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Review of, Friedrich Steinle. *Exploratory Experiments: Ampère, Faraday, and the Origins of Electrodynamics*. Translated by Alex Levine. x + 494 Pp., (Pittsburgh: University of Pittsburgh Press, 2016).

Exploratory Experiments is a book that is long overdue, being a translation of Friedrich Steinle's 2005 *Explorative Experimente*. The original represented a culmination of the reaction in the 1980s and 90s, against the theoretical certainties and strongly explanatory models of the previous decades, a reaction that saw the rise of microhistory among historians and a "turn to practice" in the history and philosophy of science. Steinle's reaction was against the view that the only experiments that are of interest to philosophy are hypothetico-deductive tests of theory. Picking up on ideas of put forward in the early 1990s by David Gooding and Ian Hacking, Steinle's main aim was to explore the epistemic processes of "exploratory experiments" – experiments that take place in a context where there is either no underpinning theory, or where the underpinning theory is, itself, at issue.

Such an event occurred in 1820, when Ørsted's discovery of an interaction between electricity and magnetism – an interaction that could not be accommodated in the conceptual framework of central forces with which natural philosophy at the time was steeped – threw the scientific world into turmoil. In the few months of frenzied work that followed, two outsiders emerged as leaders in the new field of electromagnetism: André-Marie Ampère and Michael Faraday. Detailed case studies of the working scientific practices of these two form the core of Steinle's book. They are carefully chosen, not only for their subsequent status as leaders, but for the contrasting cultural, institutional and intellectual contexts within which they were working, and for the availability of rich collections of sources. Comparisons between the two cases allow Steinle to identify commonalities as well as locally situated differences, and to suggest characteristics of exploratory experiments that clearly distinguish them as rational and more methodical than mindless fumbling.

After a brief introduction outlining his situation, aims, and methodology, Steinle plunges into an account of the state of knowledge and scientific cultures across Europe in the early nineteenth century, focusing particularly of the locales important for the rest of the book: Paris and London. This is no summary overview; in line with his emphasis throughout on the agency of individuals, he aims to "capture the perspective of actors ... from street level" (p.11). With the stage thus set, Steinle describes Ørsted's discovery of electromagnetic action, and the furore it raised across Europe. This is one of the few chapters in which he looks more widely than London and Paris, identifying three features of the

reaction that appear common everywhere: surprise; attempts to replicate; replication always confirmed the unusual and conceptually unsettling features of the effect. Chapters 3 and 4 are devoted to Ampère's scientific practice. The split corresponds to the two phases that Steinle has identified in Ampère's work: the first three weeks during which he formed concepts and sketched a research programme; and the following four months as he fleshed out that programme, fended off challenges from Jean-Baptiste Biot and Félix Savart, and managed his public image. Turning to London, chapter 5 identifies systematic differences in the British and French responses to Ørsted, characteristic of the different milieu, and looks at the work of those who formed the backdrop to Faraday's work – especially that of his mentor, Humphrey Davy. The chapter finishes with an account of the circumstances surrounding Faraday's "Historical Sketch of Electro-Magnetism" of July 1821 and argues for its importance as a springboard for his discovery of electromagnetic rotation, discussed in the next chapter. Steinle's detailed analysis of Faraday's scientific practices form the core of chapter 6. He pays particular attention to Faraday's work *after* the discovery, claiming that the exploratory nature of Faraday's work is most evident here, whilst also benefiting from the relative neglect of this phase by other historians. By this point, Steinle is in a position to compare Ampère and Faraday, and draw conclusions about the nature of exploratory experiments, which he does in the concluding chapter. He suggests that exploratory experiments can be characterised by methodological strategies such as parameter variation, and the conjoined epistemological and experimental processes of establishing new conceptual frameworks around simplified and purified experimental arrangements.

Evidence for the practice of exploratory experiments has, by its nature, to be drawn from sources created at the time, before rational reconstruction or reminiscence has imposed a theoretical gloss not present in the lived practice. Chapter 3, in particular, is based on a painstaking re-assembly of fragments of Ampère's lecture notes, written while he was in the middle of the series of experiments. The lectures, the source materials used, and a detailed description of the reconstruction process form the substance of two long appendices to the book, providing not only an invaluable new source for Ampère, but also a useful methodological guide.

The book is self-reflexively methodological throughout, justifying in detail, for example, the need for a detailed micro-study of experiment. But it is not pure micro-history. In line with Brewer's suggestion that the best histories effectively combine perspectives from different distances, Steinle frequently pulls away to reflect on the more general themes that are his primary concern. This helps to guide the reader through the narrative, and ensure that his conclusions, once reached, are well supported.

In summary form, Steinle's work has been known since his 1997 paper "Entering New Fields: Exploratory Uses of Experimentation" which, together with Richard Burian's work of the same year, opened up what proved to be a fertile field of enquiry and exposed how inadequate our concepts of experiment were. Despite the many nuances and ramifications added to the concept since, the richness of

the historical analysis in which Steinle's ideas are based – particularly that of Ampère - has remained largely unknown to English speaking philosophers and historians until now. This meticulous translation should rectify that omission and provide an impressive exemplar of integrated history and philosophy of science.

Isobel Falconer
University of St Andrews