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NYAYA SYLLOGISM AND CAUSAL EXPLANATION

Introduction and Formulation of the Problem :

Eminent philosophers of science in the west have generally tended to agree that there is a search for explanation of facts in the modern sciences.[1] The explanation that modern sciences seek has been called *scientific explanation.* What is the character of scientific explanation ? In answer to this question it has been said that firstly, science tries to answer questions of the sort ' why so ? ' and ' how so ? ' and the way these answers are given constitutes the scientific explanation; and secondly, that there is a clear-cut boundary within which such questions make sense in science, beyond which they become non-scientific,—that is to say, the scientific querry 'why'? and 'how'? must stop at certain point. Within this framework, it has been held that scientific explanation, can be, broadly speaking, causal or teleological. Controversy persistes[2] whether there is any significant difference between the causal scientific explanation and teleological scientific explanation, the causalists mantaining that the latter can be understood within the framework of the former[3] while the teleologists insisting that the latter is a radically different kind of explanation and is generally sought in the human-sciences such as history and psychology. Causal scientific explanation is generally further subdivided into deductive-nomological explanation and the inductive-statistical explanation, the latter for incorporating the *chance* phenomena within the causal fold. Perhaps the first attempt to formalise the deductive-nomological type of scientific explanation was made by Hempel and Oppenheim[4] and since then it has attracted the attention of many eminent logicians and philosophers of science resulting into continuous debate[5] which persists to date. Unfortunately, the dissatisfaction with the d-n-model of causal explanation has rather tended to increase. In quest of increasing formalisation, the essential edges appear to have been blunted and there dawns an uneasy feeling that we have been caught in a formalist jungle from where the question of returning home is gaining priority.

Now, the formal structure that Hempel and Oppenheim had suggested for the causal scientific explanation is this :

If $L_1, L_2 \ldots L_n$ are universal laws, $C_1, C_2 \ldots C_n$ are the singular statements of initial conditions which are demanded by the laws and E, a statement of the empirical phenomenon to be explained, then the causal explanation can be schematised as

1. $L_1, L_2 \ldots L_n$	(General laws)
2 $C_1, C_2 \ldots C_n$	(Singular statements of initial conditions)
3. $\therefore$ E	(statement of the fact to be explained).

Now, such an explanation is adequate if and only if (1) the statement of the fact to be explained (or sofe) is logically derivable from the explaining premises (expe.) $L_1, L_2 \ldots L_n$ and $C_1, C_2 \ldots C_n$; (2) the expe. must contain universal laws which are essential for the derivation of sofe; (3) the expe. must have empirical content; and (4) the expe. must be true. It is generally assumed that $L_1, L_2 \ldots L_n$ constitute a theory, and E is a singular statement having empirical content and not some law. Subsequent writers in this area have pointed out the inadequacy of the conditions demanded by Hempel and Oppenheim for an adequate scientific explanation and the effort has generally concentrated on the rigour of the adequacy criteria while the formal structure as suggested by Hempel and Oppenheim has generally been accepted as true. The last in the chain is perhaps Cupples who distinguishes between three types of causal scientific explanations and provides adequacy criteria for each. It is noteworthy that he, too, in spite of his refinements, accepts the Hempelian formal structure as true.

We shall here attempt at an examination of Hempelian formal structure of causal scientific explanation in the light of the classical Vaiśesika Nyāya syllogism.[6]

The Nyaya Syllogism :

According to the Vaisesika Nyāya syllogism[7] the process of *Anumān* involves the following steps :

1. There is fire on hill (Fh) (*Pratijnā*)
2. *Because* there is smoke on the hill (Sh) (*Hetu*)
3. Wherever there is smoke there is fire as in kitchen,

cigarette etc. ($\times$) (Sx $\supset$ Fx) & (Sk $\supset$ Fk) & (Sc $\supset$ Fc) (*Dṛstānta*)

4. There *is* smoke on the hill (Sh) (*Upanaya*)

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5. There is fire on the hill (Fh) (*Nigamana*)

We may note here that the syllogism involves universal law as well as singular statement in the conclusion. One might ask whether the syllogism can be said to be providing a *causal* explanation for some fact and whether it can be improved further with an eye on the scientific causal explanations ? In order to make ourselves clear about these questions, let us ask about the first premise of the syllogism. Where from does it arise? Obviously, the asse tion is made because something prior to it has occurred, namely the smoke on the hill has been *noticed.* After noticing the smoke on the hill one is sure to ask : *How* is it that there is smoke on the hill ? Thus, the statement (1) is in fact made subsequently to this thought process. If is legitimate to say that in the syllogism *the presence of smoke on the hill is being explained causally.* The presence of smoke on the hill is an empirical fact which has been *noticed* and it is to be explained what is *meant* or *implied* by the presence of smoke on the hill. Therefore, under this interpretation, the syllogism may be said to be providing us guidelines or a general framework for explaining some *noticed* fact. Notice further that the syllogism does not allow every question in this process of explaining. For example, if one were to ask ' why fire on the hill ?' then the kind of causes that are required to be investigated become of a different sort which cannot perhaps be subsumed under universal laws and therefore, such questions will be ruled out for the moment. This is precisely the demand of causal explanations which are *scientific.* Thus, explanations for questions of the sort 'why fire on the hill ? will be *non-scientific but causal in so far as no universal laws can be found* governing them although adequate causes may be traceable.

If, now, we read the syllogism under this interpretation, then (i) '1' is the *proposed* explaining hypothesis for the question ' why smoke on the hill?' (ii) premise '2' gives us the *causal connection* between the noticed fact and the proposed hypothetical statement and says in effect that ' There is fire on the hill *because* there is smoke on the hill' (iii) Premise '3' is very

crucial, for here a *universal law* is stated, namely, ' wherever there is smoke there is fire' (the converse not being always true): as also it is backed up by singular *observation* statements showing the causal connection in particular instances. In this case the singular statements are *observed* not merely *noticed* and therefore it is actually being claimed that these are true. (iv) In premise '4' the *noticed* fact is now being ascertained as being in fact true, perhaps after careful and detailed observation. It asserts that what was initially merely noticed as smoke is infact smoke and not merely a cloud or chemical fumes. (Therefore the truth of this assertion is essential to the syllogism and the step is not redundant as has been held by some opposing schools). Finally, in the conclusion the hypothesis has been *established* with sufficient certainty, and it is now different from '4' in being a ' theoretical statement'.

We can see that the Nyāya process of explanation involves the following steps :

(1) Noticing of a fact which calls for some explanation;

(2) Advancing of a hypothetical causal explanation of the noticed fact in the form of an empirical statement which may or may not be true.

(3) Ascertaining the causal connection between (1) and (2) which may or may not obtain;

(4) Providing a true covering law (universal) in conjunction with true supporting observation statements revealing particular causal connections;

(5) Ascertaining the truth of noticed empirical fact calling for explanation, after careful observation;

(6) Ascertaining the hypothesis as conclusion.

This model is potentially *scientific* because in the fourth step it requires experimental confirmation of the universal law in particular instances and in the fifth step it requires the observational confirmation of the fact initially noticed but is sought to be explained. Under this interpretation, the nyāya model can be considered as a potential model for scientific causal explanation of particular observed facts.

Now in this model, although steps (1) and (2) do not play any role in the ' derivation ' they must nevertheless be stated, so

that, at the first glance, the model gives us answers to the question ' what is to be explained?'. In the symbolised form the model can be written as follows :

1· Sh

2· Fh

.....

3. Sh⊃Fh

4. (x) (Sx ⊃Fx) & (Sk ⊃Fk) & (Sc ⊃Fc) .....

.....

5· ∴Fh

Here it may be noted that the causal connection between the ' firey hill ' and the ' smoky hill ' has been formalised as Sh⊃ Fh. One can conceive of this causal connection either as conditional or as implicational (or even as functional). If it is thought of as a condition relationship then we can see that ' fire on the hill ' is a necessary condition for the ' smoke on the hill ' (p is a necessary condition for q if, given q, p must be there) ; whereas the ' smoke on the hill ' is a sufficient condition for the ' fire on the hill ' (p is a sufficient condition for q if, given p, q will be there too). But if we attempt to formalise the causal connection in terms of condition relationship this will lead into considerations of modality and again we shall have to define the *universal* law-like relation also in terms of necessity. However, if we try to formalise the connection in terms of implication relationship then we can see that *it is false that there is no fire on the hill*, while the converse that ' it is false that there is no smoke on the hill, and there is fire on the hill ' is not true. Obviously because it is quite likely that there is no smoke on the hill and yet there is fire on the hill. Now the complex statement ' it is false that there is no fire on the hill, and there is smoke on the hill,' is nothing but the second of the material implication truth table and it, thus, suggests that we should formalise the causal connection in terms of the material implication Sh⊃ Fh. Here we can see that if Fh is true and Sh false, then the implication remains true which accounts for the possibility of smokeless fire: whereas, if Fh is false and Sh true then the implication become false. Thus, the form of the universal law—like statement would also be (x) (Sx⊃ Fx).

We should now investigate whether the Nyāya syllogism can also offer frameworks for *predication* of *new* facts and for explaining the newly *discovered* facts which may or may not be known to be subsumed under any known law. This latter will also indicate the criteria as to *when* a specific universal law is to be replaced by some newly formulated universal law so that the new fact may be covered under the latter and thus explained.

In order to consider the case of predication, take the example of simple meteorological prediction of rains. A simple predication will be of the form 'There will be rains in near future, because there is water vapour of degree × in the atmosphere'. This can easily be put in the form of Nyāya syllogism as follows :

1. There is water vapour of degree × in the atmosphere (Wa).
2. There will be rains in near future (Ra).
3. Wa ⊃ Ra
4. (×) (W× ⊃R×) & (Wc ⊃ Rc)*.....
5. Wa

6. ∴ Ra.

Here the predicating hypothesis is obtained from the assertion of material implication relationship between 'water-vapour in the atmosphere' and 'rains in the atmosphere' the assertion of a universal law like relationship that obtains between the two 'properties' and the assertion of the fact that there is actually water vapour to the degree × in atmosphere.

Consider now the context of *discovery* where new facts come into light and are either sought to be explained within the known covering laws or sought to be explained by devising hitherto unknown covering laws. Here the new fact is accepted as explained if either it is shown that it can be causally connected with a known hypothesis and thus subsumed under a known universal law: or it is shown that there exist hitherto unknown causal connections with the new fact showing thereby the new connecting hypothesis and the new covering laws as substantiated by new particular observations.

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* Wc ⊃ Rc means 'water vapour implies rains as in cloud seeding.'

For purposes of illustration consider the case of classical radiation laws and the discovery of Planck's radiation law by positing of a radiation quantum. Now, in case of physics we have to remember that the ' facts ' are variable, that is to say, here varying predicates of variables are investigated. Therefore, we must allow *varying causal connections* between variables[8]; that is to say, the variable xa can be said to causally connected to variable y if and only if x1 is causally connected with y1, x2 with y2, x3 with y3 and so on. This fact we will indicate by writing a 'v' below the sign of implication in our symbolisation. Further, we should also remember that the varying causal connections are quite complex and they demand for their truth that certain initial conditions be fulfilled, i.e., the statements of initial conditions be true. Now, while formulating our statements of facts and statements of varying causal connections, we will not mention these statement of initial conditions separately and will assume that they are always true in the syllogism.

Now, the blackbody spectral radiation was sought to be understood within the framework of classical radiation theory in terms of Wien's formula for short wavelengths and Rayleigh's formula for long wavelengths while for wavelengths in the range of 2×10^{-4} cm and 3×10^{-4} cm these formulas showed their inadequacy. That is to say, the facts in the range of the maximum intensity of radiation remained unexplained. This necessitated the revision of the known laws and resulted into the formulation of a new law which is known as the Planck's radiation law. This situation can easily be framed in terms of our syllogism so as to provide the models for explanation of new facts within known laws as well as of new facts under the covarage of newly discovered laws. We can formulate the facts to be explained in the blackbody radiation problem as follows :

1. For a blackbody B and at a given temperature T, the intensity of radiation (absorbed or emitted) *increases* as the wavelength λ increases in the short wavelength range.

2. For a blackbody B and at a given temperature T, the intensity of radiation (absorbed or emitted) *decreases* as the wavelength λ increases in the long wavelength range.

3. For a blackbody B and at a given temperature T, there is maximum intensity of radiation (emitted or absorbed) in the middle range of wavelength λ (between sav $\sim 2 \times 10^{-4}$ cm and $\sim 3 \times 10^{-4}$ cm).

For purposes of simplicity in symbolisation we can reformulate these statements of facts to be explained as,

1. The blackbody B, at a given T and λs -range, possesses the property of *continually increasing intensity of radiation with increasing* λs. If we write the italicised property as Is, then this statement can be symbolised as Isb.

2. The blackbody B, at a given T and in λe range, possesses the property of *continually decreasing intensity of radiation with increasing* λe. If we write the italicised property as Ie, then this statement can be symbolised as Ieb.

3. The blackbody B, at a given T and in λm -range, possesses the property af *maximum intensity of radiation.* If we write the italicised property as Im, then this statement can be symbolised as Imb.

Now, for short wave-lengths, Wien's law says that at a given T, the intensity of radiation is inversely proportional to the fifth power of λs multiplied by an exponential of negative and inverse multiple of a constant and λs $\left(\text{i.e. } \bar{e} / \frac{\text{Const}}{\lambda s} \right)$. And similarly, for large wavelengths, the Rayleigh's law says at a given T, the intensity of radiation is inversly proportional to the fourth power of λ. Also for *all* wavelengths, Planck's law says that at a given T, the intensity of radiation is inversely proportional to the fifth power of the wavelength multiplied by a factor $(e^{const}/\lambda - 1)$. Now, we know that the first fact is explained by Wien's law, the second fact is explained by Rayleigh's law, while the third fact could not be explained by any known classical law therefore, a new ' quantum ' law was proposed by Planck which was such that Wien's law and Rayleigh's law could be *derived*

*from it.** We can, again, formulate these three explaining hypothesis as follows :

1. The blackbody B, at temperature T possesses the property of *its intensity of radiation being inversely proportional to the fifth power of λs multiplied by a factor* $e^{-\frac{const}{\lambda s}}$ Let us symbolise this as λsb.

2· The blackbody B at temperature T possesses the property of its *intensity of radiation being inversely proportional to the fourth power of* λe. Let us symbolise this as λeb.

3. The blackbody B at temperature T possesses the property of *its intensity of radiation being inversely proportional to the fifth power of λ multiplied by a factor* $(e^{const/\lambda} - 1)$. Let us symbolise this as λb.

Now, we can quickly see the explanation pattern in the case one as :

1· Isb

2· λsb

.....

3· Isb⊃ λsb

4· (x) $(Isx \underset{v}{\supset} \lambda sx) \,\&\, (Isb_1 \underset{v}{\supset} \lambda Sb_1) \,\&\, (Isb_2 \underset{v}{\supset} \lambda/Sb_2)$

5. Isb

.....

6. ∴ λsb

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* Wein's Law $E\lambda \sim \frac{2hc^2}{\lambda^5} \cdot e^{-\frac{hc}{\lambda RT}}$

Rayleigh's Law is $E\lambda \sim \frac{2RTC}{\lambda^4}$

Planck's Law is $E\lambda\, d\lambda = \frac{2hc^2}{\lambda^5} \quad \frac{d\lambda}{(ehc/\lambda RT - 1)}$

In the case two we have,

1. Ilb
2. λlb

.....

3. Ilb
4. $(x)(\text{Ilx} \underset{v}{\supset} \lambda\text{lx}) \;\&\; (\text{Ilb1} \underset{v}{\supset} \lambda\text{lb}_1) \;\&\; (\text{Ilb}_2 \underset{v}{\supset} \lambda\text{lb}_2)$
5. Ilb

.....

6. ∴ λlb

In the third case, since the fact to be explained cannot be covered by any known universal law, a new, universal *law* has to be posited with the condition that the *laws explaining the two earlier facts are also derivable from this new law.* Thus in the context of *discovery,* the fourth step in the syllogism has to contain the additional condition of derivability. Thus, we have :

1. Imb
2. λb

.....

3. $\text{Ib} \underset{v}{\supset} \lambda\text{mb}$
4. $(x)(\text{Ix} \underset{v}{\supset} \lambda\text{mx}) \;\&\; [(x)(\text{Ilx} \underset{v}{\supset} \lambda\text{lx}) \vdash (x)(\text{Ix} \underset{v}{\supset} \lambda\text{mx})$
   $\&\; [(x)(\text{Isx} \underset{v}{\supset} \lambda\text{sx}) \vdash (\text{Ix} \underset{v}{\supset} \lambda\text{mx})]$
   $\&\; (\text{Ib}_1 \underset{v}{\supset} \lambda\text{mb}_1) \;\&\; [(\text{Ib}_2 \underset{v}{\supset} \lambda\text{mb}_2) \;\&\; \ldots\ldots\ldots]$
5. Imb

.....

6. ∴ λb

Discussion and Criticism of Hempel's Model :

Concerning our formal model of explanation, we must now investigate the adequacy criteria by virtue of which it may be claimed that some fact has been explained when the explanation pattern has been formalised in accord with it. It is clear that in this model the case of prediction is quite similar to the case of explanation of a new fact by its subsumption under a known law,–therefore, we can have the same adequacy criteria for this situation. But the explanation in the context of a discovery where a new fact has resisted subsumption under

a known law and therefore formulation of new universal law or laws, is different. Therefore, we should have different adequacy criteria for this.

In case of new fact being explainded by a known law, the following criteria of adequacy may be proposed :

1. The proposed explaining hypothesis must be derivable, if the explanation is to be correct, from
   (i) a statement that shows the causal connection between the statement of the fact to be explained and the explaining hypothesis,
   (ii) at least one universal law (which subsumes the particular instance of causal connection under it in conjunction with finite number of closely observed particular instances in which that causal connection has been established as true;
   (iii) a singular statement that the fact to be explained is true.
2. If the law is complex, demanding statements of initial conditions, then those must also be mentioned as true.
3. As far as possible, only a single fact to be explained at a time.

In case where the fact to be explained requires the formulation of a new universal law, the additional criterion of adequacy is that

4. The new universal law to be accepted as a premise should be such that the laws which were expected to cover the fact are derivable from it.

Now, if we compare this model with that of Hempel and Oppenheim we can notice that the two fundamental respects in which our model differs from it are : Firstly, that explanation consists not in deriving some 'explanandum' from some 'explanans' but rather it consists in deriving the explaining hypothesis from the premises which include the assertion of causal connection between the fact to be explained and the explaining hypothesis, one or more covering laws along with more than one supporting particular observations of these, and assertion of the truth of the

statement of fact to be explained. Secondly, that derivability is not necessary and sufficient condition of explanation although it is a necessary condition of it. We are thus saying, contrary to Hempel, that *explanation* process actually consists in showing how the *proposed hypothesis claims to explain the fact in question* which has been ascertained as true and this can be shown not by merely *deriving* the statement of fact to be explained from the explaining premises. I think, Hempel-Oppenheim model needs to be substantially criticised on these two points.

Now, in regard to the first point of Hempel that it is the statement of fact to be explained which must be derived from the explaining premises and not the explaining hypothesis, we must say that this view gives an inadequate picture of scientific causal explanation. According to Hempel scientific causal explanation of a fact has been achieved if it can be infered from higher theories. But this obscures the question of causal connection between the fact to be explained and the higher order theory as also it obscures the logical connection between the fact and the laws under which it is to be subsumed. We say that a fact is explained only if its cause can be explicitly mentioned and if the logical connection of the explaining hypothesis with the covering laws can be explicitly shown. Moreover, in such explanation scheme as that of Hempel, psuedo-explanations can not be easily avoided for a true fact can always be shown to follow from a pseudo-law which has a genuine law-like appearance. Further, Hempel's model does not give us the true account of the process of explanations that the scientist *actually* follows. It is rarely the case that a physicist, for instance, seeks to explain certain observed facts by deducing the statements of these facts from relevant theories; rather his concern is to search how the *new facts* can be explained by means of some hypotheses which are *familiar* (in the light of known theories)[9] and can be shown as the logical consquences of these theories.

As regards the criterion of *derivability*, we should like to maintain that be it the explaining hypothesis or the statement of fact to be explained, derivability alone can not suffice. While attempting to propose a formal structure of scientific explanation, we must aim at a clear picture of explanation;

therefore, we must be able to formulate an explanation–syllogism which informs us at a first glance about the fact to be explained, about the explaining hypothesis, about the causal connection between the fact and the hypothesis, and about the covering laws and supporting observations. Indeed, we must insist that derivability of the explaining hypothesis from the explaining premises be a necessery condition, that is to say, if the fact to be explained has been derived, then it is not necessarily explained but if the fact has been explained then it must be derivable. As to the question when would an explanation really count as adequate, we have already suggested earlier the relevant adequacy criteria.

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NOTES

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7. We say Vaisesika Nyāya to distinguish it from other Nyāyas, the well known ones being Buddhist Nyāya, Jain Nyāya and the Shaiva Nyāya.

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9. N. R. Hanson, *Patterns of Discovery* Cambridge University Press, 1958 p. 71