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From Hacking's Plurality of Styles of Scientific Reasoning to "Foliated" Pluralism: A Philosophically Robust Form of Ontologico-Methodological Pluralism

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This essay develops a form of scientific pluralism that captures essential features of contemporary scientific practice largely ignored by the various forms of scientific pluralism currently discussed by philosophers. My starting point is Hacking's concept of style of scientific reasoning. I extend Hacking's thesis by proposing the process of "ontological enrichment" to grasp how the objects created by a style articulate with the common objects of scientific inquiry. The result is "foliated pluralism," which puts to the fore the transdisciplinary and cumulative ways of proceeding in science, as well as the historical dimension of the genesis of scientific objects.

1. Introduction. That quarks are different kinds of things from brown dwarfs, monetary exchanges, or processes of cellular division is something that not many would deny. As platitudinous is the acknowledgment that a geologist compressing diamonds in order to reproduce physical conditions at the center of the Earth does not adopt the same methodology as an ecologist conducting field observation in the Amazonian forest or a physicist trying to derive from string theory observable imprints in the early universe. But as rightly emphasized by Richardson (2006) recently, what proponents of scientific pluralism need to establish is that "there is a philosophically important lack of unity that has somehow been missed,

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one that is not identical with the lack of unity that everyone already knows about" (5).

This essay aims at proposing such a philosophically robust form of scientific pluralism. Its starting point will be the concept of style of scientific reasoning developed by Ian Hacking, with a focus on its ontological import. As will be discussed in detail later, styles of scientific reasoning, says Hacking, create new kinds of objects. The statistical style, for instance, introduces populations characterized by their mean and their standard deviation. But how do these new kinds of objects, ontologically internal to a style, articulate with the familiar objects "out there in the world," such as stars, forest fires, or cellular processes, which are common objects of scientific inquiry? Hacking has not dealt explicitly with this articulation. I will try to fill this gap by proposing to conceive it in terms of what I will call "ontological enrichment." This essay is to that extent an essay on the ontogenesis of scientific objects.

The existence of a plurality of styles of scientific reasoning, combined with the process of ontological enrichment, will then lead to a form of ontologico-methodological pluralism that I will dub "foliated pluralism." Foliated pluralism, I will argue, constitutes a "philosophically important" form (in Richardson's sense) of scientific pluralism, for it captures essential features of contemporary scientific practices that have been ignored by familiar forms of pluralism, such as "patchwork" pluralisms.[1] To get to foliated pluralism, we need to start with the analysis of two directly relevant features of the very rich (and sometimes challenging) concept of style of scientific reasoning proposed by Hacking, to wit, the introduction of new types of propositions and the creation of new objects of studies.

2. Hacking's Concept of "Style of Scientific Reasoning." Let me first notice that nowhere does Hacking provide us with a precise definition of a style of scientific reasoning. Hacking apologizes for that but at the same time reminds us that this is also the case for concepts as influential as Foucault's "discursive formation," Kuhn's "paradigm," or Lakatos's "research program" (Hacking 1992b, 138). And as for these concepts, which are close in certain aspects, the concept of a style of scientific reasoning is introduced by a series of examples that Hacking borrows from the historian of science Alistair C. Crombie. Crombie (1988, 1994) identifies six main styles in the European tradition of scientific thinking, more or

1. By "patchwork" pluralisms, I mean here forms of ontologico-methodological pluralism based on the idea that the domain of science can be carved in various kinds of objects calling for specific methods of inquiry and the subject of distinct disciplines. This discipline-based kind of pluralisms was, e.g., the target of proponents of the unity of science such as Carnap and remains today a common view (especially among scientists) of the lack of unity of the domain of science.

less up to the seventeenth century: (i) the simple method of postulation exemplified by the Greek mathematical sciences, (ii) the deployment of experiment both to control postulation and to explore by observation and measurement, (iii) the hypothetical construction of analogical models, (iv) the ordering of variety by comparison and taxonomy, (v) the statistical analysis of regularities of populations and the calculus of probabilities, and (vi) the historical derivation of genetic development.[2] To these six styles, Hacking adds a seventh style, essential to contemporary scientific practice, to wit, the laboratory style characterized by the construction of apparatus intended to isolate and purify existing physical phenomena and to create new ones.[3]

In the absence of a precise definition, Hacking states his concept in four theses stipulating what a style of scientific reasoning accomplishes.[4] According to the *first thesis*, a style introduces new objects of studies, new types of propositions, new types of laws, and new types of explanations. The *second thesis* states that a style is "self-authenticating"; that is, it defines its own criteria of validity and objectivity. A style is not valid because it would allow us to discover some truths; rather, a style is what defines the kinds of propositions that can be a candidate for being true or false. The *third thesis* is about stability. It states that each style develops its own (more or less efficient) techniques of stabilization. The *fourth thesis* deals with the cultural history and the cognitive foundations of a style of scientific reasoning. It claims that each style, on the one hand, is grounded in some typically human cognitive and physiological capacities that are the product of evolution by natural selection and, on the other hand, is the result of human cultural history, mainly Mediterranean and later European regions, whose study pertains to philosophical anthropology.

To get to foliated pluralism, we have to focus on the first two theses, especially the idea that styles introduce new types of propositions up for being true or false and new types of objects of studies.[5]

3. New Candidates for Truth or Falsehood. Styles, says Hacking, create new kinds of propositions. This claim does not boil down to the banal

2. This wording is Hacking's (1992c/2002, 181–82), combining wordings from several of Crombie's expositions.

3. It would be very interesting to investigate whether computer simulations should be added to the list today.

4. This presentation in four theses is the one given by Hacking in the lectures he gave at the Collège de France in Paris in 2003, synthesizing ideas spread out in various papers (Hacking 1982, 1992a, 1992b, 1992c).

5. Note that for Hacking those are necessary conditions for a way of finding out about the world to qualify as a style of scientific reasoning.

claim that some sentences are not uttered before a certain time. Each style, says Hacking more radically, brings about new ways to be a candidate for truth or falsehood. Consider the sentence "the gross national product of Württemberg in 1817 was 76.3 million adjusted 1820 crowns." Uttered at a time (roughly before 1820) when no official statistics about cities or nations were available, such a sentence, contends Hacking, did not have a truth value (this is not to say that, uttered now, it does not have a truth value). Why is that so? Not only, answers Hacking, "because 'gross national product' was not defined, but because *there was no procedure of reasoning about the relevant ideas*" (1992b, 143; my italics). Hacking's thesis is that truth conditions for certain kinds of sentences are given by a style of scientific reasoning; they had not always been in place prior to the emergence of the style. This is of course not the case for any sentence. Consider Russell's famous example "the king of France is bald." Does this sentence have a truth value? Taking inspiration from Strawson's (1950) discussion of Russell's example, one can claim that this sentence is neither true nor false but is *susceptible* to being true or false. In other words, there are conditions of possibilities for truth (or falsehood), to wit, (i) there is a king of France, (ii) there is only one king of France, and (iii) the king is bald (or is not bald). But the point is that these conditions are not given by a particular style of reasoning: the sentence is susceptible to being true or false independently of any style. Hacking's essential insight is that this does not hold for a sentence such as the one mentioned above about the gross national product of Württemberg; in that case, the statistical style is what gives the conditions of possibility for truth (or falsehood) by providing a procedure of reasoning about the proposition. All propositions are thus not on a par as regards how they acquire their positivity (as Auguste Comte would have put it). And, not surprisingly, one also should not expect a single theory of truth to be adequate for all kinds of sentences. For instance, the correspondence theory of truth turns out to be very inadequate for sentences that acquire positivity with the advent of a style of scientific reasoning. Acknowledging a direct source of inspiration in Moritz Schlick's famous motto "the meaning of a sentence is its method of verification," Hacking adopts for this kind of sentences a conception of truth of a verificationist vein: "The truth is what we find out in such and such a way" (1992b, 135). But by contrast with the traditional verificationist take on signification embraced by the logical positivists, Hacking's conception of truth is strongly historicized: the procedures of reasoning that give access to truth values each have their own specific historical trajectory. For all that, Hacking does not dismiss the correspondence theory of truth as invalid in all cases. The theory might very well be adequate for certain types of declarative sentences. What is untenable, though, is its pretension to universality: "I do not think [that]

there is one theory of truth, or one semantics, that applies to all contingent empirical sentences investigated in the sciences" (1992b, 135).

This pluralistic approach is not the only noticeable feature of Hacking's standpoint on the notion of truth. It is also worth emphasizing that his historicized, verificationist take on truth for certain types of sentences does not lead to relativism (when relativism refers to the idea that the truth value of a proposition may vary from one person or one group to another and does not depend solely on how the world is). Let us recall that a style of scientific reasoning determines the type of propositions having positivity, that is, being up for truth or falsehood. *But the style does not fix what the truth value of these sentences is; the world does*. Or, as Hacking puts it (1992b, 135), "The actual truth value of those sentences is external to the style: what is true in no way depends on how we think." In a more literary vein, transposing Hamlet's (somewhat ambiguous) maxim that nothing is either good or bad but thinking makes it so, Hacking contrasts the appropriate paraphrase of the maxim "no sentence introduced by a style of scientific reasoning is either true-or-false but the style makes it so" with what would be an inappropriate, relativist paraphrase, to wit, "no sentence, which is true, is true and no sentence, which is false, is false, but styles make it so."[6]

If the pitfall of relativism is thus easily dismissed, circularity is, however, a claimed feature of Hacking's central notion of self-authentication of a style of reasoning, as attested by the following key passage:

> There then arises a suspicion of circularity. I embrace it. I welcome it. For there *is* an odd way in which a style of reasoning and truth-conditions of some sentences are mutually self-authenticating. The truth is what we find out in such and such a way. We recognize it as truth because of how we find it out. And how do we know that the method is good? Because it gets at the truth. . . . There is not a prior truth, deeper, original, independent of reason, dwelling in the very interstices of the world, and which is discovered by reasoning ("correctly") according to some style. Nor do we discover the styles that then enable us to unearth and finally state the hitherto unstatable but pre-existing truth. The truth-or-falsehood and the style grow together. (Hacking 1992b, 135)

There is thus no Archimedean point, no external standard from which one could evaluate the capacity of a style to deliver truths.

4. New Objects of Studies. Styles not only create new types of propositions up for being true or false but also create new objects of studies. The

6. This wording is the one used by Hacking (2003). See also Hacking (1982, 49).

statistical style introduces, for instance, populations characterized by their mean and their standard deviation; the mathematical style of postulation introduces abstract objects such as complex numbers or sets; the laboratory style often introduces unobservable entities (unobservable at least at the time of their introduction) such as atoms or electrons; the taxonomic style introduces various categories of classification (species, genus), and so on. Those kinds of objects are created by a style to the extent that they did not exist before the style came into being. But how exactly should we understand that they exist once introduced by a style? What is their mode of existence compared to the unproblematic mode of existence of, say, a flower or a star?

Let us consider the example that Hacking (1992b) borrows from the history of statistics. In 1844, the Belgian statistician Adolphe Quetelet published a study of the diameter of the chest of 5,738 Scottish soldiers. In this study, Quetelet introduced for the first time two new parameters to characterize a population, to wit, its mean and its standard deviation (in addition to other already used parameters such as the average). Those statistical properties are now considered, says Hacking (1992b, 148), as objective properties of a population in the same way that, say, the location of a planet at a certain time is considered as an objective property. Before Quetelet, there was no such thing as a population characterized by its mean and its standard deviation: a new object has therefore been created by a style.

For all that, does that claim make Hacking a constructivist? Well, the very idea of "construction of reality" being notoriously ambiguous, we have to be precise and careful here. So let me quote again in extenso a key passage in which Hacking situates his ontological position on a spectrum of various possible interpretations:

> Philosophical talk of creating new objects, populations and phenomena is tricky. There is a spectrum of philosophical opinion. To start at one end, consider the population of "homeless" camped on the streets of major American cities. Whatever its causes, this population is a distinct one that did not exist a decade ago, even if its members were mostly members of other populations that shifted to this one. There is no hint of nominalism in saying that this is newly created. Moving along the spectrum, I myself am happy to say that people created lasers and also the phenomenon of lasing—nothing lased until people made it do so. Many more conservative philosophers of science resist what I say, but such statements do not reveal me as a closet constructionalist. Going further along the spectrum, some have said that a new object, the solar system, and its center, the sun, came into being after Copernicus. That is clearly a more radical use of

> "new object" than my commonplace and commonsense remark about lasers. . . . Where, on this spectrum of philosophical radicalism, should we place remarks about the mean of an attribute of a social or biological population? To say that it is a new kind of object, presented to the world in 1844, is to be more radical than to say that lasers are a new kind of object, and lasing a new kind of phenomenon. It is less radical than saying that the solar system and the sun were new kinds of objects. They were, to a conservative mind, old objects reclassified. That is not true of the new kind of population and its statistical parameters. There were no such objects under *any* description. (Hacking 1992b, 148–49).

So basically, Hacking tells us here what creation of objects by a style is not, but he does not really tell us anything positive about the mode of existence of the objects created by a style. Is that a shortcoming of Hacking's scheme? Actually not since a style is not supposed to determine this mode of existence. On the contrary, a style opens a specific ontological debate for each type of objects it introduces (Hacking 1992c/2002, 189). And indeed, if you look at the history of the styles of scientific reasoning, you see that a series of broad ontological questions appeared concomitantly with the coming into being of the various styles. For instance, do numbers exist outside the mind of the mathematician (this ontological interrogation appeared with the mathematical style of postulation)? Is the standard deviation of a population an objective property of this population (this interrogation appeared with the statistical style)? Does the species *Canis lupus* mark an objective division of nature or is it only an artifact of the human mind (this question appeared with the taxonomic style)? Do the unobservable entities postulated to save the phenomena exist on the same material mode of existence as a star or a flower (this ontological debate appeared with the laboratory style)? You immediately recognize here three big "isms" at the core of traditional ontological debates—to wit, Platonism, nominalism, and scientific realism—so that those ongoing ontological debates appear as consequences of the coming into being of styles of scientific reasoning.

As interesting as they might be, it is important to see that those debates do not need to be resolved because of the *internalist* character of the ontology of styles of scientific reasoning. To make this point vivid, Hacking (2003) proposes a parallel with Kant's antinomies of pure reason and Kant's way of stating the terms of an antinomy without defending the thesis or the antithesis, explaining the very existence of the debate by going beyond the limits of pure reason. In a similar way, the point is not to resolve but to go beyond the traditional ontological debates evoked earlier by getting rid of a monist ontological pressure that requires us—

wrongly according to Hacking—to attribute the same mode of existence to objects as various as an electron, Homer, this page, or a given taxon adopted by biologists. But there is no such thing as an absolute ontological tribunal: everything happens within a style. In other words, the criteria of existence are given by the styles themselves. I would suggest here a paraphrase of Quine's famous ontological stance: to be is to be the object of a reasoning process constitutive of a style of scientific reasoning. But as in the case of Hacking's verificationist take on the notion of truth that goes hand in hand with it, this internalist take on ontology has no pretension to universality: it is relevant only for objects introduced by styles of scientific reasoning.

5. Ontological Enrichment. This limitation of the domain of relevance of Hacking's ontological internalism immediately raises the issue of how those objects ontologically internal to a style (i.e., those introduced by a style) articulate with common objects of scientific inquiry out there in the world. My claim is that when a style of scientific reasoning introduces a new kind of entity, this entity does not simply add further to the bestiary of scientific objects, independently of the objects already studied by scientists. In other words, it is not as if there are stars, dogs, electrical phenomena, or populations of Scottish soldiers to which styles would add the class of eruptive variable stars of type UG-Z Cam, the species *Canis lupus*, the electron, or a population characterized by its mean and its standard deviation. Rather, I suggest that the introduction of new kinds of entities gives rise to an *ontological enrichment* of the objects studied by science, to the extent that the use in scientific practice of different styles of reasoning widens and diversifies the classes of propositions that can be true or false about them.

Consider, for instance, a forest fire. I will say that a forest fire is enriched, qua scientific object, by the ontological addition of various entities introduced by styles of scientific reasoning. The taxonomic style, for instance, adds categories that divide the category "forest fire" of the common language in a way that is scientifically useful (i.e., useful for predictions and explanations). The statistical style adds several statistical properties (characterizing, e.g., modes of propagation). The laboratory style adds controlled and purified versions of the natural phenomenon. The result is the current scientific object forest fire, ontologically (and therefore descriptively) richer than the object forest fire of everyday life, to the extent that the mobilization of different styles of scientific reasoning has widened and enriched the class of propositions that can be true or false about it. And a similar story can be said, for instance, about galaxies. In a nutshell, the style of hypothetical modeling has added various models of galaxies (especially the Milky Way), extending

the types of propositions that can be formulated about them (in particular, propositions about physical parameters that are not observationally accessible); the statistical style has introduced populations of galaxies characterized by various statistical parameters (such as their mean intrinsic luminosity); the taxonomic style has introduced various taxa useful for the understanding of galactic formation and evolution, and so forth.

It is important to emphasize that this process of ontological enrichment is an open-ended process: the enrichment of the scientific reality of an object is never final and completed. A group of scientists may, at a certain stage in the study of a particular object, extend the range of styles of reasoning used for the study. Moreover, new styles of scientific reasoning may emerge in the future, bringing into being new entities that will add ontologically to the object under study.

It is also worth noticing that the notion of ontological enrichment does not boil down to the notion of descriptive enrichment: the use of a new style of scientific reasoning does not simply amount to grasping more aspects of a given object (as, e.g., a model of the climate today does by incorporating more components than the climate models did in, say, the 1970s); the style adds certain entities to the object. The descriptive enrichment that follows—one can formulate more kinds of propositions about the objects—appears as a mere consequence of the ontological enrichment.

6. Foliated Pluralism. What kind of pluralism follows from the existence of several styles of scientific reasoning, combined with the process of ontological enrichment just discussed? Four main properties—transdisciplinarity, synchronicity, nonexclusiveness, and cumulativeness—characterize this pluralism.

6.1. Transdisciplinarity. A style of scientific reasoning is not specific to a discipline or a scientific domain. Just think of the use of the statistical style in a large variety of disciplines (or, to a lesser extent, the widespread use of the laboratory style or the taxonomic style). Given the ontological enrichment of scientific objects brought about by styles, I will then contend that *it is not so much the object that determines the style or method of inquiry as the style that contributes to construct the object qua scientific object*. Hence the notion of *foliated* pluralism: styles simultaneously superpose various modes of knowledge, and this superposition somehow "covers," "erases," the traditional disciplinary borders. An immediate foil of foliated pluralism is thus forms of "patchwork," disciplinary-based pluralism evoked earlier (cf. n. 1).

6.2. Nonexclusiveness and Synchronicity. Scientific studies of a given object or phenomenon often combine simultaneously several styles of scientific reasoning. Therefore, the process of ontological enrichment may be brought about simultaneously by several styles, hence the nonexclusive and synchronic character of foliated pluralism. An immediate foil here is (very briefly) the form of ontologico-methodological pluralism associated with the existence of a plurality of scientific paradigms, to the extent that, in Kuhn's scheme, a scientist cannot work at the same time in several paradigms. Another immediate foil is Carnap's plurality of linguistic frameworks available to formulate scientific knowledge: the choice of a linguistic framework is for Carnap a pragmatic, revisable one, but not more than one can be adopted and used at the same time. Note also that given Carnap's strictly internalist take on ontology (the only meaningful questions of existence are the ones formulated within a given linguistic framework), his pluralism has no general ontological import, contrary to foliated pluralism.

6.3. Cumulativeness. Styles of scientific reasoning tend to accumulate in the development of science. When a style comes into being, it does not supersede an already existing one but rather enlarges the palette of modes of reasoning available to scientists. This cumulative nature of style of scientific reasoning follows from their capacity to develop techniques of stabilization (third thesis). Those techniques, specific to each style, can be more or less efficient. Some styles may thus die out, whereas others are here to stay,[7] hence the cumulative nature of the processes of ontological enrichment and the resulting cumulativeness of foliated pluralism. A foil here is again Kuhn's plurality of paradigms, given that paradigms supersede one another within a discipline.

7. Conclusion. Kuhn's and Carnap's pluralisms are admittedly far from being the most discussed forms of pluralism in today's philosophical landscape. The current focus is not so much anymore on ontology and justificatory methods as on the variety of explanatory strategies and repre-

7. The Renaissance reasoning by similitude, whose most famous representative is Paracelsus, is an example of a style of scientific reasoning that is no longer with us. As for the reasons of its disappearance, a lack of efficiency of its techniques of stabilization is part of the answer, even if no complete explanation (internal or external) should be expected of this historical fact (Hacking 1992c/2002, 194–95). By contrast, the very high efficiency of the technique of stabilization developed by the laboratory style, based on a process of self-adjustment between material elements (objects of studies, detectors, instruments, etc.), marks (data produced, reduced, analyzed, interpreted, etc.), and ideas (questions, theories, hypotheses, etc.), contributes to explaining why the laboratory style is here to stay (Hacking 1992a).

sentational resources mobilized in contemporary scientific practice, often linked to an acknowledgment of the complexity of the world (see, e.g., Mitchell's [2009] "integrative pluralism," Giere's [2006] "perspectival pluralism," or Longino's [2006] "theoretical pluralism"). Therefore, as interesting as these various forms of pluralism are, they cannot act as immediate foils to the form of pluralism I have sketched here because of this difference in focus.

In any case, by proposing the notion of foliated pluralism as a philosophically robust form of scientific pluralism, I did not intend to oppose or disqualify other forms of scientific pluralisms but rather to complement them. My aim was thus to grasp certain features of contemporary scientific practice that I take as essential but that are largely ignored by other forms of scientific pluralism, namely, the transdisciplinary and cumulative ways of proceeding in science to get new knowledge as well as those processes of ontological enrichment and the historical genesis of scientific objects that follows from them.

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