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Measurement, coordination, and the relativized a priori

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ABSTRACT

The problem of measurement is a central issue in the epistemology and methodology of the physical sciences. In recent literature on scientific representation, large emphasis has been put on the "constitutive role" played by measurement procedures as forms of representation. Despite its importance, this issue hardly finds any mention in writings on constitutive principles, viz. in Michael Friedman's account of relativized a priori principles. This issue, instead, was at the heart of Reichenbach's analysis of coordinating principles that has inspired Friedman's interpretation. This paper suggests that these procedures should have a part in an account of constitutive principles of science, and that they could be interpreted following the intuition originally present (but ultimately not fully developed) in Reichenbach's early work.

1. Introduction

A distinguished feature of Reichenbach's philosophical approach has always been the analysis of science.[1] His epistemological doctrine was in fact mainly motivated by the analysis of physical theories and their structure, as well as by the understanding of scientific *practice*, especially at the very outset of his career. Most of Reichenbach's later ideas then developed from his early writings, even though on various occasions he rejected the foundation of the early account.

An important reassessment of his early work has been presented by Michael Friedman in his *Dynamics of Reason* (2001), where he suggests a reinterpretation of Reichenbach's original idea of a priori yet *revisable* constitutive principles, for which he coined the expression "relativized a priori". In the literature that has been flourishing around this idea, the discussion has been typically revolving around general principles such as the light principle, the principle of equivalence, the principle of the least action, and the sort, all having a fundamental structural significance for the theory.[2] For the most part, these discussions have not considered the peculiar role played by measurement (and, accordingly, scientific instruments), despite its importance.[3] Recently, however, Friedman has taken some steps in this direction by sketching a reconfigured Kantian faculty of sensibility[4] that interestingly comprises some pragmatic aspects.[5] "The solution I am now exploring–he writes–involves replacing the Kantian faculty of sensibility with what we now call physical frames of references–ostensively introduced and empirically given systems of coordinates (spatial and temporal) within which empirical phenomena are to be observed, described, and measured" (2012, p. 48). In

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[1] As Reichenbach stated in 1936, "[t]he program for a philosophical method in the form of an analysis of science was first published within the context of [logistic empiricism] by the author in 1920. What he demanded was the introduction of a method of analysis of science (*wissenschaftsanalytische Methode*) into philosophy." Reichenbach (1936, p. 142).

[2] See, for instance, Friedman (2001), Ryckman (2005), and Stöltzner (2009).

[3] Defining measurement in an exhaustive way is quite difficult. For a survey of various trends in the philosophy of measurement, see Tal (2013). In this paper, I will mainly refer to measurement as to a process that, broadly speaking, aims at representing and producing knowledge of the physical world, and that is primarily conceived as involving both an interaction between instruments and the physical quantities that they are purported to measure directly, and its theoretical representation.

[4] As he explains, "I want to preserve some kind of independence for a faculty of sensibility conceived along broadly Kantian lines. In *Dynamics of Reason* I attempted to do this by appealing to physical coordinating principles (in the sense of the early Reichenbach), whose role is precisely to relate abstract mathematical concepts (such as the Newtonian concepts of absolute space, time, and motion) to concrete physical phenomena (such as the observed motions of the heavenly bodies in the solar system). And this is the primary example, in fact, of what I called 'constitutive' principles (here the Newtonian Laws of Motion). I now think, however, that this notion of distinctively constitutive principles is too thin, in so far as it does not attribute to what is given in sensibility a sufficiently rich and independent a priori structure" (2012, p. 48).

[5] See in particular his response to Mormann (2012) in Friedman (2012).

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addition, he includes elements that can be traced back to the manifold social, institutional, and engineered experimental context with which the process of observation and empirical testing is entangled. On his new account, "Kant's reliance on the a priori structure of the faculty of sensibility necessarily common to all human beings is replaced by the demand of the experimental (and therefore technological) community for universally communicable (replicable) results" (2012, p. 50). This idea of "universal intersubjectivity" has now become "a regulative ideal of reason" in Kantian terms. This ultimately leads to a revision of the Kantian distinction between constitutive and regulative principles: the latter are the ones that push theory change towards the regulative ideal of objectivity and systematicity, whereas the former, historically, are those that appear to be essential in making new laws possible, that is, they determine a conceptual framework within which the laws can be applied to experience.

In this paper, I will mainly focus on the principles that are supposed to play a constitutive role and I will argue that, independently of the principles that are interpreted to act as the fundamental ones, an account of relativized a priori principles should also be considering the peculiar function carried out by the procedures that govern the application of concepts of measure in order to define the objects of experience and so in "constituting" (i.e., allowing for the identification of) these objects. The function played by measurement procedures should indeed not just be accounted for from the wider point of view of institutional communities, or in engineered experimental contexts, but also from this more specific perspective.[6] In Friedman's account, the constitutive function of these procedures is not fully appreciated. Yet much to the contrary, it was at the heart of Reichenbach's analysis of coordinating principles. This paper, therefore, suggests that the specific role that can be performed by measurement procedures should have a part in an account of constitutive principles of science, and proposes a possible way to interpret them following the intuition originally present (but ultimately not fully developed) in Reichenbach's early work.

2. Friedman, Reichenbach, and the relative "a priori"

What are, exactly, relativized a priori principles? In general, they are interpreted as theory-relative preconditions of knowledge that play a crucial role in providing the mathematical machinery of a (physical) theory with an empirical interpretation–that is to say, they coordinate abstract, mathematical structures with reality. Further, they are supposed to be "constitutive" for a scientific framework and to have empirical content at the same time, without being confirmed or disconfirmed within the framework in which they operate. In Friedman's words,

> "Without a constitutive framework, the putatively empirical laws would have no empirical content after all, but would simply belong to the domain of pure mathematics. With a constitutive framework already in place, however, properly empirical laws can be confronted with sensory experience and the empirical world in a particularly clear and direct fashion: one can compare *calculated values of various physical magnitudes and parameters* […] with actually observed and measured values and thereby obtain an exact quantitative estimate of the fit between theory and experience" Friedman (2001, p. 83). [emphasis added]

Despite being a priori, and therefore necessary, such principles can be modified in the light of further scientific developments. But how is it possible for empirical principles to come to possess the status of relativized a priori principles? How is it possible to individuate them? The most natural way to proceed is to provide a historical analysis of the role played by certain principles in the various stages of science and their fate in the successive stages. In Friedman's historical analysis, a paradigmatic example is represented by the light principle because of its significance for relativity. As he puts it, Einstein uses his light principle "as the basis for a radically new spatio-temporal coordination", that is, "*empirically to define* a fundamentally new notion of simultaneity, and, as a consequence, fundamentally new metrical structures for both space and time (more precisely, space-time). […] Einstein calls the whole classical structure into question and uses the very same empirical discovery empirically to define a new fundamental framework for space, time, and motion entirely independently of the classical background. […] Einstein has 'elevated' an empirical law to the status of a coordinating, constitutive principle" (2001, p. 88).[7] Thus, a constitutive framework plays a crucial role in defining what Friedman refers to as a space of empirical (i.e., "logical plus real") possibilities, "a network of inferential evidential relationships, generated by both logical mathematical principles and physical coordinating principles, that defines what can count as an empirical reason or justification for any given real possibility" (2001, p. 85).

Recently, Friedman has further enriched his Kantian conception by presenting us with a "fundamentally *historicized* version of scientific intersubjective rationality" (2011, p. 432), in which the criteria for objectivity appear to be always local and contextual, namely by emphasizing how some "developments in modern science and philosophy […] have been inextricably entangled with technological, institutional, and political developments" (2011, p. 436). In this improved view, "[a]bstract (purely intellectual) mathematical reasoning acquires a necessary and very productive relationship with the concrete technological practice of experimenters and engineers" (2012, p. 50). As I mentioned in the previous Section, the notion of "universal intersubjectivity" now plays the role of a regulative ideal of reason, which "guides the progress of science as a whole towards a never actually completed goal without constitutively constraining it via prior necessary human cognitive faculties" (2012, p. 50).

However, even in this broadened perspective, Friedman does not consider the potentially constitutive role that measurement can play per se in the development of a scientific theory. In fact, as we saw in the quotation at the beginning of this Section, he basically assumes the part concerning how to "compare calculated values of physical magnitudes and parameters" (2001, p. 83) to be *fully* depending on the constitutive (and/or regulative) elements of the corresponding framework in place, and by doing so, he takes the identification of those physical magnitudes already for granted. Besides, although it is somewhat inspired by Reichenbach's (1920) interpretation, Friedman's account of relativized a priori principles does not capture the extent of Reichenbach's early worry and intuition, and so does not consider an aspect that, in my view, should deserve more attention in his proposal. Reichenbach's epistemology was basically geared towards physical practice and while he certainly did not elaborate on the "nature" of those physical quantities, he nonetheless did intend to capture the idea that these quantities are in some sense "constructed" because of the idealization and the approximation necessarily implied by measurement procedures. In other terms,

[6] This paper will not discuss "meta-issues", so to speak, such as whether Friedman's approach is actually viable. It will also not the cover issues such as the one, recently raised by Shaffer (2011), of the epistemic justification of the choice of constitutive principles instead of conventions, which would require a thorough discussion on regulative principles. My focus, here, is not if and possibly how the constitutivist view can provide a better response to the charge of irrationality that might be addressed to a conventionalist account of principles, but rather to underline that the potentially constitutive role of measurement procedures should be included in an account of the relative a priori.

[7] See, however, DiSalle (2002) for an interesting different interpretation.