The Logic of Crucial Experiments

Ioannis Votsis

votsis@phil-fak.uni-duesseldorf.de

University of Duesseldorf

Although Duhem's thesis that in physics crucial experiments are impossible contains some grains of truth in it, its effects have been greatly exaggerated. In this talk I argue against this and other associated theses by pointing out the various ways in which these theses can be curtailed. In the process of doing so, I examine a few recent attempts to overcome the problems posed by these theses and identify their strengths and weaknesses.

Duhem's main justification for the thesis that in physics crucial experiments are impossible rests on the supposition that hypotheses can never be tested in isolation. His argument for this supposition is that hypotheses do not have empirical consequences on their own. To test a hypothesis requires several other pieces of information like initial and boundary conditions as well as auxiliary assumptions about the workings of instruments employed in the particular experimental setup. In other words, only whole scientific systems (consisting of one or more central hypotheses, auxiliaries, etc.) come face-to-face with observational evidence. When a whole scientific system makes a prediction and this prediction is not borne out by our observations we may justifiably speak of a refutation. Importantly, since the whole system presumably contributes to the making of that prediction, we are only warranted to infer that at least one part of the whole system is responsible for the failure. Indeed, as Duhem insists, "the experiment does not tell us where the error lies" ([1904]1991, p. 187).

The supposition that hypotheses can never be tested in isolation seems to support the thesis that crucial experiments of *isolated* hypotheses are impossible, but it does not seem to support the thesis that crucial experiments of *whole scientific systems* are impossible. This is because the aforementioned supposition implies that non-isolated hypotheses (i.e. whole scientific systems) are testable. There is thus a tension underlying Duhem's reasoning. Duhem seems to maintain both that whole systems in physics are testable and that nothing in physics can be subjected to a crucial experiment. It is not clear why at least some of the tests cannot be crucial. To resolve the tension it has been claimed that even though whole scientific systems can be tested in some minimal sense, e.g. cohering with observational evidence, such tests can never be crucial (i.e. decisive) because there are always suitable auxiliaries that can save a given hypothesis from refutation.[1]

Yet, contrary to Duhem's non-isolation supposition, some hypotheses can be tested in isolation. For example, at least some low-level phenomenological hypotheses make direct predictions about observable phenomena, predictions whose truth or falsity can be resolved by recourse to naked-eye observations. If a hypothesis of this kind predicts one thing but another thing is observed, the only way to 'save' the hypothesis from refutation is to amend it. But by amending it we end up with a different – albeit not necessarily a radically different – hypothesis. Thus it is not always true that a hypothesis can be saved with the help of auxiliaries. In other words, Duhem's thesis is strictly speaking false.

What about whole scientific systems? Can they be subjected to crucial experiments? Some authors have attempted to address this issue by arguing that even though such systems are tested wholesale there may still be independent support for individual parts of the system. For example, Weber (2009) argues that "it might be possible to independently test some auxiliaries" (p. 23). He goes on to qualify, however, that not every auxiliary can be so tested because "each attempted test of an auxiliary assumption will require further assumptions, and so on" (ibid.). If, in his opinion, "we require that all auxiliaries be tested, there will never be any conclusive evidential support from an experiment." (ibid). To solve this 'problem of untested auxiliaries', as he calls it, Weber puts forth a mechanistic account of inference to the best explanation and argues that both the auxiliaries and the hypothesis are supported at the same time since they "are [both] inferred in one fell swoop on the grounds that the combination of them—in form of the experimental mechanism—provides a sufficient causal-mechanical explanation of the data." (p. 39).

Despite its merits, Weber's approach does not tackle the problem head on. Ultimately we want to find out if the auxiliaries in a given scientific system are indeed good auxiliaries. To do that it is not sufficient to say that the scientific system they are part of provides a sufficient explanation of the data. After all, the auxiliaries are selected for their ability to help the central hypothesis provide such an explanation. In addition to this function, the auxiliaries must enjoy some kind of independent support. Contrary to Weber's gloomy assessment, it is in principle possible to independently support each and every auxiliary

[1] Ariew (1984) argues rather convincingly that Duhem never explicitly endorsed the claim that it is always possible to find auxiliaries to save a given hypothesis.

involved in a given scientific system and hence to provide hope that the whole system can be subjected to a crucial experiment. Take a scientific system *S* which contains two auxiliaries A_1 and A_2 and a central hypothesis *H*. To provide independent support for A_1 or A_2 each auxiliary has to be tested separately from the other and from *H*. Suppose we test A_1 as part of a system *S´*, which also contains auxiliary A_3 and a central hypothesis *H´*, and find that A_1 is confirmed in this system. Although the support for A_1 will be stronger if A_3 and *H´* themselves have independent support it is not absolutely necessary that they do. Even if it were necessary the outcome is not an infinite regress as Weber laments. There are only a finite number of auxiliaries and hypotheses at any one time in scientific inquiry and these can be tested against each other and of course against the empirical world. In either case, there is no guarantee of success and hence the task is not trivial.

References:

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