Studies in History and Philosophy of Science Part A
Volume 88, August 2021, Pages 128-137
https://doi.org/10.1016/j.shpsa.2021.06.005
Preprint

The Emergence of Objectivity: Fleck, Foucault, Kuhn and Hacking

Abstract

The analytical notions of 'thought style', 'paradigm', 'episteme' and 'style of reasoning' are some of the most popular frameworks in the history and philosophy of science. Although their proponents, Ludwik Fleck, Thomas Kuhn, Michel Foucault, and Ian Hacking, are all part of the same philosophical tradition that closely connects history and philosophy, the extent to which they share similar assumptions and objectives is still under debate. In the first part of the paper, I shall argue that, despite the fact that these four thinkers disagree on certain assumptions, their frameworks have the same explanatory goal – to understand how objectivity is possible. I shall present this goal as a necessary element of a common project -- that of historicising Kant's a priori. In the second part of the paper, I shall make an instrumental use of the insights of these four thinkers to form a new model for studying objectivity. I shall also propose a layered diagram that allows the differences between the frameworks to be mapped, while acknowledging their similarities. This diagram will show that the frameworks of style of reasoning and episteme illuminate conditions of possibility that lie at a deeper level than those considered by thought styles and paradigms.

Keywords

Objectivity, thought style, episteme, paradigm, style of reasoning, historical epistemology

Highlights

- I argue that, although Fleck's, Kuhn's, Foucault's and Hacking's frameworks are based on different assumptions, they have the same goal: to understand how objectivity is possible.
- I provide a model for studying objectivity that incorporates the frameworks of Fleck, Foucault, Kuhn and Hacking.
- I show that, used together, these frameworks provide a more profound understanding of how objectivity emerges.
- I propose a layered diagram that maps the differences between the frameworks of thought style, episteme, paradigm and style of reasoning.

1. Introduction

Over the past century, scholars have put forward different analytical notions that aim to shed light on the historical development of science. It was in his paper 'Some Specific Features of the Medical Way of Thinking' (1986 [1927] pp. 39-46) and then in his book *Genesis and Development of a Scientific Fact* (1935) that Fleck introduced the notion of thought style, the distinctive mode of thinking of a community in which knowledge is produced (a 'thought collective'). Kuhn, on his part, defined a paradigm in *The Structure of Scientific Revolutions* (1962) as a general framework with components such as exemplars, ontological assumptions and values. The notion of episteme essentially highlights the structures common to the practices of a historical period and has been proposed in *The Order of Things* (1966), a book in which Foucault wanted 'to reveal a *positive unconscious* of knowledge: a level that eludes the consciousness of the scientist and yet is part of scientific discourse' (Foucault, 1994 [1966], p. xi).

More recently, in two papers published in 1982 and 1992 (Hacking, 2002, pp. 159-199), Hacking outlined 'the project of scientific styles of reasoning' (Hacking, 2012). The label 'style of reasoning' came from the historian Alistair Crombie (Crombie, 1994), who had specified six methods of scientific enquiry central to the history of Western thought: the style of geometry, the experimental style, the style of hypothetical modelling, the taxonomic style, the statistical style and the historico-genetic style. Hacking noted that each of these styles involves new types of objects, standards of evidence, laws and true-or-false sentences. He also suggested that styles have sharp beginnings and are self-authenticating, i.e. they do not answer to any higher standard of truth. In his later writings (e.g. Hacking, 2009), he insisted that styles are not only ways of thinking but also ways of *doing*: humans are embodied creatures that use their minds and bodies to think and act in the world (Hacking, 2012, p. 2).

Although Fleck, Kuhn, Foucault and Hacking belonged to a stream of epistemologists who reflected on the process of acquiring knowledge in close relation with the analysis of historical cases, their philosophical contexts were different. Fleck is one of the thinkers who, in the 1930s, rejected the 'outside time and history' investigation of scientific activities conducted by the Vienna Circle (Fleck, 1979 [1935], p. 50) and claimed that scientists' practices do not follow a timeless rule. As Rheinberger (2010, p. 19) made evident, his thought has 'a surprising number of points in common' with Gaston Bachelard's, traditionally considered, together with Georges Canguilhem, the acme of what is known as 'historical

epistemology'. The latter is a philosophical tradition that fully emerged in France at the beginning of the twentieth century, when different thinkers assumed that knowledge could be fully understood only by investigating the historical conditions under which it is produced[1].

Fleck was probably unfamiliar with many works of French historical epistemology, including Bachelard's. On the other hand, Foucault was a student of Canguilhem and belonged to the genealogy of French historical epistemologists. The relationship between Kuhn and French philosophy of science is not perfectly clear. *The Structure of Scientific Revolutions* is widely presented as a work that has substantive continuities with French historical epistemology. Indeed, Gutting (2003) compared Kuhn with Bachelard regarding their discontinuist reading of the history of science. However, Simons (2017, p. 46) argued that Kuhn has been influenced by Alexandre Koyré and Hélène Metzger and that 'the relation to the better known brands of French epistemology remains unclear'.

When we turn to Hacking, we need to remember that the expression 'historical epistemology' has been recently 'reinvented'. Indeed, Daston (1994, p. 282) characterised historical epistemology as 'the history of the categories that structure our thought, pattern our arguments and proofs, and certify our standards of explanation' and cited Hacking and Arnold Davidson as its leading practitioners. However, instead of 'historical epistemology', Hacking preferred the expression 'historical meta-epistemology' to mark a distinction with the previous use: 'where Bachelard insisted that historical considerations are essential for the practice of epistemology, the historical meta-epistemologist examines the trajectories of the objects that play certain roles in thinking about knowledge and belief' (2002, p. 9). Hacking described 'historical meta-epistemology' as the study of *organising concepts*: epistemological concepts such as probability, evidence, reason and objectivity that shape our ideas and practices of knowledge (Hacking, 1999a, p. 53) (see also Sciortino, 2017). He added that historical meta-epistemology, falls under the concept of 'historical ontology', the study of the historical trajectories of 'not only "material" objects but also classes, kinds of people and ideas' (2002, p. 2).

Despite the difficulties in pinpointing the common beliefs of these thinkers, their notions have been compared with each other since at least 1968, when Piaget (2015, p. 132) observed that 'Foucault's epistemes are reminiscent of Kuhn's paradigms' and discussed their differences from a structuralist perspective. In more recent times, Möβner (2011) pointed out important differences between the concept of thought style and that of paradigm; Elwick (2012) depicted Hacking's styles of reasoning as conditions of possibility and likened them to Foucault's epistemes; and Winther (2012) investigated the simultaneous

[1] The origins of the historicisation of epistemology are under debate. Chimisso (2008) described the rich and varied intellectual milieu in which the philosophies of Bachelard and Canguilhem developed. Brenner (2003, pp. 1-9) identified as a pivotal point the work of scholars such as Henri Poincaré (1854-1912), Pierre Duhem (1861-1916) and Gaston Milhaud (1858-1918) at the turn of the twentieth century. Rheinberger (2010) remarked that the historicisation of epistemology was the solution to a crisis that emerged in the late nineteenth century. Bordoni (2017) argued that its beginnings can be found in the debates between different scientists in France in the 1860s.

application of the notions of paradigm and style of reasoning to the history of science. The fact that these four notions are often compared to each other conceals the admission that they belong to the same genus. However, the general physiognomy of this genus has not been described yet: are these notions tools for achieving overlapping objectives? How do they reflect the different perspectives of their proponents?

Clarifying these questions will help me to combine the ideas of Fleck, Kuhn, Foucault and Hacking in a way that enables their works to be used as part of the same project. Indeed, the aim of this paper is to make instrumental use of their insights to form a new combined framework that illuminates the process of production of scientific knowledge. Section 2 lays the foundations for a reasoned answer to the questions above: I shall argue that we can view Fleck's, Kuhn's, Foucault's and Hacking's notions as frameworks that offer explanatory narratives of how objectivity is possible. The respective attempts of these thinkers to explain the possibility of objectivity will be viewed as part of their effort to historicise Kant. It would have been possible also to look at how Ernst Cassirer has had similar ambitions and to discuss how these four thinkers have been influenced by an important strand of Neo-Kantianism. However, given that Fleck, Kuhn, Foucault and Hacking have been more central in recent history and philosophy of science, I will confine my attention to their ideas. In Section 3, I shall point out some differences between the four frameworks. Finally, in section 4, I shall argue that they can be used together as a toolkit for understanding how concepts, propositions and other epistemological items emerge. Afterwards, I shall propose a layered diagram that helps to highlight the similarities and differences between the frameworks of these authors and combine their insights. I shall put particular stress on Hacking's project because I want to show that his framework can play a crucial role in revealing fundamental aspects of the process by which objectivity becomes possible.

2. Objectivity as an explanatory goal

In the following sections, I shall consider the notions of Fleck, Foucault, Kuhn and Hacking as frameworks, that is, sets of hypotheses and presuppositions that enable us to emphasise certain aspects of the past and construct explanatory narratives. One may protest that these notions have been introduced for the purpose of philosophical research rather than for understanding and narrating the history of science, but these aims align: Hacking describes the notion of style as a 'philosophical tool' and adds: 'if the tool does not provide a coherent and enlightening ordering of the record, then it has no more place in sound philosophy than would any other fantasy' (Hacking, 2002, p. 178). Indeed, when using history to address philosophical questions, historical epistemologists must decide which happenings are relevant to the answer, how to interpret them and how they can be used to produce explanatory

narratives. Thus, any notion employed must also help to order the historical record – it must be a framework for highlighting, omitting or unifying episodes.

Viewing the notions of Fleck, Foucault, Kuhn and Hacking as frameworks central to historical and philosophical enquiry provides a perspective from which they can be compared. I believe that for characterising a framework, it is necessary, firstly, to specify its *explanatory goal*: why has it been put forward? What is it meant to explain? Secondly, as Currie and Walsh (2019, p. 7) have noticed, it is necessary to pinpoint its underlying *explanatory expectations*, the preconceptions of what a good explanation should look like. For instance, Crombie's explanatory expectations were those of a continuist and internalist historian. These two features of frameworks (explanatory goal and explanatory expectations) act as principles of selection: they shape the explanatory narrative by foregrounding events and selecting its central subject (what the narrative is about) and its set of contrasts and comparisons (events or ideas compared across time). Once I will have clarified the goal and the explanatory expectations of the four frameworks, I shall be in a better position to answer the main questions of the paper.

Since the thesis I am going to argue for is that the explanatory goal of Fleck's, Kuhn's, Foucault's and Hacking's frameworks is to explain how objectivity is possible, it is better to clarify first in which sense the term 'objectivity' must be understood. Douglas (2004, p. 4) has argued that there are 'different types of processes we can examine in practice when determining whether to describe the product of that process as objective'. We can focus on: 1) 'processes where humans attempt to interact with the world'; 2) 'an individual's thought processes'; and 3) 'the process used to reach an agreement' (2004, p. 4). Once we focus on a particular kind of process, there are multiple senses of objectivity. In case 3), the outcome of a process can be considered objective in three senses: when 'the same outcome is always produced, regardless of who is performing the process' ('procedural objectivity'); when the members of a community agree on the outcome ('concordant objectivity'); and when they have 'argued with each other to ferret out the sources of their disagreements', in particular, when scientific data, theories, methods, etc. have been shared or discussed ('interactive objectivity') (Douglas, 2004, pp. 12-15).

When I say that the aim of all the four frameworks is to explain how objectivity emerges, I mainly allude to a form of interactive and concordant objectivity. In other words, to explain how a proposition (or a theory, a scientific 'discovery' or other epistemological items) becomes objective essentially will mean to explain how a community of people comes to share and discuss that very proposition as a candidate for truth or falsehood (interactive objectivity), and to agree on its truth (or falsehood) (concordant objectivity). Interactive and concordant objectivity imply that the members of that community agree (tacitly or not) on methods, standards of evidence, techniques, practices and schemas of perception that are to be used to prove or refute that proposition. As we shall see, for Fleck, Foucault, Kuhn and Hacking, the elements (methods, standards of evidence, etc.) on which agreement is obtained are historically variable. Therefore, objectivity itself comes into being through specific historical

processes. Although other senses of objectivity are important too, those I have just mentioned are of particular importance for understanding the explanatory goals of the four frameworks.

2.1 Hacking and the emergence of objectivity

In the next subsections, to show better their similarities and differences (summarized in fig.1), I shall not discuss the four frameworks in the chronological order in which they have been proposed. With this remark, we come to the explanatory goal of the framework of style of reasoning. Hacking was clear enough about this when he described his project of styles with these words: 'My study is a continuation of Kant's project of explaining why objectivity is possible […] Kant did not think of scientific reason as a historical and collective product. We do' (Hacking, 2002, p. 181). To this he added: '[Styles of reasoning] are part of what we need to understand what we mean by objectivity (Hacking, 2002, p. 181). In our terminology, the latter quotation states that the notion of style of reasoning is a framework for achieving the explanatory goal of understanding why objectivity is possible. At the same time, in the former quotation, Hacking takes for granted Kant's idea that objectivity is made possible by certain *a priori* conditions but makes a fundamental departure from him by suggesting that what is objective is the result of historical circumstances. In this sense, Hacking's explanatory aim is both a continuation of Kant's project and a radical deviation from it.

But how does the framework of style replace the Kantian apriori, and how can it help us to understand how objectivity is possible? According to Hacking, investigating the possibility of objectivity meant understanding how propositions become candidates for truth or falsehood. His point was that 'whether or not a proposition is as it were up for grabs, as a candidate for being true-or-false, depends on whether we have a way to reason about it' (Hacking, 2002, p. 160). Indeed, the emergence of a style of reasoning involves new methods, experimental norms and ways of thinking and doing that make it possible for certain sentences to become candidates for truth or falsehood. He called 'style-dependent' those sentences whose sense hinges on a style of reasoning. Style-dependent sentences are 'positive': 'positivity', term borrowed from Foucault, means 'to be up for grabs as true or false' (Hacking, 2002, p. 190). Positive sentences are objective only in the sense that they are uttered, shared and debated by a community of people that adopt the same style (interactive objectivity) and therefore agree on certain presuppositions (ways of doing, methods, standards of evidence, etc.). Once a proposition becomes positive, it might happen that it is proved true (or false) becoming 'bivalent' (in Hacking's terminology). Individual judgments on its truth (or falsehood) from different people would be in agreement and the proposition would be objectively true (or false) (concordant objectivity). To summarise, styles settle 'what it is to be objective (truths of certain sorts are what we obtain by conducting certain sorts of investigations, answering to certain standards)' (Hacking, 2002, p. 181).

An example will make this point clearer. According to Hacking, when the ancient Greeks 'discovered the very possibility of deductive proof', a new deductive style of reasoning emerged (Hacking, 2014, p. 123). Now, take Euclid's proposition 'Any prism which has a triangular base is divided into three pyramids equal to one another with triangular bases (Heath, 1908 pp. Elements XII,7 p. 394). Such a proposition would not have been a candidate for truth or falsehood for, say, a Babylonian, since 'those very sentences used to express the geometrical *a priori* propositions could not have that sense unless they were embedded in the practice of geometrical demonstration' (Hacking, 1983, p. 457). However, once the deductive style of reasoning emerged, those sufficiently trained in mathematics were able to argue with each other about the truth of that proposition, *even though nobody had yet proved its truth or falsehood*. That is, that proposition became 'positive', and also objective in the sense of interactive objectivity: a community of mathematicians shared certain presuppositions that made it possible to discuss it. Only when it was proved true, however, did it become *bivalent*. At that point, the individual judgments on its truth from different mathematicians did, in fact, agree ('concordant objectivity').

To summarise, I have argued that the explanatory goal of Hacking's framework is to understand how objectivity is possible. The rationale of his project is his claim that the emergence of a style makes certain sentences positive. It is in this sense that the framework of style of reasoning is crucial for understanding how certain sentences become objective in different historical contexts.

2.2 Kuhn and the emergence of objectivity

Before Hacking, Kuhn had already invoked the Kantian categories and attributed to his framework the role Hacking assigned to that of style: 'My structured lexicon resembles Kant's a priori […] Both are constitutive of *possible experience* of the world, but neither dictates what that experience must be' (Kuhn, 1962, p. 331). To clarify, it must be remembered that, although Kantian transcendental conditions make it possible for us to have objective knowledge of the world, their role does not consist in making our representations true but in making it possible that we can represent anything at all (accurately or not). The quotation above states that the notion of paradigm plays the same role (the fact that Kuhn distinguishes paradigm from the 'structured lexicon' that guides research in normal science does not make a difference for my argument). A remark of Paul Hoyningen-Huene, who quotes passages of *The Structure of Scientific Revolution*, clarifies better this point:

> 'Paradigms "are constitutive" of this world or nature […] the world is "determined jointly by nature and the paradigms" […]. Whatever paradigms are, since they are tools "through which to view nature", they must have some world-constitutive function […]. "World" and "nature" here coincide to some extent with what Kant calls "nature in the material sense" […]. For both Kant and Kuhn, epistemic subjects are (albeit in different ways) coconstitutive of this world […] (Paul Hoyningen-Huene, 1993, pp. 32-33)

However, Kant did not conceive of a priori conditions as historically variable collective forms of intuition, whereas Kuhn did: 'I go around explaining my own position saying that I am a Kantian with moveable categories' (Kuhn, 2002 [2000], p. 264). Thus, for Kant, 'what is objective is that to which all human beings - in virtue of their rational faculties of sensibility and understanding – must necessarily agree' (Friedman, 2011). For Kuhn, it is a given paradigm that 'yields generally agreed upon (although perhaps only tacit) rules definitive or constitutive of what counts as a "valid" or "correct" solution to a problem' (Friedman, 2001, p. 42). This is a form of concordant objectivity in that, within a paradigm, scientists agree on the solutions to a problem and on the reliability of certain methods. And it is also a form of interactive objectivity because the emergence of a paradigm makes it possible that certain problems, methods or exemplars are shared and considered important. In *The Road since Structure* Kuhn wrote: 'Hacking […] spoke of the way in which styles introduce into science new candidates for true/false. Since that time I have been realizing […] that some of my central points are far better made without speaking of statements as themselves being true or as being false' (Kuhn, 2002 [2000], p. 99). Indeed, when he elaborated the concept of 'lexicon', a network of related terms associated with a taxonomy, he described it in Hacking's terms as the condition of possibility of new candidates for truth or falsehood (see Politi, 2020).

In summary, like Kant (and Hacking), Kuhn introduced his framework in order to answer the question of what makes it possible for something to become objective (explanatory goal). On the other hand, unlike Kant (but like Hacking), Kuhn believed that objectivity comes into being through specific historical processes. Therefore, the notion of paradigm (and that of style) will necessarily have to be different from the Kantian a priori – it must be a 'moveable category', suitable for dealing with a historicised concept of objectivity. An aspect of the emergence of objectivity that Kuhn set out to investigate is related to the problem of scientific discovery. What he wanted to show was that the existence of an entity becomes objective only when certain circumstances happen to exist:

> A discovery like that of oxygen or X-rays does not simply add one more item to the population of the scientist's world. Ultimately it has that effect, but not until the professional community has re-valuated traditional experimental procedures, altered its conception of entities with which it has long been familiar, and shifted the network of theory through which it deals with the world. (Kuhn, 1996 [1962], p. 7)

That is, once the scientific community agrees on new experimental procedures and conceptions of what an entity is, the propositions concerning the discovery and existence of oxygen can be assessed as true or false, becoming objectively true (or false). He also used the term 'discovery' with regard to concepts that become objective once a new paradigm emerges (see for example (Kuhn, 1987)). The concepts of force and mass in Newton's second law of motion are a case in point: for Kuhn, these concepts differed

from those in use in the previous paradigm. Ultimately, the latter is the framework introduced by Kuhn to explain the emergence of objectivity.

2.3 Fleck and the emergence of objectivity

The question as to how facts and concepts emerge as objective for a community of people had already been posed by Fleck. Both the title *Genesis and Development of a Scientific Fact* and the opening question 'What is a fact?' (Fleck, 1979 [1935], p. XXVII) make it clear that explaining the possibility of objectivity was also Fleck's goal. Kuhn wrote that 'what the thought collective supplies its members is somehow like the Kantian categories, prerequisite to any thought at all' (Kuhn, 1976). Indeed, like Kuhn and Hacking, Fleck too referred to Kant by quoting the philosopher Wilhelm Jerusalem (1854-1923): 'Kant's belief in a timeless, completely immutable logical structure of our reason […] has not failed […] but proved to be definitely erroneous' (Fleck, 1979 [1935], p. 47). For Fleck, the study of the emergence of facts and concepts requires a historical investigation. Facts emerge from a ternary and always changing relation between the knower, the object to be known and a 'missing component' (Fleck, 1979 [1935], p. 38), the 'thought style', which is described by these words:

> If we define a "thought collective" as a community of persons mutually exchanging ideas or maintaining intellectual interaction, we will find by implication that it also provides the special "carrier" for the historical development of any field of thought, as well as for the given stock of knowledge […]. This we have designed thought style. (Fleck, 1979 [1935], p. 39)

In other words, the framework of thought style, which presupposes the cognate concept of thought collective, was introduced by Fleck in order to take into account an element that is crucial for explaining the emergence of a fact. Indeed, if a fact is described by statements such as 'someone recognizes something', then:

> The statement 'Someone recognizes something' […] is no more meaningful as it stands than the statements 'This book is larger' […]. Something is still missing, namely the addition, 'than that book', to the statement. Analogously, the statement 'Someone recognizes something' demands some such supplements as 'on the basis of a certain fund of knowledge' or, better, […] 'in a particular thought style' (Fleck, 1979 [1935], p. 38).

For Fleck what makes certain propositions meaningful is a thought style just like for Hacking what makes certain propositions positive is a style of reasoning. Once a proposition is meaningful, those who have

the same thought style can discuss it to ferret out the sources of their disagreements ('interactive objectivity') or agree on its truth-value ('concordant objectivity').

2.4 Foucault and the emergence of objectivity

In the preface of *The Order of Things*, Foucault too described the goal of his project – identifying the 'conditions of possibility' for thought in a certain period – in Kantian language:

> It is an inquiry whose aim is to rediscover on what basis knowledge and theory become possible; within what space of order knowledge was constituted; on the basis of what historical *a priori*, and in the element of what positivity, ideas could appear, sciences be established, experience be reflected in philosophies, rationalities be formed. (Foucault, 1994 [1966], p. XXII)

Here, the historical a priori represents the conditions of the possibility of positivity – the possibility that sentences, ideas, concepts and theories emerge as candidates for truth or falsehood and, possibly, become objectively true (or false):

> [W]hat I mean by the term is an a priori is not a condition of validity for judgements, but a condition of reality for statements. It is not a question of rediscovering what might legitimize an assertion, but of freeing the conditions of the emergence for statements, the law of their coexistence with others, the specific form of their mode of being […]. (Foucault, 1972 [1969], p. 127)

The priori of a given period is the 'episteme': 'the epistemic field […] in which knowledge […] grounds its positivity and thereby manifests a history' (Foucault, 1994 [1966], p. XXII). To summarize, Foucault's aim stated in the first passage is that of studying how objectivity is possible and the concept of episteme is the framework introduced for achieving it. The citation of Ulisse Aldrovandi (1522-1605) that 'the human face, from afar, emulates the sky' (Foucault, 1994 [1966], p. 19) is one of the many examples of propositions that were candidates for being true-or-false only in the episteme of the Renaissance. Similarly, Hacking argued that Paracelsus's sentence 'mercury salve might be good for syphilis because mercury is signed by the planet Mercury, which signs the marketplace where syphilis is contracted' was a candidate for truth or falsehood only in the Renaissance way of reasoning (Hacking, 2002, p. 171).

In Section one, I had pointed out the difficulties in pinpointing the common objectives of Fleck, Kuhn, Foucault and Hacking within a historical approach to the study of scientific knowledge. Now we can notice that their projects can be viewed as studies of an *organising concept* (objectivity) and therefore fall into a field of research that today is called historical epistemology ('historical meta-epistemology' in

Hacking's terminology). Indeed, objectivity shapes our practices of knowledge and is an essential organising principle of our investigations. Moreover, as we have seen, shedding light on how objectivity is possible is the necessary goal of their common program of research -- that of historicising Kant's apriori. In this connection, we can notice that historicised Kantianism has been crucial to the formation of French historical epistemology (see Chimisso, 2008). Since, as I am going to show, the frameworks of Fleck, Foucault, Kuhn and Hacking provide principles of selection for developing historical narratives, we might say that these thinkers offered different histories of objectivity. And one might reasonably ask whether the works of other practitioners of historical epistemology can be viewed as histories of objectivity. However, this remains an open question for my purposes here.

3. Histories of objectivity

In this section, my main goal is to highlight the differences between the four frameworks by comparing and contrasting their explanatory expectations. I shall argue that each of these frameworks specifies a few explanatory expectations that, together with the explanatory goal, act as a principle for the selection of historical facts in an explanatory narrative -- a history of objectivity. Given a framework, I shall ask: what were the explanatory expectations of its proponent? How they differ from those of the other frameworks? Since, as it will be clear, Fleck's and Kuhn's frameworks belong to a different explanatory perspective than Foucault's and Hacking's, I will keep the two couples apart. I shall first focus on the former and then on the latter.

3.1 Fleck's explanatory narrative

In the 1930s, the scientific community of microbiologists debated how to interpret photographs obtained by shining light on bacteria positioned on light-sensitive film: is the image of the object an observation or an artificial creation? What should a bacterium look like? As a microbiologist, Fleck realised that 'to see [means] to recreate a picture, at a suitable moment created by the mental collective to which it belongs' (Fleck, 1986, p. 78) and that a lay person looking through the microscope would not be ready to perceive what the expert considered to be the object of observation. It is plausible that reflecting on similar experiences led him to the idea that a good explanation of how a fact comes about should necessarily appeal to *sociological* factors; indeed, already in 1929 he wrote that 'any new epistemology must […] be brought into a social and historical context' (Fleck, 1986, p. 48). Later, Fleck quoted sociologists such as Durkheim and Lévy-Bruhl who recognised 'the importance of sociological

methods' and highlighted 'the force exerted on the individual by social structures' (Fleck, 1979 [1935], p. 46) (see also Braunstein, 2003, p. 410).

As documented by Zittel (2012, pp. 69-74), the debate on the concept of thought style that took place in 1939 between Fleck and the historian Tadeusz Bilikiewicz (1901–1980) showed that the former 'sought to emphasise the peculiarities of individual thinking styles and to describe their differences'. This means two things: unlike Foucault and Hacking, Fleck did not want to appeal to the existence of general rules of discourse that are valid for all areas of society in a given epoch or to pay attention to forms of reasoning. What he invoked was a narrow understanding of thought styles: different communities of scientists can have distinct ways of thinking. Furthermore, from the comparative analysis of different thought styles he expected to find a continuous development of knowledge:

> Thoughts pass from an individual to another, each time a little transformed […] Words which formerly were simply terms become slogans […] They no longer influence the mind through their logical meaning – indeed, they often act against it – but rather they acquire a magical power and exert a mental influence simply by being used. (Fleck, 1979 [1935], p. 42)

In summary, in order to provide an answer to the question of how facts emerge, Fleck appealed to certain explanatory expectations: an epistemology sociological in character, a minor role played by broad rules of discourse and a continuous process of knowledge. The concept of thought style embodies Fleck's explanatory expectations: a 'thought style […] calls for a sociological method in epistemology' (Fleck, 1979 [1935], p. 64); it must be understood in a narrow sense, and it is conceived as continuously changing. How do these features act as principles of selection that shape Fleck's narrative? *Genesis and Development of a Scientific Fact* can be divided into two parts: the first is a history of the conception of syphilis over five hundred years; the second one focuses on the origin of the Wassermann test between 1906 and 1936. The fact that in the Renaissance people believed that a conjunction of planets could cause syphilis is foregrounded; but historical events such as crucial experiments are backgrounded to obey explanatory expectations that are sociological in character: Fleck held that religious thought had 'a persuasive effect upon then-current research' (Fleck, 1979 [1935], p. 2), so discoveries were not primarily the result of experiments. The idea of corrupted blood, which slowly undergoes modifications, answers to a continuist stance, and the very choice of Wassermann's reaction as a central subject is designed to show the influence of thought styles; in turn, it selects certain facts leading to its discovery. Finally, events such as the discovery of a causative agent and the attendant epistemological consequences are compared with previous events and ideas in different thought styles in order to show that their social significance is limited compared to other sociological circumstances.

3.2 Kuhn's explanatory narrative

A few brief autobiographical notes in Kuhn's writings provide some hints about the explanatory expectations that shaped his narrative. In the foreword to *Genesis and Development of a Scientific Fact*, he wrote: 'Fleck's text helped me to realize that the problems which concerned me had a fundamentally sociological dimension' (Kuhn, 1976, p. VIII). He focused on the structure of the scientific community rather than on the logical reconstruction of theories and, for this reason, he has been credited as one of the first proponents of a 'social epistemology of science' (Wray 2011). Like Fleck, Kuhn did not appeal to the existence of general rules of discourse but rather to what unifies specific scientific communities at a certain point in history. Contrary to Fleck, however, he problematised the very concept of 'scientific community': as he noticed in the *Postscript* to *The Structure of Scientific Revolutions*, scientific communities may exist at different levels - for example, there is the general scientific community of physicists and then, at lower levels, the specialties and sub-specialties communities. This means that changes affecting a community at the lower level may not affect the community at large (see Politi, 2018). Nevertheless, as Möβner (2011) noted, the influence of social factors is more widespread in Fleck: whereas the latter applies the framework of thought style even to non-scientific areas, Kuhn is reluctant to extend that of paradigm out of the hard sciences, not to mention to ordinary life. Consequently, unlike Kuhn's, Fleck's framework is potentially suited to including factors outside the scientific realm in the study of objectivity.

When, in 1995, Kuhn was asked about the ideas he had in mind before writing *The Structure of Scientific Revolutions*, he answered: 'I didn't know quite what it was going to look like, but I knew the noncumulativeness, and I knew something about what I took revolutions to be' (Kuhn, 2002 [2000], p. 292). Already in 1947, under the influence of works such as Koyré's *Etudes galiléennes* (1939) (1996 [1962], p. IX), Kuhn had developed the view that it is impossible to provide a continuous description of scientific development. As he explained (Kuhn, 2002 [2000], pp. 13-32), at that time he realised that Aristotle looked at the world in a manner completely different from Newton: the illusion of continuity was provided by identical words such as 'motion', which mask the stark contrast between the two worlds. This discontinuist perspective makes objectivity more the product of scientific revolutions than of a slow process of the development of past ideas, as Fleck presented. For the latter, proto-ideas and old conceptions can survive changes in thought styles, serve as heuristic guidelines for new research developments and play a role at a deep level in the emergence of objectivity.

These explanatory expectations are embodied by the concept of paradigm. The latter is the basis for the set of contrasts and comparisons in *The Structure of Scientific Revolutions*, of which some of the most important concern the Copernican, Newtonian, Chemical and Einsteinian revolutions. For each of these central subjects, Kuhn compared and contrasted the concepts, terms and experimental practices of different paradigms. It is by relying on the explanatory expectations that these historical events are selected. For example, 'noncumulativeness' is a guiding principle for foregrounding the 'scientific

revolutions' of Copernicus, Newton, Lavoisier and Einstein, and it is considered explanatory of how objectivity is possible: 'in order to make […] a discovery one must alter the way one thinks about and describes some range of natural phenomena. The discovery (in cases like these "invention" is a better word) of Newton's second law of motion is of this sort' (Kuhn, 2002 [2000], p. 15) To paraphrase, we could say that the objectivity of certain concepts is not possible until a paradigm is in place.

Under the influence of Fleck, Kuhn maintained that different paradigms use concepts that are incompatible. However, as he refined his ideas, he developed a concept of incommensurability not only limited to the idea of translation failure. He argued that incommensurability was not only caused by linguistic factors but also by differences in methods for setting up research and evaluating its results. Furthermore, under the influence of the Gestalt psychologists, he also spoke of differences of perceptions between adherents of different paradigms. It is from the collaboration of all these elements that incommensurability follows. For example, he argued that in the seventeenth century different people might have viewed in a different way the same stone swinging from a string. An Aristotelian would have seen the stone as constrained in its downward motion; an adherent of the new Galilean physics would have seen a pendulum that repeats the same motion forever. Kuhn claimed that these two conceptualizations are incommensurable because there is no neutral way to adjudicate between them (Kuhn, 1996 [1962], p. 150).

3.3 Foucault's explanatory narrative

The two thinkers I am going to deal with now – Foucault and Hacking – adopted explanatory perspectives in which social influences are less important than certain underlying structures of human thought. What Foucault considered explanatory of the emergence of objectivity was the existence of implicit rules that constrain the way people think at a given period. '[O]ne cannot speak of anything at any time; […] it is not enough for us to open our eyes, to pay attention, or to be aware, for new objects suddenly to light up and emerge out of the ground' (Foucault, 1972 [1969], p. 44). Instead, Foucault claimed, an 'object of discourse' can become thinkable if it finds 'its place and law of emergence', a law which is established not by logical or linguistic formal structures but by deeper rules that limit, constrain or make possible what can be said or thought. Foucault called the attempt to bring these rules to light 'archaeological inquiry', likening his work to that of archaeologists, whose interest 'is not in the object studied but in the overall configuration of the site in which it was excavated' (Gutting, 2005, p. 34). Very early in his career, he developed a strong interest in the discontinuities in the history of thought, an interest that was already evident in the works that preceded *The Order of Things*. In the latter's preface, Foucault claimed that 'archaeological inquiry has revealed two great discontinuities in the *episteme* of western culture' (Foucault, 1994 [1966], p. XXII) that occurred at the beginning of the Classical age (the middle of the seventeenth century) and of the Modern age (the beginning of the nineteenth century).

Foucault's explanatory expectations can be summarised by saying that he wanted to offer an account of human thought that was archaeological and discontinuous. These expectations determined an explanatory narrative which was not so much a *causal* narrative as a *synchronic* analysis of each episteme. Thus, the events that Foucault foregrounded are, for example, those which reveal the semantic web of relations in the sixteenth century, from the uses of distinct forms of similitudes by certain authors to the deciphering of different 'sympathies' between entities of the world (Foucault, 1994 [1966] chapter 2). The continuity of the narrative is provided by changing the focus of the analysis from one episteme to another and, above all, by the set of contrasts and comparisons that pairs thinkers of different epistemes, through which Foucault sought to reveal deep discontinuities in the history of human thought. An example is the comparative analysis of the thought of Georges Cuvier (1769–1832) and Jean-Baptiste Lamarck (1744–1829), in which Foucault reversed the traditional assessments of these two thinkers (Foucault, 1994 [1966], pp. 263-279).

There is a substantial difference between Foucault's and Fleck's explanatory expectations: the latter believed that how people think in a certain period may essentially determine the objectivity of a fact; the former held that what is objective is made possible by the existence of implicit rules outside people's awareness. Fleck was a constructivist in that he believed that not only scientific knowledge, but also its objects (e.g. syphilis) are the product of a community's way of thinking. By introducing his framework of thought style he wanted to provide an account of how 'objective reality can be resolved into historical sequences of ideas belonging to the collective' (Fleck, 1979 [1935], p. 40). Therefore, Fleck's 'history of objectivity' is radically externalist because for him the thought collective constructs scientific facts, which entirely have a social content.

On the other hand, one might say that the early Foucault of *Les mots et les choses* (1966) provided a 'history of objectivity' *internal* to human thought: he did not want to explain how biological, economical or geographical factors influenced the thought of an epoch. Rather he wanted to identify, within that very thought, the set of rules and constrains that made certain concepts thinkable. These considerations regarding Foucault only apply to the explanatory expectations behind his framework of episteme. When one looks at the other works of Foucault, which are outside the scope of this article, one should conclude that Foucault is an externalist: in 1978, he made it clear that 'the development of scientific knowledge' can be understood in relationship to the 'changes in the ways power operates' (Foucault, 2001, p. 533).

Kuhn saw himself as an internalist: 'the intellectual milieu reacts on the theoretical structure of a science only to the extent that it can be made relevant to the concrete technical problems with which the practitioners of the field engage' (Kuhn, 1971, p. 280). As I have pointed out, for him the 'discovery' of oxygen became objective when the scientific community reforged its conception of entities, its network of theories and its experimental procedures (Kuhn, 1996 [1962], p. 7). The framework of paradigm embodies his explanatory expectations: in periods of normal science the scientific community is insulated

from 'those socially important problems that are not reducible to the puzzle form' (Kuhn, 1996 [1962], p. 37) and the objectivity of new facts and concepts is made possible by a change of paradigm triggered by a 'crisis' within science.

3.4 Hacking's explanatory narrative

Hacking defined his *The Emergence of Probability*, which can be regarded as an account of the genesis and development of the statistical style of reasoning, as an application of 'the new kind of analysis that Foucault called archaeology' (Hacking, 2006 [1975], p. II). Like Foucault, Hacking believed that concepts, sentences and theories form a superstructure that is made possible by a deeper structure, a 'depth knowledge' (Hacking, 2002, p. 77) of which we are unaware. Whereas Foucault used the framework of episteme to capture this idea of 'depth knowledge', Hacking employed that of style of reasoning, whose emergence can make certain propositions objective. In developing this idea, he remarked:

> Crombie's vision of the history favours continuity. My instinct is exactly the opposite. I like to tell the history of each style as having at least one sharp moment of crystallization, a fixing of how to go in the future (Hacking, 2009, p. 14)

Crystallization is a metaphor for that sort of sharp moment in which a given style fully emerges (Hacking, 2009, 2012). Hacking considered crystallizations to be tied to particular emblematic historical events, such as Boyle's experiments in the case of the laboratory style or the publication of Darwin's *On the Origin of Species* (1859) in the case of the historico-genetic style. Thus, crystallizations became the central subject of explanatory narratives of the emergence of different styles. These narratives can be considered histories of different ways in which objectivity has become possible. In Hacking's terms, 'my picture is more like that […] of significant singularities during which the coordinates of "scientific objectivity" are rearranged' (Hacking, 2002, p. 6).

Hacking viewed his project of styles as part of 'cognitive history' (Hacking, 2009, 2012), i.e. a study of how humans learned to use their cognitive resources. He flirted with the idea that every style is grounded in one or more modules, sorts of separate structures of the mind, which are the product of evolution (Hacking, 2009, p. 48). For example, he thought that there might be a module for geometrical reasoning and one for numerical and combinatorial reasoning (Hacking, 2011). Hacking was also been attracted by the anthropologist Scott Atran's theory that there are *universal* principles of biological classification that are employed by peoples everywhere (Atran, 1990). Like Kantian faculties of understanding, these cognitive resources are universal, but they are drawn on in different ways within distinct historical contexts.

The framework of style of reasoning summarises in itself Hacking's explanatory expectations. Indeed, styles have sharp beginnings (discontinuity) and are at the core of the inquiry into what makes new propositions objective (archaeology). Whereas thought styles emerge from communicative interactions, continuously mute and then die out in a brief timespan, styles of reasoning have sharp beginnings and persist for a long period -- they are a matter of *longue-durée*. Furthermore, unlike Kuhn's paradigms, styles of reasoning do not replace one another. Once a style emerges, if necessary, it can be adopted together with other styles for solving a scientific problem. How do these explanatory expectations shape Hacking's histories of objectivity? To give an example, I shall sketch a history of the emergence of the laboratory style from suggestions scattered throughout his papers.

In his *Representing and Intervening* (Hacking, 1983b), Hacking distinguished phenomena that can be observed without direct intervention from phenomena that do not exist in isolation but require special devices to be elicited (i.e. effects). Hacking explained that the production of effects became routine in scientific research in the seventeenth century. In 1985, in *Leviathan and the Air-Pump*, Shapin and Schaffer (1989 [1985]) presented the thesis that in the late 1650s Boyle and the English experimental community, still in its infancy, established new rules of discourse by which matters of fact had to be both generated and defended. Hacking interpreted their book as a work about the origins of the laboratory style (Hacking, 2007). Besides the air-pump, the other protagonist of that book was the philosopher Thomas Hobbes (1588–1679), who takes the role of Boyle's opponent: he did not accept the practice of acquiring knowledge, with its conventions and standards of truth, that was about to be adopted in scientific research. Hacking wrote that '[Hobbes] saw that [Boyle's] was a new and threatening style of reasoning' (Hacking, 1991a, p. 240). For Boyle, 'evidence' was not only what can be found as 'given' in nature but also what can be made by humans. Hobbes refused to accept that the result of an experiment could represent evidence on which to base our claims of knowledge. He argued that all experiments conceal theoretical assumptions whose validity could always be disputed.

The emergence of a community of people who saw phenomena that had been produced by devices as valid evidence represented for Hacking a punctuated event in the history. In the new science thus established, finding the answers to questions about the world became a matter of using many different plastic resources – the material apparatus, the background theory, as well as ideas about what the machine does and how things in it behave – each of which was adapted to the other (Hacking, 1991a, p. 237). Hobbes refused to embrace this new criterion for the validation of knowledge and maintained that the philosopher's model for knowing consequences and causes was provided by the style of geometry.

In 1800, the astronomer William Herschel (1738–1822) proved that the different colours of the spectrum are of different temperatures and discovered the infrared radiation of sunlight (Herschel, 1800). He used prisms or filters (i.e. man-made devices) in his telescopes to create a new effect, the separation of the rays of light, and then he measured the temperature of each ray. Hacking cited a sentence of

Herschel's – 'The heat which has the refrangibility of the red rays is occasioned by the light of those rays' – and argued that Archimedes did not possess the style of reasoning that Herschel used to make sense of this sentence. According to Hacking, the sentence is style-dependent:

> If another culture has acquired the laboratory style of reasoning, it can perfectly well learn Herschel's physics from the ground up – that is just what I do in making sense of Herschel's text. The problem is that the sufficiently foreign person will not have Herschel's kind of sentence as the sort of thing that can be true-or-false, because the ways of reasoning that bear on it are unknown […] [Archimedes] would not be able to effect a translation until he had caught up on some scientific method (Hacking, 2002, p. 173).

To explain Hacking's point, one can focus on the fact that the novelty introduced by the laboratory style – that phenomena elicited by apparatuses constitute the evidence for certain propositions – is also an essential element of what, since the seventeenth century, has been considered the scientific method. Bearing this in mind, Hacking is claiming that Archimedes could not make sense of Herschel's sentence because its sense hinges on a new kind of evidence that emerged later, in Boyle's time.

In connection with this point, it is important to mention the controversial problem of incommensurability, although addressing it is outside the scope of this paper[2]. I shall start by recalling that Jardine (1991 chapter 3) defined a question as *real* for a community if there is a disposition to acknowledge the relevance of evidential considerations to that question. Evidential considerations are considerations that are evident under appropriate circumstances: they could be empirical, but also theological, aesthetic or self-evident. A consideration is classed as relevant if it is taken by the community to favour one answer over the others. As Hacking wrote, '[Jardine] show[ed] […] how questions that make sense in one scientific framework are unintelligible in another' (Hacking, 1999b, p. 165). For example, from Hacking's account it follows that a question about a new effect created by man-made devices would have been *unreal* for Archimedes. There is no consideration that he could have taken in order to argue for a possible answer. However, in order to distance himself from constructionism, Hacking made it clear that 'once a question does make sense, its answer is determinate' (Hacking, 1999b, p. 165) and that

> the answer to a clear question about some aspects of the world is determined by how the world is. […] when the question is a live one, and there is a context in which there are ways of addressing the question, or even methods of verification for possible answers, then aspects of the world determine what the answer is (Hacking, 2000, p. S69).

[2] On the incommensurability of styles of reasoning see (Kusch, 2010) and (Sciortino, 2016).

In Hacking's terminology, 'live questions' are the questions that are 'important', those that a community that adopts certain styles in a given historical period asks. Hacking's point is that 'the answers to live questions about the natural world have nothing to do with us' (Hacking, 2000, p. S70).

However, he does not allay the suspicion that styles of reasoning are incommensurable. Indeed, Hacking's central claims are that: 1) there are *correct answers* to live questions 2) *correct answers* are found when there are ways of addressing the question. Now, think of an answer expressed in terms of style-dependent sentences found by a community that adopts a certain style. The problem is that we might not be able to establish that this answer is correct until we find an atemporal and universal criterion to justify style-dependent sentences. For example, in the case of the Boyle-Hobbes dispute, the question (to which Hobbes answered in the negative) was whether to accept the presuppositions (way of thinking and doing, methods, standards of evidence etc.) of the emergent Boyle's style. If both the ways of addressing the questions and the methods of verification are changeable, how can one ever know whether the answers provided by a new style are to be trusted? Hacking's arguments can only oppose alethic relativism but are a blunt spear against epistemic relativism.

The kind of incommensurability that concerns Kuhn's framework is different from Hacking's. In Kuhn's version of incommensurability, a *semantic aspect* can be recognized: two paradigms are incommensurable when there is no neutral language into which the content of both theories can be translated. In this sense, a lack of a 'common measure' translates into a lack of a 'common language'. On the other hand, Hacking's claims do not lead to semantic incommensurability. His point is that there are sentences that are meaningful in some styles (e.g. because there are methods to assess their truth) and meaningless in other styles -- the meaning of sentences does not change from one style to another.

	Historicised Kantianism	Deep Knowledge	Sociological dimension	Cumulativeness	Discontinuity
Thought style	x		x	x	
Paradigm	x		x		x
Episteme	x	x			x
Style of reasoning	x	x		x	x

Fig.1 Some of the main features of the four frameworks discussed in Sect. 2 and 3

4. A combined framework for the study of objectivity

In this section, I shall argue that the frameworks I have discussed so far can be used as a toolkit for studying the emergence of objectivity. I shall also contend that the frameworks of style of reasoning and of episteme illuminate conditions of possibility that are crucial for the emergence of objectivity and lie at a deeper level than those considered by the other two frameworks. However, I shall defend a pluralistic approach by claiming that there is no single 'correct' framework or set of frameworks to be employed in the study of objectivity. The latter should be best understood as a project that benefits from the regular introduction of new frameworks. I shall start by giving an example to demonstrate how a paradigm has been made possible by the coming into being of a style of reasoning. My example will also show that, in turn, that very style has been made possible by the emergence of a new kind of evidence. I shall then draw a general conclusion about the relationships between the four different frameworks.

In *The Emergence of Probability*, Hacking argued that what was lacking in the Renaissance was the evidence provided by things, not to be confused with that provided by the data of the senses. To use an example given by J. L. Austin (1911–1960) and quoted by Hacking (2006 [1975], p. 32), pig-like marks and buckets of food outside a sty represent the *evidence of things* that in the sty there is a pig; the coming into view of the pig represents the evidence of the senses. Obviously, people in the Renaissance did use the evidence of things, but Hacking argued that the concept was absent: 'dogs can tell there is a pig, and do not thereby have a concept of evidence' (Hacking, 2006 [1975], p. 34). In present-day understanding, books and testimony represent indirect evidence that is secondary to the experience. The Renaissance had the order reversed: testimony and authority were primary, and things counted as evidence only insofar as they resembled the authority of testimony and books.

The concept of a sign underwent several changes – for instance, Paracelsus (1493–1541) did not consider the names of stars to be conventions and thought that the 'true names' of celestial bodies were signs; but later, the distinction between conventional signs and natural ones was marked clearly. The physician Girolamo Fracastoro (1483–1553) wrote that, among the signs in the sky, air, soil or water that are premonitory, some are almost always, others are often, to be trusted. Therefore one ought not to consider them all as prognostications, but only as *signs of probability* (Hacking, 2006 [1975], p. 28). These changes opened the way for the evidence of signs to turn into the evidence of things. In the passage above, since not all signs are to be trusted with certainty, the idea of probability is connected with frequency, with what happens 'almost always'. Here, we already recognise some of the features of our statistical concept of probability. According to Hacking, in a text published in 1650 by Thomas Hobbes, the concept of evidence of things conjoined with that of frequency had already taken full shape and probability had emerged (Hacking, 2006 [1975], p. 48).

Hacking noted that 'the advent of the quantum theory has made it possible to conceive of statistical regularity as a brute and irreducible fact of nature' (Hacking, 2006 [1975], p. 174). Indeed, the

formalism of quantum mechanics cannot be interpreted as if probabilities reflected ignorance[3]. Statistical laws have become an irreducible fact of the world, and the deterministic conception of nature has given way to an indeterministic one. This transition has been presented by Kuhn as a scientific revolution in which there has been a shift from the classical to the quantum paradigm[4]. For him, it is the change of paradigm that explains how a new ontology of the world, new puzzles, methods and concepts have become possible. In the quantum paradigm, the question about whether or not a particle behaves like a wave is meaningful and objective, whereas the concept of a trajectory of a particle has no meaning. Ultimately, the emergence of the evidence of things made possible the coming to the fore of the statistical style, which in turn made possible the transition from the classical to the quantum paradigm. If probability had not emerged, there could not have been a quantum paradigm, although the coming to the fore of the latter would not have been a *necessary* consequence. The quantum paradigm inherited from the statistical style standards of evidence, methods, practices, concepts and propositions.

This example shows that it is possible to use the frameworks of style of reasoning and paradigm together to track objectivity. It could also be argued that the analysis of such a case study would benefit from the use of the framework of episteme to reveal, for instance, how in the seventeenth century language could be conceived of as a transparent structure, articulated into an arbitrary binary relation between signified and signifier. This change has been crucial for the emergence of mathematical formalism. It is possible to give many other examples in which these frameworks can be used together. Like the framework of paradigm, that of thought style is parasitic upon that of style of reasoning. In the previous section, I have shown that it was the emergence of a new kind of evidence (the 'creation of effects') that made possible the emergence of the laboratory style of reasoning. In turn, it was the emergence of the latter that made possible, for example, the thought style of the microbiologists and therefore the discovery of Wassermann's reaction. In this case, one could use both the framework of style of reasoning and that of thought style together to study how Wassermann's discovery became objective. As another example, the frameworks of thought style and paradigm could be preliminary for the study of the 'discovery' of oxygen by Priestley and Lavoisier. And one could employ both the framework of style of reasoning and episteme to account for the emergence of Darwin's evolutionary ideas: the former would provide insights into his historico-genetic thinking, the latter would place the emphasis on the role of time in his view of nature.

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[3] von Neumann (1955), Bell (1966), Kochen and Specker (1967) showed that it is impossible to provide a 'classical' reformulation of the quantum formalism.

[4] Kuhn (2002 [2000], p. 25) gave as an example of scientific revolution the origins of the quantum theory: the black-body problem 'caused the reconstruction of a good deal of physics'. Neither this essay nor his book *Black-Body Theory and the Quantum Discontinuity* (1987 [1978]) *explicitly* mention the term 'paradigm'. However, Kuhn later added a foreword to his book to clarify that he had *not* repudiated this concept: 'when I look back, I have generally been satisfied by the extent to which my narrative fits the developmental scheme that *Structure* provides. *Black-body theory* is no exception' (1987 [1978], p. 363)

Let us tie the argument together. The process by which facts, concepts or sentences come into being as objective can be depicted by a diagram of layers (Fig. 2), the 'layers of scientific objectivity'. Styles of reasoning and epistemes sit at the lowest layer of the diagram, paradigms and thought styles at the second layer and all the epistemological items which become objective sit at the highest level. Each layer represents conditions of possibility for the existence of the successive layer. The higher layer instantiates the lower layer. There will also be other layers of various contingent factors, of which the emergence of a new kind of evidence is only one, that make possible the level of styles of reasoning or epistemes. Ultimately, we could use the metaphor of the 'machine of objectivity', schematised in the figure 2: there is a bottom layer of contingent factors, which trigger the emergence of styles of reasoning or epistemes, which in turn trigger the emergence of paradigms or thought styles and lead to objectivity. Within the metaphor, 'triggering' stands for 'making possible' and not 'causing'. Models in which lower layers make possible the higher ones are known as 'stratigraphical metaphors'. James Elwick has shown how they have been used by several scholars in history and science studies and how they are useful for speculating on degrees of contingency. In particular, he has depicted 'styles of reasoning as conditions of possibility – circumstances that are necessary for other phenomena to occur' (Elwick, 2012, p. 619). On my part, I have used the stratigraphical model to depict the relations between four different frameworks and their respective roles in making possible the emergence of objectivity.

The fact that in the figure two frameworks lie in the same layer does not mean that they both will necessarily be applicable to any case study. For example, consider the layer of paradigms and thought styles. Kuhn's discontinuist explanatory expectations make it impossible to apply his framework to those cases in which objectivity is the product of a slow process of development of past ideas. On the other hand, any extended discussion of how objectivity emerges would necessarily have to include frameworks in lower layers, i.e. frameworks such as styles of reasoning and epistemes.

This is not the only reason why the framework of style of reasoning matters in the study of objectivity. As conceived by Hacking, it incorporates an explanation as to why the objectivity of certain concepts, objects, sentences or methods endures. Hacking claims that styles are 'self-authenticating'. This term refers to the circularity induced by the following double claim: the truth of certain sentences is what we find by using a style; in turn, a style is a standard of objectivity because it gets at the truth. For example, regarding the statistical style he claims that the verification methods that make statistical sentences meaningful are themselves couched in terms of probability[5]. This *circulus in probando* is for Hacking part of the explanation of the resilience of a given style of reasoning and, therefore, of all the sentences that it makes objective. Finally, the four frameworks I have discussed so far do not exhaust all the different possible explanatory perspectives from which to consider a given episode in which scientific objectivity

[5] Gigerenzer (1991) offered another interesting example of self-vindication that concerns psychologists' use of the statistical method in the 1950s.

emerges – there are as many frameworks as all the possible histories we can construct.

5. Conclusions

To make explicit the objectives, the explanatory expectations and the limits of frameworks is important for philosophical and historical practice. My analysis shows that the objective of Fleck's, Kuhn's, Foucault's, and Hacking's frameworks is to replace Kant's a priori and explain the origins of objectivity (Sect. 2). Since they all capture different channels through which objectivity becomes possible, it is possible to group the four frameworks in the same category within historical epistemology, which I have called 'histories of objectivity'. Furthermore, these frameworks answer to different explanatory expectations which foreground distinct episodes and periods of the history of science (Sect. 3). The layered diagram I have proposed incorporates common points and differences between these frameworks and shows that these latter can be used together to shed light on different aspects of the process of the emergence of objectivity (Sect. 4). Also, it makes clearer that styles of reasoning and epistemes are appropriate to highlight fundamental factors crucial for the emergence of objectivity (Sect. 4). Finally, I have advocated for pluralism with regard to historical explanation: applying multiple frameworks might reveal contingent factors that have played a role in the emergence of objectivity.

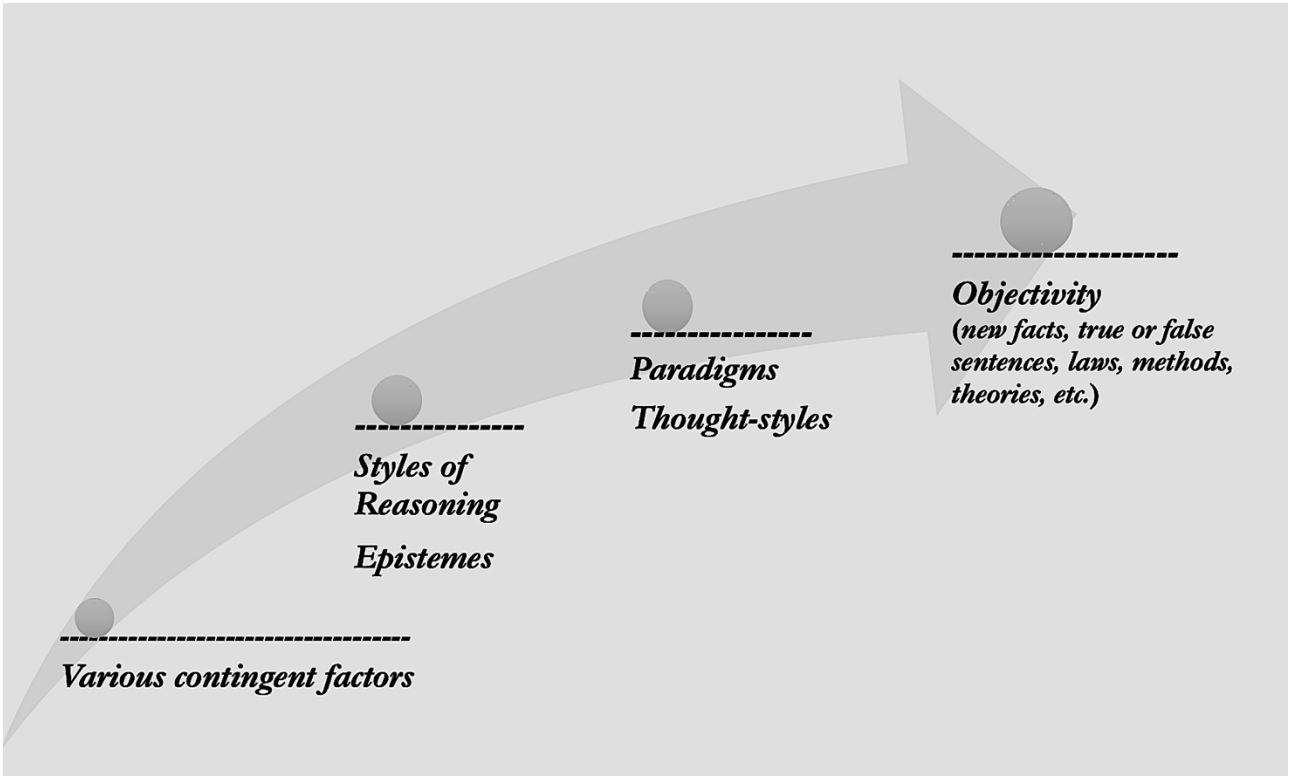

Fig. 2. Various contingent factors establish the necessary but not sufficient conditions for the emergence of styles of reasoning/epistemes. These latter establish the necessary but not sufficient conditions for the emergence of paradigms/thought styles. In turn, paradigms/thought styles and/or styles of reasoning/epistemes make possible the emergence of new positive sentences that can be assessed as objectively true or false.

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