Hacking, Ian, The self-Vindication of the Laboratory Sciences, in Pickering, A., Ed., *Science as practice and culture*, Chicago: University of Chicago Press, 1992, 29-64.

Keywords

Scientific facts, realism/anti-realism, experimental strategies, holism.

Domain

Science en general

Abstract

Throughout the twentieth century, philosophy of science has stressed the role of instability in the dynamics of scientific knowledge. This was mainly due to the unusually revolutionary character of the advances made during the first decades of the century, especially in fields such as Relativity and Quantum Mechanics. The resulting epistemological debate paid little attention to the details of laboratory activities. This has further contributed to the neglect of the stability issue, for it is within the laboratory sciences that the persistence through time and the accumulation of practices, devices and knowledge are most striking. The aim of this essay is to characterize stability in the laboratory sciences and to explain how it can arise. The structure of the essay is the following. A detailed taxonomy of the elements involved in experimentation is proposed, which paves the way to the transformation of the classic Duhem thesis into a full-blown holism that is not restricted to intellectual contents. This generalized holistic picture provides the conceptual framework for understanding how experimenters strive to obtain a broadly conceived coherence among the resources available to them. Stability appears, therefore, as the contingent result of a progressive co-adaptation of the different elements listed in the taxonomy. The remaining part of the essay elaborates, in the light of the preceding considerations, on such traditional epistemological concepts as truth and induction, and discusses how the stability achieved within the laboratory can have repercussions outside the laboratory thanks to the technical applications of scientific knowledge.

Development

Hacking proposes a taxonomy of the elements intervening in experimentation based on three main categories: **1) Ideas**, **2) Things**, **3) Marks and the manipulation of marks**.

I) Ideas

Ideas is the category of intellectual contents and comprises in turn five classes of items. First come the *questions* (I.1) the experiment is designed to give an answer to, which can also evolve during the experiment. Further, we encounter a loosely defined family of conceptual contents normally unified under the heading "background knowledge about the subject matter of the experiment". Hacking distinguishes three types of knowledge of this kind, and calls *background knowledge* (I.2) only the first one, which amounts to taken for granted and often unsystematized beliefs that, while being necessary to any scientific undertaking, "play little part in writing up an experiment" (p. 45). According to Hacking, therefore, background knowledge is, properly speaking, the deeply entrenched, implicit, and often unchallenged part of the experimenters' beliefs. *Systematic theory* (I.3) is, instead, a general and often high level theory about the subject matter, which, in spite of its being explicit, has no experimental consequences by itself, and hence requires a set of further hypotheses to be connected with experience. The latter are called by Hacking *topical hypotheses* (I.4) and include what is needed to build approximate models bridging between high level theories and experimental facts. Hacking adopts the term "hypotheses" to highlight that the experimenters are extremely prone to revise them in the course of the experiment, while "topical" refers both to their local nature and to their non-fundamental character. These hypotheses, though, have to be distinguished from what Hacking calls *modeling of the apparatus* (I.5), which is the phenomenological theory that "enables us to design instruments and to calculate how they behave" (p. 45). Some overlap is conceivable between (I.2) and (I.4) one the one hand, and (I.5) on the other.

2) Things

Things is the term adopted by Hacking for "the material substance that we investigate or with which we investigate" (p. 44) in an experiment. In this category we find first the *target* (II.1) that is an actual material object under investigation: a sample of a substance, a population of bacteria etc; and second the *source of modification* (II.2), which is used to interfere with or modify the target. Neither (II.1) nor (II.2) are necessary items in experimentation, for may experiments are conducted without preparing a material object which will be subsequently acted upon; sometimes only a *detector* (II.3) is needed. If a target is present, the detector measures the "result of the interference or modification of the target" (p. 47). A vast and heterogeneous class of material objects used in experiment is given by *tools* (II.4). It comprises any off-the-shelf device, from a hummer to a microtome, used to prepare the other material items intervening in the experiment. This class may overlap with the preceding ones and contains many limiting cases that are seldom defined as tools in current practice. An experiment often involves *data generators* (II.5), which are devices that produce data. This can be, for example, a person counting a series of events, or a camera taking micrographs from an electron microscope. No sharp distinction exists between (II.3) and (II.5).

3) Marks and manipulations of marks

Marks and manipulations of marks include first of all the *data* (III.1), which Hacking sees as uninterpreted marks or inscriptions produced during an experiment. They are what the experimenter will subsequently hand over to *data processing*, which, according to Hacking, include three conceptually distinct procedures: *data assessment* (III.2), that is the supposedly theory-free statistical handling of errors and the inevitably theory-laden evaluation of systematic errors; *data reduction* (III.3), a statistical procedure independent from the theoretical knowledge involved in a specific experiment, whose aim is to reduce exceedingly large quantities of data into more manageable amounts; (III.3) is to be distinguished from *data analysis* (III.4), which consists in the selection and the analysis of the data on the basis of the theoretical knowledge involved in the experiment (particle physics provides clear examples of this theory-laden analysis of data and events). The last class in this category is given by the actual *interpretation of the data* (III.5). Based on all theoretical levels (I.2-5), the interpretation of the data is what makes them indicate a certain result. The search for pulsars provide a classic example of the relation between (III.5) and theory, for, only when a theory of pulsars was developed, could radio astronomers interpret certain sequences of data as indicating the detection of a signal produced by pulsar.

These 15 classes define the rage of plastic resources available to experimenters. Unlike Duhem's classic statement, which was concerned only with the plasticity of the intellectual contents belonging to the category of ideas, the *generalized Duhem thesis* amounts to the claim that, when confronted with a difficulty, the experimenters can react by modifying anyone of the items mentioned in the taxonomy. Stability in the laboratory science is achieved when all these elements co-mature in order to produce a coherent "symbiosis". In this case, the elements fit well with another, and the resulting laboratory science is *self-vindicating*. "A coherence theory of truth? No, a coherence theory of thought, action, materials, and marks" (p. 58).

Methodology

Philosophical analysis based on several examples.

Specific contributions

The essay stresses the epistemological importance of stability in the laboratory sciences and provides a detailed taxonomy of the elements intervening in experimentation. The thesis of the multiplicity and plasticity of the resources available to experimenters in order to achieve stability can thus be spelt out in detail. The paper also contains interesting claims relevant for the realism/anti-realism debate, for it suggests that stability is not attained by confronting theories directly to the world, but by obtaining stable symbioses among the multiple elements involved in experimentation.

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