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Working with Instruments: Ernst Mach as Material Epistemologist, a Short Introduction

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I.

With the death of Ernst Mach on February 19, 1916, one day after his seventy-eighth birthday, a question finally became explicit that had been looming for some time. It was as simple as it was fundamental: who, in the end, was this man, a scientist or a philosopher? The importance of this question for contemporaries can easily be gleaned from the obituaries that appeared in the weeks following Mach's death: one in the *Physikalische Zeitschrift*, written by Albert Einstein, and another in the *Archiv für die Geschichte der Philosophie*, written by Mach's former student Heinrich Gomperz. They both addressed this critical issue in plain words. Einstein stressed that Mach "was not a philosopher who chose the natural sciences as the object of his speculation, but a many-sided, interested, diligent scientist who also took visible pleasure in detailed questions outside the burning issues of general interest" (Einstein 1916, 104; translation cited in Blackmore 1992, 158). Gomperz in turn first emphasized the great loss science had experienced with Mach's death, asking subsequently whether "the suffering science is physics or philosophy?" (Gomperz 1916, 321). His answer broadly followed Einstein's conclusion; relying on Mach's own words, he reminded his readers that Mach never claimed to be a philosopher, but merely was looking for a viewpoint that transcended the disciplinary constraints of particular scientific activities.

Whether a scientist or a philosopher had died was a question of significance with respect to the politics of remembrance. The evenhanded position of Einstein and Gomperz, that Mach should in the best sense be acknowledged as a natural philosopher of his time, was not very helpful in this regard. Like any other memory, scholarly memory cannot cope very well with ambiguity. Clear-cut categorization is, if not a condition, at least a useful circumstance for recalling something or someone. In Mach's

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case the fate of his legacy was probably decided ten years after his death, when in 1928 the *Verein Ernst Mach* was founded under the guidance of Moritz Schlick. Mach's name henceforth became closely associated with the neo-positivist program of the "Vienna Circle" (see Stadler 1997, 364–370).

Throughout the twentieth century the richness of Mach's interests was overshadowed more and more by an evaluation of him as a philosopher of science put forward by other philosophers of science and historians of the philosophy of science. This did not mean that Mach's ample contributions to experimental physics and physiology fell into oblivion, but the focus on his research work was largely informed by the interest in his epistemological writings. In one sentence: after the proclamation of Mach as the philosopher of science, the researcher Mach appeared as his adjunct. From this perspective it could seem that much of his laboratory work, which had been performed in Vienna, Graz, and Prague between the 1860s and the 1890s, served primarily as sample material and proof of philosophical issues. Even the more modest position that Mach's reflections on the foundations of scientific knowledge were nurtured by his experimental research does not question the hierarchy between the two activities. Of course, some of Mach's findings can claim significance of their own and have been adopted by the scientific community as eponyms like "Mach number," "Mach angle," or "Mach bands" confirm. But the majority of his experimental work seems to be of interest only as the prelude to a set of philosophical propositions.

In presenting the following papers to an English-speaking audience we want to refresh the picture of Mach. In taking Einstein's and Gomperz's evaluation of Mach as a "natural philosopher" seriously, we assume that in his laboratory – as in his scientific practice in general – epistemological and experimental issues are inseparably linked. The three papers we chose for the present issue of this journal – two texts by Ernst Mach and one by his son Ludwig who relied on one of his father's ideas – should be read along this line. They offer an insight into the practical reasoning of an experimentalist and show how his tinkering with instruments was intertwined with epistemological flashes.

II.

Ernst Mach's article on sphygmography is exceptional on several counts. To the best of our knowledge, it has never been listed in any bibliography of his works. In addition, it has not called out even a superficial analysis in the secondary literature, be it in the field of historical epistemology or in that of the history of medicine. Nor has it been perceived as one of Mach's contributions written (and published) especially for the medical profession. The brief contribution devoted to the theory of the sphygmograph was printed in the same journal, the Viennese *Medizinische Jahrbücher*, which had earlier published one of the first reports on Étienne-Jules Marey's instrument in the Austrian Empire (cf. Rollet 1861). A closer look reveals that Mach's article achieved a kind of synthesis between his sophisticated, scientific theory of the sphygmograph and the

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presentation of a revised sphygmograph, a synthesis made for easy reading by physicians particularly interested in the diagnostics of heart diseases.[1] This is to say that the brief article illustrates Mach's awareness of the demands (or expectations) of the various audiences he was addressing in the early years of his academic career.

The twenty-five years that separate Mach's paper on sphygmography and his "Remarks on the Scientific Applications of Photography" of 1888 encompass almost every research project he ever contributed to physiology and physics. In this article Mach included, among others, his striking experiments on the photography of air disturbances caused by very fast projectiles, which he had pursued together with his co-worker Peter Salcher in the years before. However, despite the title, the focus of the article was broader. Pointing to a number of instruments and practices that range from drawing graphs to stroboscopic discs, Mach developed the idea that all these tools, diverse though they may be, have in common their capacity to master time and space. In this respect photography was characterized as a means for manipulating very fast or very slow phenomena by "temporal magnification" and "temporal diminution." In terms that later became common, Mach was considering the effects of slow-motion and time-lapse photography. It is probably the power of photography that is echoed in Mach's conclusion that the issues discussed in the article were not only of practical but also of "philosophical interest." No doubt, with the possibility to "freeze," "shrink," or "expand" the time of events by technical means, an arrangement for the "relativization" of time in general took shape. Mach himself extended this line of reasoning twenty years later in his essay "On Time and Space" (1910) with the description of a train, which – now in the epoch of cinema – leaves the station against time's arrow back to the place from where it just had arrived (cf. Mach 1923, 497–499).

Ludwig Mach's paper "On the Principle of Temporal Diminution in Serial Photography" of 1893 can likewise be read in the context of cinematography. What he presented to his readers was in fact – unbeknownst to most of the histories of cinema – one of the earliest apparatuses for the projection of moving photographic images. Yet, for our purposes the example Ludwig Mach had chosen for demonstrating the capacities of the apparatus is more interesting. In 95 photographs on celluloid film, taken two times a day over the span of about six weeks, he captured the complete life cycle of a cucurbit plant (pumpkin) from the first sprout to the fading flower.

What became animated by the "principle of temporal diminution" was precisely the process of living, or life itself. For Ernst Mach, whose suggestion his son Ludwig realized, the images of a human "from the cradle" to the "deterioration into old age in but a few seconds" promised to be an ethical and aesthetic experience. But he emphasized even more that the practices of temporal diminution and magnification would "beyond doubt" generate "new insight[s]." Apart from the various examples

[1]See Jeannel 1877, 133-134. Mach's suggestion was also considered in a version of the sphygmograph presented by Jules-Louis (in some sources: Louis-Jules) Béhier on August 11, 1868, to the members of the Academy of Medicine at Paris.

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given in the paper, it must be stated that this, above all, is true for Mach's concept of scientific photography itself. That it may be understood as a powerful means of untangling scattered or dense phenomena and processes in time is not self evident. It is the result of employing photography in the laboratory, rather than of photography's inherent nature. To return to the starting point and to deepen Einstein's and Gomperz's assumption, perhaps Mach can be characterized best as a material epistemologist: i.e. as a researcher who through his everyday work learned how scientific objects and knowledge are configured.

III. Remarks

Ernst Mach's paper "On the Theory of the Sphygmograph" was originally published under the title "Zur Theorie der Pulswellenzeichner," in *Zeitschrift der k. k. Gesellschaft der Ärzte in Wien = Wochenblatt. Beilage zu den Medizinischen Jahrbüchern*, vol. 19, 1863, pp. 43–48.

Ernst Mach's "Remarks on the Scientific Application of Photography" appeared under the title "Bemerkungen über wissenschaftliche Anwendungen der Photographie," vol. 2, 1888, pp. 284–286, of the *Jahrbuch für Photographie und Reproductionstechnik*.

Ludwig Mach's paper "On the Principle of Temporal Diminution in Serial Photography" is included under the title "Ueber das Princip der Zeitverkürzung in der Serienphotographie," vol. 7, 1893, pp. 121–128, of the *Photographische Rundschau*.

The captions are added; the figures in the original publications do not have captions. In addition, the one figure in Mach's text on the application of photography originally bears the number 28 (the figures are numbered throughout the issue of the *Jahrbuch für Photographie*).

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