Philosophy of Science and its Influence on Scientific Practice: empiricism and realism in 19th century electrodynamics

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This paper aims to shed light on a general question by investigating a particular historical case: the general question is "how does a scientist's philosophical understanding of science affect their scientific practice, specifically their representational and laboratory practices?", and the particular case is 19th century electrodynamics. During the 19th century, electrodynamics was a highly contested domain of research, and different representational and laboratory practices are typical of the era. The research programmes associated with Helmholtz, Weber, and Maxwell are quite distinct, especially in terms of their daily preoccupations. Through the case of 19th century electrodynamics, I argue, we can see that philosophies of science motivate certain sorts of representational and laboratory practices.

Helmholtz's earliest scientific work laid the foundation for the physiological understanding of human perception. By giving our understanding of the human perceptual apparatus (and its limits) a scientific foundation, Helmholtz's work, on his own account, made modern empiricism truly possible. History vindicates Helmholtz on this point somewhat, for every brand of "empiricism" that has come after him has, explicitly or implicitly, built its epistemology on an understanding of human perception that derives from Helmholtz's physiological studies of sense-perception. My central claim is that, as the first modern (i.e. physiologically-grounded) empiricist, Helmholtz was disposed to prefer both a) more "open-ended" representational practices and b) laboratory practices aimed at the production of novel effects. This contrasts with his more realistically inclined contemporaries, who preferred a) more "filled-out" representations and b) laboratory practices aimed at refining these representations by making ever more precise measurements of specific parameters and constants. Since Helmholtz can in many ways be considered the father of modern empiricism, a comparison of his electrodynamics research programme in the mid-19th century with his contemporaries' provides an ideal case study for investigating how a researcher's philosophical predilections can affect the character of their laboratory and representational practices.

Helmholtz represented all electrodynamic phenomena by means of a measured "action potential," and these experimentally determined values were ascribed directly to the various mascroscopic objects found in the laboratory. These representational practices were designed so as to presuppose nothing about the ultimate cause of electrodynamic phenomena; since action-potentials represented nothing beyond dispositions for macroscopic behaviour, Helmholtz's representational practices were able to remain somewhat agnostic about the source of charge and current. In contrast, Maxwell and Weber represented all electromagnetic phenomena as mediated by some unseen bearer of the electric charge – fields and corpuscles, respectively. Unlike Helmholtz's representational practices, Maxwell and Weber's implied robust ontologies, necessarily populating the world with many imperceptible (i.e. unobservable) objects.

Prior to Hertz's "discovery" of electric waves, the idiosyncratic representational practices of Helmholtz, Maxwell, and Weber were all capable of accounting for all observed phenomena, i.e. all three programmes were able to "save" the known electrodynamic phenomena. Despite this apparent empirical equivalence, these three research programmes were characterized by radically different laboratory lives. The Weberians were concerned mostly with measuring constants, parameters, and refining their representations of the electric corpuscles. The Maxwellians were concerned mostly with “pen-and-paper” work that mimicked the sorts of problem-solving these mostly Cambridge graduates encountered in their undergraduate examinations, aimed at mathematically determining the consequences of various configurations of charged objects and configurations of the electro-magnetic field. In contrast to both of these programmes, the Helmholtzians were concerned primarily with the production of novel effects in the laboratory, not with refining their representational practices, nor with using their representational practices to investigate various abstract arrangements of objects mathematically.

While the production of novel effects was the daily goal of Helmholtzian laboratory practice, its ultimate goal was to break the theoretical stalemate between the Webereans, Maxwellians, and Helmholtzians. The basic idea behind Helmholtz’s laboratory method was that the stalemate between he, the Weberians, and the Maxwellians could be broken by producing a replicable electrodynamic effect in the laboratory that could be accounted for by some but not all of these representational schemes. Accordingly, Helmholtz developed what he considered to be the most general and robust representational practice, one capable of “saving” the widest range of phenomena. The hope was that this open-ended representational practice could be used to describe and record phenomena that would prove unaccountable on other, more rigid or ontologically “filled-in” schemes like Weber’s and Maxwell’s. And, with the help of his characteristically Helmholtzian representational and experimental practices, Hertz eventually broke that stalemate, albeit in favour of the Maxwellian scheme.
These differences in the day-to-day preoccupations of the Helmholtzians, Weberians, and Maxwellians results from the representational practices they were tied to. As Jed Buchwald (1994) puts it, the different representational practices of these three researchers would “come to life” in their respective laboratory practices. In an analogous manner, I argue, their differing philosophical conceptions of science “came to life” in their respective representational practices, and the philosophically tainted character of their representational schemes carried through into the daily practice of their laboratories as well.

In arguing for the distinctly empiricist character of these representational and experimental practices I deploy Bas van Fraassen’s recent (2004, 2008) account of the epistemic function of scientific experimentation in model-building. Van Fraassen outlines two epistemological accounts of scientific experiment, one realist and the other empiricist. On the realist account, scientific experiments serve as a “window” into an unobservable reality, providing scientists with epistemic access to a realm that would otherwise remain inaccessible, allowing them test their representations of these unobservable aspects of reality. On the empiricist account, by contrast, scientific experiments serve as “engines” for creating novel scientific effects, and do not give us epistemic access into the realm of the unobservable. Seeing scientific experiments as producers of novel, observable scientific effects proves sufficient for understanding the processes of scientific (i.e. theoretical) advancement, for a novel state of affairs may be easily accountable in one scheme while being entirely anomalous in another. I claim that Helmholtz’s programme took the later view of scientific experiments, while Weber and Maxwell’s programmes took the former view, and that this is manifest in their representational and laboratory practices.