Philosophy of Science // Fall 2015

Handout 14

Explanation: Carnap, Hempel

The D-N model. Hempel proposes the following model of explanation:

Laws: $L_1, \ldots, L_n$
Conditions: $C_1, \ldots, C_m$
Explananda: $E_1, \ldots, E_k$

One point to note immediately is that explanations are deductive arguments. The laws and the initial conditions, both understood as statements, logically entail the explananda.

Example 1. Suppose we have a container of gas (say, a syringe). We increase the volume of the container by one-third. The observed phenomenon is the decrease in the gas pressure by 25%. To explain the phenomenon we use Boyle's Law: $PV = T$, assuming the temperature remains constant:

Laws: $PV = T$.
Conditions: The volume of the container increases by one-third, the temperature is constant.
Explananda: The decrease in the gas pressure by 25%.

Two kinds of explanation. Hempel notes two features of explanation practices. One is that we often wish to explain laws themselves. We may ask why a particular law holds. What we usually do in such cases is subsume those laws under even more general laws. From these more general laws we can infer the more specific laws that are our concern. However, in page 48 Hempel also advances the idea that the less general laws are only approximations of the more general laws. If so, it is left unclear how a D-N explanation, while remaining a logical argument, is supposed to work in the cases of explaining laws with laws.

Example 2. Consider Galilean and Lorentz transformations that are at the root of Newtonian and relativistic mechanics respectively:

$$x' = x - ut \qquad y' = y \qquad z' = z \qquad t' = t,$$

$$x' = -\frac{x - ut}{\sqrt{1 - \frac{u^2}{c^2}}} \qquad y' = y \qquad z' = z \qquad t' = \frac{t - \frac{ux}{c^2}}{\sqrt{1 - \frac{u^2}{c^2}}}$$

When the velocity u is much smaller than c, we get approximately same results in the calculations. But you cannot logically derive Galileo from Lorentz.

Two major problems. The D-N model was subject to intense scrutiny and unforgiving criticism. Let us mention two difficulties that were brought up in the ensuing debate, *pre-emption* and *asymmetry*.

Example 3 (Pre-emption). Suppose that Jones drinks a poison. And suppose there is a law saying that anyone who drinks that poison will die within 24 hours. However, shortly afterwards Jones is hit by a bus. According to D-N, his death is explained by drinking the poison. This seems wrong.

Example 4 (Asymmetry). Suppose we increase the volume of the gas in a syringe. Then, given that the temperature is constant, Boyle's law should explain why the pressure subsequently drops: $PV = T$. But equally, that later drop in pressure also explains why the volume increases. This is clearly wrong.

THE P-S MODEL. The D-N model involved deterministic laws. But not all laws are deterministic: some of them are probabilistic. In such cases Hempel proposes the following model of explanation:

Probabilistic law: $0 \ll P(O \mid F) < 1$
Factors: F_i
Explanandum: O_i

Probabilistic explanations, in contrast to D-N explanations, are not deductive arguments. Assuming the law and the factors (i.e. a conjunction of factors), we must be able to conclude that the explanandum is 'very likely'. In other words: the law and the factors give inductive support to the explanandum.

Question 5. Why cannot the P-S explanation be a deductive argument?

Example 6 (Bronchitis). Suppose you fall sick with bronchitis. You are prescribed antibiotics. Your subsequent recovery was not necessitated by taking antibiotics. It is not as though you *necessarily* had to recover, for the disease might have progressed further. Nevertheless you were, we say, likely to recover: the probability of recovery having taken the antibiotics is high . We have:

Probabilistic laws: $0 \ll P(\text{Recovery} \mid \text{Taking antibiotics and having bronchitis}) < 1$.
Factors: You are sick with bronchitis and take antibiotics.
Explanandum: You recover.

DIFFICULTIES. A key weakness of Hempel's account is the demand for the dramatic increase of the inductive support for the explanandum produced by the factor F. Suppose you fall sick with a bronchitis and later, despite being treated with antibiotics, develop pneumonia. Though $P(\text{Pneumonia} \mid \text{Bronchitis treated with antibiotics}) \ll 1$, it still should be able to explain your pneumonia. Thus fulfilling Hempel's requirements will not be a *necessary* condition of a successful probabilistic explanation.

Moreover, Hempel's requirement might not even be *sufficient*. Suppose you fall sick with common cold and recover within two weeks while reading poetry every day. Well, $P(\text{Cold} \mid \text{Reading poetry for two weeks}) \gg 0$, since common cold usually disappears within two weeks. But surely reading poetry does not explain it. We would like to say that reading poetry is *irrelevant* for the explanation. But Hempel's account gives us no tools for distinguishing between relevant and irrelevant factors.

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