Disconfirmation is not modus tollens

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Abstract

Scientific disconfirmation has often been thought to be reasoning by *modus tollens*. This interpretation, however, misconstrues the conditionals in this scientific reasoning in terms of the material conditional, rather than in terms of causal conditionals. Scientific confirmation has also been thought to be a logical fallacy, affirming the consequent. Once one embraces the idea that scientists are reasoning in terms of causal conditionals, rather than the material conditional, we can avoid the peculiarity of the view that scientific confirmation is based on a simple logical fallacy. Interpreting scientists as reasoning about physical consequences of hypotheses enables a more charitable interpretation of scientific disconfirmation and confirmation.

Keywords

Disconfirmation; abduction; modus tollens.

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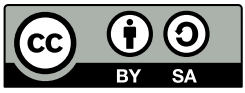

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Many philosophers of science have interpreted instances of scientific disconfirmation as instances of *modus tollens*. Karl Popper embraced this idea in his falsificationism: "The falsifying mode of inference here referred to—the way in which the falsification of a conclusion entails the falsification of the system from which it is derived—is the modus tollens of classical logic" (Popper, 2005, p. 89). Carl Hempel, discussing Ignaz Semmelweis's reasoning about the causes of childbed fever, was similarly explicit about this analysis.

> If H is true, then so is I. . . .
>
> But (as the evidence shows) I is not true.
>
> H is not true.
>
> Any argument of this form, called modus tollens in logic, is deductively valid; that is, if its premisses . . . are true, then its conclusion . . . is unfailingly true as well. Hence, if the premisses . . . are properly established, the hypothesis H that is being tested must indeed be rejected. (Hempel, 1966, p. 31)

Imre Lakatos also embedded *modus tollens* in his account of the methodology of scientific research programs (Lakatos, 1978). Much more recently, Alexander Bird seems to have embraced disconfirmation as *modus tollens*: "Imagine a case where we are investigating a hypothesis h. From h plus an auxiliary hypothesis we deduce a testable proposition o. We devise a suitable experiment and find that o is false. Normally we would regard h as refuted" (Bird, 2022, p. 187).

Philosophers who interpret specific instances of scientific disconfirmation as *modus tollens* assume that the scientific conditional

reasoning in disconfirmation involves the material conditional. To illustrate, consider a passage from Ignaz Semmelweis's discussion of the higher mortality rate due to childbed fever in his first clinic than in his second clinic:

> It has not been questioned and has been expressed thousands of times that the horrible ravages of childbed fever are caused by epidemic influences. By epidemic influences one understands atmospheric-cosmic-terrestrial changes ... by which childbed fever is generated in persons predisposed by the puerperal state. But if atmospheric-cosmic-terrestrial conditions of Vienna cause puerperal fever in predisposed persons, how is it that for many years these conditions have affected persons in the first clinic while sparing similarly predisposed persons in the second? (Semmelweis, 1983, p. 65).

Popper or Hempel would interpret Semmelweis's reasoning along the following lines:

> If the higher mortality rate in the first clinic is due to atmospheric conditions, then the first and second clinics will have the same mortality rate.
>
> It is not the case that the first and second clinics have the same mortality rate.
>
> Therefore, it is not the case that the higher mortality rate in the first clinic is due to atmospheric conditions.

The philosophical interpretation of Semmelweis's reasoning as *modus tollens* overlooks the familiar point that many conditionals in natural language are not material conditionals. Thus, one

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might say "If Jones eats all this ice cream, she will get sick." This conditional presupposes some sort of causal connection between eating the ice cream and getting sick. Eating the ice cream will make Jones sick. By contrast, the material conditional does not have this implication. The material conditional is a mere truth function. "If I eat this ice cream, then the sun is 93 million miles from the earth," while a false statement of causal connection, can be a perfectly good truth-functional material conditional.

Returning to Semmelweis's comments, there is reason to think that he is thinking in terms of causal relations among things in the world. He mentions the epidemic influences *causing* the horrible ravages of childbed fever and atmospheric-cosmic-terrestrial changes *generating* childbed fever. In other words, Semmelweis is reasoning about what one might loosely call the physical consequences of atmospheric-cosmic-terrestrial changes, namely, that those changes would affect both hospital wards equally. But, upon observation, one finds that those physical consequences do not obtain. The material conditional of symbolic logic is not meant to capture the putative causal connections between the atmospheric-cosmic-terrestrial changes and childbed fever.

A further hint regarding Semmelweis's thinking comes a few sentences later, when he claims that "epidemic influences cannot explain the differences in mortality" (Semmelweis, 1983, p. 66). This comment suggests the familiar thought that explanatory considerations have confirmation theoretic import. The thought is that the physical consequences of things in the world being as hypothesis H depicts them lead to things in the world being as E depicts them, but independent determinations reveal that things in the world are not as E depicts them. In other words, when scientists "deduce a testable proposition o"—as Bird would put it—what they are doing is determining the physical consequences of

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some hypothesis (typically in conjunction with various auxiliary hypotheses). This is a basis for disconfirmation. This, in outline, is what scientists, such as Semmelweis, mean when they imply that what a hypothesis "cannot explain" is disconfirming for that hypothesis. In other words, Semmelweis is thinking of disconfirmation as some sort of abductive reasoning regarding what a hypothesis cannot explain.

Should philosophers of science take scientists to be engaged in reasoning about causes in the world, about the physical consequences of things, they would be in a position to more charitably interpret scientific reasoning. Instances of hypothetical reasoning might be more charitably interpreted as involving something like causal conditionals, rather than the material conditional. Indeed, the idea broached for scientific disconfirmation might be carried over to scientific confirmation.

Recall that Semmelweis intended to support or confirm the view that "cadaverous particles" were responsible for childbed fever by supposing that, if the particles were chemically destroyed the mortality rate in the first clinic would be reduced: "Suppose cadaverous particles adhering to the hands cause the same disease among maternity patients that cadaverous particles adhering to the knife caused in Kolletschka. Then if the particles are destroyed chemically, so that in the examination patients are touched by fingers but not cadaverous particles the disease must be reduced" (Semmelweis, 1983, p. 65). Hempel might render this reasoning as an instance of affirming the consequent:

> If childbed fever is caused by cadaverous particles, then chemical cleaning reduces the incidence of childbed fever.
>
> Chemical cleaning reduces the incidence of childbed

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fever.

Therefore childbed fever is caused by cadaverous particles.

What is uncharitable in this interpretation is that, as Hempel noted, it takes scientific confirmation to be a deductive fallacy. See (Hempel, 1966, pp. 31-32).

An alternative reading of Semmelweis's comments is that he is tracing the physical consequences of the hypothesis that childbed fever is caused by cadaverous particles. One physical consequence is that any chemical that is strong enough to kill the cadaverous particles would reduce the incidence of childbed fever. Subsequent investigation bears this out, thus supporting the idea that disease is caused by cadaverous particles. Semmelweis's underlying thought is that the chemical cleaning destroying the cadaverous particles explains why the cleaning reduces the mortality rate. In other words, Semmelweis is reasoning abductively.

The foregoing considerations support a familiar view, namely, that philosophers of science should abandon a hypothetico-deductive interpretation of disconfirmation and confirmation. Further, it suggests an alternative: at least some of the scientific reasoning that would formerly have been interpreted in a hypothetico-deductive framework might be better interpreted within an abductive framework that recognizes scientific thinking about the physical consequences of what hypotheses propose. An abductive interpretation links confirmation to explaining and disconfirmation to failing to explain.

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