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THE PROBLEM OF INDUCTION FROM THE PERSPECTIVE OF PHYSICS

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In this note, the traditional problem of induction is analysed from the viewpoint of a physical theory in which time is fundamentally understood as encoded in the instant. From this perspective, the future and the past have a similar conjectural status, and the problem reverts to that of justifying the simplest explanation of the structure observed in the present instant.

The problem posed by the inductive sceptic – in its commonest form – is this: how does one provide a justification for the belief that the natural regularities we have observed in the past will persist in the future?

The issue becomes more interesting as the regularities in question are taken to be more law-like and less apparently accidental. Russell's celebrated chicken may have been an unsuccessful inductivist, but it is hard to see what the deep moral of this story is, or that of familiar enumerative cases involving white swans, etc. The most robust natural regularities are captured in the fundamental laws of physics, and it is in the context of physical theory, and not mere counting, that the problem of induction truly gets its bite, if anywhere.

The inductive sceptic is not of course proposing that as of tomorrow, or perhaps the dawning of the third millennium, the beautiful laws of Einstein's general theory relativity be abandoned or entertained in some modified form. No rational agent will act as if tomorrow's physics will be different from today's, simply on the grounds that the evidence to date, no matter how extensive, does not logically entail such continuity. The sceptic is, in the first instance, merely asking us to specify what principles of reason the rational agent is, or should be, appealing to. The question itself does not seem unreasonable, although the position of the hard-line sceptic – for whom deductive logic and empirical facts seem to be the only working tools for reason, and hence for whom the inductive leap seems unjustifiable in principle – is surely wrong-headed.

Why? The short answer is that there is more to physics, and science in general, than deductive logic and empirical evidence. The long answer has partly to do with the fact that our best physical theories to date entail the homogeneity of space and time – the claim that the form of the relevant laws does not change with place or time – insofar as time appears in the formulation of those laws. But equally important is the point that to the extent that inductive scepticism is applicable to the future, it is applicable to the past. And the rationale we adopt in breaking out of the present and hypothesising about the past is essentially the same as that involved in hypothesising about the future. Nothing in the nature of good scientific reasoning, *where to justify a hypothesis is merely to argue that there are no good reasons to reject it*, truly hangs on the difference, or so we will argue below.

Nothing succeeds better in driving home the conjectural nature of the past than the appearance of a more-or-less well-defined physical theory – a theory of quantum cosmology no less – which casts doubt on the existence of all or some of the past. In his recent book *The End of Time*, the British physicist Julian Barbour (1999) provides an interpretation of the so-called canonical theory of quantum gravity in which the reality of all those events which figure in our memories at the present instant is open to question. The significance of this work is, for our purposes, not Barbour's own analysis of the cosmological implications of one, very controversial, formulation of quantum gravity, but rather a much more general point stressed by Barbour and others concerning the nature of physical time.

The point is simply that we do not experience the passage of time directly. Another way of putting it, as Barbour does, is that instants are not in time, but time is in instants. Or again, in the rhetorical words of John Wheeler: the past has no existence except as it is recorded in the present.

Suppose Professor Schnitzelbaum has reported doing a number of repeated experiments over time, testing the statistical predictions in quantum mechanics, say, for some indeterministic quantum process. To say that the good Professor has corroborated the predictions of the theory is ultimately to say that 'records' of a certain kind have been compared at an instant (see for instance Page (1994) and Saunders (1998)). At a given moment, call it NOW, another physicist is finishing reading Schnitzelbaum's published paper and is aware that the experimental results therein are consistent with the theoretical predictions that also appear in the paper and which tally with the instantaneous NOW memories the physicist has of his studies of quantum theory, including the reading of Schnitzelbaum's paper.

The snapshot of the world at the instant NOW is highly structured. It contains an enormous amount of evidence of time, or history, if only we know how to read it; there is the scientific paper in the hands of the physicist, his instantaneous memories, not to mention all the astronomical structure in the heavens, and all the geological and fossil structure in the earth, and so on, which point to a certain history of the world. Yet our experience of time is indirect and inferential: we are aware in the NOW, by way of observation and memory, of a set of structures that cry out for explanation in terms of the culmination of law-like evolution of previous states of the world. But such explanation is conjectural, both in outline and in detail.

Let us put aside the lessons that Barbour draws from the attempt to unify quantum theory with Einstein's theory of gravity, insofar as they make a case for questioning the reality of all the history apparently encapsulated in the NOW. Let us suppose that all the universal NOWs since the Big Bang have happened. The problem is saying what that history is; it is in providing the historical details. The discovery of the enormous age of the earth, for instance, was the result of painstaking inferential work on the part of nineteenth century geologists based on the records in rocks. The physicist at a given NOW likewise makes sense of some fragment of the structure found in NOW by appealing to physical laws which (prior to canonical quantum gravity) contain dynamical equations determining how states of physical entities evolve over time when under the influence of forces due to the presence of other bodies.

The theories of all the fundamental forces currently accepted entail, as mentioned above, the homogeneity of space and time. (Gravity is a special case; it is not regarded as a force at all in Einstein's general theory of relativity.) By this is meant that the fundamental dynamical equations governing these forces do not vary over time or space. (It has often correctly been pointed out that the inductive sceptic should be just as concerned with space as with time – with the problem of extending knowledge of fundamental natural regularities here to hypothetical ones far out there, as much as with that of using knowledge of past regularities to make claims about the future.) But the first point we wish to stress is that such homogeneity claims, based on the evidence presented in a NOW, are conjectural. They may be false. In provisionally accepting them, we adopt the usual practice in scientific reasoning of rejecting countless possible theories which are consistent with the evidence in the NOW but which involve artificial or *ad hoc* deviations from spatio-temporal homogeneity. It is not that we can be sure such rival theories are false; theory is always underdetermined by evidence. The appeal to simplicity, or possibly (depending on the circumstances) to something like Ockham's razor, is intrinsic to scientific practice – ultimately based on the optimistic view that nature is intelligible – of casting aside hypotheses which, in relation to others which have the same claim to empirical adequacy, are ugly or artificial.

The second point is that in explaining the structure of the NOW in this way, we have provisionally adopted physical theories according to which the NOW itself has no special place. That is the meaning of the homogeneity of time. The process of explaining the NOW brings in the future as much as the past (unless the NOW happens to be the Big Crunch!). Or to put it another way, the process of explaining the NOW involves conjectural or ampliative reasoning that appeals to postulated fundamental regularities which happens not to distinguish between past and future.

Insofar as this conclusion depends on the hypothesis of the homogeneity of time, the inductive sceptic's challenge collapses essentially to the issue of justifying the adoption in science of the simplest hypothesis consistent with data: the problem of simplicity. In using simplicity to warrant the homogeneity of time as part of the task of explaining the observable structure in the NOW in terms of past goings-on, a warrant is being given for rejecting deviations from temporal homogeneity from NOW into the future. But we repeat the obvious point: we can never be sure that Nature is simple in the relevant sense.

It is this uncertainty that the sceptic will again exploit. What possible grounds are there for the claim that simple hypotheses are more reliable, or closer to the truth, than more complicated ones, other things being equal? It is hard to imagine what a satisfactory answer to this question could possibly look like. This conundrum, if it is one, will be with us forever. So be it. Science in general, and physics in particular, is in the business of providing fallible explanations, and the rational purposive agent acts on the best explanations to hand. Given the evidence in the NOW, to postulate violations of temporal homogeneity or of Ockham's razor is to provide a weaker explanation of the NOW. This is essentially because the number of ways such violations can be conceived is uncountable, and each one itself requires an explanation. We adopt the simplest hypotheses because we have no good reason not to.

Note added by HRB. Sometime in the early eighties, when I was a young professor in the Department of Philosophy at UNICAMP, Oswaldo Chateaubriand invited me to give a seminar in his department at PUC in Rio. Oswaldo couldn't have been more hospitable. Amongst other things, he had me over for a meal at his beautiful home; I have a clear recollection of sitting with him in his impressive study, when somehow the discussion turned to the problem of induction. I made a remark to the effect that I couldn't make up my mind whether it is a real problem or not. I think I was irked at being so indecisive on such a fundamental matter, in the presence of such a luminary! So when I received the kind invitation to contribute to this *Festschrift* number, I thought it might be appropriate to write, in collaboration with my graduate student Oliver Pooley, some reflections on the problem. We make no effort to review the vast literature related to it. The stance we adopt owes much to Ch 7 of Deutsch (1997) and Chs. 4 and 5 of Maxwell (1998) (although we do not endorse Maxwell's 'conjectural essentialism'), and interested readers are referred to these works, and particularly the latter, for much more systematic treatments. I hope our remarks, brief though they are, will be taken as a token of my respect and esteem for Oswaldo.

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