THREE RELATED TEMPORAL ASPECTS OF SCIENTIFIC ARGUMENTS (1)

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Hempel and Oppenheim, in their well-known study of 1948 (see Bibliography), declared that their basic pattern of scientific explanation «applies to scientific prediction as well as to explanation», the difference between the two being «of a pragmatic character». They pointed out, moreover, that «an explanation is not fully adequate unless its explanans, if taken account of in time, could have served as a basis for predicting the phenomenon under consideration». These affirmations, defensible in themselves, tend to reinforce the mistaken though widely held belief that explanation and prediction constitute a harmonious pair of complementaries. In fact, as has been noticed by several authors, explanation and prediction form neither a dichotomy of the class of scientific arguments, nor even a pair of contraries within it, but rather concern two distinct temporal aspects of such arguments. Some authors (in particular, I. Scheffler and A. Grünbaum) have extended the discussion by pointing to a third relevant temporal aspect. However, not only has the analysis become gradually more involved, but there has also appeared a rather confusing lack of agreement among the various authors as regards both the analytical findings and the terminology adopted (2).

The following observations are intended to provide a critical summary of the basic distinctions with the aid of a convenient terminology, and to contribute to the clarification of the subject through the explicit application of the fundamental and often so

(1) The following is a revised version of the author's 16-minute contribution to the 1964 International Congress for Logic, Methodology and Philosophy of Science (Jerusalem).

(2) The existing confusion is well exemplified by the term 'retrodiction' as employed to signify either of the two distinct though related types of argument hereinafter designated as 'postdictive' and 'retrodictive'.

enlightening distinction between the pragmatical and logical aspects of rational discourse.

Let **A** be a simple standard scientific argument, assumed sound, in which a factual statement E is a deductive consequence of, or is inductively supported by, a conjunction of theoretical statements T, correspondence rules C, and directly understood factual-data statements D. In the terminology adopted by Hempel and Oppenheim, E is the explanandum, while T, C and D constitute the explanans. The postulated simplicity of **A** is understood as involving the assumption that all the facts (states or events) stated in D are simultaneous, and that E, too, refers to a single time point (3). Accordingly, let t_D and t_E be the dates of the facts stated in D and in E, respectively. Argument **A** may be conceived either pragmatically, as a socio-psychological event or process, or logically, as a series of statements — ⟨T, C, D, E⟩. This is an instance of the well-known act-product ambiguity. As regards the pragmatical sense, the presentation of an argument will be here understood as involving its acceptance by the person presenting it.

In practice, t_D is generally prior to, or simultaneous with, t_E, but it can also be later than t_E. Let **A** be called *prodictive* in the former cases, and *retrodictive* in the latter. E.g., if a drop of temperature below zero degrees centigrade is mentioned among the factual premisses **D** of **A**, and the subsequent freezing of water in its conclusion E, the argument is of the common type, i.e. prodictive. But if a storm is mentioned in a premiss, and the conclusion refers to the phenomenon of cattle lying down *prior* to the storm, the argument is retrodictive. Thus:

> **A** is productive if and only if $t_D \leqslant t_E$, and
> **A** is *retrodictive* if and only if $t_E < t_D$.

It is clear that the dates t_D and t_E do not concern the external circumstances of the use of **A**, but constitute a semantical aspect of it. The prodictive—retrodictive distinction is thus an *essentially logical* one: it has nothing to do with **A** considered as an act of

(3) These restrictions are not essential to the following analysis. Their purpose is to avoid some complex distinctions which the reader may supplement for himself.

argumentation, but only with **A** conceived as the linguistic product of such an act.

But when will **A** be considered as involving an explanation, and when as involving a prediction ? The case of prediction seems a little simpler. For **A** to be predictive, the explanans must be — to use the expression of Hempel and Oppenheim — «taken account of in time», which means, of course, soon enough for **A** to be accepted before the occurrence of the fact stated in E or, at the very latest, simultaneously with it (4). So let us introduce t_{accA} — the date of accepting **A** — and we get:

A is *predictive* if and only if $t_{accA} \leqslant t_E$.

Now for **A** to be explanatory, it is obviously not sufficient that the contrary should hold — namely, that the fact stated in E should occur before **A** is accepted. But this is also not at all necessary: we certainly can explain states and events later than, or simultaneous with, the act of explanation. What is required is that the *acceptance* of E should occur prior to the acceptance of **A**. So let us complete our list of dates by introducing t_{accE} — the date of accepting E — and we have:

A is *explanatory* only if $t_{accE} < t_{accA}$ (5).

It seems clear enough that confusing t_{accE} with t_E is involved in the stubborn belief that explanation and prediction are contrary types of scientific arguments.

The most natural contrary to a predictive argument will be

(4) The latter allowance constitutes a fair price for avoiding the separate consideration of an odd transition case of argument.

(5) In order to ensure the adequacy of the rule, the temporal condition $t_{accE} < t_{accA}$ is here considered as necessary but not as sufficient for *A* to be explanatory. Indeed, an act of explanation is usually understood as involving some further conditions as well, and in particular, the actual awareness that the explanandum has already been accepted. Incidentally, the meaning rule as here formulated is compatible with the view, defended by some authors (and especially by I. Scheffler), that only 'causal' — and hence, in the terminology here proposed, prodictive — arguments can be adequately considered as explanatory. However, this view is not adhered to in the present analysis, in which — as will be seen presently — also retrodictive explanations are explicitly admitted.

an argument accepted after the occurrence of the fact stated in E. Let such an argument be called *postdictive*. Thus:

A is *postdictive* if and only if $t_E < t_{acc\,A}$.

Similarly, a natural contrary to an explanation will be an argument accepted prior to, or simultaneously with, the acceptance of E. In practice, the acceptance of E is in such cases the immediate result of the acceptance of **A**. This can be expressed in ordinary language by saying that E is inferred by means of A. So let us call an argument of this type simply an *inference*. Thus:

A is *inferential* only if [6] $t_{acc\,A} \leqslant t_{acc\,E}$.

We now have three ways of characterizing simple standard scientific arguments by their (internal and/or external) temporal aspects, viz. as (1) prodictive or retrodictive, (2) predictive or postdictive, and (3) explanatory or inferential [7]. These distinctions, combined, yield eight types of (acts of presenting) standard scientific arguments. Let us exemplify each of them by a simple non-formalized example, leaving out the T and C premisses, and retaining only one single D premiss.

(a) *Predictive prodictive explanation.* — The forecast is that water will freeze to-night. Why should it ? Because the temperature will have dropped below zero degrees centigrade.

(b) *Predictive prodictive inference.* — The forecast is that the temperature will drop below zero to-night. Subsequently water will freeze.

(c) *Postdictive prodictive explanation.* — Don't you know why water froze last night ? Because the temperature had dropped below zero, of course.

(d) *Postdictive prodictive inference.* — The temperature dropped below zero last night. Consequently, water must have frozen.

[6] Here again, as before in the case of explanation and for similar reasons, the weaker 'only if' is preferred to the equivalential 'if and only if.'

[7] Theoretically, as has been made evident by the two preceding footnotes, distinction (3) is not a dichotomy. In practice, however, an argument (in the pragmatical sense) such as *A* will normally be found either explanatory or inferential.

(e) *Predictive retrodictive explanation.* — Take it for granted that cattle will be lying down in the afternoon. Why should they ? Because there will be a storm in the evening.
(f) *Predictive retrodictive inference.* — We shall have a stormy evening, the forecast says. Hence cattle will probably have been lying down in the afternoon.
(g) *Postdictive retrodictive explanation.* — It is clear now why cattle were lying down yesterday in the afternoon: there was a storm in the evening.
(h) *Postdictive retrodictive inference.* — We had stormy weather last evening. So, I guess, cattle had been lying down in the afternoon.

In contrast to the first distinction, which was found essentially logical, the second and third are pragmatical distinctions: they concern **A** considered as an argumentative act or event, since they involve the date of accepting the argument. But there is a noteworthy difference between the two cases. On the one hand, the concepts of prediction and postdiction are *essentially pragmatical* and cannot be explicated as logical ones. It is true that the specific psychological and sociological circumstances of presenting **A** are not essential to the distinction between prediction and postdiction. But, in order to expound this distinction, the date $t_{acc\mathcal{A}}$ or, at the very least, its temporal-order relation to t_E must be mentioned, and this is still a pragmatical aspect of **A**.

On the other hand, from the pragmatical concepts of explanation and inference *logical cores* can be extracted. Let us do this in two steps. First, as before, let us forget all about the specific psychological and sociological aspects of accepting **A** and E, and retain only the temporal-order relation between the dates t_{accE} and $t_{acc\mathcal{A}}$. Next, let us also leave out the last residues of pragmatical elements still appearing in both terms of the two order relations — namely, the dates of acceptance and the acceptance itself. We are thus left only with what is absolutely indispensable in order not to lose hold of our distinction, the strict minimum being the simple (non-temporal) order of E and **A**, which may be either $\langle E, \mathbf{A} \rangle$ or $\langle \mathbf{A}, E \rangle$. (**A** itself is now construed as a series of statements.) These residual relational concepts, though abstract, are not foreign to actual usage. Indeed, 'explanation' may often

be understood to mean an argument such as A considered in relation to its conclusion ([8]), in abstraction of all pragmatical context. Similarly, 'inference' is often employed, in a non-pragmatical sense, to mean a logically established factual statement considered in relation to the argument, assumed sound, of which it is the conclusion.

To sum up, there are three distinct though related temporal aspects of scientific arguments which should not be confused: one essentially logical, one essentially pragmatical, and one affected by the pragmatical-logical ambiguity.

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([8]) In the habitual, semi-material mode of speech it should rather be said here: in relation to the fact stated in its conclusion.

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