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SPECIAL ISSUE
THE FABULOUS 1930s IN THE HISTORY OF SCIENCE AND TECHNOLOGY

Similarities, Differences, and Missed Connections between Thomas S. Kuhn, Gaston Bachelard and the Continental Historiography of Science

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Abstract: According to the American philosopher, Michael Friedman, while triggering the so-called "historical turn," Kuhn reinstated the history of science as perhaps the most important object for the philosophy of science. In this paper, I show that this reinstatement is rather a rehabilitation of the philosophical and epistemological uses of the history of science, something already present in the continental historiography of science in the first half of the twentieth century, and especially in Gaston Bachelard's work. In this sense, I undertake a review of the European history and philosophy of science during that period, paying special attention to Gaston Bachelard as one of the leading representatives of the French historical epistemology of the 1930s. I conclude with the late and quite problematic reception of Bachelard's thought in the early work of Thomas S. Kuhn. My thesis is this strand may help to outline what is continental history and philosophy of science.

Keywords: Continental history and philosophy of science; historicity of the scientific categories; philosophical uses of history of science; neo-Kantianism; historical epistemology

Is There a Continental History and Philosophy of Science?

In the last years, there has been a growing interest in the history and philosophy of science coming from continental traditions.[1] In this sense, Gary Gutting's edited book *Continental Philosophy of Science* is one of the most systematic attempts to clarify the topic.[2] For this former professor at Notre Dame University, Immanuel Kant's critical epistemology is indeed the very beginning of philosophy of science as an autonomous knowledge. According to Gutting, the need to distinguish Galileo Galilei's, René Descartes' and Isaac Newton's contributions to modern science from traditional philosophy implied a fundamental shift in the understanding of the aprioristic assumptions. Empirical approaches and methodologies produced during the seventeenth century showed the possibility of separating the philosophical knowledge from scientific knowledge. Gutting suggested "a rough but useful"[3] taxonomy for continental philosophy of science through different basic attitudes regarding the relationship between philosophy and science. On the one hand, the empirical or positivist attitude considers that science has an independent status, and philosophy is a kind of secondary reflection, which explicit the outcomes obtained by science and the methods used to reach them. Another attitude, more related to Kantian criticism, believes that science provides original knowledge, but it is in philosophy where the conditions that make scientific knowledge possible are shown. The philosophical justification requires the assumption of the validity of scientific knowledge, but the philosophical analysis is the only one connected to the realm of transcendental truths. The third and last attitude, the ontological or metaphysical one, states that the access to philosophical truths is entirely independent and even superior to science. According to Gutting, the empirical attitude is typical among scientists and philosophers who are deeply committed to science. For instance, this is the case of Ernst Mach, in Germany, and Henri Poincaré and Pierre Duhem, in France. The second attitude, the critical one, finds the greatest development with French and German neo-Kantianism. In particular, authors such as Jules Lachelier, Émile Boutroux, Léon Brunschwicg or Bachelard are representatives of the French neo-Kantianism. Instead, the German neo-Kantianism would consist of two different Schools, the Marburg school, represented by Hermann Cohen, Paul Natorp and Ernst Cassirer, and the Southwest school, with Wilhelm Windelband, Heinrich Rickert and Emil Lask. The Frankfurt School, especially Jürgen Habermas, would also be linked to this position. The last of these attitudes, the ontological one, would have its earliest expression with Henri Bergson and Wilhelm Dilthey's *Lebensphilosophie* (Philosophy of Life), the Husserlian phenomenology and, subsequently, with Martin Heidegger's hermeneutics of facticity and with Maurice Merleau-

[1] See, for instance, Mary Domski and Michael Dickson, eds., *Discourse on a New Method: Reinvigorating the Marriage of History and Philosophy of Science* (Chicago and La Salle: Open Court, 2010).

[2] Gary Gutting, "Introduction: What is Continental Philosophy of Science?" in *Continental Philosophy of Science*, ed. Gary Gutting, 1-16 (Oxford: Blackwell Publishing, 2005).

[3] Ibid., 1.

Ponty's phenomenology. A further continuation may be found, according to Gutting, in Gilles Deleuze's and Luce Irigaray's post-structuralism, among other traditions.

Gutting's attempt to map the continental philosophy of science was not followed by other analogous attempts to map the continental history of science. In this sense, a special issue on the fabulous 1930s in the history of science and technology provides a good occasion to resume this endeavor. Continental history and philosophy of science is indeed a neglected tradition overlooked by dominant analytical philosophy of science, a sort of non-received view in contemporary history and philosophy of science, i.e., in the English-speaking world. In order to clarify this issue, I will analyze the relations among Kuhn, the neo-Kantianism of Marburg and some contributions from the French historiographical tradition, in order to show that this theoretical strand may help to outline what is continental history and philosophy of science. I will argue that the missed connections between Thomas S. Kuhn and the European historiography of science may be seen as a crucial episode in the misunderstanding and dismissing of this continental tradition.

Through the consolidation of logical empiricism, philosophy of science not only took a formal turn but also discarded any historical approximation. A remarkable exception to this trend comes from the French world, which preserved a distinctive historical style in the formulation of philosophical problems and, more importantly, a theory of scientific knowledge inseparable from time. Certainly it was not Kuhn to "kill logical empiricism"[4] but he contributed decisively to the subsequent historicist backfire, rediscovering and elaborating on some historical and philosophical elements of the European tradition, although, at the same time, what is possibly the main contribution of the continental history and philosophy of science of the 1930s, the so-called "historical epistemology,"[5] was being overshadowed. Concerning this point, it should be emphasized that historical epistemology shares with Kuhn both the French background and some element of neo-Kantianism, although the historians disregarded by Kuhn are also those who had the greatest impact on historical epistemology, namely, Georges Canguilhem,[6] Bachelard and, to a lesser extent, Léon Brunschvicg. In this sense, I take historical epistemology to be in the perfect position to act as connecting point between the conventional history

[4] George A. Reisch, "Did Kuhn Kill Logical Empiricism?" *Philosophy of Science* 58, no. 2 (1991): 264-77. Further details in his *The Politics of Paradigms. Thomas S. Kuhn, James B. Conant, and the Cold War 'Struggle for Men's Minds'* (Albany: SUNY Press, 2019), chapter 10.

[5] Dominique Lecourt, *L'épistémologie historique de Gaston Bachelard* (Paris: Vrin, [1969] 1978). Translated by Ben Brewster as part of Dominique Lecourt, *Marxism and Epistemology. Bachelard, Canguilhem and Foucault* (London: NLB, 1975), 23-118.

[6] Unfortunately, I am not able to pay attention here to Canguilhem. I refer the reader to Francisco García Vázquez, *Georges Canguilhem. Vitalismo y ciencias humanas* (Cádiz: Universidad de Cádiz, 2019).

and philosophy of science and the continental history and philosophy of science.[7] To the aim of clarifying this topic, I will briefly review both the influence on Kuhn of the continental historiography of science and the contributions of several forerunners to early historical epistemology, as to then conclude on the famous missed connection between Kuhn and Bachelard.

Thomas S. Kuhn and the Continental History and Philosophy of Science

In the preface to *The Structure of Scientific Revolutions*, Kuhn acknowledges the influence on his work of several historians of science—whose names are not always famous. There he tells us about him abandoning academic and professional projects in the field of physics to devote himself entirely to the history of science. During his studies he had followed several seminars on philosophy and history, but after making up his mind he continued "to study the writings of Alexandre Koyré and first encountered those of Émile Meyerson, Hélène Metzger, and Anneliese Maier." According to him, this group shows "[more] clearly than most other recent scholars, . . . what it was like to think scientifically in a period when the canons of scientific thought were very different from those current today."[8] Evidence seems to suggest that from the systematic reading of these texts Kuhn found "a function for the history of science" ensuing from a non-cumulative understanding of scientific change:

> Historians of science have begun to ask new sorts of questions and to trace different, and often less than cumulative, developmental lines for the sciences. Rather than seeking the permanent contributions of an older science to our present vantage, they attempt to display the historical integrity of that science in its own time. They ask, for example, not about the relation of Galileo's views to those of modern science, but rather about the relationship between his views and those of his group, i.e., his teachers, contemporaries, and immediate successors in the sciences. Furthermore, they insist upon studying the opinions of that group and other similar ones from the viewpoint—usually very different from that of modern science—that gives those opinions the maximum internal coherence and the closest possible fit to nature. Seen through the works that result, works

[7] A more detailed account of this issue is included in Alberto Fragio, *De Davos a Cerisy-La Salle: la epistemología histórica en el contexto europeo* (Saarbrücken: Editorial Académica Española – Lambert Academic Publishing, 2011). Additionally, I aimed to contribute to the continental history and philosophy of science through two studies that connect historical epistemology with Hans Blumenberg's metaphorology, notably concerning the epistemological function of metaphors in the history of astronomy in the twentieth century and in the history of psychology in the nineteenth century: Alberto Fragio, *Paradigms for a Metaphorology of the Cosmos: Hans Blumenberg and the Contemporary Metaphors of the Universe* (Roma: Aracne Editrice, 2015); Alberto Fragio, *Metaphors of Subjectivity in the 19th Century Psychology, and other Essays* (Roma: Aracne Editrice, 2015).

[8] Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 2nd ed. (Chicago: University of Chicago Press, [1962] 1970), v–vi.

> perhaps best exemplified in the writings of Alexandre Koyré, science does not seem altogether the same enterprise as the one discussed by writers in the older historiographic tradition.[9]

In an essay that here guides my account,[10] the American philosopher, Michael Friedman, reminds us that the preface is not the only place where Kuhn declares his early philosophical and historiographical affiliations. Moreover, not only there he revealed his detailed knowledge of authors such as Lange and Cassirer. In an article on the development of the history of science he claimed that a new

> attitude towards past thinkers came to the history of science from philosophy. Partly it was learned from men like Lange and Cassirer who dealt historically with people or ideas that were also important for scientific development. . . . And partly it was learned from a small group of neo-Kantian epistemologists, particularly Brunschvicg and Meyerson, whose search for quasi-absolute categories of thought in older scientific ideas produced brilliant genetic analyses of concepts which the main tradition in the history of science had misunderstood or dismissed.[11]

Finally, while replying to the criticism met by his work on Max Planck and the black-body theory[12] Kuhn would explain that "the concept of historical reconstruction that underlies [the Planck book] has from the start been fundamental to both my historical and my philosophical work. It is by no means original: I owe it primarily to Alexandre Koyré; its ultimate sources lie in neo-Kantian philosophy."[13]

All these quotations suggest that a clearly non-negligible thematic core of Kuhn's work ensues from the internalization of historicism caused by the crisis of Kantian transcendental philosophy: "The view toward which I grope would also be Kantian, but without 'things in themselves' and with categories of the mind which could change with time as the accommodation of

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[9] Ibid., 3. On new scholarship on Kuhn see Robert J. Richards and Lorraine Daston, eds., *Kuhn's* Structure of Scientific Revolutions *at Fifty. Reflections on a Science Classic* (Chicago: University of Chicago Press, 2016); Thomas S. Kuhn, *Desarrollo científico y cambio de léxico. Conferencias Thalheimer, Universidad Johns Hopkins, Baltimore, Maryland, Estados Unidos de América, 12 al 19 de noviembre de 1984* (Montevideo: Universidad de la República de Uruguay, 2017); Juan Vicente Mayoral, *La búsqueda de la estructura* (Zaragoza: Prensas de la Universidad de Zaragoza, 2017); Errol Morris, *The Ashtray (Or the Man Who Denied Reality)* (Chicago: University of Chicago Press, 2018).

[10] Michael Friedman, "Kuhn and Logical Empiricism," in *Thomas Kuhn*, ed. Thomas Nickles, 19–44 (Cambridge: Cambridge University Press, 2003).

[11] Thomas S. Kuhn, "The History of Science," in *International Encyclopedia of the Social Sciences* (New York: Crowell Collier and Macmillan, 1968). Reprinted as *The Essential Tension* (Chicago: Chicago University Press, 1977), quoted in Friedman, "Kuhn and Logical Empiricism," 29-30.

[12] Thomas S. Kuhn, "Revisiting Planck," *Historical Studies in the Physical Sciences* 14, no. 2 (1984): 231-52, reprinted in Thomas S. Kuhn, *Black-Body Theory and the Quantum Discontinuity, 1894-1912*, 2nd ed. (Chicago: Chicago University Press, [1978] 1987), 311-341, quoted in Friedman, "Kuhn and Logical Empiricism."

[13] Friedman, "Kuhn and Logical Empiricism," 30.

language and experience proceeded."[14] Clearly, only a very broad definition of Kantianism and neo-Kantianism makes it possible to gather all the authors mentioned by Kuhn within the same tradition. At any rate, what they all share is the rejection of radical empiricism applied to the evolution of science and, at the same time, the support of several different strands of epistemological constructivism. Both logical empiricism and the subsequent theories stemming from it would have excluded the history of science from the new logical-formal articulation of epistemology,[15] but, as Friedman claims, "it was . . . Kuhn's great merit . . . to have reinstated the history of science as perhaps the most important object considered in the philosophy of science."[16] It is important to remark, though, that this reinstitution is in the end nothing but some sort of new renaissance of the history of science as key instrument for philosophical and epistemological inquiries, something that would have been developed precisely by the historiographic tradition outlined by Kuhn and, in particular, by Gaston Bachelard in his works from the 1930s. One should also emphasize the fact that the representatives of the French historiography of science have not always favored disagreement both internally and with the German tradition championed by Cassirer. The following statement by Koyré—at some point a student of Husserl—shows this point:

> Fortunately it is no longer necessary nowadays to insist on the interest of the historical study of science. It is no longer even necessary—after the magisterial work of those such as Duhem and Émile Meyerson, Cassirer and Brunschvicg—to insist on the philosophical interest and fruitfulness of this study.[17]

Ernst Cassirer and Neo-Kantian History of Science

The key figure in the early neo-Kantian historiographical tradition is Ernst Cassirer (1874-1945) with his four-volume book, *Das Erkenntnisproblem in der Philosophie und Wissenschaft der neueren Zeit* (*The Problem of Knowledge in Modern Philosophy and Science*) (1906-1957).[18] His work provoked a great amount of replies and polemical responses. There is no doubt that, in a way or another, the work was abundantly read and quoted. Cassirer was one of the main supporters of a history of epistemology, faithful to the neo-Kantian Marburg school,

[14] Thomas S. Kuhn, *The Road since Structure: Philosophical Essays, 1970-1993, with an Autobiographical Interview*, eds. James Conant and John Haugeland (Chicago: University of Chicago Press, 2000), 207. Further details in Michael Friedman, "Kant, Kuhn, and the Rationality of Science," *Philosophy of Science* 69, no. 2 (2002): 171-190; Michael Friedman, "Ernst Cassirer and Thomas Kuhn: The Neo-Kantian Tradition in History and Philosophy of Science," *The Philosophical Forum* 39, no. 2 (2008): 239-252.

[15] Fragio, *De Davos a Cerisy-La Salle*, 70-89.

[16] Friedman, "Kuhn and Logical Empiricism," 35.

[17] Alexandre Koyré, *Galileo Studies* (Atlantic Highlands: Humanities Press, 1978), 1. Originally published as *Études Galiléennes*, 3 vols. (Paris: Hermann, 1939).

[18] Ernst Cassirer, *Das Erkenntnisproblem in der Philosophie und Wissenschaft der neueren Zeit* (Berlin: Verlag Bruno Cassirer, 1906-1957).

subsequently developed as a historicization of epistemology by his philosophy of symbolic forms. However, authors Émile Meyerson (1859-1933) and Alexandre Koyré (1892-1964), Léon Brunschvicg (1869-1944) and Hélène Metzger (1889-1944) or Eduard Jan Dijksterhuis (1892-1965) and Edwin A. Burtt (1892-1989) did not include his name in their texts for this achievement, but for having shed considerable light in his ground-breaking work on the scientific culture of the seventeenth century and having offered many rich interpretative suggestions. Among the most impactful stands is his Platonic interpretation of Galilean science as mathematization of nature, from whose gradual transformation would have derived also Hegel's philosophy. These historical modifications would ultimately show, according to Cassirer, the existence of formal structures with mathematical predisposition that stay unchanged for long periods of time and that are then applied to the empirically given natural world. As peak of this process, the modern concept of nature features the triumph of the mathematical concept of function over the substantialist obstacles of Aristotelian metaphysics.

Evidence is available of Meyerson's opposition to the functional epistemology of the Marburg school. Although he would agree on the need for an a priori requirement of subjectivity, which would allow to bestow meaning and organization on the results of empirical science, all philosophy of history attempting to liken the understanding of science to the universal laws regulating empirical phenomena was deemed by Meyerson as unacceptable. In one of his most important contributions, *Identité et réalité* (*Identity and Reality*) (1908), while arguing at the same time for the striking position according to which the identity of substance through change is a logical a priori of experience, he claimed that scientific knowledge must not be reduced to mere normativity mediated by consciousness.[19] Claims of the like would contradict the basic tenets of *Das Prinzip der Infinitesimal-Methode und seine Geschichte*[20] (The Principle of the Infinitesimal Method and Its History) (1883) by Hermann Cohen and the anti-substantialism supported by Cassirer in *Substanzbegriff und Funktionsbegriff* (*Substance and Function*) (1910). From the opposite front, Meyerson would argue that the logical a priori must be understood in terms of identity of substance. Throughout the several perceptible alterations of nature and throughout all historical transformation an immutable underlying substantiality must stay the same. In this respect, the scientific revolution of the seventeenth century, rather than the mathematization of nature, would be the reactualization of the mechanist atomism, according to which the elementary bodies preserve their properties despite undergoing local displacement. This is not the only example of identity beyond time. The principle of conservation of matter in Antoine-Laurent de Lavoisier and of energy in Hermann von Helmholtz and Gustav Fechner would be other examples one could mention here. Nevertheless, Meyerson was fully aware that

[19] Émile Meyerson, *Identité et réalité* (Paris: Vrin, [1908] 2001). Among his most renown works, one should mention also *De l'explication dans les sciences* (Paris: Payot, 1921). An English translation is available for both books.

[20] Hermann Cohen, *Das Prinzip der Infinitesimal-Methode und seine Geschichte* (Berlin: Dümmler, 1883).

the cognitive requirements of identity cannot be fulfilled neither by nature nor by history. The a priori needs of identity meet hardly avoidable resistance. This is why, within the realm of evolution of science, he would point to the conflict between the stability requirement and the irrational chances imposed by reality.

Whereas according to Cassirer the history of science resembles a slow and endless process of improvement of our logical and formal tools as well as of our understanding of nature, for Meyerson it would rather be some sort of unsolvable dialectical exchange between the substantialist tendencies of human reason and the stubborn "irrationality" of nature. While the former would avoid any reference to an ontology of substance as foundation of our representations, the latter would reject any attempt to formulate an abstract vision, purely functional and committed to the sterile normative precision of mathematics. Meyerson would accordingly speak against anti-substantialist theories, while the contributions that take an interest in Cassirer, at least in the early Cassirer, go in the direction of a peculiar mathematical idealism. In the text, *Substanzbegriff und Funktionsbegriff*, Cassirer expresses clear criticism of Meyerson based on the remark that: "the identity towards which thought progressively strives is not the identity of ultimate substantial things but the identity of functional orders and coordination."[21]

Koyré, on his turn, partially sided with Meyerson.[22] One should not forget that the *Études galiléennes* (*Galileo Studies*) (1939) are dedicated to him, although it is true that the quarrel between Meyerson and Cassirer was not, at least in principle, the same as that developed between Koyré and Cassirer.[23] On this topic, in his "Kuhn and Logical Empiricism," Michael Friedman speculates that Koyré's loyalty to Meyerson comes to the fore in relation to the Platonic interpretation of Galileo. This point would then be confirmed by the following quote from Koyré:

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[21] Ernst Cassirer, *Substance and Function* (Chicago: Open Court, 1923) 323-325, quoted in Friedman, "Kuhn and Logical Empiricism," 32.

[22] Mario Biagioli, "Meyerson and Koyré: Toward a Dialectic of Scientific Change," *History and Technology* 4 (1987): 169-182.

[23] Further details in Jean Seidengart, "Science et réalité chez Meyerson et Cassirer: les ressorts philosophiques d'un grand débat épistémologique au xxe siècle," *Corpus. Revue de philosophie* 58 (2011): 187-200; Jean Seidengart, ed., *Vérité Scientifique et Verité Philosophique dans l'Œuvre d'Alexandre Koyré* (Paris: Les Belles Lettres, 2016); Eva Telkes-Klein and Elhanan Yakira, eds., *L'Histoire et la philosophie des sciences françaises à la lumière de l'oeuvre d'Émile Meyerson (1859-1933)* (Paris: éditions Honoré Champion, 2005); Bernadette Bensaude-Vincent and Eva Telkes-Klein, *Les identités multiples d'Émile Meyerson* (Paris: Champion, 2017).

> E. Cassirer, in his *Erkenntnisproblem*, vol. I, expresses the opinion that Galileo resurrected the Platonist ideal of scientific knowledge; from which follows, for Galileo (and Kepler), the necessity for mathematising nature. . . . Unfortunately (at least in our opinion) Cassirer turns Plato into Kant.[24]

The *Études galiléennes* are no sufficient proof that Koyré's criticism of Cassirer should be extended to the whole of the functionalist epistemology. In this direction goes, however, Koyré's article presenting Meyerson's philosophy to the German readership. In the text, "Die Philosophie Émile Meyersons" (Émile Meyerson's Philosophy) (1931), not only he endorsed the philosophy of his Polish friend—an immigrant in France as himself—but he also stated his opposition to the "anti-substantialists" claims of neo-Kantianism, according to which "science has nothing to do with substantial causes, but is occupied only with constructing functional dependencies, functional interconnections of the phenomena and clothing them in mathematical formulas."[25] Once defined the limits and affiliations of his thought, notwithstanding, Koyré could not but agree with Cassirer's basic tenet on the rationalism and mathematization of the natural world. After all, what mostly disturbed Koyré was not the Platonic interpretation of Galileo but rather the transformation of this latter in the shadow of Hermann Cohen.

French Historical Epistemology as Continental History and Philosophy of Science

So far, a fragment of the continental history and philosophy of science has been investigated in relation to Kuhn, the neo-Kantianism of Marburg and some contributions from the French historiographical tradition,[26] notably by Meyerson and Koyré. In order to provide some philosophical background for the famous missed connection between Kuhn and Bachelard, I will briefly review the cases of Brunschvicg and Bachelard, teacher and pupil.[27] Since these author are not very well known in the English speaking world, i.e., in the history and philosophy of science inspired by the analytical tradition, it is worth remembering some of their most important insights.

Brunschvicg (1869-1944) is one of the lesser known names of the French tradition, although his contributions provide essential clues to the understanding of the works of Bachelard

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[24] Koyré, *Galileo Studies*, 223, footnote 123, quoted in Friedman, "Kuhn and Logical Empiricism," 39, footnote 38.

[25] Alexandre Koyré, "Die Philosophie Émile Meyersons," *Deutsch-Französische Rundschau* 4 (1931): 105-126, quoted in Friedman, "Kuhn and Logical Empiricism," 33.

[26] Further details in Michel Bitbol and Jean Gayon, eds., *L'Épistémologie française 1830-1970*, 2nd ed. (Paris: PUF, 2015); Gary Gutting, *Thinking the Impossible. French Philosophy Since 1960* (Oxford: OUP, 2011).

[27] For the drafting of these remarks I rely on Gary Gutting, "Thomas Kuhn and French Philosophy of Science," in Nickles, *Thomas Kuhn*, 44-64.

and Canguilhem. Strongly influenced by Meyerson's thought, Brunschvicg embraces the rejection of the Kantian noumenon. His first move is to get rid the thing in itself, based on the idea that any knowledge of something that persist beyond our representation is nonsense. In short, everything that by definition is unaccessible and undeterminable is the same as nothing. Through a typically Kantian move, Brunschvicg applies this perspective to the realm of scientific knowledge and the judgments pronounced by the subjectivity in relation to the production of knowledge. What is at stake is a qualitative taxonomy of the different types of judgments and of their consequences on the several modes of knowledge based on the unity they are able to generate.[28] The key point lies here in the unity ensuing from the internal connections between ideas and the alleged exteriority of sensations. Nuances are determined by the very composition of judgments and especially by their linguistic conditions. Brunschvicg emphasizes the categorial configuration of enunciations in relation to the material provided by the senses. Like Meyerson pointed to the dialectical resistance to representation of the world, for Brunschvicg the shocks of reality[29] are what triggers some sort of exceptional state of representation which brings about a change in our conceptual system. Furthermore, like it was the case for Meyerson, these shocks of reality entail a non-conceptual core which needs to be accepted by the mind without understanding it and, to an extent, without questioning it. Around this limit an ontological match is produced, inasmuch as cognitive judgments are able to confirm mere existence without being able to penetrate the constitution of the objects of experience. As a result, reality is given to consciousness as exteriority and as world. Based on this specific and restricted positivity the history of knowledge can start as exploration of the limits of the faculty of judgment. Applied to the history of science, this means to investigate the representational transformations of the objects as much as the historicity of these very objects. In other words, to the positivity of the world showed by the representational anomalies one must add the positivity of consciousness betrayed by the historical failures recorded by the history of science.

Brunschvicg stands, therefore, among those, like Dilthey, who aimed at converting the Kantian critique of pure reason into a critique of historical reason. His historicization of the epistemology of judgment and his metaphysics of the *mundus absconditus* provides him with the basic heuristic tools applied in his monumental historical investigations: *Les étapes de la philosophie mathématique* (The stages of mathematical philosophy) (1912)[30] and *L'expèrience humaine et la causalité physique* (Human experience and physical causality) (1922)[31]. The former outlines the history of mathematical thinking from the Egyptian world and Ancient Greece

[28] Léon Brunschvicg, *La modalité du jugement* (Paris: Presses Universitaires de France, [1897] 1964).
[29] Ibid., chapitre IV, "Les modalités de la copule dans les jugements d'ordre théorique, II - Le 'Cela est'," 115.
[30] Léon Brunschvicg, *Les étapes de la philosophie mathématique* (Paris: Alcan, 1912).
[31] Léon Brunschvicg, *L'expérience humaine et la causalité physique* (Paris: Alcan, 1922).

up to the modern theories of logical foundations from the end of the nineteenth century and the beginning of the twentieth. In this essay, Brunschvicg aims to show that mathematics adds up within the millennial human efforts to understand the world, in relation to the creativity of the mind and the quest for sense. Not in vain several thinkers such as Plato, Descartes, Leibniz or Kant have taken mathematics seriously into account as soon as they had to define their philosophical stance, ultimately expecting to achieve a rigorous formulation based on the result of hard science. This was meant to allow the outlining of an ultimate vision of the world articulated by a philosophical system that can be perfected within a limited amount of time. In this regard, mathematics seemed to provide the possibility to get emancipated both from the temporality and the provisional character of our systems of representation. The downside of such epistemological optimism lies instead in the need to revise the old mathematical systems and introduce new ideas to react to the unexpected shocks of reality. The ultimate result of this historical appeal to the evolution of the mathematical statements lies in that the full representation of the world is never seen as concluded and all systematizing effort is revealed as soon or later crumbling apart.

In *L'expèrience humaine et la causalité physique*, Brunschvicg deals with the above mentioned problem by means of the historical scrutiny of the scientific and philosophical theories of causality. He notably claims that the philosophical problem of causality has remained open, despite the variety of contributions, such as that of Descartes, Bacon, Galileo, and Kant. Just like the history and philosophy of mathematics greatly contributed to the understanding of the world, also causality was assigned great epistemological importance. In particular, Brunschvicg is interested in exploring how causality has been commonly connected to the philosophy of nature and then has come to acquire empirical and experimental features. However, both the discussion about causality and the philosophy of nature have been inclined to speculation, to the postulation of principles and ideas that go beyond the real possibilities of corroboration. In this sense, Brunschvicg would reject said dogmatic abuses in order to question scientific truths. With his Kantian frame of mind, Brunschvicg deems necessary to impose limits to these developments, given that they have frequently come in clear conflict with the procedures of scientific verification. Accordingly, these are seen as speculative contents which are eliminated by history and, despite their original claim to a definitive truth about the world, would turn out to be disposable.

Finally, Brunschvicg would advocate a form of historically-aware scientism, since, according to him, science is able to share a correct vision of reality as long as it keeps memory of its becoming. This fusion of science and history allows him to situate the present in relation to its different evolutionary stages, ultimately delivering a philosophy of history that accounts for the transformations in the epistemological interaction between mind and the world.

For his part, the work of Bachelard (1884-1962) was deeply influenced by Poincaré, Meyerson and, especially, Brunschvicg, who, together with Abel Rey, supervised his doctoral thesis.[32] Like Brunschvicg, Bachelard believes that the history of science is the perfect place where to investigate the alterations in the understanding of the world and in the evolution of human rationality. He also shares with Brunschvicg an interest for the history of the physical-mathematical sciences, although, unlike his mentor, he insists more on the discontinuities and on the fractures, which have defined these disciplines. In this regard, Bachelard aims to put together a theory of scientific development articulated on epistemological breaking points (i.e., "coupure épistémologique"). This redefinition of Brunschvicg's shocks of reality appears to be linked to a theorization of scientific experience as clearly different from the everyday lived experience of the world. The notion of *coupure épistémologique* is applied to two different realms. On the one hand, as it assigns to the objects of the world properties and attributes that are not previously revealed by common perception, science fundamentally requires a fracture in relation to common sense and the ideas and beliefs it produces. On the other hand, the epistemological breaking point is part of the development of science and of the representations produced in it. Consequently, scientific change implies a dissolution of previous theories, which are in this respect presented as "epistemological obstacles" ("obstacle épistémologique") opposing resistance to alteration. Newtonian physics, for instance, would have obstructed the innovative formulations of Albert Einstein concerning gravity, space, and time. Once the obstacles have been removed a "new scientific spirit" comes about, in this case, a new interpretation of the physical world and a new scientific methodology.[33]

According to Bachelard, the transformations in scientific thinking are connected to modifications in the philosophical theories of knowledge of reality. In short, the epistemological breaks involve change at an ontological and epistemological level, which from a philosophical perspective appear as true revolutions. In this way Brunschvicg's hermeneutical trajectory is extended: the study of the history of science is also the study of the development of new philosophical visions and the imposition of scientific innovations. Nevertheless, these breaking points prevent us from hoping that epistemology will manage to establish foundations beyond time. What's more, it contradicts strategies, like the Kantian one, which seek eternal validity for certain categories, once it can be established that they have concrete historical origin. In the

[32] Bibliographical references on Bachelard are abundant. With no aim to exhaustivity, I mention here a small selection: Massimiliano Simons, Jonas Rutgeerts, Anneleen Masschelein, and Paul Cortois, "Gaston Bachelard and Contemporary Philosophy," *Parrhesia* 31 (2019): 1-16; Cristina Chimisso, *Gaston Bachelard: Critic of Science and the Imagination* (London and New York: Routledge, 2001); Cristina Chimisso, *Writing the History of the Mind. Philosophy and Science in France, 1900 to 1960s* (Aldershot: Ashgate, 2008); Gary Gutting, "Gaston Bachelard's philosophy of science," *International Studies in the Philosophy of Science* 2, no. 1 (1987): 55-71.

[33] More on this point in Gaston Bachelard, *Le nouvel esprit scientifique* (Paris: Alcan, 1934); Gaston Bachelard, *La valeur inductive de la relativité* (Paris: Vrin, 1929).

case of Kant, his categories are the contingent expression of Newtonian physics. Concerning these questions, Bachelard argues for the need of a "psychoanalysis of knowledge,"[34] in order to point out to what extent common sense includes content that is obsolete, historical prejudices that rule our thinking and should be eradicated.

The redefinition of the reality shocks and of the dialectical resistance, in terms of breaking points and epistemological obstacles, not only entails a theory of the history of science and of philosophical speculations, based on discontinuities, but it also introduces an amendment to the progressive image of scientific change. At variance with Meyerson and Brunschvicg, according to Bachelard, the becoming of science does not appear to be an essentially progressive enterprise, nor it seems to require any continuity whatsoever. This does not mean that epistemological breaks in methodology or in the category systems are incompatible with the accumulation of the achievements of previous theories. Although these can be assessed as special cases. For instance, the notion of "specific heat," developed by Joseph Black within the framework of phlogiston physics, is still taken as valid even today, like the notion of "mass" or that of "triangle."

Bachelard's history and philosophy of science aims to establish an epistemological and metaphysical model, which stands half way between realism and idealism.[35] According to him, realism supports the belief "in the prolix richness of the individual sensation and in the systematic impoverishment of abstractive thought"[36] and, also, warrants an onto-epistemic primacy to the objects given to sensibility as opposed to the theoretical formulations of scientific entities. He also wishes to avoid idealism and its transformation of the world, in mere epiphenomenon of pure subjectivity. In between these two extremes he places his applied rationalism, which combines the realist choice to stay faithful to a given experience, and the idealist alternative, which supports the natural activity of the mind.[37] Bachelard ends up advocating a form of

[34] Gaston Bachelard, *La psychoanalise du feu* (Paris: Gallimard, 1938).

[35] Daniel Mcarthur, "Why Bachelard is not a Scientific Realist," *The Philosophical Forum* XXXIII, no. 2 (2002): 159-172.

[36] Bachelard, *La valeur inductive de la relativité*, 206, quoted in Gutting, "Thomas Kuhn and French Philosophy of Science," 51.

[37] Gaston Bachelard, *Le rationalisme appliqué* (Paris: PUF, 1949). Bachelard's other works in relation to the philosophy of science are: *Essai sur la connaissance approchée* (Paris: Vrin, 1928); *Étude sur l'évolution d'un problème de physique: la propagation thermique dans les solides* (Paris: Vrin, 1928); *La valeur inductive de la relativité* (Paris: Vrin, 1929); *Le pluralisme cohérent de la chimie moderne* (Paris: Vrin, 1932); *L'intuition de l'instant* (Paris: Stock, 1932); *Les intuitions atomistiques* (Paris: Boivin, 1933); *Le nouvel esprit scientifique* (Paris: Alcan, 1934); *La dialectique de la durée* (Paris: Boivin, 1936); *L'expérience de l'espace dans la physique contemporaine* (Paris: PUF, 1937); *La psychanalyse du feu* (Paris: Gallimard, 1938); *La philosophie du non* (Paris: PUF, 1940); *L'activité rationaliste de la physique contemporaine* (Paris: PUF, 1951); *Le matérialisme rationnel* (Paris: PUF, 1953); *Epistémologie* (Paris, PUF, 1971), texts edited by Dominique Lecourt; *L'engagement rationaliste* (Paris: PUF, 1972), posthumous collection with a preface by Georges Canguilhem.

constructivism based on scientific concepts applied to objects. In this interaction between conceptual systems and basic ontology of science is nested one of his most popular ideas: instrumentation is materialized theory and, therefore, scientific instrumentation has a prominent function in the confirmation and subsequent interpretation of the physical world. This claim leads him to outline a peculiar demarcation of categories. Those that are scientific receive their concrete reality by means of a "technique of realization,"[38] which, in its turn, comes together with instrument technology in the "phenomenization" of the objects. Inspired by Husserl's phenomenology of the lifeworld, Bachelard defines this "phenomenization" in terms of "phenomenotechnique."[39] According to him, instruments play a very relevant role since "as instruments are improved, their scientific *products* will be better defined. Knowledge becomes objective in proportion to its becoming instrumental."[40] A higher degree of precision depends, then, on a higher degree of instrumentalization and, consequently, of socialization. This is what Bachelard calls "educated materialism" or "technical materialism."[41]

Well before the publication of *The Structure of Scientific Revolutions* (1962) by Kuhn, Bachelard had already assessed the becoming of some disciplines among the physical sciences as a history marked by epistemic fractures.[42] As soon as one tries to investigate scientific progress in relation to its psychological conditions, it becomes clear, according to him, that the development of scientific knowledge must be understood in the terms of its epistemological obstacles. Whenever one investigates the cognitive conditions which make scientific knowledge possible, one discovers that

> It is at the very heart of the act of cognition that, by some kind of functional necessity, sluggishness and disturbances arise. It is in the act of cognition that we shall show causes of stagnation and even of regression; there too we shall discern causes of inertia that we shall call epistemological obstacles. Knowledge of reality is a light that always casts a shadow in some nook or cranny. It is never immediate, never complete. Revelations of reality are always recurrent. Reality is never "what we might believe it to be": it is always what we ought to have thought.[43]

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[38] Gaston Bachelard, *The New Scientific Spirit*, translated by A. Goldhammer (Boston: Beacon, 1984), 13, 16, quoted in Gutting, "Thomas Kuhn and French Philosophy of Science," 52.

[39] A discussion of this topic can be found in Hans-Jörg Rheinberger, "Gaston Bachelard and the Notion of 'Phenomenotechnique'," *Perspectives on Science* 13, no. 3 (2005): 313-328.

[40] Gaston Bachelard, *The Formation of the Scientific Mind. A Contribution to a Psychoanalysis of Objective Knowledge*, translated by Mary McAllester Jones (Manchester: Clinamen Press, 2002), 217, emphasis in the original.

[41] On further developments, see Paola Donatiello, Franceso Galofaro, and Gerardo Ienna, eds., *Il senso della tecnica. Saggi su Bachelard* (Bologna: Esculapio Editore, 2017).

[42] Gutting, "Introduction: What is Continental Philosophy of Science?" 4-12; Lecourt, *L'épistémologie historique de Gaston Bachelard*, 12.

[43] Bachelard, *The Formation of the Scientific Mind*, 24.

In order to produce scientific knowledge, it is necessary to pose questions, interrogations, queries: "Nothing is self-evident. Nothing is given. Everything is constructed."[44] Bachelard believes that philosophy, the great questioner of science, must keep abreast of its time. According to Bachelard, as it was the case also for Brunschvicg, history is the first premise to the understanding of scientific knowledge development.

The French philosopher, Dominique Lecourt, referred to Bachelard's epistemological revolution as "historical epistemology," since "the discipline which takes scientific knowledge as its object must take into account the historicity of that object. . . . If epistemology is historical, the history of the sciences is necessarily epistemological."[45] Within Bachelard's philosophy of science, epistemology and history of science go hand in hand.

One should also emphasize the remarkable element of concepts' creation, as a historical ability possessed, according to Bachelard, by scientific thinking, and that somehow brings philosophy back to its origins. It is from this viewpoint that Bachelard's historical epistemology and the history of science should be seen. The former as a regulated system of concepts and the latter as the object of theoretical thinking. Unlike classical philosophy and epistemology, Bachelard revived the philosophy of the origins through the emergence of scientific knowledge concepts, later organized and materialized in institutions, congresses, etc. He then introduced the notion of history as a theoretical requirement for the work of the philosopher of science; the work of scientific thinking is then an intellectual activity whose object is the analysis of the process of production of epistemic concepts. This is also the kind of work Bachelard achieved in his contributions as early as the *Étude sur l'évolution d'un problème de physique: la propagation thermique dans les solides* (Study on the Evolution of a Physics Problem: Heat Transfer in Solids) (1928)—dedicated to Brunschvicg—where he reviewed the formation of scientific concepts in the eighteenth century. Here he resolved to present the conceptual context and the objectives pursued by experiments and observations within the framework of a history of science that presents itself more as a history ruled by its needs than by its results. As Dominique Lecourt has put it, "we may assert that once it had become historical, in the sense of taking for its object the historicity of the concepts produced by scientific knowledge, epistemology 'enveloped' in a Spinozan manner a new concept of the history of the science and a new discipline commanded by that new concept."[46] According to Bachelard, the epistemic values and the pragmatic ones complement each other so that the acquisition of scientific knowledge no longer is a purely mental activity but an

[44] Ibid., 25.

[45] Lecourt, *Marxism and Epistemology*, 25. See as well Norma Durán R. A., ed., *Epistemología histórica e historiografía* (Mexico City: Universidad Autónoma Metropolitana, Unidad Azcapotzalco, 2017).

[46] Lecourt, *Marxism and Epistemology*, 86.

activity, practice, a form of thinking with which the philosophy of science should deal:[47] the object of science is to be found inside its own activity.

Bachelard's proposal, as it has been outlined so far, could be condensed around two key points. As to the first point, Bachelard believes that the best way to penetrate reason is through the historical investigation of science. First because reason cannot be accessed by means of abstract reasoning but rather through the concrete usages of reason, and science is the main successful realm in this application. Second, because Bachelard rejects the a priori ideal principles of reason, favoring instead concrete historical and scientific developments.[48] As to the second point, which is the direct consequence of the first, Bachelard presents, as core of his philosophy of science, the shift in scientific perspective that is exemplified by the epistemic categories of "fracture," "cuts," "obstacles," "usefulness," and "acts." All of these categories allow him to reject the continuity-based vision of science, without thereby abandoning the notion of scientific progress. He believes, indeed, that science is discontinuous but progressive.[49]

Final Remarks: Thomas S. Kuhn meets Gaston Bachelard

As previously pointed out, Kuhn made reference to Cassirer, Meyerson and Brunschvicg,[50] but never to Canguilhem, Foucault or Bachelard. He also never mentioned any of the members of the *Annales* school of history. Concerning Bachelard, in particular, Gutting recalls an unsuccessful meeting Kuhn once had with Bachelard.[51] Apparently, Koyré convinced Kuhn to get in contact with Bachelard. Linguistic difficulties, the reciprocal lack of acquaintance with each other's work, the age, and cultural distance transformed this encounter into a "comedy of situation." Kuhn was aware of Bachelard's interest in the issue of imagination in literature. Maybe this led him to believe that he was also an expert of English literature and, therefore, that he mastered the English language. His hope to be able to speak his own language was

[47] Mary Tiles, "Technology, Science, and inexact Knowledge: Bachelard's Non-Cartesian Epistemology," in Gutting, *Continental Philosophy of Science*, 157-175, on 161, 164.

[48] More details on this point can be found in Zenia Yébenes, "Entre filosofía e historia: tres deseos para la epistemología histórica a partir de una lectura del *a priori*," in Durán, *Epistemología histórica e historiografía*, 55-83.

[49] Gary Gutting, *Michel Foucault's Archaeology of Scientific Reason* (Cambridge: Cambridge University Press, 1990), 13, 14 and 21.

[50] See also Kuhn, "The History of Science," and Friedman, "Kuhn and Logical Empiricism," 28.

[51] Gutting, "Thomas Kuhn and French Philosophy of Science." See also Thomas S. Kuhn, "A Discussion with Thomas S. Kuhn, a Physicist who Became a Historian for Philosophical Purposes: A Discussion between Thomas S. Kuhn and Aristides Baltas, Kostas Gavroglu, Vasso Kindi," *Neusis* 6 (1997): 145-200; Teresa Castelão-Lawless, "Kuhn's Missed Opportunity and the Multifaceted Lives of Bachelard," *Studies in History and Philosophy of Science* 35, no. 4 (2004): 873-81; Teresa Castelão-Lawless, "La philosophie scientifique de Bachelard aux États-Unis: son impact et son défi pour les études de la science," in *Bachelard dans le monde*, eds. Jean Gayon, Jean-Jacques Wunenburger, and Dominique Lecourt, 77-94 (Paris: Presses Universitaires de France, 2000).

soon shattered and the conversation failed. Despite the missed opportunity, Kuhn took a brief interest in Bachelard's work, although he claimed that "there were things to be discovered there that I did not discover, or did not discover in that way."[52]

I agree, however, with Gutting that substantial similarities subsist between the focus and problems of Kuhn's philosophy of science and the French epistemological tradition, especially concerning the historicity of knowledge and of the systems of categories in which knowledge is situated. Granted that we owe to Kuhn the restoration of the history of science as the most important object for the philosophy of science, he clearly shares this merit with those responsible for the first "establishment" of the philosophical value of the history of science: the neo-Kantian historians of science and the French epistemological tradition, most notably Gaston Bachelard in the 1930s.

While Kuhn made a record of his sympathy for Koyré, the French historiographical tradition, with which the young Kuhn came into contact, did not qualify as a uniform realm from which one could extract an organized set of philosophical ideas and interpretative approaches. In between Cassirer's mathematical idealism, Meyerson's defense of a substantialist and transhistorical ontology, and Brunschvicg's synthesis of formalism and phenomena, it seems that the early Kuhn introduced the historical structure of scientific revolutions.

Friedman goes as far as to claim that the philosophical tensions of Russian and French historiography find a suitable explanation in Kuhn's notion of scientific revolutions, especially inasmuch as it points to continuity at theoretical level and to the tendency to provide ontological interpretations instead of mathematical ones, as it was the case with Meyerson.[53] The relationship between relativistic mechanics and Newtonian mechanics, for instance, was not assessed based on the continuity provided by the same physical reference nor on the alleged unity provided by their underlying mathematical structures. As a matter of fact, Kuhn, this time at variance with Meyerson, has abundantly emphasized changes, precisely in the basic ontology of science, and therefore has sided more with interparadigmatic differences than with identities. After all, a change of paradigm means a change of world.

Kuhn's work, finally, can be added to that somehow despoiling action of selection and revision of the great topics of the continental historiography of science: the theory-ladenness in scientific experience, the irreducibility of rationality to logic, the philosophical usages of the history of science, the epistemic and ontological historicity, and the philosophy of history applied to the development of science. In this regard, however, as Gutting has pointed out, "by then the two approaches were too far apart for fruitful interaction."[54] The one was put off by the lack of

[52] "A Discussion with Thomas Kuhn," in Kuhn, *The Road since Structure*, 284-285.
[53] Friedman, "Kuhn and Logical Empiricism," 33-35.
[54] Gutting, "Thomas Kuhn and French Philosophy of Science," 46.

analytical rigor and clarity, by the literary prose and a promiscuous interchange with Central-European philosophy; the others by formal vacuity, specialism, and the absence of humanities. Nobody was convinced by logical empiricism in its most radical versions, and would rather self-confine themselves in their own jargon. The truth is that historicism was at work in the neo-Kantianism of Marburg, as much as in the French historiography, in Kuhn's theory of paradigms, and, in our time, in the contemporary historical epistemology of sciences.

The missed connections between Kuhn, Bachelard and the continental historiography of science may be seen as a crucial episode in the misunderstanding and dismissing of the continental history and philosophy of science, in its becoming a non-received view. This strand not only may provide some clues to further clarify what is indeed continental history and philosophy of science, but also what entails this neglected tradition for current historiography of science.

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