Evaluation:

Relativity and the a priori: Reconsidering Friedman's Dynamics of Reason *in light of Darrigol's comprehensibility principles*

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This is an outstanding Doktoral, and the assessment committee are in complete agreement that it is worthy of being defended. The author, Claus Festersen, takes up a timely and challenging topic—the role of *a priori* reasoning in the transition from Newtonian physics to Albert Einstein's theory of relativity. In this report we sketch the background to the research area, outline the objectives and structure of the Doktoral, give a detailed summary, and then critically discuss Festersen's contributions. We conclude with our overall evaluation: this is an excellent piece of work, one that demands a defence.

Background

The role of *a priori* reasoning in physics, and in particular the transition from Newtonian physics to Einstein's theory of relativity, is an issue that drove major disputes in twentieth century analytic philosophy. The logical positivists believed that Einstein's theory of relativity destroyed Immanuel Kant's notion of the synthetic *a priori*. They proposed replacing it with Henri Poincaré's notion of a convenient convention. But then W.v.O. Quine argued that the notion of a convention—or, more generally, of any analytic truth—could not be made sense of. Quine's views on this and related questions set the precedent for much of what occured in analytic philosophy from the 1960s until today.

However in the late 1990s, Michael Friedman argued that Quine had misunderstood the logical positivists, and more importantly, that the history of science cannot be understood without some role for *a priori* principles. Friedman attempted to revive a notion that can be found in the early work of Hans Reichenbach, namely that at each stage of the evolution of science, there must be some constitutive principles, even if these principles change over time – in short, a form of "relativized apriori" . Friedman also linked this change of a priori principles to Thomas Kuhn's notion of a scientific revolution.

Friedman's revival of Reichenbach's "relativized apriori" has not yet had much influence in mainstream analytic philosophy, which still operates under the influence of Quine, and his successors (for example, David Lewis). However, in 2004, an incisive analytic philosopher, Marc Lange, wrote a critical review of Friedman's book *The Dynamics of Reason*. Here Lange raised some difficult questions for Friedman's account of the origins of Einstein's (special) theory of relativity. But Lange's review was brief, and he didn't return to the topic. That left a crucial gap in the literature which Festersen has now filled with this Doktoral.

Objectives and structure

The main purpose of this Doktoral is to confront Michael Friedman's notion of the "relativized a priori" with the history of (special) relativity and to propose improvements of this notion in the light of the Helmholtzian notion of comprehensibility principle. The work is divided in three parts, the first on Friedman's notion, the second—by far the largest—on the historical genesis of special relativity and its various formulations and reformulations, and the third is an attempt to solve the contradictions between this history and Friedman's notion by means Olivier Darrigol's take on Helmholtzian comprehensibility.

To give a brief sketch of the argument (a more detailed summary follows), Festersen first agrees with Lange's criticism of Friedman. Indeed, Festersen shows in great detail that a given theory of physics (e.g. electrodynamics) does not necessitate one particular set of constitutive principles. Festersen suggests, however, that even if a theory doesn't necessitate a particular set of constitutive principles, it might still need some or other constitutive principles. Here the dialectic between Friedman, Lange, and Festersen is long and complex. However, to caricature the positions of Friedman and Lange somewhat: the former says that, at each stage of science, some principles are not up for grabs, but are presuppositions for the testing of other claims. In contrast, Lange adopts a position that looks like Quine's: at each stage of science, *everything* is up for grabs. In this dilemma, Festersen seems to side primarily with Friedman – his argument against the uniqueness of constitutive principles does not show that there is no need for constitutive principles. However, Festersen doesn't actually endorse, or try to defend, the details of Friedman's view. In fact, Festersen decides not to adopt the notion of "constitutive principles" at all. Instead he adopts a Darrigol's Helmholtzian notion of comprehensibility principle

Detailed Summary

The first part of the Doktoral reviews Michael Friedman's *Dynamics of Reason*, Friedman's later improvements, and a few objections he has received (those by Lange are at the beginning of Part II). Festersen recalls Friedman's original motivation, which was to avoid the pitfalls of Quinean holistic naturalism by reactivating the neo-Kantian views that Hans Reichenbach and Ernst Cassirer developed around 1920 in the wake of relativity theory. Festersen pays special attention to Friedman's identification of the relevant constitutive principles, defined as general and necessary presuppositions for the coordination between theory and experience. He emphasizes the uniqueness of Friedman's principles: even though the same empirical ground may be covered by two theories based on different sets of constitutive principles, their choice is unique in the specific philosophical context of each theory. In Friedman's approach, a lack of uniqueness would indeed jeopardize the coordination between theory and experiment, or so it seems. Festersen also addresses Friedman's understanding of the transition from one set of constitutive principles to another, including Poincaré's idea of elevating a broad empirical generalization to an organizing principle, and Einstein's meta-theoretical motivations for questioning received principles.

In the second part of his Doktoral, Festersen begins by recalling Marc Lange's main criticism of Friedman's *Dynamics of Reason*, which is the lack of proof for the alleged uniqueness of

constitutive principles. He then proceeds to an extensive historical inquiry in the origins, different versions, and reformulations of relativity theory, with the aim of shedding more light on presumptively constitutive principles. The result is impressively detailed, lucid, and accurate, and it corrects many misunderstandings found in the simplified histories on which philosophers too often rely. For some notoriously difficult texts such as Poincaré's memoir of 1900 on “Lorentz's theory and the principle of reaction” or Poincaré's more famous Palermo memoir of 1906, the author has produced highly authoritative analyses, sometimes covering aspects that historians have heretofore neglected. One may naturally wonder whether such thoroughness was needed to decide the philosophical issues in which the author is primarily interested. There is little doubt, however, that the main conclusions he drew regarding the implied kinds of a priori would not have been apparent in a more superficial inquiry.

These conclusions and their conflict with Friedman's views are summarized at the beginning of Part III. The first point concerns Friedman's choices of Newton's three laws of motion as constituting Galilean space-time. Although this choice echoes Kant's own transcendental derivation of these laws, it does not square well with Friedman's analysis of Poincaré's version of relativity theory. Indeed, Friedman asserts that Poincaré maintained Galilean space-time in his theory, and at the same time he (Friedman) regards Newton's second law as constitutive of this space-time. As Festersen remarks, Friedman thereby ignores the fact that Poincaré, since 1904 at least, believed in the necessity of a new dynamics to replace Newtonian dynamics. Another choice of constitutive principles, implying only Newton's first law, would seem more adequate in this context. Festersen's second point is the possibility of conceiving constitutive principles valid both for Galilean and for relativistic space-time. Not only several choices of constitutive principles would be possible for the same theory, but two different theories could be made to share the same constitutive principles. According to Festersen, Ignatowski achieved the latter sharing in 1910 when he proved that the principle of relativity and principles of homogeneity together led to the Lorentz group and to the Galilean group as a limiting case of the former. Altogether, according to Festersen, Friedman exaggerates the difference between Poincaré's and Einstein's theories by having Poincaré stick to Newton's laws as constitutive principles, and also by ignoring the possibility of shared constitutive principles.

In the rest of Part III, Festersen argues that the very notion of constitutive principle fails to capture the kind of relativized *a priori* that is needed to understand the relativistic revolution, and he proposes to replace this notion with the type of comprehensibility principles Olivier Darrigol proposed as an alternative to the neo-Kantian approaches of (young) Reichenbach, Cassirer, and Friedman.

The main ideas Festersen retains draws from Darrigol’s approach are the following:
– The constitutive principles named by Friedman are not the effective means for the coordination between theory of experiment. What truly serves this function is a variable set of interpretive schemes, namely blueprints for conceivable experiments involving the formal characterization of measurable quantities by means of theoretical modules that can be trusted independently of the core theory.

– Owing to their variability (within the same theory as its application evolves), the interpretive schemes are not a good candidate for a new definition of the relativized *a priori*.
– A better candidate is the comprehensibility principles, namely principles of measurability, causality, correspondence, homogeneity etc. that can be judged natural at a given stage of the history of physics and that sometimes suffice to derive an entire theoretical framework. The choice of these principles is not unique, and their precise implementation depends on preconceived interpretive schemes and on previously known theoretical modules. Their naturalness and their structuring power make them good candidates for a relativized constitutive apparatus.

Although Festersen draws on these ideas from Darrigol's work, his motivations are somewhat different, and so is the way he implements them. Arguably, the main defect of Friedman's approach is the impossibility of drawing a clear line between constitutive principles and empirical laws in a given theory, whereas Festersen believes the lack of uniqueness in the choice of principles to be in itself problematic. As for the implementation of comprehensibility principles, Darrigol was mostly interested in showing that they enable us to rationalize a given theory by deducing it from a small set of natural presuppositions about a comprehensible world—he did not say much on the transition from one theory to the next, except that this transition sometimes involves comprehensibility arguments and that in some cases the new theory may be obtained by weakening an earlier set of comprehensibility conditions. In contrast, Festersen dwells on the transition from Newtonian to relativistic physics, and he argues that comprehensibility principles served to orient this transition. In particular, he shows that Poincaré, Einstein, and Ignatowski all essentially relied on principles of homogeneity (in addition to the relativity principle), which partly explains why they arrived at equivalent theories.

To give a little more detail here: it was recourse to additional comprehensibility principles—of measurability for Einstein, or of least action for Poincaré and Landau—that led to different versions of the relativity theory. The lack of uniqueness in the choice of these principles is here a virtue, since according to Festersen different principles serve different versions of the relativity theory. In particular, Festersen shows that Landau's combined use of principles of homogeneity, relativity, and least action simultaneously generates kinematics and dynamics, whereas Einstein and Ignatowski generate firstly a new kinematics. As Festersen realizes, an essential condition for the comparison of the empirical contents of different theories (either for the sake of equivalence or for the sake of correspondence arguments) is their sharing a set of interpretive schemes. He gives an example of such sharing in his chapter on trolley clocks that can be described both in relativistic and non-relativistic contexts.

Assessment and critique
Evident qualities of the Doktoral are the great clarity of expression and presentation, the careful reading of source texts, the conceptual precision, and the serious attention to technical details. There are no useless digressions, the author goes directly to the main points, and he is able to convey difficult arguments in simple, lucid terms.

Another key quality is the importance accorded to history. Although Friedman himself paid more attention to the history of physics than the average philosopher of physics does, and although he has produced valuable insights into some aspects of the history of relativity, he has never engaged in a full-fledged historical inquiry or studied much of the relevant secondary literature. In contrast, Festersen judged it necessary to enter the details of the history of relativity in order to gauge philosophical interpretations of the implied conceptual transitions. He has studied the historic papers in detail, reconstructing with skill and precision the tricky bits of reasoning, including detailed mathematical calculations. His grasp of the material here is always sure-footed. This kind of careful scientific reconstruction can only be done by someone who has mastered a great amount of physical science, which is quite impressive given the philosophical (and historical) sophistication of the Doktoral.

On the negative—or perhaps neutral—side, Festersen does not always offer precise definitions of the terminology he uses, as one would expect if this were a Doktoral written for an analytic philosophy department. For example, in his discussion of Lorentz and Poincaré's reasoning about electromagnetism, Festersen frequently invokes a notion of a phenomenon being “invariant” without saying how this word is to be understood. That said, this is not written in the genre of analytic philosophy, and asking it to meet the criteria of that genre would be a bit unfair. The strength of this Doktoral lies, rather, in historical understanding, and in understanding of the details of scientific theory.

Overall evaluation
Altogether, this Doktoral demonstrates its author's superior command of the history of relativity theory in its most subtle aspects, and his ability to exploit this history in assessing the merits and difficulties of competing varieties of neo-Kantianism. The third part of this Doktoral contains original and convincing arguments in favor of a variety of neo-Kantianism better adapted to the genuine history of relativity, and we hope that it will trigger further research in this direction. The members of the committee are unanimous in finding this to be a first-rate contribution, one that has earned the right to be defended.

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