientific hypothesis. Would this enterprise succeed, it would provide strong arguments for creationist demands for teaching religion in school on equal rights with evolution theory. It has even been attempted to justify creationism by an explicit application of methods that are quite prominent in contemporary philosophy of science – namely by Bayesian methods of justification (Swinburne 1979, Unwin 2005). If that were really possible, then the demarcation problem – that is, the quest for an objective demarcation between science and speculation – would be unsolvable. In fact, after the turn in philosophy of science which was initiated by Thomas Kuhn, many philosophers begun to doubt the pos-

¹ There exist further variants of the AP which cannot be discussed here (cf. de.wikipedia.org/wiki/Anthropisches_Prinzip).

sibility of such a demarcation. The demarcation problem which earlier philosophers of science such as Popper or Carnap intended to solve was regarded as obsolete. Philosophers of that time were mainly concerned with the criticism of a too narrow-minded scientific positivism, while only a few of them were aware that a society which is built up on public education has a strong demand for a plausible delineation between established knowledge versus mere speculation.

The majority of contemporary philosophers of science are opposed to the neo-creationist attempts to establish religion as a scientific hypothesis. But after all that self-criticism which was going on in post-Kuhnian philosophy of science, how could such a demarcation be made to work? Can a plausible demarcation between science and rationalized religion be found at all? In my talk I will argue that the answer is *yes*, but bayesian confirmation theory is not sufficient for this purpose – this account provides only necessary but not sufficient conditions for rational confirmation. The intended demarcation has to be established in a different way.

2. *Empirically criticizable versus uncriticizable creationism*

First of all we have to distinguish between two kinds of creationist belief systems:

(1.) *Empirically criticizable creationisms* entail empirical consequences by which they are testable. These belief systems include most traditional religions, which are falsified by their false empirical consequences or at least made rather unlikely. This diagnosis does not only apply to strict *genesis-creationisms*, which entail wrong historical claims such as that the world has been created 60.000 years ago. The diagnosis is also true for many *design-creationisms*, which are more liberal in regard to genesis. but which stress the functional perfection of the God-made living beings. For as a matter of fact, the products of evolutions are not perfect but full of imperfections. No intelligent engineer would, for example, come to the idea to furnish the fin-skeleton of whales with five finger limbs – only the evolutionary

descendance of whales from land-living mammals yields a plausible explanation for this (cf. Ridley 1993, 45). In the same vein, the products of evolution are not morally good, but full of cruelties – which is, by the way, a variant of the classical problem of theodicy.

Contemporary philosophy of science and epistemology doesn't have a problem with the criticism of these kind of creationisms, because they can be criticized based on their conflicts with the empirical facts.

(2.) *Empirically uncriticizable creationisms*: More difficult are those rationalized forms of creationism that have been developed by scientifically educated people into a form which avoids any conflict with established empirical knowledge. One is tempted to think that these empirically uncriticizable creationisms can be criticized because they don't have any empirical consequences by which they can be 'tested' – in the logical sense of 'testing' as of comparing these consequences with observed facts. But this is not the case – in the contrary, it is always possible to furnish creationist explanations with empirical consequences.

For example, the following formulation of 'minimal creationism' is indeed void of content and untestable:

(C-empty) How ever our world is like, it has a creator (about which nothing else of empirical content is asserted).

But as soon as we enrich the effects of the creator in (C-empty) in regard to known empirical facts of our world, we obtain rationalized versions of creationism which entail empirical facts – as for example

(C-rat) Our world has a creator that has brought about the following facts: ... (here follows a correct list of all empirical facts which are scientifically known so far, for example, a list of all known living beings, etc.)

In contrast to (C-empty), (C-rat) has correct empirical consequences (see also Sober 1993, 45-49). Argumentations along the line of (C-rat) are presently found in the anglo-saxon *intelligent design* movement, whose proponents claim that the improbable parameter settings of our world are best explained by the assumption of an intelligent creator, without entailing special hypotheses about the creation history or the achieved degree of perfection (see Behe 1996, Dembski 1998; for criticism cf. Sober 2002, 72). Does this really mean that rationalized creationism has now become a scientific hypotheses that can explain the same empirical facts as science? Intuitively we feel that there is still something wrong with (C-rat) – but what could that be?

The problem we encounter here is nothing but the already mentioned demarcation problem: by which criteria can scientific hypotheses be distinguished from unscientific speculations? There is consensus in contemporary science that earlier suggestions of demarcation criteria were too simple. Let me pick out two prominent suggestions of that sort:

The first suggestion is the criterion of *empirical definability*.² According to this criterion only those hypotheses are scientific whose non-logical concepts are definable by pure observation concepts. This criterion has been defended by classical empiricists and positivists. However, it is *too narrow*, because also scientific theories contain empirically undefinable, so-called *theoretical* concepts (such as "magnetic force", "quantum state", etc.) which designate unobservable things or properties (Carnap 1956; Schurz 2006, ch. 5).

The second suggestion, developed by Popper and members of the later Vienna circle, only requires from scientific hypotheses that they entail empirical consequences. This criterion, however, is *too wide*, because, as we have seen, also purely speculative hypotheses can be turned by trivial means into hypotheses with em-

² Even more narrow is the criterion of empirical verifiability which was held by members of the early Vienna circle.

empirical content (see Stegmüller 1970, ch. V). For example, the sentence

"God exists"

is clearly void of empirical content. But we need only conjoin this sentence with an implication towards an arbitrary known empirical fact, in order to obtain from it a sentence that has empirical content, such as

"God exists, and if God exists, then grass is green".

The same procedure has been applied in the construction of (C-rat) above.

Because of such difficulties many contemporary philosophers of science regard demarcation attempts of this sort as out-fashioned and not worthwhile to be pursued. A prominent trend that takes this view is *Bayesianism*. According to this view the confirmation of a hypothesis merely depends on its probability conditional on the given empirical evidence; requirements on scientific hypotheses which go beyond this are neither necessary nor reasonable. In the following section I want to show how it comes that this position is used by creationists in order to defend their views.

3. *The Bayesian justification of rationalized creationism*

For Bayesians, probabilities are rational degrees of belief. The conditional probability $P(E|H)$ of an (empirical) evidence E given a hypothesis H is also called the *likelihood*. Not always but often is this likelihood objectively determined. For example, the likelihood of $E = \text{'throwing heads'}$, given $H = \text{'throwing a regular coin'}$ is $1/2$ by the laws of statistics. And the likelihood of E , given a hypothesis H which logically implies E , is 1 on logical reasons. What one is interested in is of course $P(H|E)$, the probability of the hypothesis H given the evidence E . According to the famous bayesian formula this probability is computed by the likelihood and the so-called prior probabilities as follows:

(*Bayes1*): $P(H|E) = P(E|H) \cdot P(H) / P(E)$.

Thereby, $P(H)$ is the prior probability of H , which is the most problematic part of Bayesianism, because degrees of belief which are 'prior to experience' are subjective and merely reflect one's own prejudices. $P(E)$ is the prior probability of E – it is usually computed as

$$P(E) = \sum_{1 \leq i \leq n} P(E|H_i) \cdot P(H_i),$$

with $\{H_1, \dots, H_n\}$ as a partition of alternative hypotheses containing the hypothesis H in question. This computation of $P(E)$ involves an additional problem, since the partition will often contain a default-element of the form "no one of the other hypotheses is true", such that the likelihood of E given this default-hypothesis is completely unknown – but I will ignore this problem here.

To avoid the dependence on the subjective value of the prior probability $P(H)$, Bayesians have suggested a *comparative* notion of confirmation according to which an *increase* of H 's probability by E , $P(H|E) > P(H)$, is a sufficient criterion for the confirmation of H by E (where E assumed to be consistent and H non-tautological).

Comparative bayesian confirmation: A (consistent) E confirms a (non-tautological) H if $P(H|E) > P(H)$.

Assuming the *normal case* $0 < P(E) < 1$ one can easily prove that $P(H|E) > P(H)$ holds exactly if $P(E|H) > P(E)$ is true, in other words, if the so-called likelihood-ratio $P(E|H)/P(E)$ is positive. But the latter must always be the case if H is a hypothesis which logically entails E . We thus obtain the following consequence:

(Bayes2): Every (non-tautological) hypothesis H which logically entails an empirical evidence E with $0 < P(E) < 1$ is confirmed by E (in the comparative sense).

This consequence can be exploited by proponents of all sorts of rational speculation. For according to (Bayes2) every hypothesis, be it as weird as you want, will be confirmed by a given evidence E if it only entails E (cf. Schurz 2008a, §7.1). For example, the fact that grass is green confirms the hypothesis that God exists and has brought it about that grass is green. The same fact also confirms the hypothesis that there exists a spaghetti-monster which has brought it about that grass is green – the spaghetti-monster-movement is a counter-movement to creationism initiated by physicists which intends to turn the demands of teaching creationist belief systems in school into absurdity (see www.venganza.org/aboutr/open-letter). Again, the same fact also confirms the hypothesis that two spaghetti-monsters together have effected that grass is green, or a god together with a spaghetti-monster, a god and a devil, and so on ... until the scientific explanation of the green colour of grass in terms of chlorophyll. All these explanatory hypotheses H_i get comparatively confirmed by E . If they have a different conditional degree of belief $P(H_i|E)$, then, according to (Bayes 1), this can only be because of their different prior probabilities, since the likelihood $P(E|H_i)$ is 1 for all of them, and the value of $P(E)$ is independent from the chosen hypothesis.

Bayesian philosophers of science are aware of this fact (comp. Howson/Urbach 1996, 141f). They argue that scientific hypotheses have a significantly higher prior probability than religious hypotheses (cf. Sober 1993, 31f). But it seems to be inappropriate to ground the distinction between scientific hypotheses and speculations on subjective prejudices. From the religious point of view creationism will have a higher prior probability than evolution theory. And this is the reason why creationists can utilize bayesian confirmation theory to demonstrated that the creationist hypotheses is confirmed by scientific evidence. An earlier example of this sort is Swinburne (1979, ch. 6). More recently Unwin (2005) has computed with help of Bayes' formula the posterior probability of God's existence to be 67%, thereby as-

suming a 1:1 priori probability.³

The difficulty to find a demarcation line within this framework appears also in Richard Dawkins' rather agitational book "The God delusion (2006). For one of Dawkins main arguments against the existence of God is the

Improbability argument: the hypothesis of a creator who has intentionally brought about all these improbabilities of our world is prima facie itself extremely improbable, while the assumptions of evolution theory are prima facie much more probable.

But Dawkin's argument is dubious. Since also the premises of the evolutionary explanation must assume that the world has those improbable parameter settings to which the anthropic argument refers, it is intuitively not clear that their prior probability is greater than that of the premises of the creationist explanation – apart from the fundamental problem that prior probabilities are always subjective, and an objectively founded demarcation along these lines seems to not to be possible at all.

The fact that with help of the Bayes formula one can confirm entirely absurd hypotheses seems to show that Bayesian confirmation theory is too *weak* to capture genuine confirmation and to demarcate genuinely confirmed hypotheses from mere speculations. Not that the Bayes formula would be false; in the contrary it is of course mathematically correct, and the bayesian condition of a positive likelihood ratio is surely a necessary condition for confirmation – but not at all a sufficient condition. The demarcation problem cannot be solved within this framework. In the next section I am going to develop an alternative suggestion.

4. Novel predictions as demarcation criterion

Intuitively, the cognitive defect of rationalized creationism (C-rat) is obviously the

³ This motivated the editor of the magazine *Sekptic*, Michael Shermer, to set up a counter-computation with the result of merely 2%.

following: an explanation of this sort can always be given, however the empirical facts look like. The creationist explanation is completely *ex-post*, constructed in retrospect and cutted to the shape of the explanandum. A demarcation criterion should place this defect into the centre of its attention. The *ex-post* character of a hypothesis manifests itself in its disability to deliver new predictions. In fact, rationalized creationism cannot predict anything because the creationist hypotheses tells nothing about the properties of the creator except that (s)he has causes the facts asserted in the explanandum. Therefore the creationist hypotheses "God brought it about that E" can only be given in retrospect, when E is already known.

I call this criterion the *prediction criterion*. The basic idea of this criterion has been suggested by many other scientists and philosophers of science (e.g., Lakatos 1977; Ladyman and Ross 2007, §2.1.3). The prediction criterion has been criticized to be too narrow, because several disciplines, including evolution theory, deliver only a few predictions, if any at all. But this criticism rests on a misunderstanding. For in this criterion, the concept of prediction is not understood in the temporal sense, but in the epistemic sense of an *ex-ante* argument (see also Stegmüller 1983, 976). It is not required for an *ex-ante* argument that the conclusion refers to the future, but merely that the premises have been known already *before* the conclusion was known, and the conclusion has been inferred from them afterwards. In contrast, in an *ex-post* argument the conclusion is known in beforehand, and the premises are found or postulated afterwards. This opens the possibility of fitting suitably tailored premises towards the conclusions. Such a fitting of the premises towards the conclusion is impossible in the case of an *ex-ante* argument, i.e. a prediction in the epistemic sense.

Depending on whether the conclusion refers to the future or to the past, an epistemic prediction is either a temporal prediction or a temporal retrodiction. Evolution theory makes hardly any predictions, but it yields great wealth of retrodictions, which are independently testable by present tracks, such as geological tracks, fossils, or archaeological sites (in other words, temporal retrodictions about past

events imply temporal predictions about discoverable tracks). Exactly this *independent testability* is guaranteed by the satisfaction of the prediction criterion – the testability by facts which are independent from those facts for the explanation of which the hypothesis has been constructed.

However, in one respect the prediction criterion is in need of improvement. A creationist ad-hoc explanation could predict new facts simply by exploiting inductive connections. For example, a creationist could offer the following explanation:

"The sun rises every day, also tomorrow, because God wants it to rise"

and point out that his explanation can predict new facts, namely that the sun will rise tomorrow, and the day after tomorrow, and so on.

This is a further complication of our problem. "God" is, like "magnetic field" an *unobservable* or 'theoretical' concept, or in the terminology of statistics, a *latent* (non-manifest) variable. We arrive here at the time-honoured *Ockham-problem* – namely the question, when it is scientifically appropriate to postulate 'hidden' unobservable entities for the purpose of explaining empirical facts. I will suggest two answers to this problem, a simpler and a more complicated one. The simpler answer says, in the sense of 'Ockham's razor', that this is scientifically appropriate if it is not the case that an equally good explanation could be given *without* the assumption of unobservable entities, solely in terms of inductively inferred lawlike connections between the observed variables. In the above example this is the case, because the rising of the sun tomorrow is predictable solely by the empirical law that the sun is passing over the earth's horizon every day. We thus arrive at the following demarcation criterion:

(Prediction criterion no. 1): An explanatory hypothesis which introduces or postulates unobservable entities is scientifically legitimate only if it implies potentially novel predictions – these are empirical consequences, which go beyond what can

be inferred by simple inductive generalization from those facts which the hypothesis explains and which have been known beforehand (i.e., before the hypothesis was constructed).

Prediction criterion no. 1 requires merely the entailment of *potentially* novel predictions – thus its satisfaction depends only on the content of the hypothesis and the evidence at the time of its construction, but not on the pragmatic circumstance that the novel predictions are not known yet. Hence, a hypothesis does not cease to be scientifically legitimate merely because its formerly novel predictions now have been observed.⁴

With an inductive generalization I mean a generalization of observed regularities into the open future. Of course, such regularities may be very complex, whence I restrict my criterion to "simple" inductive generalizations. The "simplicity" of an inductive generalization is, of course, graduated, and therefore also our first prediction criterion is graduated. Yet I think that for all practical demarcation purposes this criterion is sufficient, because if a hypothesis predicts facts which are neither known nor can be obtained by simple inductive extrapolations from the evidence, then it should be taken serious, even if it makes speculative assumptions or postulates unobservable entities. In fact I do not know of any religious systems which would entail such predictions and have not been falsified yet.

One may explain in an even more stringent way when and why it is scientifically appropriate to introduce latent variables for explanatory purposes, if one assumes certain weak assumptions of causality – namely the so-called *Reichenbach-conditions* of causality. According to these conditions every correlation between two or several manifest (observable) variables is either the result of directed causation relation between these variables, or of a latent (unobservable) variable which is a common cause of the manifest variables. Thus, when ever the correlation be-

⁴ On this reason our prediction criterion is not beset by the problem of "old evidence", which is intensively discussed in Bayesianism (see Howson und Urbach 1992, 403ff).

tween a set of given empirical variables cannot be explained in terms of cause-effect-relations between these variables, the assumption of unobservable common causes is justified. This is in particular the case if the manifest variables are empirical *dispositions*. Dispositions of objects consists in their regular production of specific effects under specific conditions. In this understanding dispositions are functional higher order properties which express lawlike connections between first-order properties, whence they are not suitable candidates for being a cause of other dispositions (cf. also Prior et al. 1982).⁵ In Schurz (2008a, §7.2, 2008b) I have tried to show that a manifold of theoretical concepts of science (and maybe even all) have been introduced as common causes of correlated dispositions. Thus the second version of my prediction criterion runs as follows:

(Prediction criterion no. 2): An explanatory hypothesis which introduces or postulates unobservable entities is scientifically legitimate if it figures as a common cause of correlated dispositions.

In Schurz (2009) I have tried to show that an explanatory hypothesis which asserts a common cause of this sort will always entail novel predictions which go beyond simple inductions, because with help of such a common cause hypothesis it is possible to infer from the observed regularities in one domain of applications something about what will happen in an entirely different domain of application – for example, to infer from the weight of bodies on the earth something about their trajectory in an orbit around the earth, etc.

The prediction criterion no. 2 understands the notion of "cause" in the probabilistic sense and, hence, does not exclude that besides the asserted common cause there exists further common causes, or that the asserted common cause is part of an

⁵ Other concepts of "disposition" have been suggested in which dispositions can indeed be causally effective – in these accounts dispositions are not identified with regularities (see Mumford 1998).

entire network of causally connected latent variables. On reasons of precaution I have formulated my prediction criterion no. 2 merely as a sufficient and not as a necessary condition, because there might exist other cases in which the introduction of a theoretical concept is scientifically legitimate, although so far I am not acquainted with such a case. In contrast, I have formulated prediction criterion no. 1, again on reasons of precaution, only as a necessary condition which maybe has to be strengthened by further conditions.

5. *Solution of the demarcation problem within Bayesianism?*

Since Bayesianism is a methodological account which has also many advantages, it would be desirable if the inadequacy of ex-post explanations could be demonstrated within the bayesian framework. Prima facie the following way would seem to be promising. As explained, the ex-post character of a hypothesis goes hand in hand with the fact that in this way one may construct arbitrarily many alternative hypotheses, from Gods until to spaghetti monsters, etc. This means that if one admits speculations, then there exist always *infinitely many* alternative hypotheses which are *equally* worth to be considered. This implies that one has to assign a prior probability of *zero* to all these alternative hypotheses. And this implies, via (Bayes1), that independent from the likelihood $P(E|H)$ the resulting value of $P(H|E)$ must always be zero, if only $P(E)$ is greater zero:

$$P(H|E) = P(E|H) \cdot P(H) / P(E) = 0 / P(E) = 0.$$

Even if one argues that our explanandum E, those properties of our world which enable life, are so improbable that also $P(E)$ has to be set to zero, we do not obtain a positive value of $P(H|E)$, but merely the value $0/0 = \text{indefinite}$.

In other words, this argumentation says that the application of Bayesianism to speculative hypotheses arrives nowhere, because of their infinite multitude. Only

in regard to hypotheses for which one has *reasons* to believe them with a prior probability greater than zero, bayesian confirmation criteria are capable of producing sensible results about their confirmation status. And such reasons can be possessed only for hypotheses which are not purely ex-post explanations but satisfy the prediction criterion.

The problem of this argumentation lies in the fact that it seems hard to deny that for a given explanandum there could also exist infinitely many alternative scientific explanation hypotheses which all yield novel predictions which go beyond simple inductions and hence satisfy the prediction criterion no. 1. If one takes into account that the postulated common causes can be part of an entire network of latent causes, then all these infinitely many explanatory hypotheses could even satisfy the prediction criterion no. 2. Since all these infinitely many explanatory hypotheses are *prima facie* equally justified, one would also have to assign to all of them a prior probability of zero, and we arrived at the same problem as we had before with the infinitely many speculative hypotheses. Thus, instead of having discovered a bayesian solution to the demarcation problem, it seems more likely that we have discovered a further problem of Bayesianism.

Our reasoning that an explanatory hypotheses is only worthwhile to be empirically tested if it satisfies the prediction criterion, because only then it is *capable* of being confirmed, remains still valid. It is questionable, though, whether this reasoning can be based on considerations concerning distributions of prior probabilities. This concluding consideration supports our diagnosis that Bayesianismus is only a necessary but not a sufficient criterion for the confirmation of hypotheses.

Address of the author:

Prof. Dr. Gerhard Schurz

Department of Philosophy, University of Duesseldorf

Geb. 23.21, Universitätsstrasse 1, D-40225 Duesseldorf, Germany

schurz@phil-fak.uni-duesseldorf.de

www.phil-fak.uni-duesseldorf.de/philo/personal/thphil/

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