Inductive-Statistical Explanation

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1 Introduction

The earliest modern conceptions of scientific explanation are the deductive-nomonological, deductive-statistical and inductive-statistical approaches.[2] The approach that will be discussed here is the inductive-statistical approach, or IS-explanation for short, by summarizing Hempel's 1965 paper on the topic.[1] While the deductive-statistical and deductive-nomonological method have true conclusions if the premises are true, the same is not the case for the inductive-statistical approach. The conclusion is instead uncertain, which may give it an upper hand to the other types of explanation which could have the problem of explaining something with complete certainty despite not being epistemically privileged to such a status.

To describe IS-explanation, let's use Hempel's original example in his paper; let's say there exists a person j who is infected by some disease S in which penicillin P can be given as treatment such that the person can recover R. We can then make an argument that states something in the style of "given that j has gotten sick and is receiving penicillin, and that people who are sick who receive penicillin recover with high probability, then we can conclude that j will recover with high probability". In that case we get the following schema:

$p(R|S \wedge P) \approx 1$
$S_j \wedge P_j$
$\overline{R_j \text{ is true with very high probability}}$

For conditional probability $p(\cdot|\cdot)$. But there are problems with this notion of statistical explanation that has been prevalent in the literature, according to Hempel. The untenable position comes in the fact that the conclusion statement is neither true nor false, R_j itself is either true or false, so the entire statement can only be characterised as more or less probable. Hempel proposed the following change to the schema as a solution:

$p(R|S \wedge P) = r$
$S_j \wedge P_j$
$\overline{\underline{\text{with probability } r}}$
R_j

With a double line which symbolise the conclusion bar with the certainty of the inference between the two conclusion bars rather than a certain, deductive inference. This solves the problem by changing the derivation from a deductive step to an inductive step. This means the truth value of the conclusion R_j is properly taken into account.

2 Ambiguity

But what of when two explanations can make opposite conclusions from different "knowledge classes", that is to say, datasets? One major criticism of IS-explanation that Hempel discusses is what he calls "the ambiguity problem for IS-explanation". If we let S^* stand for a sickness of antibiotic resistant bacteria, then the opposite conclusion can be represented by the following schema

$$\begin{array}{l} p(R|S*\wedge P) \approx 1 \\ S_j^* \wedge P_j \\ \hline \text{with probability} \approx 1 \\ \hline \neg R_j \end{array}$$

Or perhaps, we can let S^{**} stand for a type of heart diseases makes recovery with antibiotics even on non-antibiotic resistant bacteria unlikely.

$$\begin{array}{l} p(R|S^{**} \wedge P) \approx 1 \\ S_j^{**} \wedge P_j \\ \hline \text{with probability} \approx 1 \\ \hline \neg R_j \end{array}$$

Whatever the case may be, they both contradict the conclusion in the introduction. This means any event can be explained equally well.

The problem in its largest generality, an given event that can be a member of multiple reference classes $\{S \wedge P, S^* \wedge P, ...\}$ that have opposite effect. So the explanans of two different explanations can both be true while having opposite conclusions, which would lead to a contradiction in the system. The deductive argument does not have this problem, since if the reference classes are true and consistent then there can never be a contradictory conclusion. But even a consistent set can yield contradictions in the IS-explanation.

Assume a consistent set K_t of all sentences of accepted scientific statements at time t (time dependent due to the fact that the set changes over time as science progresses). Then subsets can be used to construct an inductive inference. Because K_t is consistent, then the rival argument cannot be a part of K_t despite being concluded by the same overwhelming probability as the other argument. The same is not the case for the deductive argument, since K_t is consistent it cannot contain any set of premises that can conclude a contradiction.

Hempel does acknowledge uncertainty in scientific knowledge. Set of scientific knowledge at time t is K. This set is according to Hempel logically consistent, so there cannot be any subset of premises for any explanation that derives a contradiction in the way the statistical one does.

3 Maximal Specificity

The ambiguity problem might be resolved by going over all the evidence and all relevant information at any timepoint. We obviously don't want every statement in K_t to be in the explanans, and likewise we don't want to leave out relevant information. If we are to explain why a sick person recovered then we cannot leave out information of antibiotic resistant bacteria while leaving information that the earth revolves around the sun. This condition is called "the requirement of maximal specificity". It is not a theorem of inductive logic, but rather a maxim, or a postulate of rationality, atleast according to Carnap.

The example Hempel uses for demonstrating the requirement of maximal specificity is with radioactive decay. Let F_1 stand for the knowledge class of the theory of atomic structure and atomic number for radioactive decay. Whenever we add extra information, like humidity, pressure, temperature, magnetic field e.t.c for F_2, F_3 e.t.c then for the statistical explanation it is enough to include F_1 since our current best theories in science states that radioactive decay is unaffected by any such variables.

Hempel goes over lengthy calculations and appeals to theorems in probability theory to eventually come to the conclusion that maximal specificity completely answers the criticism of ambiguity for IS-explanation.

References

[1] Carl G Hempel. "Inductive-Statistical Explanation". In: *Aspects of Scientific Explanation* (1965).

[2] Weasly Salmon. *Four decades of scientific explanation.* 1989.