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## Dossier Pierre Duhem

# Was Pierre Duhem an *Esprit de finesse*?

Víctor Manuel Hernández Márquez [1]

## Abstract:

Although Pierre Duhem is well known for his conventionalist outlook and, in particular, for his critique of crucial experiments outlined in his thesis on the empirical indeterminacy of theory, he also contributed to the scholarship on the psychological profiles of scientists by revising Pascal's famous distinction between the subtle mind and the geometric mind (*esprits fins* and *esprits géométriques*). For Duhem, the ideal scientist is the one who combines the defining qualities of both types of intellect. As a physicist, Duhem made important theoretical contributions to the field of thermodynamics as well as to the then-nascent physical chemistry. Due to his rejection of atomism and his unrelenting critique of Maxwell's electrodynamics, however, in his later years, Duhem's work was surpassed and abandoned by the dominant tendencies of physics of the time. In this essay, I will discuss whether Duhem himself can be understood through the lens of his own account of the scientist's psychological profile. More specifically, I examine whether the subtle mind – to which he seems to assign greater cognitive value – in fact plays a key role in Duhem's critique of the English School (*école anglaise*), or if his preference for the axiomatic structure of theoretical physics shows a greater affinity with the geometric mind.



## Keywords:

Pierre Duhem; subtle and geometric minds; abstract and axiomatic theories; physical theory

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## Introduction

Perhaps the most overlooked, among Pierre Duhem's diverse contributions to the understanding of the sciences, is his study of the psychological dimensions of scientific practice based on his approach to the Pascalian distinction between the subtle mind and the geometric mind (*esprit de finesse* and *esprit de géométrie*). There are several reasons for this oversight, but the most evident comes from the point of view of classical philosophy of science, since the emphasis made on the distinction between the context of discovery and the context of justification left aside historical, sociological, and psychological features of scientific practice to focus solely on the logic of justification. Another, more precise, reason is the belief that Duhem makes use of Pascal's dichotomy to settle scientific matters by means of nationalistic prejudices. By the other side, Duhem's appropriation of the Pascalian distinction seems difficult to hold because one finds

[1] Víctor Manuel Hernández Márquez is a Professor at at the Autonomous University of Ciudad Juárez. Adress: Av. Universidad y Av. Heroico Colegio Militar S/N Zona Chamizal C.P. 32300. Ciudad Juárez, Mexico. Email: vmhernandezmarquez@gmail.com

problems to determine whether we are deal with a sharp and fundamental distinction, or whether Duhem makes informal use of it in order to support his view about the value of theoretical physics as abstract theory. Taking the latter interpretation allows us to deal with the inconsistencies that stand out when we closely examine the way in which Duhem reworks that distinction to discuss the scientific contributions of what he calls *l'école anglaise* (English School) in contrast to his argument about the German and French way to build the physical theory in his late "war writings." In what follows, I will compare and contrast Duhem's use of the Pascalian distinction in his treatment of the theoretical practice of the English School in *La théorie physique* as well as in his early writings on the subject; namely, in his review of the French translation of William Thomson's papers. I argue that, although he claims that both modes of thought coexist at the heart of the scientific community, and that the improvement of theoretical physics renders impersonal its findings (cf. Duhem 1987a [1893a], 144; 1915, 103), Duhem's philosophical and methodological papers exhibits an unquestionable preference for the subtle mind. Then, I will examine whether Duhem's theoretical practice coincides with his own account of the subtle mind, or if, on the contrary, it ultimately corresponds with the geometric mind. Finally, I hope that this essay sheds light on other aspects of Duhem's thought that may be worth revising.

## Modes of Thought

There are several approaches to understand how human creativity works, but all of them share a certain parallelism that makes it possible to reduce them to a kind of cognitive dualism. The most popular among these approaches is by Isaiah Berlin (1953, 1), found in a fragment by the ancient poet Archilochus: "The fox knows many things, but the hedgehog knows one big thing." This analogy is quite productive, allowing us to categorize the intellectual world into those who are guided by a single regulatory principle – at most a handful – and those who make use of all kinds of assertions without a concern for internal consistency as long as they achieve their intended goal.

Those with a hedgehog's mentality need order and a system; whereas, on the other hand, those who possess a fox's mentality can navigate – without difficulty – in a sea of information without details, for that matter, disregarding their intended goal. This distinction is not exclusive. We need not assume we are dealing with a sharp distinction, since Berlin makes use of it only as a guiding principle to locate the salient features of specific thinkers by classifying them as either foxes or hedgehogs. Thus, he characterizes Aristotle, Montaigne, and Erasmus as foxes, and Plato, Lucretius, Pascal, and Hegel as hedgehogs. There are, indeed, those who dream of being of the opposite mindset despite their nature. Thus, for example, in his early years, Wittgenstein – a fox by nature – thought of himself as a hedgehog. The reverse, however, seems implausible, if not impossible. It is for this reason that, for James (1981 [1907]), far from being a purely intellectual matter, a distinction of this kind is a matter of temperament; this despite the fact that the majority of us are incapable of possessing a well-defined intellectual temperament (in this case, we are only ordinary people). With regard to philosophical inclinations, for James, one is either an empiricist or a rationalist according to his temperament, not by choice. In other words, we do not choose to be foxes or hedgehogs, we simply are one or the other.



If we put Berlin's distinction in Jamesian terms, a fox would be, by definition, an empiricist, a lover of crude facts and would, therefore, be of a rough mindset. Whereas the hedgehog would always be a rationalist, a lover of abstract principles and therefore, his or her mind would be subtle. Here, nonetheless, James performs a sleight of hand insofar as he makes use of the known Pascalian distinction between the subtle mind and the geometric mind. Moreover, since James was familiar with Pierre Duhem's oeuvre, he takes from it what better suits his pragmatist character.[2]

Having said that, although there are commonalities between the overall methods of each of these mindsets, for Duhem, the Pascalian distinction serves, first and foremost, the explicit purpose of

[2] In the fifth Lowell lecture, entitled "Pragmatism and common sense," James (1981 [1907], 86) writes: "Just now, if I understand rightly, we are witnessing a curious reversion to the common sense way of looking at physical nature, in the philosophy of science favored by such men as Mach, Ostwald and Duhem. According to these teachers no hypothesis is truer than any other in the sense of being a more literal copy of reality. They are all but ways of talking on our part, to be compared solely from the point of view of their *use*. The only literally true thing is *reality*; and the only reality we know is, for these logicians, sensible reality, the flux of our sensations and emotions as they pass".

differentiating the way English physicists conceive of physical theory from the French and German view. However, this theoretical articulation does not appear in Duhem's work until the later period of his intellectual development, as we do not find aspects of this in his early writing in what will serve as the basis for the chapter that makes up the first part of *La théorie physique* – a chapter he devotes to abstract theory and mechanical models.

Before delving into an examination of such transformation in Duhem's thought, it is appropriate to take a moment to consider the historical context that gives rise to and explains some of its most prominent features. To a certain extent, it is here that we can locate a turn from Duhem the physicist to Duhem the methodologist or philosopher of physics – or, to put it in contemporary terms, to a physicist's explicit formulation of his *scientific philosophy*.[3]

We can wonder, however, whether we are dealing with changes in the particular intellectual orientation of a specific physicist or with a mode of thought common to a transitional period in the establishment of a new field of knowledge. In order to answer this question, let us turn to the distinction Holton appropriates from Nietzsche to reestablish the debate about public image of science during the second half of the twentieth century.

## The New Apollonians and Dionysians

Following the dominant standpoint of our current scientific framework – reaffirmed by Kuhn's contributions – today, most members of the scientific community ignore the epistemological questions that emerge at the heart of scientific practice; and when they do address them, it is only as a pastime not unlike stamp collecting or heraldry. In the new division of intellectual labor, which brought about a reconfiguration of knowledge in the twentieth century, the ones in charge of understanding and defending scientific practice are professional philosophers of science like the Logical Positivists, Karl Popper and his predecessors, and the current naturalized philosophers. Holton calls these *New Apollonians*.[4] On the other hand, we find the critics of science, who question its reductionism and its complex relations with power and the industry. Holton calls these *New Dionysians* or *Neodionysians*. Both Neodionysians and New Apollonians enjoy a degree of recognition among broad sectors of society. They also exert some pressure on the scientific community, although the latter pays little attention to their claims and demands. Holton's essay itself is a rare exception, and perhaps he owes his reputation as an outsider with an understanding of science to the fact that, since the beginning of his academic career, he was associated with one of those New Apollonians who rose from the ranks of the Vienna Circle, namely Philipp Frank. At the same time, it appears that this very proximity made Holton lose sight of the fact that the first generation Apollonians were either scientists in their own right or thinkers trained in some branch of science. It is not difficult to see, then, that Frank belongs to that lineage of philosopher-scientists who contributed to the stability of theoretical physics toward the end of the nineteenth and beginning of the twentieth centuries.[5]



During this transitional period, the quest for a disciplinary identity engenders a debate among physicists themselves: they argue explicitly on the scope and value of their conceptual elaborations; they establish the boundaries of experimental physics in light of the limits of theoretical physics; and they resort to ingenious metaphors to explain the relationship between the two subdisciplines. Thus, for example, Poincaré compares physics with a library that is constantly growing, where experimental physics is in charge of acquiring new books (i.e., facts), while mathematical physics is in charge of composing the catalogue

[3] Although we may think it was Abel Rey who, in 1904, coined the term *philosophie scientifique* to refer to Duhem's conception of science, the phrase was already in use several years before and can be found, for example, in Paul Tannery's reviews in *Revue philosophique de la France et de l'étranger.*

[4] Holton (1978, 102) writes: "The philosophers who have taken it on themselves to protect rationality in the narrowest sense of the word are also members of a long tradition. Some of their genes can be traced back to the logical positivists of the pre-World War II period, who are themselves descended from a long line of warriors against the blatant obscurantism and metaphysical fantasies that haunted and thwarted science in the nineteenth and early twentieth centuries."

[5] Cf. Laszlo Tisza's report on Frank's undertakings as a physicist, whom he regarded more as a philosopher of science, or, in the best-case scenario, as a philosopher of physics (cf. Blackmore, Itagaki and Takana 2001, 68-69).

(and therefore, is the one responsible for grouping and categorizing facts);[6] meanwhile, Duhem (1987a [1894]) makes sure to point out that there are no experimental observation devoid of theory nor crucial experiments.[7]

Nonetheless, we can easily lose sight of the relevance of metatheoretical questions once the disciplinary domain has been fully delineated. As Bordoni (2012) and others have argued, we cannot have a suitably clear idea of Duhem's contributions to theoretical physics if we do not take into account the role metatheoretical considerations play in the process of institutionalization of the discipline. I argue, however, that the process of institutionalization in question has different characteristics from those elucidated in previous scholarship on Duhem. According to Roberto Maiocchi (1990, 386), for example, "It is not the crisis of science, but its successes which impose upon Duhem the necessity of epistemological reflection."[8] Broadly speaking, by the *success* and *crisis* of physics (and chemistry), Maiocchi refers to what is usually catalogued under the so-called internal history of science, whereas the process I have in mind corresponds, more or less, to its external history. That being said, however, I do not find the distinction between internal and external histories adequate to describe the complex interrelations that took place among physics, philosophy, and the public image of science of the time, and, in particular, in the organization of science during the *Troisième République* (Third Republic), as well as in the preceding, chaotic decades. For a number of reasons, it is a mistake to speak of the success of the discipline in the last decade of the nineteenth century, except for in hindsight, since its physiognomy was actually determined at the time if we consider, for example, that rational mechanics was regarded as a branch of mathematics while, previously (before Maxwell's theory), others branches were regarded as unrelated – as was the case with electric and optical phenomena. This lack of disciplinary cohesion manifests itself in different ways in the processes of institutionalization. Suffice it to say that in the Netherlands there were only two university chairs in theoretical physics until well into the twentieth century. As far as France is concerned, we may recall the decades of theoretical scarcity that separate Fresnel, Ampère, Cauchy, and Fourier from Poincaré and Duhem (cf. Buchwald and Hong 2003). On the other hand, the turn of the century witnessed an increased interest in science among the general public, which did not go unnoticed for scientists and philosophers (the Apollonians and Neodionysians, to use Holton's terminology), insofar as they described it as the "bankruptcy of science" (*faillite de la science*).



This lack of perspective is also evident, for example, in one of the first English commentaries on Duhem's oeuvre. In the last chapter of *The methodology of Pierre Duhem*, under the section entitled "Critical remarks and conclusions," Armand Lowinger (1967, 163) states:

> The fundamental idea guiding our criticism is the modest role which we conceive methodology to play vis-à-vis science. Methodology takes science for granted and is essentially a description of the scientific process. With regard to every question, therefore, which arises concerning the scope and meaning of science, it always has to keep a weather eye on the actual scientific process as it is carried on in the laboratory and in the study of the scientific theoretician and to give as faithful an account of it as possible. It must explain the scientific process, not explain it away by some sort of verbalistic or conceptual legerdemain; it must follow after science, not attempt to dictate or domineer science.

Indeed, Lowinger's remarks make sense once the disciplinary field achieves a considerable degree of institutionalization and normalization. Furthermore, as noted above, Holton and Lowinger – as is, and can only be, the case for most scientists – view methodological questions as *a posteriori* to scientific practice itself, and, therefore, tend to display a strong bias against normative approaches in the philosophy of science.

[6] He (1905, 144) concludes: "If the catalogue is well done the library is none the richer for it; but the reader will be enabled to utilise its riches". "Si ce catalogue est bien fait, la bibliothèque n'en sera pas plus riche. Mais il pourra aider le lecteur à se servir de ces richesses" (Poincaré 1905, 160).

[7] According to Maiocchi (1990, 392), the main concern of Duhem's reflections on the nature of physical theory was to critique the empiricist basis of the positivist conception of science, but it is difficult to ascribe such conception even to Comte, as Elias (1978, ch. 1) and Laudan (1981, ch. 9) have rightly pointed out.

[8] For a critical, albeit sympathetic, analysis of Maiocchi's preceding study on which on which this essay is based, refer to Stoffel (2002, 87-94).

This is not, however, a critique that affects Duhem since his reflections on theoretical physics rest on a careful analysis of scientific practice based on several schools of thought, and since they do not aim to regulate the practice of physics, at least not explicitly. On the other hand, Lowinger is right in subsuming methodological questions under the category of metaphysics and in pointing out that Duhem's thesis on the autonomy of physics excludes any attempt at legislating methodological matters.[9] As I will explain below, Duhem *feels* that methodological controversies will fade away with time once common sense becomes the *bon sens* of the scientific community.

## The English Scientific Practice of the Nineteenth Century

As noted above, in his early analysis of English science, Duhem does not employ the famous Pascalian distinction between the subtle and geometric minds; however, he does hold that its defining qualities – those that set the English apart from the French and German scientists – help us identify the fundamental character of the English mentality (*esprit*). For example, English scientists stand out in their striking ability to imagine complex sets of countless, concrete objects, without losing sight of the place each of these occupies and the relations they have with each other. Thus, rarely do English scientists engage in more abstract research, and when they do, the results tend to be unsatisfactory. This approach is found equally among writers, philosophers, and scientists. When we focus on the activity of the English theoretical physicists, the first thing that stands out, Duhem argues, is the use of what they call a "model." Unlike the abstract theory of German and French physicists, models allow us to establish a mental image of the phenomena in question. Nonetheless, the English scientists' insistence on the construction of models leads them to equate theory with the models themselves, which is evident in W. Thomson's (Lord Kelvin) assertion that it is only by means of the creation of models that we can understand physical phenomena. However, the English School's notion of model should not be equated with the abstract notion of a mathematical model employed in contemporary science; after all, Duhem was primarily concerned with the use of mechanical models; that is, with representations that imitate or simulate the phenomenon in question in a mechanical fashion, such that "understanding the nature of material things will be the same thing as imagining a mechanism that will represent or simulate the properties of bodies by its action." (Duhem 1996 [1893], 55)[10] As Duhem also notes, it is not the insistence on the mechanical representation of phenomena that sets the English School apart, but rather the particular manner in which it brings about this aim by means of models. In the young Duhem's budding, positivist interpretation of the history of physics, mechanistic explanations epitomize the triumph of the imagination over reason, or, as he claims later, of the subtle mind over the geometric mind, of modern science over the rationalist metaphysics of Scholasticism:



> If Descartes and the philosophers who followed him refused to admit the existence of any property of matter not reducible to geometry or kinematics, it is because any such quality would occult, and, being conceivable only by reason, it would remain inaccessible to the imagination. The reduction of matter to extension by the great thinkers of the seventeenth century showed clearly that during that period, the metaphysical sense, exhausted by the excesses of scholasticism during its decadence, entered into the decrepit state in which it still languishes today. (Duhem 1996 [1893], 55-56)[11]

It may be worth recalling that this brief, historical observation squares with Whitehead's later interpretation in *Science and the modern world*, wherein he argues that it would be wrong to regard Galileo's

[9] In "La valeur de la théorie physique", Duhem (1991 [1954], 334) sharply remarks: "The study of the method of physics is powerless to disclose to the physicist the reason leading him to construct a physical theory."

[10] "[C]omprendre la nature des choses matérielles, ce sera imaginer un mécanisme dont le jeu représentera, simulera, les propriétés des corps." (Duhem 1987a [1893a], 119)

[11] "Si Descartes et les philosophes qui l'ont suivi ont refusé d'admettre l'existence de toute qualité de la matière qui ne se réduisait pas à la géométrie ou à la cinématique, c'est parce qu'une telle qualité était *occulte*; parce que, concevable seulement par la raison, elle demeurait inaccessible à l'imagination; la réduction de la matière à l'étendue par les grands penseurs du XVII[e] siècle montre clairement qu'à cette époque le sens Métaphysique, épuisé par les excés de la Scolastique en décadence, entrait en cet état de décrépitude où il languit encore aujourd'hui." (Duhem 1987a [1893a], 119-120) Cf. Duhem 1906, 115.

natural philosophy as a revolt of reason against the dark forces of tradition, since, on the contrary, and as Galileo's friend Paolo Sarpi's account of the Council of Trent demonstrates, his was an anti-intellectualist movement in line with the anti-metaphysicial attitude of the Counsel.

Duhem will further elaborate his account of the Cartesian conception of physics in the first chapters of *La théorie physique*, underscoring the explanatory (metaphysical) aspects underlying the system (especially in the *Optics*) – even when, for Duhem, these aspects are dispensable from the representational or logical point of view of theoretical physics. Likewise, in an essay published between the aforementioned texts entitled "L'évolution des théories physiques, du XVII$^{e}$ siècle jusqu'à nos jours" (1896), Duhem situates Descartes' theory as an important development in physics insofar as it overcomes the hidden entities of the physics of the preceding era and incorporates the theories of the English School as a form of Neocartesianism, or as a partial return to it. But these remarks do not prevent Duhem from noting that Cartesian mechanics is ultimately false; nor will they prevent him from foreseeing, without much success, that this *cartésianisme nouveau*, like its predecessor, will render "the mind […] discouraged by the complexity, the bizarreness, the arbitrary and far from natural ways, by the improbable combinations which it employs in 'constructing the world machine.'" (Duhem 2002, 209)[12] This position, founded on sentiments and not on logic, represents an improvement from the ambivalent assessment evident in his critical review of W. Thomson's physics, and of the English School more generally.

For now, I hasten to note that the distinction between the subtle mind and the geometric mind that Duhem will employ in the well know chapter of *La théorie physique* does not appear in this essay. In *La théorie physique*, Duhem revises his initial views with the intention of offering a systematic exposition of the aim of theoretical physics. Nonetheless, it is important keep in mind the position that Duhem outlines in the early texts with regard to the transitory character of English physics, which he attributes to its *arbitrary* character and lack of natural ways – features that differ from the characteristics proper to the subtle mind, but which also constitute aspects of the physical theory conceived as abstract representation. Is there, then, an evident contradiction in Duhem's outline here? Scholars like Martin (1991, 107-108) argue that Duhem fell prey to imprecisions and shortcomings due to his approach to writing and revising his early texts. For this reason, it would be important to determine whether Duhem himself noticed these flaws, given that clarifying this issue would be crucial to determine whether Duhem was a subtle or geometric mind.



## Hermeneutical Perplexities in Duhem's Realism and Conventionalism

Aside from whether we are dealing with a mistake in exposition or with a more profound inconsistency, it is unquestionable that the verification of that fact leads to the establishment of hermeneutical warnings and precautions regarding the scope of what I am outlining in this essay; but neither should we lose sight of the particular context of Duhem's claims if we wish to eliminate readings that contribute to an increase in perplexity. In order to try to understand Duhem himself, it may be necessary to appeal to the hermeneutical criteria Pascal (1910, 684) sketches in one of his well-known reflections: "We can only describe a good character by reconciling all contrary qualities, and it is not enough to keep up a series of harmonious qualities without reconciling contradictory ones. To understand the meaning of an author, we must make all the contrary passages agree."[13]

As I have noted before with regard to the contemporary scientific understanding of Duhem's methodological inquiries, it is equally important to know what it is exactly that Duhem opposes when he affirms that the end or purpose of the physical theory is to represent experimental laws, and not to explain them. Besides, when we undertake a contemporary reading of this assertion (that is, presupposing a current meaning of *explanation*), we arrive at the conventionalist conception usually attributed to Duhem. Nonetheless, when someone does that, she or he overlooks the fact that the representational and explicative

[12] "À rebuter l'esprit par la complication, par la bizarrerie, par l'allure arbitraire et peu naturelle, par l'invraisemblance des combinaisons qui lui servent à 'construire la machine du monde.'" (Duhem 1987a [1896], 228) Cf. Duhem 1987a [1893b], 82.

[13] In the original: "On ne peut faire une bonne physionomie qu'en accordant toutes nos contrariétés et il ne suffit pas de suivre une suite de qualités accordantes sans accorder les contraires. Pour entendre le sens d'un auteur il faut accorder tous les passages contraires." (Pascal 1963, 257)

character of the physical theory runs parallel to the distinction between physics and metaphysics underpinning the famous thesis on the independence of theoretical physics from metaphysics. In addition, according to Duhem, she or he also forgets that the elimination of the explanatory element is not a matter of methodological normativity, but rather a historical stage in the development of theoretical physics. In my opinion, this is evident when in the early paper on the English School, Duhem describes and confronts the manner in which W. Thomson appeals to the imagination and not to reason when representing the properties of the elements involved in the phenomena in question. These elements are named after objects present in everyday life, and their properties (e.g. fluidity and condensation) behave in the same manner that do normal liquids and air. Generally speaking, "their nature does not need to be defined philosophically. It suffices that their properties fall under senses. The mechanisms they serve to make up are not destined to be grasped by reason; they are destined to be seen by the imagination." (Duhem 1996 [1893], 57)[14] For this reason, Duhem points out that the physics of English scientists is the physics of engineers; whereas, on the other hand, the physics of Continental scientists is usually philosophical. To use the productive metaphor of *La théorie physique*, when we delve into English physics, "we [think] we [are] entering the tranquil and neatly ordered abode of reason, but we find ourselves in a factory." (Duhem 1991 [1954], 71)[15]

It would be a mistake to claim that Duhem is contradicting himself when he argues that "the English School has thus acceded entirely to purely mechanical explanations of physical phenomena", (Duhem 1996 [1893], 55)[16] or when he states, "this predilection for explanatory and mechanical theories is, of course, not a sufficient basis for distinguishing English doctrines from the scientific traditions thriving in other countries." (Duhem 1991 [1954], 72)[17] To frame the issue as a question: can we legitimately read the term *explanation*, presupposing the meaning that Duhem gives to metaphysical explanation, which he had previously rejected? In my opinion, we cannot do so, just as we cannot equate abstract reason with the metaphysical reason of Scholasticism, or geometric reason with the pure reason that conceives hidden causes. When we assign a rigid and exclusive meaning to the notions of "conventionalism" and "realism" these apparent contradictions inevitably leave us with a reading of Duhem marked by false dilemmas. Hence, we cannot reconcile all the paradoxes that emerge when the two notions are used as opposites. The same can be said about the subtle mind and the geometric mind, since, while we can have a sense of what Duhem means when, in *La théorie physique*, he claims that the way of conceiving the English theory of physics corresponds to the broad mentality, or subtle mind, this does not mean that there are no geometric minds who foster the creation of abstract theories among the English scientists, as is in fact the case with Rankine.



It may be the case that the clarification of these concepts would suffice to answer the question posed as title of this paper in the affirmative; nonetheless, it is evident that the relationship between the English School and the subtle mind has, in *La théorie physique,* a negative connotation – one of rejection – and which differs from the positive connotation he give it in *La science allemande*, wherein he links it to French science.

## The Philosophical Dimension of Abstract Theory

As stated before, we do not find the references to Pascal of the late writings in Duhem's early methodological writings, nor is there an appeal to the distinction between the subtle mind and the geometric mind, which appears for the first time – albeit in a rather implicit manner – in 1902, with the publication of *Le mixte et la combinaison chimique*. The only foregoing, explicit "philosophical" reference to the distinction can be found in his essay on the development of the theory of physics, and in that case, only to further support Duhem's

[14] "Leur nature n'a pas besoin d'être philosophiquement définie; il suffit que leurs propriétés tombent sous les sens; les mécanismes qu'ils servent à composer ne sont pas destinés à être saisis par la raison, ils sont destinés à être vus par l'imagination." (Duhem 1987a [1893a], 122) Cf. Duhem 1906, 118.

[15] "[…] nous pensions entrer dans la demeure paisible et soigneusement ordonnée de la raison déductive; nous nous trouvons dans une usine". (Duhem 1906, 111)

[16] "[…] l'École anglaise est donc acquise entièrement aux explications purement mécaniques des phénomènes physiques." (Duhem 1987a [1893a], 119)

[17] "Cette prédilection pour les théories explicatives et mécaniques n'est pas, assurément, un caractère qui suffise à distinguer les doctrines anglaises des traditions scientifiques qui fleurissent en d'autres pays." (Duhem 1906, 114)

negative valuation of English physics discussed above.[18] When he argues, however, that a unyielding sentiment leads him to think that Thomson's and Maxwell's theories cannot be adequate, he is implicitly appealing to a distinctive quality that he will associate with the *esprit de finesse*; this time, not only in *La théorie physique*, but more importantly, in the texts that make up *La science allemande*. However, in the former context, this intuition turns out to be somewhat paradoxical since this sentiment lends support to the conception of the theory of physics as abstract representation of experimental laws. As Duhem argues in this essay, however, this approach is first and foremost logical, philosophical, and metaphysical, while the English School's conception is imaginative, anti-metaphysical, and thus, practical. In order to show this, he notes that Thomson does not pose any philosophical problem (e.g. whether the resulting elements of matter can occupy varying volumes, that is, if they can be condensed) since their approach to build mechanical models is not structured to be grasped by reason, but rather by the imagination (cf. Duhem 1987a [1893a], 122). This is the anti-metaphysical feature of English physics. In short, English physics lacks a *cosmology*.[19]

In the case of mathematical tools, the logico-philosophical nexus is linked to the process of abstraction employed to determine concepts in physical theory; however, in the case of the English School's mechanical models, algebraic analysis is readily available to represent relations established in the model without a concern for the existence of an analogy with the actual properties of bodies; that is to say, whether or not the algebraic magnitudes correspond to real elements. By the same token, there is no concern for the logical origins of equations. In fact, the fundamental differences between both conceptions about the physical theory can be figure out whether the theory exhibits or not an axiomatic structure. For example, Duhem reproaches the chaos Maxwell introduces into electrodynamics when he determines the behavior of dielectic bodies by means a new element – namely, the displacement current –, which Duhem views as strange and lacking in adequate characterization. In sum, the lack of definitions of the new electromagnetic elements, by means of axioms and postulates, makes us think that English theory "c'est le système des équations de Maxwell." (Duhem 1987a [1893a], 126)[20]

On the contrary, axiomatic abstract theory as conceived by the German and French scientists of the time satisfies – through the rigorous, logical sequencing of all its elements – the criteria of unity, order, and



[18] Cf. note 11. "An invincible sentiment warns us that matter cannot be constituted as W. Thomson and Maxwell imagine, and we are tempted to agree with Pascal: "This is all ridiculous; for it is all useless, uncertain and laborious." (Duhem 2002, 209) In the original: "Un sentiment invincible nous avertit que la matière ne saurait être faite comme l'imagine W. Thomson ou Maxwell, et nous sommes tentés de nous écrier avec Pascal: 'Tout cela est ridicule; car tout cela est inutile, et incertain, et pénible'" (Duhem 1987a [1896], 228). In his review of Leray's *Essai sur la synthèse des forces physiques*, Duhem (2006, 19) had already cited said aphorism, but he immediately points out that "[Pascal] carefully retains this useful and practical consequence of Descartes's system, the refusal to explain every natural effect by inventing a new propriety, a special virtue." In the original: "Retient soigneusement cette conséquence utile et pratique du système de Descartes qui se refuse à expliquer chaque effet naturel par l'invention d'une propriété, d'une vertu special." (Duhem 1987a [1893b], 66)

[19] In his reply to the critique launched by the Thomist Eugène Vicaire to his essay on the subject of physical theory, Duhem (1996 [1893], 30) clarifies the modern meaning of the distinction between physics and cosmology as follows: "To conform to contemporary usage, we give the name *physics* to the experimental study of inanimate things, considered in three phases: the observation of facts, the discovery of laws, and the construction of theories. We regard the investigation of the essence of material things, insofar as they are causes of physical phenomena, as a subdivision of *metaphysics*. This subdivision, together with the study of living matter, forms *cosmology*." In the original: "Nous nommons *physique* l'étude expérimentale des choses inanimées envisagée dans ses trois phases: la constatation des faits, la découverte des lois, la construction des théories; nous regardons la recherche de l'essence des choses matérielles en tant que causes des phénomènes physiques comme une subdivision de la *métaphysique*, subdivision qui forme, avec l'étude de la matière vivante, la *cosmologie*." (Duhem 1987a [1893c], 85). On the relationship between this essay and his review of the English school, see Leite (2006, section 2.2), and, more broadly, Leite (2016).

[20] Few lines before, he writes: "Maxwell studies the transformation of the equations of electrodynamics in their own terms, most often without seeking to see behind his transformations the coordination of physical laws. He studies them as one examines the movements of a mechanism. This is why is a futile effort to seek behind these equations a *philosophical idea* which is not there." (Duhem 1996 [1893], 60) The original reads: "Maxwell étudie en elles-mêmes les transformations des équations de l'électrodynamique, sans chercher le plus souvent à voir sous ces transformations la coordination des lois physiques; il les étudie comme on regarde les mouvements d'un mécanisme; voilà pourquoi c'est un labeur illusoire de rechercher, sous ces équations, *une idée philosophique* qui n'y est pas." ( Duhem 1987a [1893a], 126; my italics)

simplicity proper to deductive reasoning. These epistemological criteria define the philosophical dimension of the physical theory conceived as an abstract theory;[21] however, once Duhem reworks this essay and includes it in *La théorie physique,* this dimension eventually disappears and is substituted by the association of abstract theory with the geometric mind (which before only appears as '*les facultés logiques de l'esprit*'), and by the economic conception of scientific thought.

There are two reasons that may have motivated these modifications. The first is the definitive disassociation of the axiomatic structure of the physical theory from cosmological presumptions, which, within the mechanistic tradition, were linked to the deductive capacity of abstract theory. This separation constitutes an acknowledgment of the limits of his science on the part of the physicist, an acknowledgment that emerges from the ephemeral character of the cosmological element within the development of physics, since, as Duhem argues in *La théorie physique*, everything that is good within a physical theory can be found in its representational components, while its unstable and sterile elements are found in its explanatory components. Or as Duhem asserts more emphatically:

> What is lasting and fruitful in these is the logical work through which they have succeed in classifying naturally a great number of laws by deducing them from a few principles; hat is perishable and sterile is the labor undertaken to explain these principles in order to attach them to assumptions concerning the realities hiding underneath sensible appearances. (Duhem 1991 [1954], 38)[22]

We should point out, albeit briefly, that this fundamental feature of the growth and development of physical theory suffices to overthrow any simplistic and untenable idea about the accumulative character of physics in Pierre Duhem's thought since what is currently referred to as a scientific revolution would be nothing other than the substitution of cosmological components – which given their own explicative nature are, for their protagonists, as dramatic as they are incommensurable. Nevertheless, cosmological components are not the only factor under consideration, since other elements related to the representation of phenomena come into question; for example, the emergence of new discoveries or the difficulty in assigning magnitudes to physical properties – aspects that fall outside the field of competence of logical analysis, and that, therefore, refer back to the imagination or to intuition. Moreover, as Crowe (1990) notes, in *La théorie physique,* Duhem opposes the development of the physical theory to the properly accumulative development of mathematical theories.



As I mentioned above, the notion of abstract theory that Duhem has in mind refer to the axiomatic structure of the physical theory, and the ideal of such structure is still the system explained in Euclid's *Elements*. This is sufficiently evident when he claims that nothing keeps us from providing Maxwell's equations with an appropriate axiomatic formulation in the future:

> No doubt what is exact and truly fertile in the work of Maxwell will one day take its place in a coherent and logically constructed system, in one of those systems in which thoughts are conducted in order, in the image of Euclid's *Elements*, or of those majestic theories unfolded by the creators of mathematical physics. (Duhem 1996 [1893], 64)[23]

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[21] "Without doubt, all branches of pure and applied mathematics treat concepts that are abstract. It is abstraction that furnishes the notions of number, line, surface, angle, mass, force, temperature, and quantity of heat or electricity. It is abstraction, or *philosophical analysis*, that separates and makes precise the fundamental properties of these various notions and enunciates axioms and postulates." (Duhem 1996 [1893], 58) In the original: "Sans doute, toute branche des mathématiques pures ou appliquées traite de concepts qui sont des concepts abstraits; c'est l'abstraction qui fournit les notions de nombre, de ligne, de surface, d'angle, de masse, de force, de température, de quantité de chaleur ou d'électricité; c'est l'abstraction, c'est *l'analyse philosophique* qui démêlent et précisent les propriétés fondamentales de ces diverses notions, qui énoncent les axiomes et les postulats." (Duhem 1987a [1893a], 123; my italics).

[22] In other words: "Ce qui, en elle, est durable et fécond, c'est l'oeuvre logique par laquelle elles sont parvenues à classer naturellement un grand nombre de lois en les déduisant toutes de quelques principes; ce qui est sterile et périssable, c'est le labeur entrepris pour expliquer ces principes, pour les rattacher à des suppositions touchant les réalités qui se cachent sous les apparences sensibles." (Duhem 1906, 57-58)

[23] In the original: "Sans doute, ce qu'il y a d'exact et de vraiment fécond dans l'oeuvre de Maxwell prendra place, un jour, dans un système cohérent et logiquement construit, dans un de ces systèmes où les pensées sont conduites par ordre, à l'image des *Eléments* d'Euclide ou de ces majestueuses théories que déroulaient les créateurs de la physique

Duhem's own scientific endeavors usually exhibit an axiomatic structure and grant high esteem to those who, like Gibbs and Helmholtz, proceed in similar fashion. For example, in his "Commentaire aux principes de la thermodynamique" (1892-1894), Duhem justifies his axiomatic treatment of theory by arguing that a return to the foundations allows us to evaluate the degree of development a theory has achieved in an extended period of time, and to predict new consequences, but also to overcome the obstacles that have accumulated during a given period.[24] Donald Miller (1970, 229) has claimed that the axiomatic outlook that Duhem employs with regard to the first law of thermodynamics was novel in physics while it simultaneously anticipated, to some extent, the inquiry into the foundations of mathematics that took place at the turn of the century. Yet this claim is an exaggeration with regard to the work on the foundations of mathematics since Duhem's axiomatic outlook is, in fact, informal (or intuitive) with respect to the initial definitions because they do not present themselves in symbols, and there is no trace of the distinction – even in a primitive form – between the language-object and the metalanguage by means of which the axiomatization takes place.[25] In short, he does not sketch a method to address the mathematical problems proper to axiomatization, such as the nature of rudimentary terms, the independence and self-sufficiency of a given cluster of axioms, or the consistency and comprehensive nature of the system.[26] But neither would he have motivations to do so, since, although he was awarded the degree of Doctor in Mathematics, he did so with a dissertation on the theory of physics – focusing on "magnetism by influence" (*aimantation par influence*)–,[27] employing an axiomatic framework proper of the geometric mind.

On the other hand, at the outset, he specifies which theories are presupposed (geometry and kinematics) in the process of establishing of a system, but he also discusses, at length, the philosophical considerations that seem to not belong to an axiomatization, which takes place when he holds that it is impossible, and useless, to know the real constitution of matter, or when he speaks of physicists who deny the possibility of bodies that are the result of mixtures or combinations of two bodies A and B.[28]

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mathématique." (Duhem (1987a [1893a], 131) In *La science allemande,* he notes Helmholtz's and Hertz's respective treatments of the subject – although he assigns a greater success to the latter (cf. Duhem 1915, 128-129). On the other hand, his reference to the Euclidian framework should not lead us to think that Duhem overlooks the logical shortcomings of that axiomatization, i.e., the independence of its axioms (cf. Duhem 1915, 113-114).



[24] "It becomes necessary to return to the foundations on which the science is based, to examine anew their degree of soundness, to assess exactly what they can support without giving way. Once this work is done, it will be possible to build up the new consequences of the theory." (Duhem 2011 [1892-1894], 35)

[25] Cf. Miller (1970, 229). It appears Duhem was not familiar with the axiomatic systems developed by Frege and Hilbert – now known as Hilbert systems – nor with the new mathematical logic Couturat sought to introduce, without much success, in the French intellectual milieu based on the works of Peano, Schröder, and Russell. For a brief approximation to Duhem and Couturat, see Hernández (2016).

[26] This does not mean that he refrains form framing the question in a traditional way and with regard to the roles the subtle and geometric minds play within them: "[…] the axioms that a science of reasoning demands that we grant to it ought no merely to agree among themselves without any shade of contradiction. They ought, further, to be as few in number as possible. Consequently, they ought to be independent one from another. If one among them, in fact, could be demonstrated by means of the others, it would be deleted from the number of the axioms and relegated to the class of theorems […]. To find out whether all the axioms of Euclid are truly independent of each other is a question under the jurisdiction of the mathematical mind […]. But to decide whether the postulate of Euclide is true is a question that the mathematical mind, left to itself, could no answer. It must, in this case, have recourse to the aid of the intuitive mind." (Duhem 1991 [1915], 87-88) In the original: "[…] les axiomes qu'une science de raisonnement demande qu'on lui concède ne doivent pas seulement s'accorder entre eux sans l'ombre d'une contradiction; ils doivent encore être aussi peu nombreux que possible; partant, ils doivent être indépendants les uns des autres; si l'un d'entre eux, en effet, se pouvait démontrer à l'aide des autres, il devrait être rayé du nombre des axiomes et relégué parmi les théorèmes […]. Reconnaître si tous les axiomes d'Euclide sont vraiment indépendants les uns des autres, c'est une question qui ressortissait à l'esprit géométrique […]. Mais décider si le postulatum d'Euclide est véritable, c'est une question à laquelle l'esprit géométrique, abandonné à lui-même, ne saurait donner de réponse; il lui faut, ici, le secours de l'esprit de finesse". (Duhem 1915, 113-114)

[27] Duhem's theory only deals with the magnetism of solid bodies, such as crystals, with quite modest theoretical intentions: "nous espérons que le présent travail, quelque restreint qu'il soit, aura contribué à élucider quelques points obscurs ou douteux dans la théorie de l'aimantation par influence." (Duhem 1888, 136)

[28] Cf. Duhem 2011 [1892-1894], 38. It may be worth recalling that, in the introduction, Duhem acknowledges that his treatment may be viewed as more philosophical than mathematical as to be included in the *Journal de mathématiques pures et appliquées*.

That being said, the second reason why Duhem was able to suppress the characterization of abstract theory as a philosophical view of the physical theory is also linked to another negative aspect of the axiomatic structure since as the deductive capacity of the theory promotes the desire to overcome the representational domain in search of a cosmological explanation of laws. Similarly, the exclusive attachment to consequences derived from the theory makes philosophers hostile toward any discovery not previously accounted for by the theory. In contrast to the English School, whose model favors technological invention and application, abstract theory, for a young Duhem, has the shortcoming of fostering "an unimaginative mindset, hostile to novelty, and for which Continental scientists, and their academies tend to be reproached." (Duhem 1996 [1893], 70)[29]

In *La théorie physique*, Duhem removes both shortcomings of abstract theory as an axiomatic system. In addition, he undermines the positive aspects of the mechanical models while simultaneously, complaining about its lack of logical rigor and its de-structured quality – a critique already at work in some of his scientific works.

## What is the Extent of Pascal's Influence?

If we compare Duhem's critical review of the English School with Chapter IV of the first part of *La théorie physique*, what is most evident is that the association of the subtle mind with the English mentality does not add substance to what Duhem argues in the preceding essay since the changes described above are also not associated with the English mentality, but instead, to the Continental one, which favors an axiomatic outlook. Is Pascal's influence on Duhem, then, more apparent that real? Given that Martin (1991), Stoffel (2007), and Cortese (2016) hold – with their respective differences –[30] that there is a marked Pascalian influence on Duhem's thought, it seems convenient to outline some of the arguments that lead me to believe that this influence is, at least, not as significant as the three authors argue.

The first, and most apparent, evidence for the rhetorical, rather than actual, use of the distinction between the subtle mind and the geometric mind lies in the fact that in *La théorie physique*, the subtle mind is associated with the English way of doing physics, while in the writings collected in *La science allemande,* the subtle mind is primarily associated with the French mentality, while the geometric mind is associated with the German mindset. In other words, when compared to the English, the French display a deductive mindset; whereas, compared to the Germans, the French display a broad, but weak mode of thought. How is this possible? If we immediately rule out the hasty reading that ties nationality, strictly speaking, with one of the two mentalities, it becomes clear that the modes of thought are defined not in function of the specific nationality, but rather by the physicists' approach to the physical theory, since, if Duhem has gone to great lengths to criticizing the English approach it is precisely because the success of mechanical models has led to their use beyond the English channel, and to their triumph in the kingdom of abstract theory, namely, France and Germany.

On the other hand, we can delimit the scope of the subtle mind in the French context if we grant that both French and German scientists are advocates of abstract theory, but that they differ in the way they view a system's axioms and postulates, so that the geometric mind depends on because of the consequences they may derive, while the subtle mind is capable of *feeling* or *intuiting* their truth. However, although this interpretation is plausible in theory, it has the burden of being appropriate when applied to mathematical theories, but indefensible when applied to the physical theory. This is the case because the subtle mind is the one in charge of filling in the gaps the geometric mind is unable to reach, which exceed the domain of principles and of the physical theory itself, as is the case with the relationship between theoretical and



[29] "Our need to admit nothing except what can be clearly deduced from accepted principles makes us mistrustful of any unexpected discovery. This need leads to the bureaucratic mind, hostile to novelties, for which continental scientist and their academies are so often reproached." (Duhem 1996 [1893], 70). In the original: "Notre besoin de ne rien admettre qui ne se déduise clairement des principes reçus nous rend méfiants à l'égard de toute découverte inattendue; de ce besoin découle l'esprit routinier, hostile aux nouveautés, si souvent reproché aux savants du continent et aux académies qu'ils composent." (Duhem 1987a [1893a], 140)

[30] Stoffel (2002) makes a strong critique of some of Martin's main theses without denying for that matter the influence of Pascalian thought, while Cortese (2016) follows Stoffel's (2007) reading closely.

experimental physics; as Duhem says, it is not something to be deduced, but rather *intuited* (Duhem 1915, 131).

Besides, as he states in *La théorie physique* – but also in his application for admission into the Academy of the Sciences, and elsewhere – theoretical laws are free creations of the intellect and their permanence is determined by their ability to synthesize experimental laws and by the productivity of their consequences.[31] What truth, then, can be felt about a law, like the law of conservation of energy, which is taken to be a hypothesis that must be verified by means of its most immediate and distant consequences?[32] We can respond to this question by arguing that it is up to the subtle mind to contrast and verify the theory; but this response suffers from the great inconvenience of presupposing that the problem at hand pertains to experimental, and not theoretical physics (except, perhaps, if the point is to free theory from hasty refutations). Moreover, for Duhem, contrary to axioms in mathematics, in physics, common sense does not suffice to *feel* or *intuit* the truth of principles; instead, scientific experience – which does stop with the perfection scientific instruments and the emergence of new discoveries – is necessary:

> More complex yet is the choice of hypotheses upon which will rest the entire edifice of a doctrine pertaining to experimental science, of a theory of mechanics or physics. Here the matter which ought to furnish the principles is no longer common experience, spontaneously available to every man from the time he leaves infancy. It is scientific experiment [*expérience*]. To the mathematical sciences common experience furnishes autonomous, rigorous, definitive data. The data of scientific experiment are only approximate. The continual improvement [*perfectionnement*] of instruments increasingly modifies them, while the fortunate chance of discovery each day comes to enlarge the treasury with some new fact. (Duhem 1991 [1915], 81-82)[33]

I think it unnecessary to expand on how problematic it is to give full significance and coherence to an intuition that requires a scientific experience, which renews itself endlessly in light of multiple factors, but that, at the same time, pretends to attain – in advance – the truth itself about hypotheses that are accepted as highly arbitrary and subject to revision according to pragmatic criteria linked to the productivity of their consequences. On the other hand, it seems appropriate to suggest that this appeal to scientific experience foreshadows a key concept in physics' recent historiography, which Buchwald and Hong (2003, 180ff) have called unarticulated knowledge, refering to the implicit knowledge that makes possible the configuration of a theory but which also guides experimental practice in the laboratory.[34]



[31] *Notice sur les titres et travaux scientifiques de Pierre Duhem,* written in May of 1913, but published posthumously, which deals with the supposed Newtonian method to arrive at principles by means of inductive reasoning, notes that according to Energetism: "The principles are laid down as pure postulates, arbitrary decrees of human reason; they are considered to have successfully fulfilled their role when they yield numerous consequences that conform to experimental laws." (Duhem 1987b, 334) Unfortunately, the English translation lacks the section devoted to his work as a physicist.

[32] With regard to the first law of thermodynamics, he notes: "[…] it is a *physical hypothesis* […]. It is for experience to verify its immediate and more distant consequences." (Duhem 2011 [1892-1894], 63)

[33] "Plus complexe encore est le choix des hypothèses sur lesquelles reposera tout l'édifice d'une doctrine appartenant à la science expérimentale, d'une théorie de Mécanique ou de Physique. Ici, la matière qui doit fournir les principes, ce n'est plus l'expérience commune, celle que tout homme pratique spontanément dès qu'il est sorti de l'enfance; c'est l'expérience scientifique. Aux sciences mathématiques, l'expérience commune fournit des données autonomes, rigoureuses, définitives. Les données de l'expérience scientifique ne sont qu'approchées; le perfectionnement continuel des instruments les retouche et les modifie sans cesse, tandis que le hasard heureux des découvertes, chaque jour, de quelque fait nouveau en vient grossir le trésor." (Duhem 1915, 106)

[34] As Buchwald and Hong (2003, 181) elucidate, this implicit knowledge can become explicit at a given moment: "Specifically, by 'unarticulated knowledge' we intend knowledge that is generally unexpressed but that guides research. This not at all the same thing as *unexpressible knowledge*, such as the kind of skill that is needed to form a beautiful piano leg on a lathe. Not at all – it is knowledge that is *unexpressed*, that exists below the surface of explicit discourse. Such knowledge is accordingly tacit, in the sense of unspoken, but it can be – and often eventually is – heard, particularly when a science settles into a reasonably stable form."

## Closing Remarks

If what I have argued thus far seems plausible, then we can ask whether Duhem's use of the distinction between the two mentalities has the significance scholars like Martin, Stoffel, and Cortese ascribe to it; or whether, on the other hand, Duhem resorts to the dichotomy because of its popularity among the French audiences at the turn of the century without much of a concern for a consistent and systematic treatment. The latter may be due to the fact that Duhem's oeuvre addressed three different audiences: those who, following Holton, I have called New Apollonians and Dionysians, and, of course, their theoretical and experimental counterparts. Additionally, in some cases, a number of these writings were revised and published – in part or in whole – for a different type of audience, as is the case, for example, with *La théorie physique*, but also with *Le mixte et la combinaison chimique* (1902), which takes up previously published essays with a philosophical audience in mind, and is, therefore, published in *La revue de philosophie* – a journal with Catholic inclinations in which Duhem participated in from its inception.

As I noted toward the beginning of this essay, the philosophical inquiry into the end and value of theoretical physics is related to the process of institutionalization and recognition of the discipline; or, as Bordoni (2012, 128) states, "the emergence of theoretical physics corresponds to a new sensitivity to meta-theoretical issues: we find explicit designs of unification, and explicit methodological remarks, as well as explicit questioning of the foundations of physics." In my opinion, however, Bordoni is not appropriately consistent when, immediately following the above quote, he argues that "[s]cientists did not entrust philosophers with reflections on aims and methods of science: metatheoretical remarks began to emerge from inside science, rather than being addressed to science from the outside." There is a simple explanation for this. When a discipline is in the process of its stabilization and professionalization, it is not easy to determine who is inside and who is outside. In the case of physics, as Bordoni himself acknowledges, "Maxwell, Boltzmann, Rankine, Gibbs, Helmholtz […] may all be described as natural philosophers and physicists," but there are also protagonists whose professional profiles put them on the side of engineers, mathematicians, *self-made men* (as in the case of Faraday), amateurs, and philosophers.

On the other hand, in many cases, methodological discussions are aimed at literate audiences, at young students (as was the case with most of the essays collected in *La science allemande)*, but also at New Apollonians (like Abel Rey) and New Dionysians (like Bergson and Le Roy). In my opinion, Duhem resorts to Pascal's distinction, because – besides his undeniable admiration – it is present in the collective imaginary of the French people when it was not unusual to resort to it as a rhetorical and stylistic device, as can be seen in the profiles of the characters developed by Saint-Simon (cf. van Elden 1975). Therefore, my reading does not assume a skepticism toward his sympathy for Pascal, neither would I call into question the claim that Duhem saw himself as an *esprit de finesse*. It does not follow from this, however, that he can be regarded as a disciple of Pascal's, as his daughter Hélène claimed (1936, 229), or that there is a strong Pascalian influence on Duhem's main theses on theoretical physics.



For example, Stoffel (2007, 287) lists three themes "ponctuelles et textuellement attestées" that, regardless of how much we stretch them, do not justify talk of a decisive influence, since the very fact of referring to related *themes*, and not to ideas and theories, suggests, in principle, a weak connection. Moreover, in each case, we can have serious reservations about the possibility of attributing a Pascalian influence. The first thematic affinity Stoffel points out is the critique of mechanism; the second one refers to the different orders of knowledge; and the third refers to the distinction among the different kinds of mindsets or intellects. However, it should be evident that to take Pascal as a critic of mechanism because of his critique of Descartes, is, on the one hand, to mistake a part for the whole; on the other hand, it is to overlook the existing overlaps between both seventeenth-century thinkers, which, moreover, Duhem himself points out.[35] Regardless, if we can claim a significant connection between Pascal and Duhem, it is the one Duhem (1905) makes with regard to the evaluation of Pascal's scientific work, where he argues that while we cannot

[35] Alluding to Pascal's well known Aphorism 60, Duhem goes so far as to equate the universality of logic to moral law: "It is beyond argument that logic is unitary. Its principles impose themselves, with the same ineluctable rigor, on the French, the English, and the Germans […]. In the same way, the moral law is the same on either side of the Pyrénées." (Duhem 1996 [1893], 73) In the original: "Il est hors de contestation que la logique est une; que ses principes s'imposent, avec la même inéluctable rigueur, à un Français, à un Anglais et à un Allemand […]. De même la loi morale est identique en deçà et au delà des Pyrénées." (Duhem 1987a [1893a] 144-145)

attribute the discovery of great truths to him, his merit lies in his reconfiguration of preceding knowledge. In Duhem's case, this work of conceptual elucidation takes place through the axiomatization of a unified abstract theory underlying his project for a general, or energetic thermodynamics. These organizational abilities, however, cannot be ascribed to the activities of a scientist who possesses a subtle mind, but rather to one with a geometric mind.

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