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Hacking on Unity, or How to Pluralize the History and Philosophy of the Sciences

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Abstract:

In this paper, we analyze Ian Hacking's conception of unity regarding the sciences and try to use his categorization to reinterpret some of the major unitarian philosophies of science of the twentieth century. In two of his papers, Hacking (1992a, 1996) proposed a dual notion of unity – "singleness" and "harmonious integration" –, which, although apparently simple, help us complexify the very notion of unity and its counterpart, plurality. To do so, and after a short review of unity *qua* ideology (section 2), we shall look into Hacking's classification of unities and its relation to plurality in the sciences (section 3); then, we shall describe and qualify the notions of scientific unity in some of the most relevant philosophies of science (section 4); finally (section 5), we shall use this analysis to engage with and criticize the notion of "special sciences" and its relationship to the notion of "general science". One of the main conclusions will be that *a pluralist conception of unity is possible through the notion of integration*.

Keywords: Ian Hacking; Unity; Singleness; Integration; Pluralism

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Introduction

In his discourse at the Nobel Prize lectures of 1989, Ian Hacking argued that "one of the grounds for skepticism is a mistaken self-conception – how off-duty scientists describe their own activity" (Hacking 1992a, 34). In other words, Hacking was calling attention to the fact that contemporary skepticism or "vulgar relativism" (Kusch 2020) about the sciences, and even "anti-science" phenomena (Holton 1993), may be partially provoked by the view that some scientists portray about their own work. This self-conception, or what Louis Althusser (1967) called the "philosophie spontanée des savants", constitutes a naïve ideology of

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science that Hacking rightly described as a "self-sustaining power of science", as an ideology coming from within "that keeps it going" (Hacking 1992a, 35). One such element would be the common use of the word "science" in the singular: the "metaphysical" idea that "there is one world, one reality, one truth" (Hacking 1996, 44).

Indeed, the unity of science has been a common trope since the inception of philosophy of science *qua* discipline. Perhaps the best-known example of this is the oft-quoted project of the Vienna Circle and its manifesto, "The Scientific Conception of the World". In recent decades, however, many philosophers of science have advocated for pluralistic approaches: Nancy Cartwright, John Dupré, Sandra D. Mitchell or Hasok Chang, to name a few. In this paper, we suggest exploring the ideas of Hacking in these debates about unity and plurality in the sciences. Much has been written about his pluralism in the "styles of thinking and doing" but less so in his more explicit analysis of the idea of unity in the sciences.[3] And this will be our first goal: to understand and distinguish the ways he thought about unity and plurality. For that, we will pay particular attention to two related papers by Hacking seldom mentioned in the literature: the above-mentioned Nobel lecture and a revised version of it published in 1996.

After a short review of unity *qua* ideology (section 2), we shall look into Hacking's classification of unities and its relation to plurality in the sciences. This will introduce us to the distinction between unity as "singleness" and "harmonious integration" (section 3), a categorization with which we shall describe and qualify the notions of scientific unity in some of the most relevant philosophies of science of the twentieth century (section 4). Finally (section 5), we shall use this analysis to engage with and criticize the notion of "special sciences" and its relationship to the notion of "general science" proposed by Stathis Psillos (2012). With all this, we hope to show that, in spite of the *philosophie spontanée des savants* above mentioned, unity is no simple matter and often includes aspects of plurality.

Unity qua Ideology

As Hacking noticed, the first historians-philosophers of the modern sciences (William Whewell and Auguste Comte) often wrote about the "sciences" in the plural. This is no minor point. As Stephen Gaukroger (2020) convincingly argued, the nineteenth and early twentieth centuries witnessed the increasing consolidation of *science*, in the singular, *qua* ideology; an ideology that was intrinsic to other political ideologies, such as nationalism and imperialism. The creation of modern nation-states and global empires saw in the *word* science one of the tools to justify and enforce the political unity that science-related technologies (like the railway or the telegraph) could help implement.

Historian of science Kostas Gavroglu (2012) has analyzed and exposed some scientific ideologies in a wider historical-philosophical frame, regretting that the work of historians of science (their "Sisyphean fate") has little impact and is often neglected by scientists. Their hegemonic frameworks –their *philosophie spontanée*– seldom change, especially when it comes to scientists' popular science. Technocracy and endless energy "utopias" came from Physics, as much as atomic and nuclear physics enhanced reductionist attitudes. Later on, "the movement away from physics and the atom into biology and the gene, was accompanied by attempts to associate with it a new utopia: a world without diseases; a world with plenty of food for everyone" (Gavroglu 2012, 93). Despite the proper biological practices undermining reductionism from inside, "the public perception of biological research is heavily anchored in reductionism" (as an ideology), giving to the genes the power of

[3] An exception can be found in the use of Hacking's dual conception of "Unity", applied to the history of CERN's UA1 and UA2 experiments that gave rise to the bosons *W* and *Z* (see Panoutsopoulos and Arabatzis 2021).

explaining everything. A power probably given because of their utopian content –i.e., because they are basted as "promises" (Mülberger and Navarro 2017).

But the rhetorical device of unity, with all its implicit philosophical implications, does not sit well with diversity. Let us take two journalistic headlines: "Science Discovers Another Avenue That Could Lead to an HIV Cure",[4] and "Scientists discover that the universe is awash in gravitational waves".[5] They both share the same subject and the same structure, giving the impression that they both refer to the same activity. But if we change the word science in the first sentence by, e.g., 'Particle Physics' and say that 'Particle Physics Discovers Another Avenue That Could Lead to an HIV Cure', the absurdity becomes obvious.

Many philosophers of science in the twentieth century turned unity into an axiological and normative aspect of the work of scientists. The symbiosis between professional philosophy of science and the *philosophie spontanée* of some scientists only made things worse. To quote a famous example, Paul Dirac (1929, 714) stated that "the underlying physical laws necessary for the mathematical theory of a large part of physics and the whole of chemistry are thus completely known", and the rest of science could be eventually reduced to those laws. It is in that context that the reductionist proposal for 'Unity' by Paul Oppenheim and Hilary Putnam (1958), among many others, makes sense. Their so-called "hypothesis" can be understood as a reinforcement of a basic argument going back to Mach: there seem to be multiple sciences, but they will all eventually unify by micro-reduction to particle physics –whatever that unification looks like. It seems that many unitarian ideas are based on what Hacking called a "metaphysical sentiment" related to religious monistic worldviews (see Hacking 1996, 44-46). In the same sense, Dupré (2012) also spoke about this metaphysical sentiment, calling monism and the unity of science a "myth".

Hacking on Unity and Pluralism

At a time when mainstream philosophy of science was still pursuing ways to advocate for the unity of science, Hacking proposed his pluralistic methodological approach through the notion of "styles of scientific reasoning" (Hacking 1982, 2002) –later matured as scientific "styles of thinking and doing" (Hacking 2012). To do so, he began by borrowing from Alistair C. Crombie's (1994) six "styles of scientific thinking" (mathematical, experimental exploration, hypothetical modeling, taxonomy, probability, and historic-genetic explanation) and tried to develop some philosophical implications. In Hacking's interpretation, each style was not only different from the others in the way they worked, but also in their evolution throughout the history of the sciences; a kind of "anarcho-rationalism" by which each style would have its own and independent self-organizing features (including "self-authentication" and "self-stabilization"). In his words, "the very mention of styles, in the plural, corrects the direction of the debate: we shall stop talking of science in the singular and return to that healthy nineteenth-century practice of William Whewell and most others". It was time, he claimed, to "speak of the history and philosophy of sciences –in the plural. And we shall not speak of the scientific method as if it were some impenetrable lump, but instead address the different styles" (Hacking 1992b, 17).

Hacking further developed his views about styles in many of his major works, and they became one of the identifiers of his philosophy. Yet, the plurality he introduced with them remained at the methodological, ontological and practical levels. It was only in a few papers

[4] Available in: https://www.hivplusmag.com/print-issue/2021/11/17/science-discovers-another-avenue-could-lead-hiv-cure
Accessed September 28, 2023

[5] Available in: https://www.reuters.com/science/scientists-discover-that-universe-is-awash-gravitational-waves-2023-06-29/
Accessed September 28, 2023.

(Hacking 1992a and 1996) that he directly addressed the fundamental notions of disunity and unity and, with them, only implicitly, that of plurality. As a first approach, he argued that unity does not have a unique meaning but, at least, two, distinguishing between "singleness" (as "oneness") and "harmonious integration" (Hacking 1992a, 1996). Singleness or oneness can be understood as a "singleton", i.e., "being the only instance of a concept"; while "harmonious integration" refers to a process of "integration or harmony of the parts", like "concerts", "novels", "speeches" or "political platforms" (Hacking 1996, 41). Thus, in his words, "not even unity is united" (Hacking 1992a, 39). With this first distinction of the meanings of unity, Hacking could break the identification between monism and unity and open the latter to pluralism. At times unity would mean "singleness", others "harmonious integration", and most often than not it would involve a combination of both. Hacking himself proposed this double notion acknowledging that they were "two distinguishable although interconnected ideas" (Hacking 1992a, 39).

Complexifying this initial distinction, Hacking expanded his analysis and identified up to eleven theses about unity present in the scientifico-philosophical literature, which he classified under four families of theses: metaphysical, epistemological, logical and historical.

A. Metaphysical

1. The metaphysical slogan: "One world, one reality, one truth".
2. Interconnectedness thesis.
3. Structural thesis.
4. Taxonomic thesis.

B. Epistemological

5. Science knows (parts of) the Truth about the World.
6. The search for Grand Unified Theories.
7. Reductionist thesis.
8. Linguistic thesis.

C. Logical

9. Rationality thesis: only one standard of reason.
10. Methodological thesis: only one scientific method.

D. Historical

11. Success in unifications.

Certainly, this is not the only classification of unities we find in the literature. More recently, Peter Galison (2016), Jordi Cat (2017) and Tuomas Tahko (2021) have followed after Hacking's tradition and suggested their own classifications. Galison's (2016) is constructed through some metaphors and applied to unity in different historical political contexts; Cat's (2017) classification in the *Stanford Encyclopedia of Philosophy* is a general one, covering similar aspects of Hacking's eleven kinds of unities; and Tahko's (2021) classification is more concrete and centered in the debate of reduction and emergence around the unity of the sciences.

With so many different theses, Hacking wanted to expose the impossibility of one only kind of unity. This did not mean, however, the dismissal of any talk of unity in the philosophy of science. Indeed, he often argued for "disunity", a term which eventually became one of

the identifiers of his philosophical work; but he did not reject unity, "especially in the sense of harmonious integration", since, historically speaking, "some of our noblest intellectual achievements have been unifying ones" (Hacking 1992a, 43). James C. Maxwell, Michael Faraday, and a long list of scientists achieving unifications can be evidence for that. That is why Hacking encouraged "careful attempts to study unification and reduction", adding that "the best among them imply neither that there is *one* kind of unity, nor that *all* science has even one of my eleven kinds of unity" (Hacking 1992a, 44).

In exploring the many ways in which the sciences actually produce unifications, he introduced the term "unifier". Some of his examples are: "mathematics", "tools" or "instruments", "practices" and "bodies of knowledge" (see Hacking 1996, 68-69). For example: "instruments are speedily transferred from one discipline to another (…) in order to interface with the phenomena", like in the case of the "scanning tunneling electron microscope", which was at first "suitable only for metallurgy", and then expanded into "cell biology" (Hacking 1996, 69). Different branches of mathematics applied as practical tools unified different sciences, as renormalization did for Quantum electrodynamics or Lagrangians helping to the unification of Electroweak theory. Thus, unifiers are plural, and there are multiple ways of unifying "epistemic activities" to become "scientific systems of practice". This is what Chang (2022) sees as providing a systematic "operational coherence", i.e., an "aim-oriented coordination"; or, in Hacking's general classification, an "harmonious integration".

At the same time, history also provides us with multiple examples of diversification: "Yes, unification does work –and so does diversification" (Hacking 1996, 56). In Physics, lots of unifications have been attained: electromagnetism, gauge theory, etc. Molecular biology or evolution also constitute an advancement through successful unifications, although Hacking would ask: "But surely biology and chemistry are now unified?" (Hacking 1996, 56). As he puts it, the overdepartamentalization of the sciences in the universities and in journals are an institutional wake-up call to the excess of unifications.

Yet, no unifying process could ever lead to the unification of all sciences into the "hypostatization"[6] of *a* Science: "Is science then one kind of thing at all? There is no set of features peculiar to all sciences, and possessed only by sciences. There is no set of necessary and sufficient conditions for being a science. There are a lot of family resemblances between sciences" (Hacking 1996, 68). Here we can see the constant tension in Hacking's thought between his rejection of a monistic view of science while preserving a particular status for the sciences. This was important at a time when scientific skepticism was beginning to spread in some public and philosophical circles: "my doctrine of self-authentication, which sounds like part of the current mood for skeptically undermining the sciences, turns out to be a conservative strategy explaining what is peculiar about science, distinguishing it to some extent from humanistic and ethical inquiry" (Hacking 1996, 67).

The ironic fact here is that, for Hacking, it is the plurality of styles what paradoxically allows some general and peculiar kind of unity of the sciences: one based on the fact that styles, however multiple, refer only to the sciences. In his words, "the sciences can be grouped together in terms of one of their disunities, their styles. In that sense only, perhaps, *E Pluribus Unum*" (Hacking 1996, 74). Hacking, thus, put his "styles of scientific thinking and doing" (Hacking 2012) as diversifiers among the sciences; but he also said that they are, in some sense, what unifies the sciences. His general argument can be summed up quite simply as follows: styles have their own historical-but-internal characteristics –through self-authentication, self-stabilization, introduction of new objects, etc. (Hacking 1994); moreover,

[6] While discussing mathematical ontology, Hacking follows Peirce in the employment of the late-ancient Greek-Christian theological notion of "hypostasis", meaning making abstract conceptions actual or counting them as real" (see Hacking 2014, 254-256). A similar modern concept could be found in that of what Karl Marx called "reification".

each style has its own way of developing such characteristics. Styles, with their own characteristics, can only be found in scientific research systems; hence, styles are a benchmark for distinguishing sciences from non-sciences. In other words, and using the early distinction between singleness and integration, we could say that styles constitute a criterion for grouping the sciences through their methods of inquiry –thus *achieving unification by integration*.

The old notion of demarcation based on one scientific method was coming back, albeit differently, through his styles and their self-stabilization and self-authentication processes. "Once we have a clearer understanding of what, from case to case, keeps each style stable in its own way", he argued, "we shall not think that there are just endless varieties of … [social] conversations" that can be qualified as scientific, since only some of them "are part of a discourse that has developed techniques of self-authentication" (Hacking 1996, 74). The "natural history of humankind", he continued, showed that "larger parts of morality and humanistic thought" did not have a "set of self-stabilizing techniques". In this way, Hacking seems to buy into the old distinction between the so-called two cultures: "I believe that we can get a grip on the difference between moral reasoning and scientific reasoning –without invoking any 'absolute conception of reality'" (Hacking 1996, 74). With the last remark, the open question, and one we will not address here, is whether Hacking considered this demarcation simply temporally contingent or built on some sort of necessity.

Wrapping up, for Hacking, it is the employment of one or more "styles of thinking and doing" that characterizes an activity as scientific. Styles unite or integrate the sciences as opposed to what happens in other human practices. And that is why many styles (*E Pluribus*) allow for that kind of integration of the sciences (*Unum*), while preserving their historical, practical and ontological differences.

Unity in the History of Philosophy of Science through Hacking's Lens

In this section we want to briefly explore how Hacking's dual conception of unity may be used to challenge the received view on some supposedly well-established philosophical monisms.[7]

Neutral Monism (Mach, James and Russell). One of the main theses of neutral monism is that even though psychological and physical phenomena appear as incompatible, they refer to one and the same reality. A canonical example is Ernst Mach (1886), who followed Richard Avenarius' "critique of pure experience". In his positivist or empiricist philosophy, the sensorial and scientific experiences were both systems of knowledge about reality. Although he perceived an apparently incompatible plurality of spaces and times, he assumed a fundamental *continuum* between matter and mind that would unify physical and psychological phenomena. No perspective would be fundamental, thus the supposed neutrality of his monism.[8]

Following Mach, although in a critical way, American pragmatism was another context in which neutral monism was *sui generis* defended[9]. For William James, "*the relations that connect experiences must themselves be experienced relations, and any kind of relation experienced must be accounted as 'real' as anything else in the system*" (James 1904, 534;

[7] We have also considered previous analysis of some canonical *pluralistic* interpretations of the Viennese movement for the unity of science. See Friedmann (1999, 2001); Uebel (1991, 1996); Cartwright, Cat, Fleck and Uebel (1996); Cat, Cartwright and Chang (1996); Reisch (1997, 1998); Sebestick (2011); Cat and Tuboly (2019).
[8] Quoting diverse texts of Mach's, Gori (2023, 114) calls our attention for what this "neutrality" means.
[9] See Holton (1993), Misak (2013) or Banks (2014 and 2019).

emphasis in the original). But by avoiding a primordial foundation, James actually supported "the pluralist notion that there is no point of view, no focus of information extant, from which the entire content of the universe is visible at once" (James [1907] 1922, 146). His supposed neutral monism, thus, acknowledged a pragmatist pluralism.

There was also a time in which Bertrand Russell followed neutral monism.[10] Some of his formulations argue for perspective-dependence in investigating a same reality: "the whole duality of mind and matter according to this theory is a mistake; there is only one kind of stuff out of which the world is made, and this stuff is called mental in one arrangement, physical in the other" (Russell 1914, 162). The "fundamental difference" between the two is that "physics treats as a unit the whole system of appearances of a piece of matter, whereas psychology is interested in certain of these appearances themselves" (Russell [1921] 2023, 75-76). Indeed, "classification by perspectives is relevant to psychology, and is essential in defining what we mean by one mind" (Russell [1921] 2023, 76).

As described above, if we apply Hacking's distinction, the 'unity' in this kind of monism involves integration. Thus, neutral monism can be summarized as a *plurality of phenomena* that are part of an *integrated reality*. If that is so, neutral monism should be conceived as a non-monistic (or pluralistic) conception of unity –despite having "monism" in its very name. As a matter of fact, as argued by Pietro Gori (2023), we could see neutral monism as a foregoing "perspectival realism" in the way of the new philosophy proposed by Michela Massimi (2022).

Neurath on the *Encyclopedia* and the Unity of Science. In his explanation of the project to create an *Encyclopedia of Unified Science*, Otto Neurath argued that this was "the only answer" to the question about "what is the maximum coordination of the sciences which remains possible" (Neurath 1937, 176-177). Far from the notion of "system" that had permeated much of modern philosophy, Neurath stressed the importance of "coordination" as a way to understand the unity of science. Contrary to "pyramidism", encyclopedia seemed the right term for the Vienna Circle's unifying project, especially if encyclopedia did not refer only to the final product (like the original project of the French Enlightenment) but also included the process of putting it together. In this way, it also referred to aspects of scientific practice such as "cooperative work", "coordination" or "orchestration" (Neurath 1946). His view on unifying was consciously anti-absolutist and pro-integration, as his famous example of the forest-fire shows (Neurath 1931). Thus, Neurath's unity had pluralism written all over it and, if that is the case, we can easily use Hacking's analysis to describe the *Encyclopedia*'s goal as one of pluralistic-integrated unity.

Another line of inquiry about Neurath is that of his anti-foundationalism, represented in the famous metaphor named later as "Neurath's boat". For Neurath everything comes from something else, nothing comes from an *epistemic void*. That is why, he says, "we always have to do with a whole network of concepts and not with concepts that can be isolated", which for him "puts any thinker into the difficult position of having unceasing regard for the whole mass of concepts that he cannot even survey all at once" (Neurath [1921] 1973, 198-199). Neurath's anti-foundationalism avoids a singleness of epistemic systems: "there is an unlimited number of equally applicable, possible systems of hypotheses" (Neurath, [1934] 1983, 105). But in this plurality, systems are not disconnected from each other, although connections are always partial, preventing a global kind of unity *qua* singleness: "the phenomena we encounter are so interconnected that they cannot be described by a one-dimensional chain of statements" (Neurath [1913] 1983, 3). Contrary to what one might think, as Neurath says, interconnection allows integration, but not singleness.[11]

[10] Russell (1914) saw himself in a family of philosophers like E. Mach, W. James and R. B. Perry.
[11] Potochnik (2011) follows and develops this idea of Neurath of approaching the unity of science not by reduction, but by "coordination".

As mentioned above, Neurath conceived the task of the unity of the sciences as "cooperation". That is why he praised "uniformity" not as a "logical consequence" of the Viennese program, but as "a *historical fact* in a sociological sense" (Neurath [1935] 1983, 115). Is that uniformity as monist as the notion seems to be? Certainly not. He was talking about "communication" between sciences, and not reduction to a unique, single and absolute science: "we do not arrive at 'one' system of science that could take the place of the 'real world' so to speak; everything remains ambiguous and in many ways uncertain. *'The' system is the great scientific lie*" (Neurath, [1935] 1983, 116). Moreover, he would declare that "*multiplicity* and *uncertainty* are essential" (Neurath [1935] 1983, 116). That is why he did not aim at developing a "superscience", but to integrate fields in order to produce "cross-connections" between the sciences.

How, then, should this interplay between unity and plurality be understood? For Neurath, unity is a cooperation between the different sciences based on the same general language (i.e., with spatio-temporal references). Unity, understood as practical cooperation, far from eliminating it, presupposes some plurality; "unified science" results from "comprehensive collective work". On this, it resembles the notion of "coordinated aggregation" (Cat, Cartwright and Chang 1996), a pragmatic integration of sciences working on the same phenomena.

In the 1996 paper, Hacking dismissed Neurath's integrative project as totally different from his. In his understanding, "the core of the logical positivist vision of unity" relies on "the precept of linguistic unity" (Hacking 1996, 58). Yet, as we have seen, linguistic unity (or physicalism) is not the only ground on which Neurath's unity is based. His project is ultimately a pragmatic project, thus fitting Hacking's idea of "harmonious integration".

Carnap on Unity and Linguistic Frameworks. Rudolf Carnap's notion of unity was more obscure. Here we shall pay attention to an article explicitly addressing the unity of science where he wrote that "Science is a unity, that all empirical statements can be expressed in a single language, all states of affairs are of one kind and are known by the same method" (Carnap [1934a] 1995, 32). This is an apparently obvious defense of unity under a "single language", stating that all states of affairs are of "one kind", and all under one "same method". Yet, what kind of unity does this involve? Singleness or Integration? Many interpreters have argued that Carnap's monism was of the "singleness" type. However, at times he can be interpreted as involving some sort of integrationist pluralism. This is perhaps clearer when he says that

> The thesis of the unity of Science has nothing to say against the practical separation of various regions for the purposes of division of labour. It is directed only against the usual view that in spite of the many relations between the various regions they themselves are fundamentally distinct in subject matter and methods of investigation. (Carnap [1934a] 1995, 101)

Moreover, the integration he claims assumes that all science is "physicalist" (a term that he identifies with "spatio-temporal language", i.e., a language that works with operational references). Hence, physicalism does not mean at all singleness (by reduction to physical sciences): it is the integration of all sciences through using a common kind of language.

But here we should remember Carnap's principle of tolerance, with the famous slogan "*In logic, there are no morals*", and by which he meant that "everyone is at liberty to build up his own logic, i.e., his own form of language, as he wishes" (Carnap [1934b] 2002, 52). If we take this into consideration, Carnap appears as a strong pluralist, but only with respect to what he called linguistic frameworks that unify the sciences; i.e., systems of thinking about entities. In other words: integration came by appealing to a common linguistic framework,

but the existence of many such frameworks allowed for an indefinite number of parallel integrations.

For Carnap, when someone wishes "to speak in his language about a new kind of entities, he has to introduce a system of new ways of speaking, subject to new rules" (Carnap [1950] 1991, 86). As Ruphy (2016, 16-17) put it, Carnap's frameworks are "excluding" and "synchronic" and, therefore, impossible to integrate in any way. Thus, while each linguistic framework would be an example of "integration" (system), the collection of them might better fall into some idea of plurality, yet not integrated (thus becoming an excluding pluralism).

Reductions and Reductionisms. Reduction, understood as a process towards unification, constitutes one instantiation of unity in the sciences. Two classic examples we want to compare under Hacking's categorization are those given by Ernst Nagel and by Oppenheim and Putnam. The micro-reductionism proposed by Oppenheim and Putnam (1958) suggests a very straightforward way of achieving the unity of science: all the sciences could and should be reduced or explained by particle physics. In that sense, the existing plurality of sciences would eventually dissolve into a one and only science, into Hacking's singleness. It comes as no surprise that this thesis emerged in the late 1950s, at the time of the exponential growth in the number of elementary particles and the popularity of atomic and nuclear physics.

More complex was Nagel's theory, since he argued for multiple kinds of reduction in the sciences (see Nagel 1935, 1961). At a first glance, his goal might look the same as Oppenheim and Putnam's, but he talked of a multiplicity of possible processes to achieve unity, thus introducing a degree of pluralism. Moreover, the aim towards a unified primary science, while possible in principle, was not always necessarily desirable. In his words, "an integrated system of explanation by some inclusive theory of a primary science may be an eventually realizable intellectual ideal. But it does not follow that this ideal is best achieved by reducing one science to another with an admittedly comprehensive and powerful theory, if the secondary science at that stage of its development is not prepared to operate effectively with this theory" (Nagel 1961, 363). As a matter of fact, only history would eventually tell which sciences dissolved into the one science in a process of reduction, thus introducing elements of contingency and historicity in such processes. But more importantly, with his mention of "integrated systems of explanation" and "inclusive theory", Nagel was implying more pluralism than Oppenheim and Putnam would allow for, thus allowing us to relate it to Hacking's integrative unity.

Popper, the "non-pluralist". In a letter to Carnap explaining his work on pluralist and anti-pluralist philosophies, Neurath mentioned "Popper's writings", saying that they were based on a "non-pluralist" view (Neurath 1945).[12] Indeed, as Stadler (2001, 253) showed, Karl Popper's rejection of verificationism can be partly seen as an attack on the pluralistic philosophy of the Vienna Circle. Looking at Popper's main epistemological notions, it seems that Neurath was right: his notion of "falsifiability" was at the same time the unique scientific method, the unique criterion of verisimilitude or falsehood, and the unique demarcation criterion. Thus, Popper appears as a paradigmatic *multidimensional monist*. Actually, in his introduction to the fourth edition of *Against Method*, Hacking remembered Paul Feyerabend's words as a student of Popper: "On numerous occasions Feyerabend was to recall that Popper began his class by saying that there is no scientific method. And then (said Feyerabend) he began to go wrong, enunciating, in effect, the method of conjectures and refutations" (Hacking, in Feyerabend [1975] 2010, 11). Thus, Popper's notion of the uniqueness of falsifiability could be based on a singleness notion of methodological unity.

[12] In Cat and Tuboly (2019, 593-594).

If we wanted to find some pluralistic features within Popper's logic we could pay attention to his notion of "degrees of falsifiability": this notion "'relativizes' the requirement of falsifiability by showing falsifiability to be a matter of degree" (Popper [1935] 2002, 95). By introducing those "degrees", Popper was arguing against an absolutist notion of falsifiability: some theories could be more falsifiable than others, or fallible in a major or minor degree. Thus, in addition to being more or less scientific, one theory could be more explanatory about the facts than another. And the same goes for his notion of "degrees of truth", where the correspondence was never absolute, but partial and unprovable (see Popper 1963). In any case, the notion of an absolute truth was a regulatory ideal that justified his plural vision of verisimilitude. Moreover, his advocacy for simplicity sends us back to the ideal of unity: "Simple statements, if knowledge is our object, are to be prized more highly than less simple ones *because they tell us more; because their empirical content is greater; and because they are better testable*" (Popper [1935] 2002, 128). In other words, the ideal, though impossible, of simplicity as a step towards absolute truth leads us to classify Popper, as Neurath did, as a "non-pluralist" or, in Hacking's terms, as holding *singleness monism*.

Kuhn: Anti-foundationalism between Monism and Pluralism. In this section we will systematically assess some of Thomas S. Kuhn's major concepts so as to enquire how the notions of pluralism and monism relate to them.

Structure is probably Kuhn's most monistic concept. For this reason, his work is titled "*The" Structure*, in the singular: in Kuhn's history, all scientific revolutions follow the same pattern: normal (paradigmatic) science, anomalies, crisis, *Weltanschauung* change, new paradigm (with its own new normal science). Every scientific revolution follows a single pattern or has a single structure. In that sense, the formal account he gives about how paradigms change (the very structure) implies a notion of singleness. Yet, the outcome of a revolution is a totally new paradigm, which introduces us to an absolute diachronic pluralism that cannot have any hint of integration. Incommensurability of paradigms fundamentally prevents their integration in any form whatsoever.

Paradigms also share in this duality of unity and plurality. Since paradigms "establish, inspire and foster particular coherent scientific traditions, and (…) issue patterns and models of scientific research" (Kindi 1995, 77), they play a role of unification; they involve a unique exemplar, a unique way of thinking and doing (singleness). However, the paradigm also includes a number of puzzles, often solvable and, indeed, solved through a number of methods and theories that are part of the paradigm, giving it a plural, often cumulative, flavor. The interesting thing about paradigms is that here both of Hacking's notions of unity are mixed: we have *singleness*, because there is one and only paradigm; and we have also *integration*, because paradigms' internal unity consists in the integration of all kinds of theories, methods, instruments, etc.

Incommensurability seems to strongly play against any possibility for integration. No scientist can *be* in two paradigms at the same time. What's more: the inhabitant of one paradigm cannot inhabit or work in the second in any way. Therefore, it is impossible to integrate or make paradigms compatible (neither their theories, laws nor models), since the changes are radical. Following the distinction suggested by Paul Hoyningen-Huene and Howard Sankey (2001), we shall consider two types of incommensurability: the semantic and the methodological. The first refers to the change in the meaning of scientific concepts (such as mass for Newtonian physics and for relativity). In this sense, paradigms are "a set of 'grammatical' drills after which scientists model their research" (Kindi 1995, 78), and this causes a total impossibility of communication between them. Kuhn (1970), partly to avoid the relativistic consequences of this incommunicability, was insightful enough so as to later introduce some nuances and leave the door open to a less absolute pluralism: "since the vocabularies in which they discuss such situations consist, however, predominantly of the same terms, they must be attaching some of those terms to nature differently, and their

communication is inevitably only partial" (Kuhn [1962] 1970, 198). So, there would be room for partial integration within incommensurability. "Methodological incommensurability", on the other hand, would have a more practical character since it refers to the fact that "there are no shared, objective methodological standards of scientific theory appraisal… As a result, alternative scientific theories may be incommensurable due to absence of common methodological standards capable of adjudicating the choice between them" (Hoyningen-Huene and Sankey 2001, xv). This makes methodological incommensurability the case for "radical empirical anti-foundationalism" in Kuhn (Patton 2023, forthcoming),[13] which sets him abreast with the likes of Neurath and Carnap. Thus, like with them, Kuhn's anti-foundationalism also deals with unity in a twofold way: it prevents the integration of paradigms into a global singleness, but it allows internal integration within each paradigm.

Special Sciences: A Hidden Enemy for Pluralists

Finally, we would like to discuss the popular notion of "special sciences", which is common in the historiography and philosophy of science. Special sciences normally refer to Physics, Chemistry, Biology, etc.; or even more "special" sciences, like Thermodynamics, Microbiology, Volcanology, Analytic Chemistry, Neurophysiology, Quantum Chromodynamics, and so on. Are they a symptom of intrinsic pluralism or should they be regarded as yet another manifestation of hidden monism? Following Hacking, in this last section we shall address this question; and to do so, we will attempt a dialogue with the seminal paper by Stathis Psillos (2012), "What is general philosophy of science?", not surprisingly published in the periodical called *Journal for General Philosophy for Science*.

Broadly speaking, the term "general philosophy of science" can only exist with its correlative term "special philosophy of science", though the latter is more often referred to as philosophy of the special sciences. The first would be an attempt to distinguish or characterize the supposed transversal or common characteristics to all the sciences, while the latter would be the analysis of a concrete science. The two philosophical approaches work, or should work, in a kind of mutual aid. There is here an analogy with the much-used term of interdisciplinarity in the sciences: philosophies of the special sciences might work together, collaboratively or in synergy to forge a broad, general vision of a general notion of science. The problem here arises as to how far can we talk about a general philosophy of science without assuming a general science. As Hans-Jörg Rheinberger wrote, "since there is nothing like 'science in general' to be observed out there in the world, what could the object of a post-unity-of-science general philosophy of science look like?" (Rheinberger 2012, 107).

Thus, the problem with the term "general science" is that it may imply the existence of some entity which would by definition be the *genus* including all the species (i.e., the 'special sciences'). But if, following the previous quote by Rheinberger, there is no, and has never been, a general science, what would be the point of talking about special sciences? Yet, in his otherwise very interesting paper, Psillos (2012) argued in favor of a renewed "general philosophy of science" precisely appealing to a *genus* he called "science in general". As he put it, "the key thought here would be that what constitutes a science is a genealogical nexus of theories (and perhaps practices)" (Psillos 2012, 101). But both historically and philosophically, this argument seems to be a *hasty generalization*: a science is related genealogically with its past; but this does not necessarily involve that all the sciences are related genealogically to a unique past (or common ancestor). Moreover, Psillos' argument involves a *non sequitur* that takes a leap from the philosophical to the scientific thesis: *Science in general* is not the same as *General science*. That is not to say that individual sciences have

[13] We thank Lydia Patton for circulating her paper with us before publication.

no common features; what is at stake here is the very nature of the communion of *all* the sciences. But, from our point of view, Psillos (2012, 101) goes too far when he concludes that there is "enough unity among the various sciences (despite their distinct historical essences) to count as being members of the same *genus*: science". We could make a *reductio ad absurdum* by asking: we know the names of individual sciences, but what is the name of that *genus* called "general science"?

In order to deal with the common features of the sciences, Psillos (2012, 101) considers an analogy from Darwinian evolution, namely the idea of a common ancestry. Aware of the problems with his notion of unity by generality, he considered that "The (similarity-based) unity of the *genus* does not seem to warrant the conclusion that there is a *genus* essence—even a nominal one". At the same time, however, he argued that "the members of the *genus* have important methodological and conceptual similarities among each other". Specifically, "the most significant" similarities are "a special claim to knowledge and a special relation to reality". But, as he recognizes, such a generality of Science is profoundly philosophical: "Science as such is a theoretical abstraction and general philosophy of science is the laboratory of this theoretical abstraction".

Psillos's reasoning implies a first science (*genus*) to which all the others refer diachronically; or, in other words, that common source would justify the synchronic similarities of contemporary individual sciences. In contrast, as we explained above, Hacking's integration of the sciences, by having in common the usage of "styles", shows the historical process by which the sciences share some features without having to refer to a common essence. The difference is significant. Psillos' quest for a general science through genealogy contrasts with the generalization through horizontal analogy in Hacking. The former involves a deep and temporally *a priori* monism, while the harmonious integration *à la Hacking* only achieves unity *a posteriori*. Yet, to be fair, Psillos' theory cannot be described as "singleness" in Hacking's terms since he allows for contemporaneous essential differences between the special sciences. His monism would not be reductionist: "there is enough unity among each individual science to count as a separate science" (Psillos 2012, 101).

Thus, pluralist references to 'special sciences' may be explicitly or implicitly implying a general science – and more often than not that general science is identified with physics. But if we reject the existence of a general science, perhaps we should also avoid using terms such as 'special sciences', let alone 'science' in the singular.

Concluding Remarks

Unity is a recurring theme for philosophers and historians of the sciences. Despite the historical and political milieu in which unity of science emerged, the notion later got its conceptual independence through acquiring philosophical prestige. Despite the fact that quite a number of philosophers have been recently trying to "disunify" *the* science and *the* scientific method, unity of science *qua* ideology still remains a strong element in the popular accounts of scientific research.

Ian Hacking's conceptual and historical analysis was an attempt to free and complexify the very notion of unity. Particularly interesting is that he very explicitly did so in the major scientific event of every year, the Nobel ceremony, a speech that, with the modifications he later introduced, has been the major source of this paper (Hacking 1992a and 1996). We have tried to explain and analyze his dual notion of unity as "singleness" and "integration" and see what kind of consequences could be obtained. We have also applied this dual notion to some major philosophers of the history of philosophy of the sciences. And finally, we have brought into this discussion the notion of "special sciences".

As we see it, Hacking's dual (and plural) conception shows a fracture in the very notion of unity. Unity is not a univocal concept: there are many ways to think of unity in the sciences. That is one of the most relevant things of his analysis, as Hacking himself repeated. But our main conclusion after introducing the notions of "singleness" and "harmonious integration" is that the latter is in itself a pluralist notion of unity, since integration allows for the plurality of the parts that are integrated to be preserved. Thus, in our view, by understanding integration as a pluralist notion of unity, Hacking liberates the notion of unity from monism. Hence, any pluralist has the right (and perhaps the duty?) to defend unity as integration.

The textbook-kind approach to the history of philosophy of science has often been a hotbed for simplistic accounts about previous philosophies. Who has not read that positivists defended theses that anyone will consider as rigid scientism which, of course, includes monism? Applying Hacking's dual notion, we have explored some works of Mach, James or Russell, but also Neurath, Carnap, Oppenheim and Putnam, Nagel, Popper and Kuhn. We have tried to shed light in the notions of unity used and implied by those philosophers. In that attempt, we have argued that Neutral Monism can be understood as a pluralistic philosophy similar to the current school of Perspectival Realism. In the same tradition of those innovative re-interpretations of the Vienna Circle, we have seen that both Neurath and Carnap were more likely to be pluralists in search of integration. We have shown that singleness is the guideline for some reductions (Oppenheim and Putnam), but that integration may fit better with others (Nagel). We have explained why Popper seems to be a representative of singleness, of "non-pluralism"; and we have shown that Kuhn has singleness and integration mixed all over his *Structure*. The main conclusion is that studying this history through Hacking's lens reveals that some notions of unity are more plural than one might initially think.

Finally, we have shown that the notion of "special sciences" implies a hidden monism with the assumption of a "general science" which cannot, however, be identified neither historically nor philosophically. This hidden monism can be understood at least in two general ways: if we pay attention to singleness, special sciences are just temporary because some day they will be absorbed or reduced by the general science to which they belong (as for Oppenheim and Putnam 1958); if we pay attention to integration, special sciences maintain their autonomy, but also share common elements because they belong to the same *genus*, a general science (as for Psillos 2012). Although the latter option accepts some plurality, it begs the question not only about the concrete ways individual sciences share common features, but also about their hierarchical relationship to an entity, general science, about which nothing is known. That is why we suggest avoiding the term "special sciences" from the philosophical vocabulary altogether.

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