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The constitutive a priori and the distinction between mathematical and physical possibility

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ABSTRACT

This paper is concerned with Friedman's recent revival of the notion of the relativized a priori. It is particularly concerned with addressing the question as to how Friedman's understanding of the constitutive function of the a priori has changed since his defence of the idea in his *Dynamics of Reason*. Friedman's understanding of the a priori remains influenced by Reichenbach's initial defence of the idea; I argue that this notion of the a priori does not naturally lend itself to describing the historical development of space-time physics. Friedman's analysis of the role of the rotating frame thought experiment in the development of general relativity – which he suggests made the mathematical possibility of four-dimensional space-time a genuine physical possibility – has a central role in his argument. I analyse this thought experiment and argue that it is better understood by following Cassirer and placing emphasis on regulative principles. Furthermore, I argue that Cassirer's Kantian framework enables us to capture Friedman's key insights into the nature of the constitutive a priori.

1. Introduction: Friedman and the Kantian legacy in contemporary philosophy of science

Friedman's (2001) *Dynamics of Reason* has been greatly influential in the recent move to re-evaluate the relevance of Kant's philosophy for contemporary philosophy of science.[1] Friedman's project is most well-known for his attempt to rehabilitate Reichenbach's notion of a relativized, yet still constitutive, version of Kant's a priori. In the *Dynamics of Reason*, Friedman's position is very close to Reichenbach's. He argues that certain physical principles – notably the equivalence principle and the light postulate – are coordinating principles that perform precisely the same role as Reichenbach's *axioms of coordination*: that is, they serve to coordinate physical experience with mathematical formalism. However Friedman has moved away from treating the relativized a priori in this way because (i) it assumes an over-simplified formalistic understanding of abstract mathematics and (ii) "even worse" portrays abstract mathematics as being directly attached to intuitive perceptible experience.[2]

Friedman now defends a historicized version of transcendental philosophy in which relativized constitutively a priori principles are appealed to in order to explain the application of pure mathematics to perceptual experience in successive theories of space-time and motion. So, while he no longer tacitly accepts Reichenbach's formalistic account of mathematics, Friedman still argues that constitutive principles are required in order to relate perceptual experience to mathematical formalism.

The central argument of this paper is that constitutive principles – as Friedman understands them – did not play a role in the historical development of space-time theories. Friedman's account of constitutive principles rests heavily upon his interpretation of the role of the equivalence principle and the rotating disk thought experiment in the development of general relativity. I examine the significance of this thought experiment and argue that while it had an important role to play in motivating Einstein to use four-dimensional mathematical

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[1] In particular DiSalle (2006), Massimi (2005) and Ryckman (2005) all seek to respond to features of Friedman's account. There have also been collections of essays devoted to exploring the relevance of Kantian themes for contemporary philosophy of science: see, Bitbol, Kerszberg, & Petitot (2009), Domski & Dickson (2010), Massimi (2008) and Suarez (2012).

[2] Friedman (2010, p. 698).

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methods in order to represent rotations, this does not warrant the additional claim that the equivalence principle – through its role in the thought experiment – should be viewed as constitutive of general relativity.

This does not mean, however, that Friedman's broader goal of understanding the development of space-time theories in Kantian terms need fail. Friedman aligns his project with Reichenbach's (1965) attempt in *The Theory of Relativity and A Priori Knowledge* (1965 [1920]) to relativize the constitutive a priori; however I argue that Cassirer's account of the development of general relativity in *Einstein's Theory of Relativity* (1923 [1921]) provides a more plausible – yet still Kantian – means to understand the development of the theory.

Cassirer and Reichenbach represent two divergent Kantian methodologies. Reichenbach took the most significant Kantian claim to be that there was a constitutive function of the a priori. So, he argued that physical principles can be understand as a priori in a meaningful sense if they are constitutive from the perspective of a particular theory. In Kant's philosophy the constitutive function of the a priori is closely related to the division of the human intellect into the faculties of sensibility and understanding[3]: it is precisely the rejection of this division that marks Cassirer's alternative approach. For Cassirer the Schematism – in which Kant argued that objects could be brought under concepts only by appeal to mediating spatial and temporal *schema* – is the most significant feature of Kant's philosophy. Without the manifold of intuition, this solution is impossible. As such, Cassirer's transcendental logic sought to provide an alternative to the Schematism according to which objects are brought under concepts by emphasising a functional understanding of objects.[4] While Cassirer, like Reichenbach, did attempt to provide an account of constitutive principles[5] he placed much greater emphasis on the regulative role of reason in Kant's philosophy and sought to develop an understanding of contemporary science that is based upon regulative principles.

Friedman has sought to distance his work from Cassirer's brand of neo-Kantianism. In particular, Friedman has expressed reluctance to follow Cassirer in rejecting an independent faculty of sensibility and, instead, seeks to reconfigure the Kantian understanding of sensibility so that it retains a significant role in his account of the development of physics.[6] The reason that Friedman is reluctant to follow Cassirer is that if we reject an independent faculty of sensibility, it becomes impossible to distinguish between constitutive and regulative principles. This is because, for Kant, constitutive principles are those that govern the application of the intellectual faculties – understanding and reason – to the distinct faculty of sensibility. Regulative principles are those that govern the operation of the intellectual faculties independently of sensibility. Friedman's concern, then, is that if there is no distinction between understanding and sensibility, then it is not clear how we can distinguish between constitutive and regulative principles.

In Section 4.2 I will outline a different way to understand the distinction between constitutive and regulative principles. I argue that this means that Cassirer's framework provides a more promising means to understand the relevance of the relativized a priori in contemporary philosophy of science than Reichenbach's does; as such I recommend amending Friedman's account to reflect this alternative emphasis. I begin, in Section 2, by examining Friedman's account of the relativized constitutive a priori, focussing in particular on the modified account of his (2010) and (2012). Here Friedman argues that constitutive principles are those that have played a historical role in making purely mathematical possibilities physically meaningful. Friedman places great emphasis on the role of the rotating disk thought experiment in the development of general relativity as an example of this process: as such, in Section 3 I turn my attention to the question of whether Friedman's analysis of the role of this thought experiment in the development of general relativity is correct. I argue that it was important because (i) it led Einstein to introduce four-dimensional mathematical methods and (ii) because it prevented Einstein treating coordinate differences as corresponding to measurements with rods and clocks. In Section 4.1 I argue that Cassirer's neo-Kantianism provides a quite natural description of the process by which Einstein came to represent gravitation as curvature of four-dimensional space-time. Finally, I develop an alternative understanding of constitutive principles, which both captures the historical development of general relativity and does not require the problematic commitment to a contemporary analogue of Kant's faculty of sensibility.

2. The dynamics of reason and the relativized synthetic a priori

Friedman's account of the nature of scientific theories is a development of his earlier work on the philosophy of the early logical empiricists. His reconstructive account of the early works of Moritz Schlick, Hans Reichenbach and, especially, Rudolf Carnap has proven hugely influential in reversing the perception – prevalent at the end of the twentieth century – of logical empiricism as a deeply flawed research programme. Friedman (1999) showed that the early work of each of these key logical empiricist figures was deeply influenced by Kantian considerations. In his *Dynamics of Reason* (2001) Friedman sought to develop his work on logical empiricism into an account of conceptual change in science. The project can be seen as addressing two central questions. The first is as to how theoretical concepts acquire empirical content. Friedman answers this along Reichenbachian lines by appealing to the relativised a priori: i.e. some empirical content must be assigned to theoretical concepts to ensure the concept's empirical applicability. There are two philosophical developments that pose significant obstacles to a contemporary defence of the relativized a priori: Quinean epistemological holism and the Kuhnian account of scientific revolutions. Epistemological holism questioned any distinction between constitutive and empirical principles and Kuhn's historiography of science accepted the importance of conceptual frameworks but insisted that precursor and successor frameworks were radically incommensurable.

Against Quine, Friedman argues that scientific theories are better understood as having a coordinative part to link abstract theoretical concepts with empirical content. Against Kuhn he suggests that there is a role for philosophy in securing commensurability between paradigms. Philosophy, he claims, acts as a "meta-paradigm" in which ideas from competing paradigms can be discussed and this allows scientists of differing paradigms to have meaningful discourse. Friedman, then, ultimately argues that science has the following, tripartite, structure:

(1) The base level consists of empirical laws which are directly tested by rigorous experimentation.
(2) The intermediate level consists of the set of constitutive a priori principles that enable empirical testing.
(3) A final level consisting of philosophical meta-paradigms which motivate and sustain scientific revolution.

[3] This is why, as we see in Section 2, in seeking to relativize the constitutive a priori Friedman attempts to reconfigure the distinction between sensibility and understanding.

[4] I introduce Cassirer's function-theory of concepts in Section 4. For an excellent recent discussion of Cassirer's function-theory of concepts see also Heis (2011b).

[5] The extent to which Cassirer was successful in this respect is disputed: I discuss the extent to which Cassirer is able to provide an account of constitutive principles in Section 4.

[6] This goal is explicit: see Friedman (2012, pp. 47–48). I discuss Friedman's reconception of the Kantian faculty of sensibility in Section 2.