Popper, Demarcation and Falsification

qwerty

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Demarcation The demarcation problem aims to answer: what separates "science" from "not-science"?

Karl Popper argued, although this is not necessarily a settled consensus opinion, that that the criteria is "falsifiability" of hypotheses, i.e. of predictions. This was a reaction to the positivists or "verificationists" who thought that science should only be concerned with verifiable statements.

Falsifiability Note that falsifiability referred to here only has to do with the ***logical structure*** of statements. This is an important point: for example, classical physical laws make absolute claims; so *falsifiability is the hypothetical ability to measure something different to what the law claims.* The concept of falsifiability lies in pure logic, and one cannot claim theories are "falsified" by experiment.

Any actual interaction or measurement with the real world, in which you gather evidence or run experiments, always involves known or unknown errors – for example with instruments or detectors, or with experimental design. We are generally interested in model selection or hypothesis testing, using *statistical* methods such as Bayesian updating, once it clear that the hypothesis is in the realm of science, i.e. passes some demarcation test such as being falsifiable. We then have degrees of evidence for or against each model, which may be quantified by measures such as p-values, confidence limits, odds ratios, e.t.c.

The main point of Popper's falsification: science can deal with statements that are not verifiable, in the language of logic, (e.g. positively formulated universally quantified statements, such as "all X are Y". If you cannot observe all X, then this is not a verifiable statement), as long as it is falsifiable ("all X are Y" can be hypothetically falsified by observing an X which is not Y).

Note that these philosophers believe science was interested in universal laws rather than particulars, so statements such as "not all X are Y" or its negation "at least one X is not Y", both are as easy to verify as the original is the falsify, and where both statements are both verifiable and falsifiable, were not of interest.

For most scientific theories, you could write it in the language of logic, as the following. Assuming a theory or hypothesis H makes predictions in the form $H : Q \rightarrow R$, i.e. a statement Q implies result or statement R. For example:

H: If today is a Tuesday, John goes to work.
Q: Today is Tuesday.
R: John goes to work.

or

H: All dogs are mammals. (OR, If something is a dog, then it is a mammal.)
Q: Fido is a dog.
R: Fido is a mammal.

Such constructions are called *modus ponens*, closely related to *modus tolens*, and we can determine the relation between the veracity of H, Q, and R using "truth tables". If we observe R is true, this does not imply that Q is true. However, if R is false then Q is false.

Note that implication is more general than causation; e.g. being a dog implies being a mammal, but it doesn't cause it. Implication is a logical relation, holding between propositions, or declarative sentences. All dogs are mammals (proposition H), Fido is a dog (proposition Q), therefore Fido is a mammal (proposition R).

Some Issues Discussed

- Let's not consider quantum mechanics, which gives probabilistic predictions. Popper openly struggled to make sense of quantum physics (in particular the popular Copenhagen interpretation), probabilities, and Bayesian inference. However, quantum theory can also give non-probabilistic predictions.
- Not clear what Bayesian epistemology is; but Popper et al. believed in one Objective truth, so had issue with Bayesian subjective degree-of-confidence anyway. If you concede that knowledge processing is necessarily subjective, you've already eliminated a bunch of philosophies from the competition – all these early contenders like both Popperian falsificationism and the logical positivists were about objective methods of scientific knowledge. Falsificationism, in terms of a Bayesian framework, might say something like: You may never assign 100% as a prior to any scientific law. In fact this is known as Cromwell's rule.
- Most theories have many layers between the assumptions about how the world works and what is measured (e.g. the notion of "particle" much more removed from what you see in a detector than you might think). The problem with falsificationism in that context is that our theory is not of the form "If A, then B", but of the form "If A and B and C and D, then: If E, then F." and people go and test the "If E, then F" part and take it as support or not for believing in A, B, C and D.
- It's not possible to falsify a claim experimentally in physics, and extremely hard to actually obtain strong evidence against one. You could simply claim that there was a problem with the detector, that there was an external influence, and so on – and of course the theory of the detector is itself a very complicated matter. If your theory of the detector is wrong you could also blame that.
- Some philosophers go as far as to say that scientific theories aren't even true or false, they're just conventions.
- It should be clear that Popper does not answer how to "do science", only provides one possible way to define science.