What Does the Underdetermination Argument Show?

By Andrew Langridge

Several distinct types of underdetermination are encountered in scientific practice. I will argue that while nonradical types of underdetermination pose severe problems for scientific realists, they do not give us cause to abandon realism.

In assigning truth to a scientific theory we imply that it is empirically successful. A measure of the truth of a theory is how well it explains and predicts what we observe, but how can we be sure that theories are uniquely determined by our observations? The problem of underdetermination has contributed to general scepticism in epistemology towards the existence of an external world, but I will restrict what follows to an analysis of the problem as it relates to the practice and philosophy of science.

The historical record appears to contain clear cases of empirical equivalence between contrasting scientific theories, even if the tension was later resolved in favour of one of the theories. An example is the opposition between the Cartesian vortex and Newtonian theory of planetary motion in the early 18C, which was later resolved in favour of the latter. It is arguable that cases of 'contrastive' underdetermination have proliferated in the modern period as scientists invoked unobservable entities to explain physical phenomena. Recorded cases present a problem for scientific realists, whose principal claim is that scientific theories are true, or approximately true, descriptions of reality. If more than one theoretical description is supported by the evidence, the difficulty of convincing us that there is one true description is significantly increased.

A good place to start in the examination of underdetermination is with the problem of induction. Inductive inference has long been recognised as a cornerstone of the scientific method and is based on the premise that repeated observations of a particular phenomenon justify the inference of a universal generalisation in respect of that phenomenon. Doubt was cast on this justification by Hume, who showed that it is impossible to prove that any generalisation will continue to hold in the light of future observations. From a purely logical point of view, the sceptical alternative that a generalisation will cease to hold is just as likely as the generalisation that it will continue to hold. In other words, the choice between the generalisation and the sceptical alternative is underdetermined by the data. Nelson Goodman (1955) presented a more radical challenge to inductivists (1) . If all observed emeralds have been green, it might be theorised that 'all emeralds are green', but it could also be the case that 'all emeralds are grue', where 'grue' is the property of being green up to the current time and blue afterwards. Observations can support contrasting theories and language plays a key role in determining what theories entail. Incommensurability between theoretical domains is said to occur when conceptual schemes are not translatable from one empirically equivalent domain to another.

Another radical argument for underdetermination is founded on the analogy between theory construction and fitting a curve through a collection of points on a graph. For example, Boyle's law can be demonstrated by fitting a curved line through graphed coordinates representing pressure and volume readings. But it is easy to see that an indefinite number of possible curves (theories), whatever their mathematical complexity, are consistent with any finite data set. There is a sense in which theories 'correct' the observations, and the freedom that is involved in this process is a driver of underdetermination.

One line of attack against these arguments for underdetermination that I am calling 'radical' is to argue that tokens of this type are unrepresentative of real scientific theories. In contrast to simple inductive inference and curve-fitting, the acceptance of real theories never relies solely on the presence of confirming instances. Theories are evidentially adequate if, besides their empirical adequacy, they pass stringent, potentially falsifying tests and are non adhoc. Empirically equivalent theories are also potentially separated by epistemic attributes such as simplicity, surprising predictive ability, wideness of scope or possession of external support. Unfortunately, none of these latter indicators of robustness is singularly sufficient to uphold a theoretical inference, and they can also

conflict in their support. It has sanctioned the drafting of a stronger version of the underdetermination argument premised on the evidential (not just empirical) equivalence of rival theories. The argument has been adopted by social constructivists and relativists, who following Kuhn, Lakatos, Feyerabend and Quine, insist that social or psychological factors fill the epistemic gap left by underdetermined theories. However, the fact that so many cases of underdetermination in the scientific record have later been resolved must give us cause to doubt if evidence is as inadequate in facilitating theory choice as these theorists claim.

Scientific realists deny that radical arguments for underdetermination pose any real threat. They argue that all logically possible alternatives to a theory are not equally justified, and the success of a well tested theory is not reliant on proof that no other theories can match this success. Since theories structure observations, it is impossible to determine if a theory is empirically superior to all possible contenders. Realists believe that there is a 'natural' development, or linear progression, in favour of superior theories, and we can continue to search for better theories without having to certify each stage of the process. Of course, the challenge remains for realists to show why it is reasonable to expect any theory to be more truthful than its predecessors, or why a theory is probably true. It is important to note that it is also a challenge for empiricists to show why any theory is empirically adequate, by which it is meant that all observations are consistent with what the theory entails.

Besides ‘contrastive underdetermination’ considered above, there is also 'holistic underdetermination', which owes its formulation to Pierre Duhem in the early 20C (2) . Duhem showed that theories in physics are empirically testable only when conjoined with other 'auxiliary' theories associated with the experimental apparatus or other background beliefs. Any test failure can just as easily be attributed to one of the auxiliary theories as to the main theory, so all the possible responses to the failure are underdetermined with respect to each other. For example, when making observations of the behaviour of a planetary body, astronomers have to rely on auxiliary optical theories for explaining how light is reflected through their telescopes. It is equally rational for them to respond to a failed test by blaming one of these observational theories as it is to conclude anything about the planetary body's behaviour. Duhem shows us that it only makes sense to perform tests on a whole theoretical group. Unlike the radical forms of underdetermination discussed above, it is undeniable that holistic underdetermination is a real issue for practising scientists, whose work involves a constant accommodation between the theories that they are testing and the background theories and experimental procedures with which they are associated. Nevertheless, in most cases, scientists are able to assume the reliability of individual auxiliary theories and procedures that are well supported and have a good track record, while testing others. The optical theories that govern the workings of a telescope are considered robust enough for the purposes of current astronomical investigation owing to the fact that they have proved reliable in so many diverse past experiments.

The presence of real cases of holistic and contrastive underdetermination in the scientific record are certainly problematic for realists, but it is important as Larry Laudan (1990) pointed out, not to conflate radical and limited arguments for underdetermination (3). AntiRealists and empiricists replace the criterion of truth with that of empirical adequacy, but this is also a radical thesis and, in practice, other evidential criteria are necessary to decide between empirically equivalent theories. Pragmatists appeal to internal and external consistency of theories as the ultimate criterion, but neither does this seem sufficient to explain the remarkable sense of security that surrounds our best scientific theories. The paradox is that although we have little warrant for believing that any of our best theories are true, the accumulation of rational procedures and the search for truth are proper aims of science. Underdetermination is often mitigated by stringent testing, mutual support of theories and translation of concepts between theoretical groups. Scientific theories with a good track record are the offspring of solved puzzles, locally clarified terms and critical tests. Gainful scientific theories have succeeded in 'orientating themselves' towards the truth, even if it is impossible for them ever to attract the status of being true.

(1) Goodman, N., 1955, Fact, Fiction, and Forecast, Indianapolis: BobbsMerrill.
(2) Duhem, P., [1914] 1954, The Aim and Structure of Physical Theory, trans. from 2nd ed. by P. W. Wiener; originally published as La Théorie Physique: Son Objet et sa Structure (Paris: Marcel Riviera & Cie.), Princeton, NJ: Princeton University Press.
(3) Laudan, L., 1990, “Demystifying Underdetermination”, in Scientific Theories, C. Wade Savage (ed.), (Series: Minnesota Studies in the Philosophy of Science, vol. 14), Minneapolis: University of Minnesota Press, pp. 267–297.