Kelvin's dictum revived: the intelligibility of mechanisms

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Lord Kelvin (1824–1907), the epitome of nineteenth-century physics, famously declared: "It seems to me that the test of 'Do we or not understand a particular subject in physics?' is, 'Can we make a mechanical model of it?'." Kelvin's dictum implicitly assumes that understanding is an important aim of science and explicitly states that this aim can only be achieved by devising mechanical models. Kelvin's dictum was widely supported in the nineteenth century but proved to be untenable in the light of later developments in physics. It was in particular the advent of quantum theory that has refuted the universal applicability of mechanical modeling as a road to understanding. To be sure, present-day physicists still talk about mechanisms but often this talk is only metaphorical (esp. in the case of fundamental particle physics, the so-called Higgs mechanism being a prominent example). For this reason Salmon's causal-mechanical model of explanation (Salmon 1984) cannot be a universal theory of scientific explanation: the ontology it presupposes doesn't square with the basic ontology of modern physics.

But the inapplicability of mechanical models in fundamental physics does not imply that mechanistic understanding has to be rejected in other fields and disciplines as well. In other subfields of physics and in other scientific disciplines it may still be useful. Indeed, recent years have witnessed the rise of the 'new mechanists': philosophers of science who have developed new mechanistic models of explanation that are inspired by the contemporary practices of the life sciences (e.g. Machamer, Darden and Craver 2000; Glennan 2002; Craver 2007). The core of these models is an analysis of mechanisms as organized wholes that by virtue of the interaction of their parts produce specific behavior or perform a particular function.

How do such mechanisms provide understanding? An important feature of mechanistic explanations is that they are typically not purely linguistic but contain visual (pictorial or diagrammatic) representations. Mechanisms are visualizable, and most scientists prefer visualizations to linguistic descriptions because of their pragmatic advantages: visualizations directly convey the spatial organization of complex mechanisms (and temporal change can be represented visually too). Thus, they are more tractable than linguistic representations. Moreover, visual reasoning can be facilitated by simulation tools such as scale models or computer models.

But is tractability the same as intelligibility? Does tractability lead to understanding, and if so, how? The answers to these questions depend on one's conception of scientific understanding. I will argue that understanding lies in the ability to use a model or theory to generate predictions of the target system's behavior. In the case of mechanistic explanations, one has achieved understanding if one is able to see how (functional) behavior is produced by the (hypothesized) mechanism. In other words, mechanistic explanations render phenomena intelligible by specifying productive relations. The new mechanists have as yet merely defined explanation as description of mechanisms, without specifying why such descriptions provide understanding. I will defend a view of scientific understanding and intelligibility (in terms of recognition of qualitative consequences of theories and models) that makes sense of the claim that (mental models of) mechanisms provide understanding by allowing the modeler to see how the system produces particular behavior. I will show that visualization can be an effective tool to achieve such understanding.

My pragmatic account of scientific understanding (with its emphasis on abilities, tractability, and use) leads to the question of whether the mechanisms that provide explanatory understanding should be regarded as real or as (merely) representational. In other words, what is the ontological status of mechanisms and mechanistic explanations? Are mechanisms realities out there, or are they (merely) our mental representations of the observable phenomena? The new mechanists seem to be divided over this issue. I will argue that explanatory understanding does not require scientific realism: it is perfectly possible to achieve understanding of phenomena via theories or models independently of whether they are true representations of a reality underlying the phenomena. My claim contradicts the traditional association between antirealism and descriptive aims on the one hand and realism and explanatory aims on the other. However, I will argue that such an association has to be rejected.

This view has a precursor in the epistemology of Ludwig Boltzmann, who, at the end of the nineteenth century, defended his Bildtheorie (picture theory) of scientific knowledge, a sophisticated epistemological position which stated that scientific theories and models are mental pictures having at best a partial similarity to reality. While Boltzmann (1899) admitted that mechanical models could no longer be regarded as realistic representations of physical reality (developments in physics led to the collapse of the mechanical world-picture in the 1890s), he argued that such models could still be employed to achieve understanding of the phenomena. My analysis of scientific understanding follows Boltzmann's approach, implying that mechanical models can provide understanding even if they defy realistic interpretation. In this way, Kelvin's dictum can still be relevant for twenty-first-century science.

References

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