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Constitutive Principles and Scientific Knowledge
The Concept of Constitution Between Neo-Kantianism, Logical Empiricism and Phenomenology

Titolo della tesi

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Every scientist must invoke assumptions or rules of procedure which are not dictated by sensory evidence as such, rules whose application endows a collection of facts with internal organization and coherence, makes them simple, makes a theory elegant and acceptable. Ask an investigator why he prefers a simple explanation, why he hangs his knowledge of the universe upon a continuous and undifferentiated reference frame of space and time when his immediate experience is strongly accented by peaks of attention amid valleys of boredom. Ask him why he invokes a principle of cause and effect when his experience presents him with nothing more than temporal succession.

−Margenau (1950, p. 13)

To ask not about a particular object, but instead about the laws by which it and indeed any object of science first form themselves into objects, is really an entirely novel stage of reflection.

−Natorp (1921/2011, p. 202)

Abstract

This study is situated within the contemporary debate in the philosophy of science, in which various authors characterize certain physical principles as "constitutive," yet without providing a satisfactory definition of the concept. The research first involves an examination of the original meaning of "constitutive principle" in Kantian philosophy, to then reconstruct the conceptual evolution of the term within the three twentieth-century philosophical movements that most extensively employed it in interpreting scientific knowledge: Neo-Kantianism, logical empiricism, and phenomenology. The study is limited to occurrences of the concept of constitution specifically in reference to physical theories. For this reason, it outlines the meaning and reinterpretation of the Kantian-inspired term with respect to Ernst Cassirer's philosophy of quantum mechanics, the correspondence between Moritz Schlick and Hans Reichenbach on conventionalism, and Husserl's analysis of the object of physics in the second volume of *Ideas*. The work thus reveals a plurality of meanings and approaches that preclude a single, unambiguous definition of the concept of constitution; at the same time, it emphasizes the attempt to trace the common thread connecting the various reformulations of the notion, contributing to a heterogeneous yet coherent understanding of a term that may also prove useful for interpreting contemporary scientific theories.

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Motivation for this work

1. Philosophy as elucidation

The evolution of certain philosophical terms is interesting for reasons that go beyond history and philology. In certain cases, paying close attention to the polysemy of specific notions and how different authors use them can provide valuable theoretical insights and offer a clearer understanding of fundamental conceptual issues. My analysis of the notions of 'constitution' and 'constitutive principles' should be read in this spirit. This research is primarily motivated by the absence of a philosophically satisfactory clarification of the term 'constitutive', despite its technical centrality and decisive role in the works of numerous authors belonging to diverse theoretical traditions.

Consider the following intuitions related to the expression '*x* is constitutive of *y*', drawn from ordinary language. Firstly, it evokes the idea of 'being a component of something': *x* is constitutive of *y* when it is part of *y*; for example, a football team is constituted of eleven players, since each player is part of the team. Similarly, two hydrogen atoms and one oxygen atom constitute a water molecule because they are its components. However, the adjective 'constitutive' is often used more strongly than the verb 'to constitute': it does not denote *any* part of a target, but rather the parts that are *necessary and sufficient* to define or univocally designate it. Hydrogen and oxygen can be described as constitutive of water in that any substance lacking these components *cannot be considered water*. Therefore, even at the most basic level of ordinary language, the issue becomes more intricate: the expression '*x* is constitutive of *y*' concerns the components that define the essence of *y*. Etymology is on our side: the Latin 'cum-statuere' refers to the activity of *jointly establishing* or *decreeing*. This process of 'decreeing' can refer to a group of people (as in a *constitution* or a set of laws) or to objects, describing the components that constitute them.

At the same time, the notion of 'constituting' also evokes the idea of *construction* or *assembly*. When speaking of the constitution of a machine or system, one may be referring to parts that are *actively* installed, fitted or welded together through deliberate effort. Therefore, it is unsurprising that the various meanings of 'constitution' have often been associated with *scientific knowledge* in a technical philosophical context. Both meanings of the term — one pointing to the defining components of something and the other to the

act of assembling those components — offer instructive images of scientific practice. Scientists seek to identify the elements that define reality — the components that determine what something is — yet they do not do so passively. Rather, they proceed through experimentation, modelling and, at times, constructing the very phenomena they aim to observe.

Therefore, in order to extend this analysis beyond ordinary language, while a general linguistic inquiry into the various uses of the term ‘constitutive’ would undoubtedly be fruitful, the concept’s primary relevance — both historically and in contemporary debate — lies in its connection to the foundations of scientific knowledge. Within this domain, numerous authors have sought to identify specific *principles* as ‘constitutive’. In line with ordinary usage, the *constitutive principles* of a theory may intuitively denote its essential components. More specifically, certain principles may be said to constitute a theory insofar as they establish the standards and guidelines for its formulation. However, this general assertion admits various specifications that must not be conflated in a rigorous analysis.

The fundamental principles that underpin the construction of a scientific theory might be identified as its axioms: non-deductible statements that define basic concepts and their relationships to one another, establishing the theory as a formal system. Another perspective emphasises the postulates or *desiderata* of a theory as those statements needed to articulate it; a notable example is Einstein's elevation of the principle of relativity and the light principle when formulating special relativity. Furthermore, scientific theories rely on a range of metaphysical and methodological assumptions, such as the idea that nature can be understood in mathematical terms, the principle of uniformity in nature, and the characterization of the interaction of systems through causality.

The question then arises: can all of these be classified as ‘constitutive principles’? Might they be ‘constitutive’ in distinct senses? What is the relationship between the alleged constitutive role of these principles and their conventional or empirical nature? What precisely is being ‘constituted’, and which discipline is responsible for overseeing this process?

My attempt to address these questions and advance our understanding of the status and role of principles in science is rooted in an historical analysis. This methodological choice

stems from the fact that any investigation into the meaning of the notion of ‘constitutive’ cannot overlook its systematic articulation within Kant's transcendental philosophy. While the meaning of a term inevitably evolves and adapts to new contexts, excising the Kantian approach to 'constitutivity' reduces the term to a synonym of 'fundamental' or 'essential', thereby rendering it conceptually indistinct. It is no coincidence that the notion of constitutive principles has been consistently debated by philosophers and physicists in reference to the Kantian framework.

From a broader historical perspective, the Latin ‘constitutivus’ — a translation and conceptual enrichment of the Greek ‘συστατικός’ (systatikos, meaning ‘component’ or ‘essential to an argument’) — was employed by Porphyry and later medieval logicians to denote the *differentia* that defines a species within a genus (Porphyry, 2023, p. 72). For example, the genus 'animal' can be specified by the difference ‘rational’. This difference bifurcates the genus into two species (‘rational’ and ‘irrational’), and is *constitutive* of the species ‘rational animal’, which defines human beings. The term’s primary philosophical application is thus associated with defining a species by making its essence explicit.

I would argue that Kant adopted the same usage. However, he was the first author to twist its meaning by attributing a transcendental sense to constitutive principles. ‘To be constitutive’ still means ‘To define objects’, but always in relation to our modes of knowledge. Rather than grasping the substantial essence offered by the objects, our process of defining reality *imposes conditions that are necessary for such a reality to exist*. The emphasis shifts from how the objects are constituted to how *we* constitute them. Constitutive principles define the concepts without which experience would not be possible. They highlight the essential traits of the objects of experience without assuming a substantial essence behind our conceptualisation of them.

Although Kant often employs the term ‘konstitutive Prinzipien’ with a specific and technical meaning in the context of his works, different post-Kantian traditions adopted the term as central to their own developments, evolving the original Kantian stance. As Alberto Coffa observes, “Constitution is one of a handful of landmark notions that dominated nineteenth-century developments in epistemology” (Coffa, 1991, p. 231). Several authors from this period, ranging from Hermann von Helmholtz (1878; see de Kock, 2014) to Hermann Cohen (1885), revived the Kantian idea that experience is *constituted* by our categories, explicitly adopting the vocabulary of constitution. Another

example that confirms Coffa's assertion is Hermann Lotze, who devotes a significant portion of his *Logik* (1885) to the concept of 'constitutive law'. According to Lotze, any content of experience can be described using different concepts, each highlighting specific marks of it. However, there is a privileged concept, known as the *constitutive law* or *idea*, that acts as a rule for identifying all the other concepts of that content (Lotze, 1885, p. 125). To clarify his view, Lotze stresses that "Analytical geometry possesses in the equations by which it expresses the nature of a curve, just that constitutive concept of its object which we are looking for. A very small number of related elements, the indeterminate abscissae and ordinates in their combination with, constant quantities, as constituting a primary proportion, contain, implicit in themselves and derivable from them, all relations which necessarily subsist between any parts of the curve." (Lotze, 1885, p. 115). This idea of 'constitutive' as a specific kind of definition will be seen many times in the following chapters.

Interest in the vocabulary of 'constitution', however, did not remain confined to the nineteenth century. In the twentieth century, at least three major traditions inherited and reworked this conceptual framework: The Marburg neo-Kantians (from Natorp to Cassirer), the logical empiricists (in particular Schlick, Reichenbach and Carnap), and Husserlian phenomenology. All of these appropriated the Kantian terminology, extending and transforming its meaning in different ways. From Reichenbach's notion of non-necessary yet constitutive principles (Reichenbach, 1920/1965), developed in his correspondence with Schlick in the early 1920s, to Husserl's analysis of the constitution of the material object in the second volume of *Ideas* (Husserl, 1952/1989), the concept of constitution underwent a complex process of modification and renewal.

The relevance of the term has endured to the present day. Over the past two decades, numerous scholarly endeavours within the realms of the history and philosophy of science have identified specific facets of scientific enquiry as 'constitutive'. Notably, Michael Friedman used such terminology in his *Dynamics of Reason* (2001), in which he argued "for the importance of relativized yet still constitutive a priori principles in understanding the (evolving) conceptual frameworks at the foundations of modern mathematical physics" (Friedman 2001, p. 117). His framework has aptly been described as *Constitutivism* (Sanjuán, 2021).

Beyond Friedman, Berkovitz (2020, p. 125) claims that "mathematics is constitutive of the physical"; Bitbol's, Kerszberg's and Petitot's (2009) is entitled *Constituting Objectivity*; Bland (2011, 2012) compares the constitutive and conventional aspects of Poincaré's and Schlick's works; Chang (2022) claims that coherence is constitutive of truth; Gryb and Thébault (2023) distinguish between the constitutive, nomic, and spatiotemporal structures of a theory; Longino (1983) differentiates between constitutive and contextual values in science; Luchetti (2021) argues for the minimally constitutive function of the Hardy–Weinberg principle in population genetics; Pincock (2012) analyses the constitutive and derivative character of mathematical representations; and Toepfer (2011, p. 118) demonstrates "the constitutive role of teleology for biology". In these works, the term 'constitutive' is rarely explicitly defined, raising the question of its precise meaning. Unsurprisingly, the term is occasionally used in an everyday sense to denote essential aspects in a general or colloquial manner. Nevertheless, the concept of constitution is so conceptually dense and historically significant that an attempt to elucidate its various technical meanings is neither trivial nor redundant. Assuming there is merit in Wittgenstein's assertion that "A philosophical work consists essentially of elucidations" (Wittgenstein, 1961, p. 49), the present inquiry may be warranted.

2. Friedman's relativized a priori

Although the notion of constitutive principles dominated much of early philosophy of science, it has recently regained prominence through Michael Friedman's account of scientific knowledge. It is therefore useful to briefly outline the main elements of his framework in this introduction, in order to clarify the issues that will be developed in the following chapters.

Michael Friedman's account of scientific knowledge is one of the most recent and convincing alternatives to Quine's naturalized epistemology and the post-Kuhnian tendency toward relativism as a consequence of the discontinuity between paradigms. At the heart of Friedman's proposal lies the identification of a hierarchy of elements that constitute scientific theories, particularly physical theories concerning space, time, and motion — from classical mechanics to Einstein's theory of relativity. Among these elements, Friedman distinguishes empirical laws from the *relativized a priori* or *constitutive principles*. The former "squarely and precisely face the 'tribunal of

experience' via a rigorous process of empirical testing" (Friedman, 2001, p. 45), while the latter provide the spatiotemporal framework within which the former can be formulated.

Newton's law of universal gravitation and Maxwell's equations of electromagnetism exemplify empirical laws at the surface level. The upper level of constitutive principles encompasses formal systems and physical principles. The former provide the tools for the mathematical formulation of empirical laws—such as calculus and Euclidean geometry for Newton's law of universal gravitation—while the latter mediate between the abstract mathematical formalism and empirical phenomena, as in Newton's three laws of motion for classical mechanics. Friedman's constitutive principles represent an updated version of Reichenbach's *axioms of coordination* (Reichenbach, 1920/1965), that may change and evolve over time without losing their constitutive function "of making the empirical natural knowledge thereby structured and framed by such principles first possible" (Friedman 2001, 175).

Friedman's proposal challenges Quine's naturalized epistemology, which holds that the statements of a scientific theory form a coherent web of beliefs while exhibiting the same degree of revisability. According to Friedman, modifying Newton's law of universal gravitation would produce a new law, whereas altering the second law of motion would give rise to an entirely new theory. This difference stems from the asymmetry between the two laws: Newton's law of universal gravitation presupposes the laws of motion to possess meaning and empirical applicability (Friedman, 1997, 2001, 2002). Quine's web should then become a pyramid.

Although *relativized a priori* statements cannot have the same status as empirical laws, they can change as the result of a cross-disciplinary, multifaceted dialogue within the scientific community involving different interpretations of experiments, analyses of data, philosophical debates about conceptual meaning, and a plurality of accounts of the foundations of scientific knowledge. For this reason, Friedman proposes a third, meta-paradigmatic level comprising these dialogical elements, which "plays an indispensable role, by serving as a source for suggestions and guidance - for orientation, as it were - in motivating and sustaining the transition from one paradigm or conceptual framework to another" (Friedman, 2001, p. 46; see also Friedman, 1997). This level completes Friedman's three-layered structure of scientific knowledge. While the second level

challenges Quine's web of beliefs, the third contradicts the Kuhn-inspired tendency to characterise the history of science as an irrational, discontinuous sequence of incommensurable theories[1].

Among the many criticisms raised against Friedman's framework[2], the most pressing and still unresolved one – that motivates the present work – concerns the clarification of what exactly it means for a principle to be *constitutive*[3]. While the idea that some principles need to be assumed to articulate a theory may seem intuitively sound, the requirement for clarification immediately raises non-trivial difficulties. For example, Friedman often claims that something is constitutive of a target system – whether a law or a theory – if it makes the target possible or if the target presupposes it. However, this clarification merely begs the question, as it does not explain what 'making possible' or 'presupposing' actually entails[4].

Beyond articulating general and unsatisfactory definitions of 'constitutive', Friedman offers many examples to illustrate his view, ranging from classical mechanics to the special and general theories of relativity. Yet the strategy of clarifying the notion of a *constitutive principle* through specific examples of scientific laws has two drawbacks. First, it merges different types of scientific statement, often blurring the distinction between constitutive principles and related concepts such as postulates, presuppositions, necessary conditions, axioms, and conventions[5]. It also encompasses what the logical empiricists termed *coordinative principles*—that is, principles intended to bridge the mathematical and physical components of a theory[6]. The light principle and the relativity

[1] The three-layered account of scientific knowledge is also presented in Friedman (2002) and Friedman (2010). An overview is exposed in Grozdanoff (2014), Ryckman (2010), Stump (2015), and Sus (2024).
[2] For comments and criticisms concerning Friedman's proposal, see Allison (1994), Darrigol (2020), Dimitrakos (2016), Everett (2015), Ferrari (2012), Mormann (2012), Nordmann (2012), Padovani (2015), Ryckman (2010), Stump (2015), Tanona (2010), Uebel (2012), Vaccarino Bremner (2023).
[3] This specific point is partly raised by de Boer (2011), Everett (2015), Luchetti (2021) and Sus (2024).
[4] To be fair, Friedman proposes a formal account of presuppositions, borrowing from Brittan (1978) the idea that presuppositions endow what follows from them with a truth-value (Friedman 2001, p. 74). However, Friedman refers such an account to all of Kant's a priori principles, constitutive and regulative. What would be expected, conversely, is a definitional aspect of constitutive principles alone. If Friedman defines constitutive principles as presuppositions and then identifies presuppositions with all kinds of a priori principles, the resulting framework is confusing. Notice also that Friedman often stresses the indispensability of differentiating constitutive from regulative principles within his account (see for example Friedman (2010)).
[5] Of course, one might argue that these alternative notions have a constitutive role. Nevertheless, she should define the term 'constitutive' independently of them and justify its use beyond transcendental philosophy, where it often proves meaningless.
[6] The conflation of constitutive and coordinative principles would not be an error from a Reichenbachian perspective, since Reichenbach (1920/1965) equated the two. On this topic, see Darrigol (2020) and

principle, for example, were both elevated by Einstein to the status of postulates (*Voraussetzungen*) in his *On the Electrodynamics of Moving Bodies* (1905); therefore, they should both be considered constitutive principles — in the provisional and general sense of *fundamental assumptions* — within Friedman's framework. Nevertheless, they are very different. The light principle establishes a general correspondence between the Minkowski spacetime (the mathematical aspect of special relativity) and concrete empirical phenomena such as the electromagnetic interactions described by Maxwell's equations. However, it refers to an empirical fact—the speed of light in a vacuum. The relativity principle, by contrast, can be regarded as a meta-principle concerned with the form that the laws of nature must take. While being both general assumptions of special relativity, the two notions have different relationships with the empirical realm. Similarly, many other lists of examples of constitutive principles highlight the limitations of overlooking their conceptual nuances.

Second, defining a term through specific examples limits its scope: is *constitutive* a useful adjective for describing the role of certain elements of science in general, or is it restricted to particular cases? Friedman sometimes appears to treat the theories he mentions not merely as examples of what '*constitutive'* means, but as the sole focus of his research (see Friedman 2010, p. 715). Nevertheless, he also discusses possible interpretations of quantum mechanics and biology from his neo-Kantian perspective to the point that various commentators have described his work on the constitutive as a "rationalist model of scientific knowledge" (Grozdanoff 2014, p. ix) or a "theory of the constitutive elements in science" (Stump 2015, p. 140)[7].

It should be noted that Friedman does offer some clarifications that address the objections just raised. More specifically, he grounds his understanding of the term '*constitutive principle'* in Kant's transcendental philosophy and he elaborates this notion in his works on Kant (Friedman, 1991, 1992, 2005). Yet the fact that this clarification relies on a specific—and frequently criticised—interpretation of Kant and ultimately fails

Padovani (2011, 2015). Coordinative principles are often considered as a subclass of constitutive principles in the literature. My work focuses on distinguishing proper constitutive principles, as defined by Kant, from other types of principles, including coordinative principles, which may only be considered constitutive in a different sense.

[7] Koertge (2010) raises the problem concerning the scope of Friedman's account.

to dispel the ambiguity of constitutivity, warrants a more detailed analysis. The stage is thus set for my attempt at clarification.

3. Summary of this work

My strategy will first involve tracing the term back to its Kantian roots. Through a historical analysis of constitutive principles starting with Kant and crossing through the traditions of Neo-Kantianism, Logical Empiricism and Phenomenology, the meaning of the term will be clarified for contemporary discussions. The methodology of this study can be justified by situating it within the *Integrated History and Philosophy of Science* (HPS) tradition, which adheres to the historicist-hermeneutic maxim that "understanding something means understanding how it came into being" (Arabatzis & Schickore, 2012, p. 399). Giambattista Vico was the first to articulate this idea: "The nature of things is nothing but their coming into being at certain times and in certain fashions" (Vico, 1948, p. 58). Consistent with this tradition, the purpose of this work is not merely to trace the origins of a term out of historical curiosity. Rather, the aim is to examine a term that, despite its widespread use, remains inadequately defined, seeking to clarify its meaning through the perspectives of authors who have made it central to their philosophy. In doing so, I demonstrate the deep intertwining of historical and theoretical issues. As von Weizsäcker stated, in both philosophy and science "tradition is preserved progress and progress is continued tradition" (Weizsäcker, 1971, p. 374).

This work contains five chapters. Chapter 1 clarifies the meaning of 'constitutive' in Kant's epistemology; chapter 2 explores how this term has been generally adopted and developed by three post-Kantian traditions: Marburg neo-Kantianism, Logical Empiricism, and Husserl's phenomenology. Chapters 3, 4 and 5 take a closer look at each of these traditions individually. The latter chapters emphasise the link between the respective accounts of constitutivity and scientific knowledge. Moreover, some aspects of 'constitutivity' are emphasised in each of them. Chapter 3 clarifies the transcendental nature of constitutive principles by examining Cassirer's principle of causality and applying the abstract debate on constitutive principles to the early discussion of the interpretation of quantum mechanics. Chapter 4 delves into the differences between constitutive principles and conventions by reviewing the correspondence between Schlick and Reichenbach from the 1920s. Chapter 5 emphasises how an account of constitution

mediates between metaphysical realism and idealism more than the other chapters do, highlighting Husserl's approach to scientific knowledge and his shift from the idea of a set of constitutive principles to a plurality of constitutive processes.

Before beginning, I would like to justify some of the methodological choices I have made in this work. Firstly, my investigation focuses solely on constitutive principles, not *a priori* ones. A priori and constitutive principles can be viewed as two sides of the same coin. In Kant's philosophy, constitutive and regulative principles are simply two types of a priori principle. While acknowledging that these two notions overlap in the works of many authors that I have studied, this work will focus on 'constitutive principles'. This is because the notion of the a priori gives rise to endless literature and debate, which would distract from the strict 'constitutive' role of principles.

To hint at the complexity of the concept of 'a priori', consider the threefold discussion on its validity and evolution, concerning: (i) the philosophy of science and the status of scientific principles and laws (Friedman, 1999, 2001, 2010; Ryckman, 2005); (ii) epistemology, rationality, and justification (Boghossian & Peacocke, 2000; BonJour, 1998; Casullo & Thurow, 2013); and (iii) the analytic tradition's debate concerning modality, knowledge, and naturalism (Putnam, 1983; Quine, 1953, 1969; Sellars, 1953).

The fact that my work does not address the details of these discussions does not mean that the notion of a priori will not emerge in the following: I will sometimes mention issues that are specific to the problem of the a priori, especially in Chapter 2, while contextualising them within my broader analysis of constitutive principles. Additionally, some of my conclusions regarding the classification and role of constitutive principles can also be applied to a priori principles. However, I will stick to my methodological choice of focusing on the notion of constitutivity and leave the extent to which a priori and constitutive principles coincide for future work.

A second significant debate intertwined with that of constitutive principles is that concerning the source of lawlikeness in Kant's system. This discussion involved Michael Friedman and Gerd Buchdahl, among others, who developed their view of constitutivity exactly in response to the issue of lawlikeness. While Friedman claims that it is the faculty of understanding and its constitutive principles that transform a regularity into a proper law in Kant's framework, Buchdahl argues that only the regulative use of reason can establish the law-like nature of something (see Cooper, 2022; Messina, 2017). As for the

a priori, my dissertation will not address this issue. Unlike those who attempt to evaluate scientific principles by assuming the accuracy of this debate, such as Massimi (2005), my examination takes a step back and asks whether the notion of 'constitutive' has been clearly defined within the discussion.

A third topic also receives less attention than it deserves: although I previously noted that the concept of constitutivity was central to nineteenth-century philosophy, my analysis effectively "jumps" from Kant to twentieth-century reformulations. One might justify this by noting that many key nineteenth-century figures—such as Helmholtz, Lange, Lotze, and Cohen—developed ideas that were later assimilated into the traditions I focus on. For this reason, they are partially addressed indirectly or mentioned in passing; yet, this fails to do justice to their original contributions. This underrepresentation is purely a matter of space. I had to select a range of accounts, which meant excluding significant other authors. This work specifically omits rigorous examinations of the early neo-Kantians (from Herbart and Lange to the Baden School), Fries and the New Friesian School, French neo-Kantianism (from Renouvier to Brunschwig), and the pragmatist tradition (from Peirce and James to Lewis' pragmatic and Pap's functional a priori), despite their vital roles in shaping discourse on constitutive principles and scientific knowledge. For a comprehensive overview of these and related approaches, I point the reader toward Luft and Makkreel (2010), Ferrari (2003), Köhnke (1991) and Pulte, Baedke, Koenig, and Nickel (2024).

Building on this point, I would also like to say a few words about my reference to neo-Kantianism, Logical Empiricism and phenomenology. These three philosophical movements did not represent unified groups with a clearly established set of shared claims. Therefore, my attempt to focus mostly on the points of comparison between members of these groups — for instance, by showing the continuity between Cohen, Natorp and Cassirer in their approach to the 'fact' of science, or between Shlick, Reichenbach and Carnap in their analysis of the relationship between the empirical and the conceptual — should not hide their individual differences. I will treat the three traditions as units only for the purpose of my reconstruction of the conceptual evolution of the notion of constitution, aware that this approach sacrifices the details of their specificity.

The fifth and final consideration concerns thus the difficulty of identifying points of convergence in the use of the same concept by authors from different traditions while highlighting the specificity of each interpretation and avoiding reducing their differences. This is particularly true of the concept of 'constitutive': its general meaning is almost impossible to grasp without specifying it within the system of a particular author, while at the same time its meaning within specific philosophies continually refers to an earlier tradition and a broader class of senses. Consequently, my approach will inevitably be partial. To maximise the clarity and readability of my analysis, I have decided to first provide a general overview of the meaning of 'constitutive' in the context of Kant's philosophy and in the twentieth century (chapters 1 and 2), before delving into the work of individual authors in subsequent chapters.

Although this work aims to clarify the concept of constitutivity and limit its ambiguity, a certain degree of vagueness is unavoidable and will occasionally arise in the discussion. In some cases, principles will be described as constitutive of experience, nature or objectivity interchangeably, in line with established philosophical usage — even when such usage lacks full terminological rigour. Furthermore, several of the examined authors do not clearly distinguish between the constitution of objects of ordinary experience and their constitution within scientific theories—the so-called manifest and scientific images (Sellars, 1963). This ambiguity is sometimes reflected in my analysis of their views. Finally, some aspects of constitutivity can only be properly evaluated when the argumentative framework of the work is considered in its entirety. In a word, the general ambiguities underlying the central theme of this work will not be hidden or artificially resolved, but mapped instead, enabling the seemingly obscure terminology to be understood as representing a group of distinct yet related approaches.

Chapter 1: What Kant Meant by Constitutive

Abstract: Any attempt to clarify the notion of constitutive principles in the early twentieth-century philosophy of science cannot avoid a preliminary analysis of its meanings within Kant's transcendental philosophy. In this chapter, I analyse the occurrences of the term *constitutive* in the *Critique of Pure Reason*, showing five different ways in which Kant defines its core features. By clarifying and comparing them, three dimensions of constitutivity will emerge: (i) object-defining, (ii) object-positing, and (iii) meaning-conferring. By employing my threefold definition, I criticize Friedman's and Banham's interpretations of constitutivity and support the reading of Kant's constitutive and regulative dimensions as cooperating and merging procedures that make knowledge possible. The clear articulation of this Kantian framework frees Kant's project from its historical dependence on Newtonian mechanics, thereby allowing his constitutive principles to be understood as universal, foundational requirements for evaluating and structuring knowledge across diverse scientific paradigms.

Introduction

Kant's notions of *constitutive principles* and the *constitution of experience* have been recognised as relevant not only within the Kantian scholarship (Aportone, 1990; Böhme, 1981; De Pierris, 1992; French, 1967; Friedman, 1991; Hossenfelder, 1978; König, 1907, p. 142; Krijnen, 2007; Scaravelli, 1968) but also in recent analyses of scientific theories and principles influenced by transcendental philosophy (Berkovitz, 2020; Bitbol, Kerzberg and Petitot, 2009; Bland, 2012; Darrigol, 2020; de Boer, 2011; Domski and Dickson, 2010; Everett, 2015; Friedman, 2001; Gryb and Thébault, 2023; Luchetti, 2021; Mittelstaedt, 2009; Mormann, 2021; Padovani, 2015; Sanjuán, 2021; Szabó, 2019; Stump, 2015; Toepfer, 2011). Nevertheless, these notions have not been adequately defined in the literature. In the recent reformulations concerning scientific knowledge, the meaning of 'constitutive principle' is often taken for granted, relying on the vague and ambiguous intuition that principles are constitutive if they are fundamental or hardly revisable. Although the Kantian scholarship is much more aware of the complexity and contextuality of this term, focused analyses of the occurrences of 'constitutive' are still

lacking[8]. Additionally, while Friedman (1991) stands as a notable exception to this general neglect, his account depends on a specific—and frequently criticised—interpretation of Kant and ultimately fails to dispel the ambiguity of constitutivity[9].

As a matter of fact, Kant himself does not offer a precise definition of the term 'constitutive' in his works. Instead, he distinguishes between constitutive and regulative principles or uses of reason in specific contexts within his *Critiques*, thereby only hinting at certain aspects of what he means by these terms. The ambiguity becomes even more pronounced in a crucial passage where Kant asserts that the dynamical principles of the understanding are constitutive with respect to experience (*in Ansehung der Erfahrung),* but merely regulative with respect to intuition (*in Ansehung der Anschauung*) (*CPR*, A664/B692[10]). How, then, should the term 'constitutive' be understood in order to account for this distinction, while still preserving a coherent internal meaning—assuming such coherence exists?

In the absence of any unambiguous clarification of what 'constitutive' means, we are left to examine how Kant uses the term in practice. For this reason, in this chapter, I analyse all the occurrences of the term[11] in the *Critique of Pure Reason,* to shed light on its possible meanings. The aim of this investigation is twofold. On one hand, I aim to address the lack of detailed analyses concerning the use of the term 'constitutive' in Kantian scholarship. Clarifying this usage can foster a deeper understanding of Kantian principles and their relation to scientific knowledge, despite Kant's own limited attention

[8] Aportone (1990), Banham (2013), Friedman (1991) and Guyer (1987, 188-190) are some of the few works aimed at disentangling Kant's notion of constitutive principles, and I address them in section 1.4. Beyond them, De Pierris (1992) and French (1967) offer some insights without yet a precise analysis of Kant's texts. Höffe (2010, 195-221), Rush (2000), Sutherland (2022), and Watkins (2010) tackle Kant's system of principles, and yet they do not dwell on specific occurrences of the term 'constitutive'.

[9] I will employ throughout this work the term 'constitutivity' to indicate the specifically constitutive dimension of Kant's principles, and 'constitution' to describe the activity pursued by constitutive principles. Kant does not use these terms, but only 'constitutive' with respect to either principles or uses of reason.

[10] References to Kant's works are to the Academy edition (Kants gesammelte Schriften, ed. by the Royal Prussian Academy of Science, Berlin: de Gruyter, 1900-), except for references to the *Critique of Pure Reason*, which use the standard A/B notation. English translations are drawn from The Cambridge Edition of the Works of Immanuel Kant (ed. Paul Guyer and Allen W. Wood). Abbreviations are as follows: CPR = *Critique of Pure Reason*; CPrR = *Critique of Practical Reason*; CJ = *Critique of Judgment*; LL = *Lectures of Logic*; OP = *Opus Postumum*.

[11] I am considering only the German 'konstitutiv' and possible declinations. I have deliberately excluded similar terms from my analysis, such as 'Konstruktion', 'Beschaffenheit' or 'Erzeugung', as they do not seem to exhibit the same technical role as 'konstitutiv'. However, section 1.1 highlights the strong connections between these terms. The occurrences that I have considered for developing this chapter are the following (indicated by the notation of the B edition and collectively presented in section 3): B221, B222, B537, B544, B647, B672, B692, B694, B700, B703, B708, B713, B717, B722, B730.

to the precise definition of his terminology. On the other hand, I intend to elucidate the original meaning of 'constitutive', a term of considerable significance that has been repeatedly invoked in recent studies, precisely to inform a *historically grounded* and *conceptually rigorous* reconsideration within contemporary philosophy of science.

Although moving from one part of the *Critique* to another may appear haphazard and risk decontextualizing certain quotations, I will make every effort to preserve the internal coherence of my inquiry. Moreover, the focused investigation on the term 'constitutive' should help avoid unnecessary digressions within the Kantian text. I will show that Kant does not employ the term with a single, fixed meaning, but rather with a general idea that takes on different nuances across his work. Therefore, I argue that, despite the absence of precise definitions, the notion of constitutivity can still be characterized by certain *core features* that consistently inform its use. More specifically, five definitions of the term 'constitutive' will emerge from the analysis of its occurrences:

> (a) Principles are constitutive when they prescribe that wholes must be composed of a succession of parts via construction, thereby enabling the application of mathematics to appearances. (B221)
>
> (b) Principles are constitutive when the objects to which they refer are given. (B222, B672, B694)
>
> (c) Principles are constitutive when they establish the criteria for positing objects (B647, B713, B708, B722)
>
> (d) Principles are constitutive when they extend knowledge, enriching our catalogue of existing objects. (B537, B700, B703, B714)
>
> (e) Principles are constitutive when they confer upon concepts the capacity to refer to given objects — that is, when they endow concepts with meaning. (B692, B296)

I will investigate to what extent these definitions are interconnected or mutually exclusive. After a further selection, as a final result, Kant's notion of constitutive will be shown to include three definitional dimensions: (i) defining what a given object is, (ii) positing objects as existing bearers of properties in an intersubjective reality and (iii) endowing the concepts of those objects with referential content. The obscure expressions

in the mentioned definitional dimensions, such as 'given' or 'posit', will be clarified in due course.

My strategy will be the following. Section 1.1 focuses on the occurrences of the term 'constitutive' in the *Analytic of Principles*, mostly concerned with the construction and givenness of objects. Section 1.2 focuses on the occurrences in the *Appendix to the Transcendental Dialectic*, enriching the term with a (quasi) semantical twist. Section 1.3 summarizes the results, setting the stage for the comparison with the accounts of constitutivity exposed in Friedman (1991) and Banham (2013) in section 1.4. In section 1.5, I consider the single occurrence of the term constitutive in the *Critique of Practical Reason* and the evolution of the notion in the *Critique of the Power of Judgment*, without claims to exhaustivity. The conclusion reformulates the various meanings of 'constitutive' schematically, arranging them for the next chapters in which its role in twentieth-century philosophy of science is explored.

1.1 Constitutive principles in the Analytic

Kant characterizes various principles as constitutive in relation to different domains. The two principles that he retains to be constitutive of intuition state that "All intuitions are extensive magnitudes" (CPR, B202) and that "In all appearances the real, which is an object of the sensation, has intensive magnitude, i.e., a degree" (CPR, B207)[12]. The much-discussed[13] Analogies of Experience—which assert that "Experience is possible only through the representation of a necessary connection of perceptions" (CPR, B217)—are considered by Kant as constitutive of experience. Among such principles, the former posits a substance that persists in all changes, while the second prescribes the conformity of any alteration to the lawful connection of cause and effect.

Additionally, Kant considers the principle of systematicity, according to which cognitions need to belong to a hierarchy of concepts under a common idea to be scientific, along with other specifically regulative principles, to be necessary for making science possible. By stretching the already intricate jargon that Kant employs, some scholars regard these principles as also playing a constitutive role in the sense that they make the

[12] They are characterized as constitutive in CPR, A178/B221. This passage is addressed below.
[13] For an overview of the various interpretations of the Analogies, see Allison (1994; 2004), Beck (1978), Engelhard (2015), Friedman (1992b), Thöle (1991), Watkins (2005), and Wilkerson (1971). A better clarification of the Analogies and of how they differ from empirical laws is provided in section 1.4.

objects of nature possible (Brittan, 1991; Kitcher, 1994; Rush, 2000). In this broad sense, most a priori principles of Kant's transcendental philosophy appear to function constitutively, insofar as they disclose the conditions for the possibility of both theoretical and practical experience[14]. Even the aesthetic judgment of the third *Critique* exhibits a constitutive dimension "with regard to the feeling of pleasure or displeasure" (CJ, 5:197). So, what did Kant really mean when he used this adjective?

To clarify the meaning of the term constitutive, it may be more fruitful to avoid delving into the specific content of all the particular principles that Kant considers as such and instead investigate the occurrences of the term 'constitutive' itself in the *Critique of Pure Reason*. Although such an analysis cannot be entirely detached from the content of the aforementioned principles, my focus will not be on the specific subject matter of these principles but rather on why they are designated as constitutive.

1.1.1 Mathematical principles and construction

After introducing the two mathematical principles of the understanding—namely, the axioms of intuition and the anticipations of perception—Kant characterizes them in a dense passage as constitutive:

> The preceding two principles, which I named the mathematical ones in consideration of the fact that they justified applying mathematics to appearances, pertained to appearances in regard to their mere possibility, and taught how both their intuition and the real in their perception could be generated in accordance with rules of a mathematical synthesis, hence how in both cases numerical magnitudes and, with them, the determination of the appearance as magnitude, could be used. E.g., I would be able to compose and determine a priori, i.e., construct the degree of the sensation of sunlight out of about 200,000 illuminations from the moon. Thus we can call the former principles constitutive. (CPR, A179/B221)

[14] To be clear, Kant explicitly characterizes the Ideas of reason and the principle of systematicity, as well as the principle of purposiveness, as regulative and not constitutive of experience, and yet our cognition of experience would arguably not be possible without them. For this reason, some scholars have considered all Kant's a priori principles as constitutive—assuming constitutive means to make possible experience in general—and others have even challenged the very constitutive-regulative distinction (Beiser, 2006; Friedman, 1991; Guyer, 1987; Herman, 1991; Rush, 2000). The whole discussion depends on how the terms constitutive and regulative are defined, as will emerge in the next sections. For the notion of constitutivity in relation to practical reason, see section 1.5.

This first use of the term constitutive is associated with two key ideas: (i) the mere possibility of appearances, and (ii) the application of mathematics to appearances in order to achieve the generation (*Erzeugung*) of an intuition. Kant's reference to possibility can be better understood by considering the sentence that follows, in which he asserts that existence — as opposed to possibility — cannot be constructed, and therefore requires different principles. Thus, Kant links constitutivity to possibility, and possibility to construction. By transitivity, then, constitutivity involves construction. As H. J. Paton confirms, "To be constitutive always implies for Kant the possibility of construction" (Paton 1936, p. 179).

In a passage just prior to the one cited above, Kant clarifies what it means to construct appearances, describing an operational process:

> I cannot represent to myself any line, no matter how small it may be, without drawing it in thought, i.e., successively generating all its parts from one point, and thereby first sketching this intuition. It is exactly the same with even the smallest time. I think therein only the successive progress from one moment to another, where through all parts of time and their addition a determinate magnitude of time is finally generated. (CPR, A163/B203)

This passage should not be read in psychologistic terms. Kant is not describing how the mind happens to represent a line. Rather, he is emphasizing that the representation of a line, insofar as it is spatially extended, presupposes the existence of multiple parts composing it. What is important here is Kant's portrayal of construction (*Konstruieren*) or generation (*Erzeugen*) as a successive process in which the parts of a whole are added together (*Zusammensetzen*)[15].

The operational nature of construction is exemplified in the earlier passage on the constitutive character of the mathematical principles. One of the sun's properties—its luminosity—can be decomposed into conventional units and expressed, for example, as "200,000 illuminations from the moon." Despite the oddity of using the moon's (only reflected) luminosity as a unit, Kant here appeals to a compelling idea: intuitions, that is, spatiotemporal phenomena, can be *structured as sequences of magnitudes*. This constructive process pertains to possibility, not existence, since phenomena like sunlight

[15] See Ferrarin (1995), Jauernig (2013) and Lenhard (2015) for more details on Kant's notion of construction.

cannot be constituted with respect to their existence — which means, *generated ex nihilo*. However, we can re-generate them conceptually — i.e., create an abstract model instantiating the same property as the phenomenon. This modelling is an early step toward justifying the objectivity of scientific knowledge. If the object were conceived as an entity in itself, it would remain forever beyond our reach, as an unknowable substrate of our perceptions. Conversely, once actively generated through a model, the object becomes a carrier of interrelated properties represented by magnitudes; it then becomes available for scientific investigation.

Furthermore, a key characteristic of magnitudes is that they are, *by definition*, properties that can be quantified by using a numerical value. This grounds the association between concrete entities and abstract quantities. Consequently, by constructing an object of intuition as a succession of parts, one can establish an index that links the object to a numerical system, thus allowing for the application of mathematics to appearances. This completes the circle: constitutive principles, by dealing with mere possibility and construction, permit the application of mathematics to phenomena.

This (still somewhat vague) idea of a constitution can be specified within scientific knowledge as a condition that enables the *measurability of a target system*, as Brittan (1978, p. 91) suggests. Galileo's experiment with the inclined plane, mentioned in the B-Preface of the *Critique*, serves as a clarifying example of this claim. Galileo sought to analytically describe the motion of freely falling bodies, which occurs too rapidly for direct observation by the human senses. His key innovation was to slow down the phenomenon by substituting free fall with the gradual descent of spheres along a gently inclined plane. In one variation of the experiment, a sphere rolls down a wooden slope fitted with several bells and a pendulum at the bottom[16]. The bells are positioned so that the rolling sphere strikes each one in synchrony with each oscillation of the pendulum, ensuring that they are spaced by equal time intervals. Once the experiment is set up, it becomes evident that the sphere covers increasingly greater distances over successive time intervals, leading to the formulation of the equation $s = \frac{1}{2} gt^2$, where s represents the distance traveled, g is the acceleration due to gravity, and t is time. Through this

[16] I'm referring to a later variation of Galileo's experiment, which can be found in the Museo Galileiano in Florence (https://catalogo.museogalileo.it/oggetto/PianoInclinato.html). For Galileo's various experiments with the inclined plane, see Büttner (2019).

method, Galileo turned his inaccurate sensory experience into objective scientific knowledge by *constructing* free-fall motion as a *sequence of temporal* units. Again, the stress is on modelling a phenomenon to express it as relations between magnitudes.

Still, unpacking Kant's argument in A179/B221 does not immediately resolve what 'constitutive' means in this context. The word "Thus" in that same passage seems to suggest that constitutivity is linked to the "use of numerical magnitudes," which is then illustrated by the sunlight example (and by Galileo's inclined plane). Since these examples involve the procedure of *composing a system out of successive units*, 'constitutive principles' could here be understood as referring to the *literal operation of constitution* or *assembling*—i.e., sticking together a number of parts (or units) that make up a whole (a quantity).

In summary, constitutive principles, in their first occurrence, are associated with mere possibility, construction, and the application of mathematics. These elements converge on a common theme: the literal assembling of a whole from a succession of parts. This yields our first working definition:

> (a) Principles are constitutive when they prescribe that wholes must be composed of a succession of parts *via* construction, thereby enabling the application of mathematics to appearances.

Both mathematical principles, asserting that all appearances exhibit extensive and intensive magnitudes[17], exemplify such a definition. Yet only a few lines later, Kant again uses the term 'constitutive', now in the context of *analogies*:

> In philosophy analogies signify something very different from what they represent in mathematics. In the latter they are formulas that assert the identity of two relations of magnitude, and are always constitutive, so that if two members of the proportion are given the third is also thereby given, i.e., can be constructed. In philosophy, however, analogy is not the identity of two quantitative but of two qualitative relations, where from three given members I can cognise and give a priori only the relation to a fourth member but not this fourth member itself, although I have a rule for seeking it in experience and a mark for discovering it there. An analogy of experience will therefore be only a rule in

[17] While extensive and intensive magnitudes are today associated with additive (like mass) and non-additive quantities (like temperature), Kant's distinction concerns the magnitudes that involve units in space and time vs. those that involve a scale of degrees. See Sutherland (2022).

> accordance with which unity of experience is to arise from perceptions (not as a perception itself, as empirical intuition in general), and as a principle it will not be valid of the objects (of the appearances) constitutively but merely regulatively. (CPR, A180/B222)

Here, 'constitutive' refers to mathematical proportions in which a fourth number can be derived from the other three. At first glance, this seems coherent with the earlier use: both involve construction. Just as a phenomenon can be constructed in an experiment or within a scientific theory, a numerical value can be constructed within a mathematical operation. However, two distinct senses of construction emerge here: one refers to *calculating* a number; the other to *modelling* a phenomenon as expressing magnitudes.

Kant is not identifying these two forms of construction but rather emphasizing a shared feature, and he coherently specifies such feature in the above quotation: any proportion is "constitutive, so that if two members of the proportion are given, the third is also thereby given" (Kant 1998, A180/B222). The act of construction results in *giving an object*, and it is this givenness that renders a principle constitutive. This yields our second definition:

> (b) Principles are constitutive when the objects to which they refer are given.

This definition is confirmed by other passages of the *Critique*. At A644/B672, for example, Kant states that "the transcendental ideas are never of constitutive use, so that the concepts of certain objects would thereby be given" (A644/B672).

At this point, two questions arise: How is (b) related to (a)? And what does it mean for an object to be given in Kant's sense? Even the concept of 'object' itself still requires clarification. The first question has already been addressed. The composition of wholes from parts occurs through the operation of construction. A byproduct of this construction is that it gives an object—in a sense yet to be fully unpacked. Thus, constitutive principles, by dictating the construction of objects, refer by definition to given objects. The second question—what *given* means for Kant—now demands further investigation.

1.1.2 What given means

A refined analysis of the notion of givenness in the *Critique*, limited to its link with constitutivity[18], reveals two points. First, Kant connects givenness with the notion of 'objects in general'. This notion indicates the objects that can possibly be experienced, thereby abstracting from any particular experience and specific theory concerning the natural world. Second, Kant extends what can possibly be given to those non-observable entities needed to explain the given experiences. This second point differentiates given objects from mere sensible experiences and opens to an interpretation which refers to the ontology of a scientific theory, without however committing Kant to a specific set of entities limited to the physics of his time. Let me examine in more detail these two aspects of givenness.

Although Kant does not provide an accurate or precise enough account of what 'given' means exactly (see Chignell 2017; Grüne 2017; Stang 2021; Watkins and Willaschek 2017), the objects referred to by the constitutive principles can be identified as *schematised appearances in space and time*. For example, Kant claims that a set of principles is constitutive rather than merely regulative when a "corresponding schema of sensibility" is present, as this provides the principles with a concrete object (CPR, A664/B692). According to Kant's doctrine of schematism, applying pure concepts to empirical intuitions requires a third element to bridge these two heterogeneous domains. This third element is the transcendental schema, which conceptualises time and temporalises the concepts[19].

The fact that the given refers to schematised intuitions is crucial in order to exclude the idea of 'givenness' as either the presence of objects *outside* experience or the *cause* of experience. Kant confirms in multiple passages that the concept of givenness must be conceived *within* experience. For instance, he states that "To give an object, if this is not

[18] The notion of givenness in Kant's *Critique* is also linked to the distinction between phenomena and noumena, and the infamous issue of the thing-in-itself. For an overview on this topic, that goes well beyond constitutivity and the focus of this chapter, see Allison (2004), Guyer (1987), Jauernig (2021), Lugarini (1950) and Prauss (1974). Although my analysis avoids making significant commitments on this issue, it does suggest a view that is sympathetic to the Marburg neo-Kantian interpretation. According to Cohen (1877, 1885), things in themselves are not substrates of appearances: the phenomenon is limited to the lawful connection between systems; there is nothing else behind it (Ferrari, 1988, pp. 41-42). This idea is today characterised as a "two-aspect methodological interpretation", defended by Prauss (1974) and Allison (2004).

[19] My interpretation does not depend on a specific reading of the chapter on schematism. For an overview, see Allison (2004) and Guyer (1987).

again meant only mediately, but is rather to be exhibited immediately in intuition, is nothing other than to relate its representation to experience (whether this be actual or still possible)" (*CPR*, A155/B195). In this passage, given objects are described as the *product* of the relationship between intuition and experience. While these terms have sparked extensive interpretive debates, for present purposes they can be defined as follows: intuition is the organisation of sensations into the forms of space and time, while experience is the organisation of spatiotemporal phenomena into pure concepts. More specifically, intuition can be described as the immediate representation of appearances (where appearances are the indeterminate objects of empirical intuition) in space and time, while experience is the synthesis of such appearances conceptualised through categories. Consequently, in this passage, Kant defines 'givenness' as the property of spatiotemporal intuitions that makes them *amenable to the application of the categories*. Kant stresses that the appearances in intuition acquire *real possibility*[20] through their conceptualisation. The givenness of objects never appears outside the conditions imposed by the subject and is defined within the act of representation itself. Given objects indicate what can be possibly presented by the sensibility to the understanding.

Crucially, Kant also expresses what can possibly be given in intuition using the formula "object in general" (*CPR*, B411). Kant employs the term 'object' in multiple ways (Stang 2021). Since the principles of understanding, constitutive with respect to intuition—the mathematical principles—and with respect to experience—the dynamical principles—all concern the application of the categories to the schematised appearances, they involve the constitution of the objects of the categories, and these latter contain exactly "the form of thinking of an object in general" (*CPR*, A51/B75), or, alternatively, they "constitute the thinking of an object in general through combination of the manifold in an apperception" (*CPR*, B158; see also B147 and A290/B347). Kant employs the formula 'object in general' to denote a *fictional entity* that abstracts from any particular experience or property of objects.

This point strongly compels us to recognise a gap between the specific laws of Newtonian mechanics and Kant's constitutive principles, which apply to what can

[20] 'Real possibility' is a technical term in Kant's lexicon. Whereas an item is logically possible when it is merely self-consistent, the domain of real possibility includes whatever conforms to the a priori conditions of experience. See Brittan (1984) for a clarification of this term within Kant's account of science. See also Milmed (1967) and Ottaviani (2014).

possibly be experienced in general. This is continuous, for example, with the interpretation supported by many scholars, according to which the second analogy does not point to a specific kind of empirical causality, nor to a strictly deterministic worldview. Conversely, it states the general requirement of a lawful connection to define what an experience can be. As Rush puts it, the second analogy "says nothing whatsoever about iterations of types of events (the basis for empirical laws), rather it attempts to show that the concept of cause and effect is a necessary condition upon that of an event" (Rush 2000, 846).

Without entering the specifics of the second analogy, the first lesson drawn from the analysis of Kant's notion of given objects is that it refers to the entities that can possibly be experienced, and that it does not indicate specific entities—like those of the physics of Kant's time—but rather a general, fictional correlate of our epistemic process. The constitutive—either of intuition or of experience—principles of the understanding can only "anticipate the form of a possible experience in general" (*CPR*, A246/B303). Of course, this does not mean that they lack application to the empirical domain. Kant's critical project concerns exactly the building of a system that includes transcendental formal principles as well as concrete, particular experiences, among which the data of scientific research. And yet, such a connection involves many of the conceptual tools that Kant articulates, among which regulative principles and reflective judgment. When considering *only* constitutive principles, Kant indicates very general and formal requirements.

While Kant does not *limit* his analysis to the science of his time, he *opens* to the application of constitutive principles as referring to scientific knowledge. Indeed, he specifies that given objects are not only those possibly experienced by perceptual apprehension, but also those that can be lawfully linked to perceptions. At A493/B522, Kant states that "Nothing is really given to us except perception and the empirical progress from this perception to other possible perceptions". This statement is key in showing that Kant's notion of givenness — and, consequently, of schematized appearances — encompasses not only perceptual objects in space and time, but also the unobservable entities ("other possible perceptions") postulated by natural science in accordance with empirical laws. As Kant illustrates: "We cognise the existence of magnetic matter penetrating all bodies from the perception of attracted iron filings,

although an immediate perception of this matter is impossible for us given the constitution of our organs" (*CPR*, A226/B273).

'Theoretical' objects and events that are hypothesised to explain the properties and behavior of systems and events in space and time are also 'given objects' in Kant's viewpoint. These objects do not have to be perceived; it is sufficient that they can potentially be perceived or be lawfully linked to possible experiences. This claim further tempers the apparent rigidity of Kant's account. Not only constitutive principles refer to objects of experience in general, thereby abstracting from specific empirical applications, but they also refer to any object that, in the historical and situated progress of science, is postulated by a theory as given.

1.1.3 Circularity and position

Having clarified givenness, we must now explore in more detail its link to constitutivity. I started from the definition (b), according to which principles are constitutive when the objects to which they refer are given, and then clarified that a given object is an empirical entity, in space and time, which instantiates an object in general — i.e., something that conforms to the forms of sensibility and the categories — or, alternatively, a postulated entity used to explain — *via* lawful dependencies — an empirical experience. Now, however, Kant's association of constitutive principles with given objects may seem puzzling. Can an object be both *given* and *constituted*?

This question can be answered in two ways. The first possible solution is to note that Kant's characterisation of what is given is not chronological. Kant does not mean 'given' in the sense of being *fully formed* prior to the application of the categories and principles, like Minerva emerging from Jupiter's head. From the analytical and rational reconstruction of the epistemic process, a first moment of receiving some 'given stuff' can be abstracted: Kant himself writes, for example, that "Thinking is the action of relating given intuitions to an object." (*CPR*, A247/B304). Nevertheless, this analysis distinguishes logical moments that are chronologically merged in the actual epistemic process. Therefore, it is more faithful to Kant's methodology to consider given objects as *results*—rather than the driving cause—of the constituting activity of the understanding, a perspective that may help in conceiving constitutivity and givenness as linked. While this argument successfully disentangles the elements of an analytical model from its

concrete realisation, it does not adequately address the fact that, in the former, Kant appears to define constitutivity in terms of givenness and givenness in terms of constitutivity, resulting in a circular argument[21].

The second attempt to save Kant and the soundness of his concept of constitutivity is based on the following argument: the application of principles would only be incompatible with their constituting role if they were interpreted as what *produces* the object, in an idealist sense. If cognition were to generate the objects via constitutive principles, then it would be an insurmountable paradox that these principles also need to refer to those objects as previously given to be constitutive. However, Kant employs the notion of constitution exactly to distance his account from the idea of a mind that "creates" reality. Indeed, as already argued, constitutive principles concern the determination, not the production, of objects.

But what kind of determination belongs to constitutive principles? Is constitution comparable with the activity of Plato's Demiurgus, who models some previously given material? Kant writes that "Determination is a predicate which goes beyond the concept of the subject and enlarges it" (*CPR*, A598/B626). But how exactly do constitutive principles rule the determination of objects in general? Beyond the two controversial answers provided, then, the real issue that needs to be tackled is in which sense constitutive principles *refer to* given objects—as stated in (b).

I believe that this issue can be appropriately addressed by linking constitutive principles with the process of *positing*. In different passages, Kant explicitly connects constitutivity with *position*. For example, he states that a principle is regulative and not constitutive when it does not posit its object (*CPR*, A685/B713), thereby indirectly linking constitutivity with positing. Furthermore, he asserts that a regulative principle is illicitly used constitutively when it *hypostatises* its object (*CPR*, A619/B647; A694/B722), implying that constitutive principles affirm the concrete existence of the entity they refer to—i.e., the same process involved in positing.

To posit – *ponere* in Latin and *setzen* in German – is exactly to impute existence to an object. The concept of positing was very popular in scholastic logic and in early modern manuals (La Rocca 1999, p. 77). However, it was Kant who first turned the concept into

[21] This is a slightly different version of the problem exposed in Lohmar (1991) and Caimi (2013) on the relationship between concepts and objects.

a means of recognising the existence of something (absolute positing) or the relationship between two of its characteristics (relative positing) in his *The only possible argument in support of a demonstration of the existence of God* (1763) (translated in Kant 1992b, 107-202). As Kant stresses in his *Blomberg Logic*, something is posited when there is sufficient ground to empirically "hold-it-to-be-true" (Kant 1992a, p. 155). In the same text, he writes that "philosophy does not look to see *quotiem aliquid positum sit* [how often something is to be posited] but rather only *quod positum sit* [what is to be posited]" (Kant 1992a, p. 17). Consistently with the previous quotations, the concept of positing is used within the framework of the *Critique of pure reason* to denote the attribution of existence to the objects of a concept (*CPR*, A598/B626; see La Rocca 1999, pp. 74-85; and Stang 2021).

The reasoning behind positing is as follows: in empirical experience we apprehend only the properties of objects, not the objects themselves as unified entities. To avoid an empiricist view that collapses reality into mere impressions, we require a theoretical act that postulates a bearer of the properties we perceive[22]. The notion of 'position' articulates this act within a more rigorous epistemological framework: through positing, reason treats the bearer of the properties we perceive as an entity whose unity, persistence, and causal efficacy must be assumed. In this way, the object is located as existing within an intersubjective and independent reality, rather than being reducible to the flux of individual impressions. It seems, however, that we should not posit objects from our impressions *arbitrarily*: some criteria are needed. I claim exactly that Kant's constitutive principles *refer* to given objects in the sense of *prescribing the rules to posit them*. Thus, a refined definition of constitutive principles might be as follows:

(c) Principles are constitutive when they establish the criteria for positing objects.

According to (c), constitutive principles determine what can be postulated as existing empirically and what can be attributed to the domain of intersubjective reality.

[22] I am referring here to the distinction between mere sensory impressions and objects understood as unified entities. Crucially, I am *not* invoking the distinction between phenomena and noumena, since Kant denies the possibility of positing anything "behind" phenomena.

Constitutive principles can be considered a specific type of definition, that expresses what can qualify as an object of experience[23].

According to Kant's *Critique*, only that which exhibits extensive and intensive magnitudes, while also enduring in time and belonging to lawlike relationships, falls within the standards required to be considered an object in general, i.e., as a spatiotemporal entity of possible experience and a potential part of the ontology of a scientific theory. Therefore, only givenness is properly defined by constitutive principles, whereas such principles are not defined themselves but are instead filled with content by given objects. Consequently, I would reject any accusation of circularity in Kant's account, while nonetheless highlighting a tension between constitutivity and givenness. Constitutive principles and given objects are indeed two notions that would lose their meaning if considered in isolation.

According to (c), the constitution implemented by the principles is not the *concrete production* or *assembling* of items from our mind, but rather the *real definition* of what a given object is. Kant states that a real definition "does not merely supply other and more intelligible words for the name of a thing, but rather contains in itself a clear mark by means of which the object (definitum) can always be securely cognised, and that makes the concept that is to be explained usable in application." (*CPR*, A241). Since the criteria to posit something as a given object are the standards to identify what a given object is in experience, they involve a real definition, in which the notion of 'object' is defined not in abstract but rather in its empirical application. The real definition of 'object' provided by Kant's constitutive principles may be understood as a set of instructions to empirically apply the concept of 'object in general' or 'given object'[24] (as in Cleve, 1979).

Since the conformity of an object to the constitutive principles attests that it meets the very definition of a 'given object', this conformity licenses us to posit it as a real entity in the world, one that bears the properties perceived in our representations[25].

[23] Crucially, constitutive principles cannot represent analytic definition, that is, semantic clarifications of a definiendum. They are rather synthetic, as they add determinations to the concept of 'object in general' that are not contained in it (de Boer 2011, p. 510).

[24] The link between these two concepts have been highlighted in the previous section. For a recent reconsideration of 'real definitions' see Rosen (2015).

[25] Kant's 'inversion of thought'—his so-called "Copernican Revolution"—becomes here particularly clear: we do not encounter objects whose conformity to the conditions of experience is to be later verified; rather, the conditions of experience have conceptual priority, as they provide a definition that prescribes what an object must be.

Consequently, parallel to the constitution of objects, the understanding renders the concepts that refer to them objectual (i.e., capable of subsuming objects) and objective (i.e., neither arbitrary nor illusory, but instantiated by spatiotemporal entities). The objectivity resulting from this process transcends individual subjectivity by referring to a shared spatiotemporal reality—what Kant calls *phenomena*. Note how such a view escapes the traditional duality of naïve realism and absolute idealism: constitutive principles determine an intersubjective reality, independent of thoughts, desires and conventional assumptions of empirical individuals (*contra* idealism), while highlighting the methodological act of positing such reality as necessary for its determination, so that claiming existence outside of such constitutive activity becomes meaningless (*contra* realism).

A fourth definition of constitutive follows from (c). Indeed, when an object is not only given in sensation but is *recognised as a given object*, it contributes to the expansion of our empirical knowledge. Many passages of the *Critique* stress this point (*CPR*, A509/B537; A672/B700; A675/B703; A686/B714). Hence, the following definition should be formulated, as adding another aspect of the term constitutive:

> (d) A principle is constitutive when it extends knowledge, enriching our current list of existing and given objects.

Definition (d) accounts for a key element of Kant's philosophy, as it clarifies the distinction between constitutive and regulative principles. When Kant claims that the idea of a soul or a God exhibits a merely regulative function, he is stressing that they *do not augment the set of objects that can be legitimately posited as given*. Rather, as Ideas of reason, they *implement a method* to enrich the list.

Let me summarise the results of this dense subsection before moving on to the *Transcendental Dialectic*. In several passages of the *Critique of Pure Reason*, Kant explicitly links *constitutivity* with *givenness*. After a brief detour concerning the meaning of 'given', I attempted to pinpoint the sense in which constitutive principles *refer to* a given object. To clarify this issue, I adhered to Kant's own words: he describes the relationship between principles and objects as one of *positing* (*CPR*, A685/B713). Positing means asserting the existence of an object, but how are we authorised to do so?

Here constitutive principles enter the scene: they establish the criteria for positing, providing the rules that authorise us to claim that something is an object.

This characterisation of constitutivity yields two further results. First, it depicts the process of constitution as *definitional*: principles do not semantically clarify what an object is — an analytic definition — but rather set instructions for identifying what instantiates the concept of a 'given object' in experience — a real definition. Second, they imply that 'constitution' involves both the conformity of objects to the concepts of the understanding — named by Kant *real possibility* of objects — and the empirical application or realization of such concepts — named by Kant *objective reality* of concepts. This point will be further clarified in the next section. Finally, I emphasised that a fourth definition (d) follows from (c): when objects are posited as potentially existing, they enrich our ontology. Whether this enrichment is fixed or open to change will be discussed in Section 1.5.

1.2 Constitutive principles in the Dialectic

In the *Appendix to the Transcendental Dialectic*, Kant revisits the results achieved in the Dialectic concerning the boundaries of reason. Yet he also enriches his project by introducing a *pars construens* — that is, by clarifying how reason can be properly used to attain genuine knowledge. This addition is crucial, as it lays the foundation for the two subsequent *Critiques*. In this context, Kant significantly reorients his definitions of 'constitutive' and 'regulative' principles.

> In the Transcendental Analytic we have distinguished among the principles of understanding the dynamical ones, as merely regulative principles of intuition, from the mathematical ones, which are constitutive in regard to intuition. Despite this, the dynamical laws we are thinking of are still constitutive in regard to experience, since they make possible a priori the concepts without which there is no experience. Principles of pure reason, on the contrary, cannot be constitutive even in regard to empirical concepts, because for them no corresponding schema of sensibility can be given, and therefore they can have no object in concreto. (CPR, A664/B692)

Two aspects of this passage fundamentally challenge earlier definitions of the term *constitutive* (discussed in definitions (a) through (d)). First, Kant here describes constitutive principles as applying to *concepts*, not *objects*. Second, he claims that the

dynamical principles of the *Analytic* are both constitutive and regulative, depending on their target — intuition or experience. I will address the first point immediately, before turning to the second and examining which of the four previous definitions remain viable in light of this passage.

1.2.1 Objects and concepts

In B692, Kant states that constitutive principles make certain concepts possible, whereas in other passages — such as B708 — he directed constitutive principles toward *objects*. This duality is central to later attempts to revise the notion of constitutive principles in post-Kantian philosophy, where the debate often centered on the *target system* of such principles. Yet, a way to reconcile these seemingly conflicting claims has already been proposed in the previous section: Kant suggests a parallel process of constitution, in which *concepts attain objectivity by subsuming objects*, while *objects become such by being subsumed under concepts*. More precisely, constitutive principles confer both *meaning* — the capacity to figure in true or false judgments — and *objectivity* — the reference to possible objects of experience — on concepts, while at the same time establishing those objects as really possible bearers of properties. In this way, both the blindness and emptiness of Kant's famous expression on intuitions and concepts is avoided (*CPR*, A51/B75).

The latter process — the constitution of objects as bearers of properties — has already been addressed in the preceding section. We must now examine the other dimension of the constitutive process mentioned earlier: the endowment of meaning to concepts. At A155/B194, Kant writes that an object must be given if a cognition is to "have significance and sense [*Bedeutung und Sinn*] in that object". The notions of sense and meaning are conceptually dense, and they often evoke the Fregean account. However, as Land (2013) and others caution, one should avoid simplistic comparisons between Kant and Frege. While Kant undoubtedly influenced Frege in some respects, he lacked the formal apparatus to develop a rigorous and complete semantic framework.

For present purposes, a precise and systematic distinction between *Sinn* and *Bedeutung* is not essential; what matters is the relationship between constitutivity and meaning. At B194, Kant treats a concept as having meaning (*Bedeutung*) when *it refers to a given object*. In the passages most relevant here, meaning is then restricted to the *empirical*

extension of a concept — that is, to concrete objects of experience that instantiate it in empirical reality. The connection between meaning and the subsumption of empirical objects under concepts appears elsewhere in the *Critique*. For instance, Kant notes that mathematical propositions "would still not signify anything at all if we could not always exhibit their significance in appearances (empirical objects)" (CPR, A240/B299). Thus, meaning is bound to objectivity and concrete spatiotemporal instantiation: if a concept has meaning, empirical experience must provide objects that fall under it.

Scholars such as Capozzi (1987), D'Agostino (2023), Hogrebe (1974), La Rocca (1999), and Schönrich (1981) have argued that this implies at least a minimal semantic dimension in Kant's framework, one in which objectivity and language are linked. On this view, a concept tends toward subsuming objects under itself in order to form assertoric statements — empirical claims that possess a truth value.

From this limited conception of meaning, a further aspect of Kant's constitutivity emerges. Given (i) that Kant states that constitutive principles *make concepts possible*, (ii) that making a concept possible is related to the concept being about given objects, and (iii) that the reference of concepts to given objects is related to the notion of meaning in the sense of referential content (A155/B194), the process of 'making concepts possible' may consistently be described as *allowing concepts to be employed in synthetic judgements about the empirical world that can be true or false*. This conclusion leads to the following fifth definition:

> (e) Principles are constitutive when they endow concepts with the capacity to refer to given objects — that is, when they confer empirical meaning upon them.

This definition contrasts sharply with the regulative case. The Second Analogy, as a constitutive principle, grants the concept of cause empirical meaning by enabling the formation of truth-evaluable judgments like "The virus is the cause of the illness." By contrast, the concept of God—regulative rather than constitutive—does not license such judgments about empirical reality. The judgment "God is the cause of the illness" exemplifies the illicit constitutive use of a regulative concept, which cannot be part of meaningful empirical statements. Sentences like "God is God" or "God is omnipotent"

may be intelligible, but they lack empirical instantiation and therefore constitutivity[26]. These examples illustrate Kant's emphasis on the "experienceable" nature of meaningful concepts.

If constitutive principles "make concepts possible," they do so by enabling those concepts to be employed in synthetic judgments that can be true or false about the empirical world. This semantic dimension does not exhaust the meaning of constitutive in the *Dialectic*, but it represents one crucial aspect. To "make concepts possible" in this sense is to endow them with empirical reference, thereby enabling the formulation of truth-evaluable statements[27].

This explains why Kant alternates between object-directed and concept-directed definitions of constitutive principles: definitions (c), (d), and (e) are deeply interrelated. To *make a concept possible* is to render it *objective*—to apply it to appearances. Outside Kantian terminology, one might say that the application *realizes*, *objectifies*, or *actualizes* the concept. This same application simultaneously constitutes objects as bearers of properties. When concepts are applied to appearances, experience itself becomes possible—since experience consists in a synthesis of the manifold through *a priori* forms and concepts. As Kant puts it: "The possibility of experience is, therefore, that which gives all of our cognitions a priori objective reality" (CPR, A156/B195).

1.2.2 The dynamical principles and the duplication of constitutivity

Let me now return to the second issue posed at the beginning of this section: how can a principle be both *constitutive* and *regulative*, depending on whether it relates to intuition or experience? In the previous section, these two notions were minimally but helpfully defined: *intuition* refers to the immediate representation of objects in perception, while *experience* involves the application of concepts to sensory content. Hence, intuitions are synchronic spatiotemporal snapshots, while experience is a diachronic sequence of intuitions that are conceptualised. If we accept the interpretation of A664/B692 in which "making concepts possible" means "endowing them with meaning," then Kant's claim on the dynamical principles as both constitutive and regulative becomes less puzzling.

[26] A statement like "God is the main character of the Bible" is trickier. While it does not refer to an object of empirical experience, it still points to some (forgivable) shortcomings in Kant's account.
[27] As Stang stresses, in Kant's system "the concepts of object, existence, what there is, quantification (i.e., absolute positing), singular term, and reference all move in a very tight circle" (Stang 2021, 315).

The issue can be formulated as follows: Kant claims that the mathematical principles do to intuition what the dynamical principles do to experience — that's why they are both constitutive. Let us assume the hypothesis that this constitutive activity consists in endowing the respective concepts with referential content — providing them with objective reality — while simultaneously defining what counts as an object within their respective domains. This hypothesis aligns with the principles in question: the mathematical principles prescribe that an object of intuition must exhibit extensive and intensive magnitudes, whereas the dynamical principles prescribe that an object of experience must persist and belong to a lawful chain of causes and effects. But can the dynamical principles also refer to intuition—that is, can they prescribe that the immediate, synchronic spatiotemporal snapshots of intuition must exhibit persistence in time and a lawful chain of causes and effects? The answer is no, as persistence and causation cannot apply to isolated moments.

The dynamical principles—those of substance, causality, and reciprocity—do not confer meaning within intuition itself, because the very concepts of persistence and causation require more than one immediate representation to function. These principles operate diachronically, whereas intuition involves a synchronic snapshot of sensory content. To define what such a snapshot *is*, one can appeal to the mathematical principles of magnitude and quantity, but not to the dynamical principles of causal connection or persistence. The latter define *experience*, which involves a succession of intuitions over time.

In this light, it becomes coherent to say that dynamical principles are *regulative* in relation to intuition but *constitutive* in relation to experience. Mathematical and dynamical principles are not constitutive in entirely different ways; rather, both are constitutive insofar as they endow concepts with meaning — whether applied to intuitions or to experience.

In addition to clarifying the mysterious passage in which Kant multiplies constitutivity, this interpretation adds a further piece to the understanding of Kantian thought. It invites us to think of not so much principles as *uses of principles* as constitutive. The same principle is used constitutively when it gives empirical meaning to a concept by positing its object. This does not mean that it cannot also have a regulative function with respect to other domains, in which it merely prescribes a methodology

without referring directly to the empirical. The connection and cooperation between the constitutive and regulative dimensions will be better addressed in section 1.5.

1.2.3 Modality and transcendental arguments

In the next section, I will revisit the five definitions provided in the previous sections to consider whether they are compatible with the additional arguments presented in this section. Before moving on, however, a further consideration must be added. In B692, Kant states that constitutive principles "make possible a priori the concepts without which there is no experience". I have already clarified the expression 'making concepts possible', but not the final part of the same passage— 'without which there is no experience'. But how to demonstrate that experience cannot be possible without the concepts made possible by constitutive principles?

Kant, by indicating that there would be no experience without some conditions, refers to a special kind of justification. Indeed, it is not possible to positively show the absence of experience as a consequence of the absence of constitutive principles. On the contrary, Kant gives a transcendental justification for his framework, using a strategy called *transcendental argument*[28] (see Bubner, 1975; Pereboom, 2023; Schaper, 1972). While the formula transcendental argument was first articulated by P. F. Strawson (1959) for theoretical purposes that had been criticized as un-Kantian (Hintikka, 1972), the argumentative strategy behind this notion reflects the same one Kant adopted referring to his constitutive principles.

As Stern and Cheng (2023) stress, "transcendental arguments are taken to be distinctive in involving a certain sort of claim, namely that X is a necessary condition for the possibility of Y—where then, given that Y is the case, it logically follows that X must be the case too". The idea is that any sceptic who seeks to deny the validity of a claim must assume that very claim to support her objection. The examples from Kant's *Critique of pure reason* are many, and they do not involve only constitutive principles but any condition of the possibility of experience that pertains to sensibility or understanding. For

[28] It is crucial to disambiguate between different meanings of 'transcendental argument'. In this section, it refers to the particular kind of justification of a thesis based on the self-defeating nature of the antithesis. This strategy can be compared with Kant's deductions, intended to determine the legitimacy of using something (*quid iuris*). Kant took the term from the *Deduktionsschriften*, legal publications of his time. Indeed, 'in Holy Roman Empire Law, '*Deduktion*' signifies an argument intended to yield a historical justification for the legitimacy of a property claim' (Pereboom 2023). See also Henrich (1989) and Møller (2023). I do not refer to the merely conceptual arguments criticized by Bencivenga (1987).

example, anyone who claims space to be an object out of us has already to presuppose it to provide the notion of 'out of us' with sense. Additionally, anyone who claims the possibility of objects of experience to be independent of the pure concepts of understanding has already to presuppose the application of the pure concepts to intuitions to provide the notion of 'object' with sense. In all these cases, the sceptics' game backfires on them.

The validity of transcendental arguments in general has been deeply debated between the '60s and the '70s (Stroud 1968; Hintikka 1972). Beyond such a debate, which was not entirely faithful to Kant's original notion (see Kitcher, 2011, Ch. 15; Rush, 2000), the strong link between constitutive principles and the transcendental justification concerning their validity should not be ignored[29]. A significant example is the Second Analogy, through which Kant defines experience as a lawful, in the sense of rule-obeying, network of events. Stern (2022) provides a compelling interpretation of the necessity of Kant's principle of cause and effect as transcendentally justified. This principle exhibits a constitutive role in defining a feature (to be a lawful network of facts) without which events would not be events: "unless we apply the concept of cause, we would lack the criteria by which to treat it [any experience] as an experience of an event rather than as part of a subjective sequence, and so could not claim to have any knowledge of it as an event to begin with." (Stern 2022: 399).

The transcendental justification of the principles Kant considers constitutive of experience shows that experience would not acquire any meaning or objectivity without them. Indeed, once an x is proved necessary to get a y, it means that y would not be y without x. This aspect of constitutive elements is often captured in ordinary occurrences of the term: the trunk is constitutive of the tree insofar as something without a trunk would not be a tree. Glazier (2022) states that a game without clubs would not be golf, hence clubs are a constitutive element of golf. Similarly, according to Kant, if something does not involve causality (in the sense of a ruled sequence of events) it is not experience.

This point can be appreciated as continuous with the previous analysis of constitutive principles as providing *real definitions*, in which, however, the metaphysically loaded notion of essence dissolves into an analysis of the structure of knowledge. Recent

[29] See Apel (1971, 1973) for a pragmatic approach that extends the Kantian transcendental strategy to the conditions of possibility of intersubjective communication.

attempts to provide a relativised and dynamic version of a priori principles, mentioned in the motivation for this work and analysed further in sections 1.4 and 5.4, stem from a rejection of the necessity that Kant attributed to his own principles. However, these attempts rarely address the transcendental strategy that Kant employed to determine the extent to which his principles could be considered necessary. The approach suggested here is potentially fruitful in that it stresses that constitutive principles are necessary not in the sense of *unchangeable*, but rather in the sense of *justified through a transcendental argument*, independently of experience. Although Kant does conflate these two meanings in some passages, claiming that transcendentally justified principles are unchangeable, the resulting attitude of this approach remains faithful to his own account of modality, focusing more on non-empirical justification than fixity.

1.3 Comparing definitions

The seemingly straightforward task of collecting and commenting on the occurrences of the term 'constitutive' in the *Critique of pure reason* has, in fact, opened up a broad horizon of definitions and interpretations. It is now necessary to bring some order to this conceptual landscape. The five distinct definitions that have emerged so far are listed below, along with the corresponding passages of the *Critique of Pure Reason* in which they appear (quoted according to the B edition only):

> (a) Principles are constitutive when they prescribe that wholes must be composed of a succession of parts *via* construction, thereby enabling the application of mathematics to appearances. (B221)
>
> (b) Principles are constitutive when the objects to which they refer are given. (B222, B672, B694)
>
> (c) Principles are constitutive when they establish the criteria for positing objects. (B647, B713, B708, B722)
>
> (d) Principles are constitutive when they extend knowledge, enriching our catalogue of existing objects. (B537, B700, B703, B714)

(e) Principles are constitutive when they confer upon concepts the capacity to refer to given objects—that is, when they endow concepts with meaning. (B692, B296)

I think that definitions (a), (b) and (d) may be either reduced to the others or set aside as merely necessary conditions for a principle to be constitutive, lacking in definitional status themselves. I have already hinted at the reasons to do so with (a). In section 1.1.1, it emerged that the activity of construction *gives* an object, so that definition (b) can be preferred to definition (a) as more complete. Moreover, maintaining definition (a) is difficult in light of passage B692, where Kant states that the dynamical principles are constitutive of experience but only regulative of intuition. One might argue that these principles have a constructional function solely within experience, not intuition; however, further clarifying the notion of construction in this context risks vagueness and conceptual imprecision.

A closer examination of the definitions reveals that (b) and (d) are similarly problematic. While (b) was useful to pinpoint that constitutive principles *refer to* given objects, it is (c) that specifies what kind of reference is at play. Furthermore, definition (d) appears to be a mere consequence of definition (c). Once an object is posited as given, it naturally contributes to an enrichment of our ontology. Kant indeed associates constitutivity with this ontological enrichment, yet it would be misleading to infer that constitutivity consists in such enrichment. As previously discussed, this remains an important aspect of Kant's account and must be acknowledged in order to grasp the full complexity of the notion. Nevertheless, only definitions (c) and (e) should be regarded as central to understanding what Kant means by "constitutive."

Ultimately, I argue that Kant's notion of the constitutive comprises these main elements: with respect to objects, constitutive principles posit them, thereby determining and guaranteeing their givenness; with respect to concepts, these principles confer meaning, allowing them to figure in truth-apt judgments. These two functions combine in defining what can qualify as an 'object' according to transcendental philosophy. Although this definitional role is not separated from definitions (c) and (e) but rather a combination of them, I will distinguish it as a third aspect of Kant's constitutivity for its relevance in both Kant's framework and in the post-Kantian accounts. For the sake of brevity, I propose to employ in the following sections three labels that summarize the aforementioned dimensions of Kant's constitutivity:

i. The *object-positing* dimension, which highlights that constitutive principles establish the criteria to posit the objects to which they refer as bearers of properties belonging to an intersubjective reality. This first element reflects definition (c) and is supported by passages B647, B713, B708, B722.

ii. The *meaning-conferring* dimension, which stresses that constitutive principles endow the concepts to which they refer with referential content, thereby making them objectively real. This second element reflects definition (e) and is grounded in the passages B692, B296.

iii. The *object-defining* dimension, which emphasizes that constitutive principles define what can qualify as an object. Note that such a definitional feature is not merely nominal or analytic—in the sense of offering purely semantic clarifications of what the word 'object' means—as it involves *real definitions*[30]. This third element combines definitions (c) and (e)[31] and emerges notably in the passages B222, B672, and B694. To add the content of the specific constitutive principles, only appearances in space and time, exhibiting intensive and extensive magnitudes, persisting and belonging to a lawful chain of causes and effects, are candidates to become genuinely given objects.

To these three dimensions, a fourth aspect should be added, namely the modal specification of constitutive principles, as argued in the previous section. So, once the three dimensions are completed with the transcendental strategy that grounds their necessity exposed in section 1.2.3, what Kant meant by constitutive comes to light.

This threefold — fourfold with modality — characterization addresses nearly all the questions raised in the Introduction. First, it distinguishes the various senses in which Kant uses the term constitutive, while also recognising an underlying internal

[30] I will link Kant's object-defining dimension with the notion of a *functional definition* in section 2.2.2. To suggest a terminological clarification which is more faithful to Kant's own lexicon, real definitions may be considered as a particular declination of what Kant calls *synthetic definitions*. In his logic lectures, Kant distinguishes between analytic and synthetic definitions. The former exposes the marks of a concept, while the latter adds or connects marks to a concept (*CPR*, A730/B758; *LL*, 24: 757; *LL*, 24: 914–18). In the case of constitutive principles, they are synthetic definitions insofar as they express their target (the object of intuition or of possible experience) as a network of relations, connecting marks, and resulting in a *made concept*. For an overview of Kant's theory of definition, see McAndrew (2023).

[31] The object-defining dimension reflects also aspects of definitions (a) and (b), that I have not explicitly mentioned due to the reducibility of these definitions to (c). Notice, for example, that the notion of construction that emerges in (a) denotes the real definition of mathematical objects, such as a triangle: the instructions to construct a triangle are those rules that define what a triangle is, and they abstract from specific triangles (Palumbo 1984, Ch. 3).

consistency. Second, it accounts for Kant's characterization of the dynamical principles as both regulative and constitutive: as argued in section 1.2.2, their role of positing objects and providing meaning to concepts requires a diachronic dimension that only experience — and not intuition — can satisfy. Hence, they are constitutive only of experience. Third, this approach may help to address the limitations of other interpretations of Kant's constitutive principles. The next section addresses this third point.

1.4 Other interpretations: Friedman and Banham

Despite its foundational role in Kant's epistemology, the notion of 'constitutive' has received limited attention in the literature. Notable exceptions include Friedman (1991) and Banham (2013) (see note 8). In what follows, I critically examine their interpretations and situate them in relation to my own, seeking both contrast and integration.

Friedman (1991) not only clarifies what 'constitutive' might mean but also sets the stage for some of his subsequent work on interpreting spacetime theories. Friedman unpacks Kant's terminology by focusing on the *Metaphysical Foundations of Natural Science* (Kant, 2002). His argument unfolds in three main steps. First, he specifies that a principle is constitutive if it refers to empirical concepts. Crucially, empirical concepts can be *given*, unlike regulative principles, such as the ideas of God or the soul: this is continuous with the above definition (b). Second, Friedman demonstrates how Kant transforms the transcendental dynamical principles of understanding—the permanence of substances, the lawful relationship between causes and effects, and the interaction between phenomena—into the metaphysical principles of pure natural science. These principles acquire empirical meaning when aligned with Newton's laws of motion: the principle of inertia; the proportionality of force to mass multiplied by acceleration; and the mutuality of opposed forces. Specifying the dynamical principles as empirical laws demonstrates that their referents are indeed given in experience: "Substances, causes, and so on are indeed given in experience—in virtue of precisely the fact that material substances interacting in accordance with the laws of motion through the fundamental forces of attraction and repulsion are given in experience" (Friedman 1991, 83). These premises support his conclusion that Kant was justified in characterizing the dynamical principles as constitutive of experience. Consequently, Kant's 'constitutivity' becomes closely tied to the validity of Newtonian mechanics.

Friedman also addresses why the dynamical principles are constitutive only of experience and not of intuition. He argues that the transcendental principles, identified in his reading with Newton's laws, are required to derive the law of universal gravitation. By connecting empirical regularities with laws of motion—and, through them, with transcendental principles—the empirical law acquires necessity and universality. This connection highlights the indispensable role of transcendental principles in rendering empirical laws possible: "It follows that the dynamical principles of pure understanding are 'constitutive with respect to experience,' not only because they make possible an empirical concept, but also—and, indeed, especially—because they at the same time make possible an empirical causal law" (Friedman 1991, 86). In short, according to Friedman *constitutive principles render empirical laws possible*. Since Kant's constitutive principles are divided into mathematical and dynamical, the mathematical principles underpin mathematical laws, while the dynamical principles underpin physical ones. As far as intuition—which is related to the domain of mathematical principles—is concerned, dynamical principles remain regulative, while becoming constitutive for experience—their proper domain.

Friedman's acute analysis has two merits. First, he skillfully navigates the Kantian works, merging passages of the first and the third *Critiques*, as well as parts of the *Metaphysical Foundations of Natural Science* and of the *Opus Postumum*. The result is a coherent picture of Kant's multifaceted account. Second, he provides an ingenious solution to justify Kant's duplication of constitutive principles: constitutivity is related to the possibility of formulating laws, and such laws are differentiated between the domains of intuition and experience. Nevertheless, I claim that Friedman's framework also exhibits four drawbacks.

Firstly, he does not adequately address how mathematical principles give rise to mathematical laws, nor does he specify what constitutes a mathematical law within Kant's framework. Although his analysis is consciously limited to dynamical principles, more consideration of the constitutivity of mathematical principles would be expected to fully define what 'constitutive' means.

Secondly, his Kant is too committed to Newtonian mechanics. Kant undoubtedly had Newton in mind when writing the *Critique* and emphasized the application of transcendental principles to the empirical realm. However, strictly aligning Kant's

constitutive principles with specific laws of a particular physical theory, such as Newtonian mechanics, seems inaccurate; at best, it works for the analogies of experience. Kant explicitly describes the mathematical principles—the axioms of intuition and anticipation of perception—as constitutive principles, yet these do not correspond to any specific part of Newtonian mechanics or Euclidean geometry[32]. Even the link between the analogies of experience—the dynamical principles of understanding—and classical mechanics remains controversial. De Boer (2011) criticizes Friedman exactly for this reason. As she rightly stresses, "both logical positivists and commentators such as Friedman tend to overlook the difference in kind between the synthetic a priori principles of pure understanding at stake in the *Critique* and those of physics proper" (de Boer, 2011, p. 513). Consistently with such an objection, several scholars have emphasized that the transcendental method exposes a priori principles as conditions for the possibility of experience, thereby abstracting from any empirical form of knowledge and encompassing more than the phenomena explained by classical mechanics (Brittan, 1978, 1994; Buchdahl, 1992; Höffe, 2010; Pulte, 2025; Stan, 2017; Sturm, 2022; Watkins, 2019; Wartenberg, 1992). From this perspective, the permanence of substance or the causal connection between events represent general requirements that any theory must satisfy.

Thus, Kant's particular examples should not be identified with what he wanted to exemplify (see Watkins, 2019, pp. 89-117). A clue to this distinction is that Kant's constitutive principles refer to objects and experience in general (*überhaupt*). Friedman strengthens the relationship between constitutivity and Newton's mechanics to contrast Buchdahl's interpretation of Kant's epistemology, which focuses on the regulative role of reason and tends to separate the transcendental level of analysis from the specific account of nature provided by Newtonian mechanics (see Friedman, 2005). According to Buchdahl, "Common to many scholars is the belief that Kant intended to lay the foundations of Newtonian 'nature' in the analytical portions of the first *Critique*. In reality, there is a considerable gap" (Buchdahl, 1974, p. 128)[33]. Buchdahl's reading seems more faithful to the Kantian texts. Indeed, Friedman's translation choices sometimes distort textual evidence. For instance, he claims Kant's constitutive principles only render

[32] Cohen (1883) argues that the Anticipations of perception ground the applicability of Newton's infinitesimal calculus to experience. I believe, however, that they cannot be reduced to such a purpose. For an account of these principles as involving measurement in general, see Brittan (1978) and Sutherland (2022).

[33] For a direct objection to Buchdahl interpretation, see Friedman (2005).

empirical concepts possible, defined as the fundamental concepts of classical mechanics. This is based on A664/B692, where Kant distinguishes between constitutive and regulative principles (Friedman, 1991, p. 79). However, Friedman omits the word 'even' (*einmal*) in his translation of that passage, significantly altering the meaning. A more faithful translation, confirmed by Guyer and Wood (Kant, 1998), shows Kant stating that regulative principles can never be constitutive, "even in regard to empirical concepts," suggesting a broader scope for constitutive principles than Friedman allows. These points do not diminish the importance of Newtonian mechanics in Kant's system but indicate the need for an account of constitutive principles not monolithically tied to a single physical theory.

One might attempt to defend Friedman by suggesting that his notion of constitutivity refers only to the possibility of laws in general, not necessarily to the specific laws of Newtonian physics. Yet Friedman insists that Kant's transcendental principles must refer to given concepts to be constitutive—and that these concepts are only "given" when the formal system is applied to Newtonian mechanics. Furthermore, the definition of constitutive principles as those that make laws in general possible is still problematic even if detached from Newtonian mechanics. Buchdahl (1974) and Allison (1994) convincingly disentangle lawfulness and constitutivity, stressing the textual evidence in which Kant connects the formulation of empirical laws to the regulative rather than constitutive use of reason (see also Rush, 2000, p. 846, n. 21). For example, Kant highlights that an empirical law becomes such by being located within a *system*, in which a hierarchy of concepts is ordered under a common idea. The requirement of systematicity, however, pertains to the regulative use of reason, and its relationship with the empirical domain opens to the reflective judgment of the third *Critique* (Brittan 1991; Sturm 2009; Vaccarino Bremner 2023). Anyway, even if we interpret Friedman's account as more general and we ignore Buchdahl's and Allison's remarks, a further issue remains, and this is my third criticism of his account of constitutivity: his notion of givenness is underdeveloped. Although he explicitly links constitutivity to givenness, he does not explore the definitional role of this connection or the potential circularity it introduces—what I attempted to show in section 1.1.2.

Finally, Friedman's analysis draws on the *Metaphysical Foundations of Natural Science*, which, although essential for understanding Kant's account of science, never

employs the term *constitutive* (*konstitutiv*). By contrast, the term appears twenty-eight times in the *Critique of Pure Reason*, which grounds the present reading.

My interpretation aims at solving all four downsides of Friedman's reading. First, it does not privilege the dynamical principles but rather provides a coherent meaning of constitutive which is declined in two different ways for the mathematical and dynamical principles. As the former define what an object of intuition is, the latter define what an object of experience is. The focus on positing and conferring meaning rather than on enabling the formulation of empirical laws avoids the ambiguity regarding the laws enabled by the mathematical principles. Second, the positing and meaning-conferring dimensions concern the notion of object of experience in general, independently of the specific scientific paradigm considered. Continuously with the scholars who emphasize the independence of Kant's project from Newtonian mechanics, constitutive principles become, under my interpretation, general requirements[34]. For example, they concern the measurability of physical systems, their lawful behaviour that ought to be described by mathematical laws and functional dependencies, their independence from subjective thoughts and projections[35]. All of these principles are distinct from the specific assumptions of classical mechanics, as they set the standard also for relativity or quantum mechanics, thereby providing rationality and coherence among theory-changes[36]. Third, my reading attempts to disentangle what 'given' means within Kant's account. Although this term is also ambiguous, Kant furnishes some central insights on this concept that cannot be ignored in a clarification of what constitutive means — as the constitutive dimension is opposed to the regulative one exactly for its reference to given objects. The tension between constitution and givenness is not solved but rather emphasized as unavoidable by Kant, who cannot accept either an unconditionally given reality

[34] The resistance to reducing Kant's critical project to a mere justification of Newtonian mechanics—which underlies the present work—is further reinforced by the fact that some studies explicitly caution against interpreting even Kant's expressly scientific writings, such as the *Metaphysical Foundations of Natural Science* or the cosmological writings, solely through their relation to Newtonian mechanics, highlighting the plurality of their sources and aims (Brittan, 1986; Buchdahl, 1992; Pulte, 2025). I will return on this tradition of scholarship in the next chapter.

[35] Chang (2008) and Falkenburg (2007) formulate specific examples of what I am here labelling 'constitutive principle', presenting some general and irrefutable requirements for developing scientific knowledge in the first place. I consider their proposal in more detail in the Conclusion.

[36] Cassirer (1936/1956) argues exactly for this claim in his analysis of the principle of lawfulness: both the causal laws of classical mechanics and the statistical laws of quantum mechanics conform to the general requirement of representing nature through the mathematical language, that makes it comprehensible, explainable and predictable. I analyse Cassirer's view in detail in chapter 3.

(givenness without constitution) or an abstract, non-referential set of conditions (constitution without givenness). Fourth, the threefold dimension of Kant's constitutive, aimed at defining what can be an object, emerges directly from all the actual occurrences of the term in the *Critique*.

Building on his reading of Kant's philosophy, Friedman (2001) famously characterizes scientific knowledge as a three-layered structure: the first level involves the empirical laws of a theory, the second its relativized a priori—i.e., those principles that provide the spatiotemporal framework to formulate the empirical laws of the respective theory—which Friedman labels 'constitutive principles', and the third a meta-paradigmatic discussion on the scope, problems and evolution of that theory (as exposed in the *Motivation for this work*). This third level encompasses a meta-scientific discourse, in which researchers maintain a plurality of perspectives that can trigger a revision of second-level principles by debating the philosophical foundations of their field. According to my interpretation, Kant's constitutive principles — as general requirements to posit objects and confer meaning to concepts — should not be placed at the second, but rather at the third level of Friedman's three-layered structure, among the conditions for a rational and continuous meta-paradigmatic discussion between theory changes. Nothing prevents the use of other concepts — such as coordinative principles, conventions, axioms, or postulates — to describe the presuppositions at the second level, while preserving an independent and clearer meaning of 'constitutive'.

Let me now turn to Banham (2013), whose work also explores the dual senses of constitutive and regulative as employed within the *Analytic* and the *Dialectic*. With regard to the mathematical principles in the *Analytic*, Banham emphasizes that "Kant terms them 'constitutive' principles as with them it is possible to construct a procedure for quantification" (Banham, 2013, p. 15). By contrast, in the *Dialectic*, the entirety of the principles discussed in the Analytic is also considered constitutive, insofar as they specify the elements that make an object intelligible as such: "The constitutive principles are so described as they provide rules for construction of quantities whilst the reference to the whole group of concepts of understanding as constitutive is meant to indicate they combine together to enable us to understand what 'objects' are" (Banham, 2013, p. 18).

Banham's interpretation aligns with mine in regarding constitutive principles as those that determine what counts as an object. Moreover, he offers a compelling and coherent account of regulative principles and ideas[37].

What Banham does not address, however, is why Kant uses the same term—constitutive—to describe two apparently distinct roles of principles. If, in the *Analytic*, constitutive refers to the construction of quantities, and in the *Dialectic* to the specification of what defines objects, then what justifies Kant's application of the same term in both contexts? It seems that some continuity between these uses must underlie Kant's choice of terminology.

My own contribution seeks precisely to establish this continuity, rather than to deny the two senses outlined by Banham. It seems more plausible to interpret constitutivity consistently — in both the *Analytic* and the *Dialectic* — as referring to what defines concepts by endowing them with meaning, and concurrently determines the objects of those concepts by positing them as given. The difference between the two applications of the term, then, lies not in the structure of the principles themselves, but in their respective domains: intuition versus experience. Concepts such as substance and cause cannot be adequately defined within the bounds of individual intuitions, since they presuppose a diachronic dimension — namely, experience — in order to acquire full significance.

To conclude this section I would like to address also the shortcomings of those accounts which interpret constitutive principles as either (i) axioms of a conceptual framework, or (ii) necessary conditions for experience. Both of these views can be challenged by recognising that Kant's a priori (both constitutive and regulative principles[38]) have the logical form of *presuppositions*. The notion of a presupposition has been usefully defined by Gordon G. Brittan as a semantic relation that, as Bas van Fraassen (1968) was the first to argue, is characterized as follows:

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[37] I also agree with Banham's criticism to Guyer's interpretation of constitutivity, which thus dispenses me from addressing it in this section. In short, Guyer (1987, 188) proposes to reduce the constitutive-regulative distinction to that between determinate and indeterminate principles. Banham rightly stresses that "It is the difference between rules of perception and intuition on the one hand and rules that enable us to speak meaningfully about experience on the other that is at issue in the distinction between constitutive and regulative, not that between principles that are determinate and those that are indeterminate." (Banham, 2013, p. 17).

[38] I would like to emphasise that it is not only compatible but also logically coherent to both use the characterisation of all Kant's principles as presuppositions to distinguish them from other notions, and simultaneously criticise its use to define *only* constitutive principles (as I did in note 4 of the 'Motivation for this work').

> A presupposes B if and only if A is neither true nor false unless B is true; or, what comes to the same thing:
>
> A presupposes B if and only if (a) if A is true, then B is true, (b) if A is false, then B is true. (Brittan, 1978, p. 35)

For example, the statement 'The car hit the wall' presupposes the truth of the statements 'There is a car' and 'There is a wall' to have a truth value, since the falsity of the two presuppositions would mark the former statement as *meaningless*. This notion of presupposition is classical, partially formulated by Strawson (1952) (see Beaver, Geurts, and Denlinger 2024; Govier 1972)[39]. However, as Brittan claims and as emerges in earlier neo-Kantian approaches like Pap (1944), it has Kantian roots.

The presuppositional structure of Kant's principles distinguishes them from both axioms and necessary conditions. Axioms are unproven premises of a formal system from which theorems are derived. Yet, a premise provides evidence for the truth of its conclusion, while a presupposition provides a truth value in general to what follows from it[40]. A presupposition differs also from *implication* or *entailment*: the logical rule of inference of *modus tollens* is valid for the latter, but not for the former (see Brittan, 1978, p. 23). On the other hand, the concept of presupposition should be distinguished also from that of a 'necessary condition'[41]. The necessary condition of p, according to the standard theory, is the consequent of the material implication $p \rightarrow q$. As already argued, presuppositions differ from implications. Furthermore, Kant's constitutive principles might be described as necessary conditions of experience, but this definition would be too broad. Having a brain, for example, is a necessary condition to have any experience for the human beings; however, it falls outside the domain of transcendental philosophy,

[39] For reasons of space, I cannot present other formal accounts of presuppositions here. Russell (1905), for example, sets out a theory of definite descriptions according to which the statement "The King of France is bald" presupposes the statement "The King of France exists". If the latter statement is false, the former is not meaningless, but also false. Friedman (2001, p. 74) relates Strawson's approach to Russell's. In my work, I demonstrate that *if* the Strawsonian–Kantian account of presupposition is valid, then Kant's principles differ from axioms and necessary conditions. Future work may address the validity of this premise.

[40] Axioms are sometimes described as more than mere premises, as they define the very terms that follow in a system. Hilbert's implicit definitions work this way (see Friedman, 1999, Ch. 3; Giovannini and Schiemer, 2021; Hale & Wright, 2000). I believe that this account does not really undermine my view, since it shows that axioms within formal systems and scientific theories *may sometimes exhibit a constitutive role* in defining the concepts without which those systems would not be possible or applicable—continuously with my definition—and *not* that constitutive principles can be reduced to axioms generally speaking.

[41] Govier (1972) describes the two as equal without, however, motivating it.

as it points to an empirical presupposition (see Allison, 1983, pp. 3-13; Bubner, 1975; Ottaviani, 2014, p. 81)[42].

1.5 Hints at the other *Critiques*

The aim of this final section is not to provide a precise and thorough analysis of constitutivity in the *Critique of Practical Reason* and *Critique of Judgment*. It is rather developed under the guiding idea that if my interpretation is correct (and if Kant used the term coherently), it should be consistent with (at least some of) the occurrences of the notion of 'constitutive' in the other *Critiques*. Through this section, I hope to provide not exhaustiveness but at least a glimpse of comprehensiveness to my analysis, as Kant's terminology should not be reduced to the only domain of theoretical knowledge.

1.5.1 The highest good of practical reason

In the *Critique of Practical Reason*, Kant considers the fact that the three ideas of freedom, God, and immortality do not refer to any object that is instantiated in experience. Nevertheless, Kant states that the three ideas "become *immanent* and *constitutive* inasmuch as they are grounds of the possibility of *making real the necessary object* of pure practical reason (the highest good)" (*CPrR*, 5:135). For theoretical purposes, so for our investigation of how nature works, the three ideas are *empty,* i.e. concepts devoid of objects to subsume. Kant characterizes them also as *transcendent*: by not applying to objects in space and time, they exceed the boundaries of knowledge. However, for our practical reason, so for our need to *act* as rational agents, they *define* the notion of the *highest good*, which denotes a synthesis of morality and happiness. Freedom, God, and immortality make the highest good a *real possibility*. This single occurrence of the term constitutive in the *Critique of Practical Reason* seems then consistent with the previous analysis, describing constitutivity as establishing the *positing of an object*. The ideas become constitutive by providing a *real definition* of the highest good, which acquires

[42] The main difference between empirical and transcendental necessary conditions can be summarised as follows: the former can be overcome, eliminated or substituted in a counterfactual situation without altering the corresponding reality—for example, I can conceive of organisms that experience things without a brain, as could be argued for plants. The latter, however, cannot be thought of as being different from how they are. I acknowledge that this distinction may be subject to interpretation depending on the definition of 'necessary'. For a more detailed explanation, I refer the reader to the sources cited above. See also note 4 in the *Motivation for this work*.

meaning, *objectivity,* and *necessity* within practical reason. Constitutivity within practical reason should not fully identified with the constitution of nature within scientific knowledge, and indeed Kant nuances his terminology by describing the principle that posits the highest good as not objectively but "subjectively constitutive" in the third *Critique* (CJ, 5:453). Nevertheless, Kant's consistency in employing his terminology can be still appreciated, while accepting that the positing (or providing meaning to the concept of) a moral object cannot work in the same way as positing an object of nature.

1.5.2 The interplay of constitutive and regulative: toward the third Critique

While the second *Critique* contains only the aforementioned occurrence of the term 'constitutive', it is way more frequent in the third *Critique*. Most of such occurrences highlight simply that constitutive principles *determine* the objects of experience, with a connection to the notion of determinant judgment. A complete investigation of constitutivity should then include some references to the role of *judgments*. Such references may prove crucial for the following reason: the third *Critique* expands on the function of regulative principles and their relationship to constitutive ones. Since my clarification of the notion of constitutive involved a link to given objects, one would expect regulative principles—often employed by Kant as the opposite of constitutive—to refer to non-given objects. Indeed, this is exactly the case. And yet, the *Critique of Judgment* elaborates on the fact that these two functions of reason are not in contrast, but rather *cooperate* in enabling scientific knowledge.

This point is already suggested in the first *Critique*. In the Appendix to the Transcendental Dialectic, Kant describes regulative principles in a broad sense[43] as involving concepts forming judgments that are neither true nor false, i.e., concepts with empty references (Hanna, 2016; Zuckert, 2017). French (1967, p. 627) describes regulative propositions as even non-denotative and unverifiable. Indeed, Kant outlines the aim of the regulative use of the Ideas of Reason as "that of directing the understanding to a certain goal respecting which the lines of direction of all its rules converge at one point, which, although it is only an idea (*focus imaginarius*) […] nonetheless still serves to obtain for these concepts the greatest unity alongside the greatest extension" (CPR,

[43] I'm here referring to the Ideas of reason, i.e. the regulative principles of reason, and not to the dynamical principles (that are regulative with respect to intuition).

A644/B672). Ideas, as regulative principles[44], provide the ultimate goal of the scientific research towards which our results should approximate asymptotically.

As Meer (2020) specifies, Kant borrowed the term '*focus imaginarius'* from Newton's *Opticks*. In particular, in section 14 of this work, Newton "determines with such a concept [of focus imaginarius] an apparent location of an object on the visual axis of a perceiving subject in front of a mirror, although the same object is located behind or to the side of the subject" (Meer, 2020, p. 25). While being deceived by a mirror on the real location of an object, a perceiving subject can either be deluded or correctly understand the situation. These two options are the same that Kant describes in his Dialectic, referring to a delusional Reason whose Ideas are employed in a constitutive use, and a critical Reason, whose Ideas are employed in a regulative use[45]. To use Ideas constitutively means to posit (or, in this case, hypostatize) the objects of the concepts they make possible, i.e., provide with the capacity to be either true or false something that cannot intrinsically be true or false (*CPR*, B544, B717, B730)[46].

However, it would be an error to simply contrast constitutive and regulative principles without first pinpointing their interrelation. Indeed, in the Appendix Kant provides a useful distinction, that can help to both (i) specify the relationship between constitution and regulation, and (ii) understand how the *Critique of the Power of Judgment* comes into play.

The distinction in question is in A644/B672, where Kant specifies that "just as the understanding unites the manifold into an object through concepts, so reason on its side unites the manifold of concepts through ideas by positing a certain collective unity [*kollektive Einheit*] as the goal of the understanding's actions, which are otherwise concerned only with distributive unity [*distributive Einheit*]". So, the unity of experience can be defined as either distributive or collective, namely as the sum of *each one* (*ein jedes*) of its parts or as a totality of parts *all together* (*Alle zusammen*) (see Hohenegger, 2004, pp. 97-124, and Varaschin, 2022, p. 656).

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[44] Some scholars urge not to confuse the different principles of reason in the Dialectic, distinguishing between Ideas and principles, and further subdividing the Ideas themselves; see, for example, Howard (2024).

[45] On the regulative use of Ideas, see Allison (1994), Buchdahl (1967, 1992), Cooper (2022), Friedman (1991), Gava (2022), Godlove (2013), Massimi (2017), and Morrison (1989).

[46] It is fascinating that Kant does not only explain what it means to confuse the metaphysical Ideas of Reason for constitutive principles, but he also suggests why it happens so: our laziness (*ignava ratio*) forces us to hypostatize regulative principles to consider our investigation of nature complete (CPR, A689/B717).

A simple but effective way to grasp the distinction between distributive and collective unity is by distinguishing a case in which a single feature is discovered as occurring in more and more things (*one in many*) from another case in which a set of things is defined as sharing a common feature (*many in one*)[47]. Only collective unity is systematic, in the sense of hierarchically ordering multiple cognitions under a common idea[48]. The constitutive principles of the understanding provide the first type of unity, without which we could not know anything, while the regulative principles of reason provide the second type of unity, wider although only *projected*, without which we would only know an endless number of irrelated objects (see Aportone, 1990, pp. 717-718). Hence, the regulative principles rule experience to gain not just extensionally wider unity but also a richer type of cohesion: experiences are not *added one to another*; they are *mutually interrelated*.

We can now turn back to the relationship between the constitutive and the regulative dimensions of principles. Not only do they cooperate to gain both distributive and collective unity, but both operations would lose meaning in isolation. To be more specific, Kant's argument may be summarized as follows. If constitutive principles provide meaning and determination to objects, how can the concept of an object of experience be meaningfully articulated while abstracting from the systematic whole in which it is ideally situated? A tree is not merely the sum of our experiences of it; it occupies a determinate place within the systematic framework of botany. Likewise, an electron is not simply what is detected in cloud chambers, but a theoretical entity characterized by a set of properties defined by quantum mechanics and further articulated within the Standard Model of particle physics. The constitution of nature therefore cannot rely solely on the definition and determination of objects through constitutive principles. Objects must also be situated within a coherent system—namely, in scientific contexts, within models, theories, and intertheoretical relations—and this requirement of systematic unity is supplied by regulative principles.

The specific procedure that applies such regulative principles to the empirical research is described by Kant as reflective judgment in the *Critique of the Power of Judgment*. The

[47] Kant describes the two unities in this way in his *Opus Postumum* (OP, 21:247.15), referring to the couple "analytically-universal" and "synthetically-universal". The identification of these latter terms with distributive and collective unity is claimed in Friedman (1992, p. 307). See also Hohenegger (2004, p. 120).
[48] On systematicity, see Fulda, Stoltzenberg (2001) and Sturm (2009).

next subsection concludes the whole chapter by elaborating on this notion and completing the analysis of the constitutive-regulative relationship.

1.5.3 Reflective judgment and the third Critique

Many important Kantian scholars agree on the fact that the notion of *reflective judgment* is articulated by Kant to solve the unfinished epistemological business of bridging the transcendental principles of the first *Critique* with the empirical research of laws of nature (Allison, 2003; Garroni, 1998; Geiger, 2022; Guyer, 1990; Kitcher, 1994; Makkreel, 1991; Mathieu, 1994; Scaravelli, 1968).

In the third Critique, Kant defines judgment in terms of its function and also of its collocation in the critical project. Regarding its function, "the power of judgment in general is the faculty for thinking of the particular as contained under the universal" (*CJ*, 5:179). Regarding its collocation "in the family of the higher faculties of cognition", the power of judgment is an "intermediary between the understanding and reason" (*CJ*, 5:177). Then, Kant proceeds to divide two types of judgments, "determinant [*bestimmende*]" and "reflective judgment [*reflectirende Urtheilskraft*]" (translated as "determining" and "reflecting power of judgment" by Guyer and Matthews[49]):

> If the universal (the rule, the principle, the law) is given, then the power of judgment, which subsumes the particular under it (even when, as a transcendental power of judgment, it provides the conditions *a priori* in accordance with which alone anything can be subsumed under that universal), is determining [or determinant]. If, however, only the particular is given, for which the universal is to be found, then the power of judgment is merely reflecting [or reflective]. (*CJ*, 5: 179)

Thus, the determinant-reflective distinction is just a logical one between two operations: finding the particular for a given universal, or finding a universal for a given particular[50].

The constitutive-regulative and determinant-reflective distinctions should not be identified: the former represents uses of reason, the latter kinds of judgments. While the *Critique of Pure Reason* investigates the transcendental level of cognition, the *Critique*

[49] For this choice of translation, see Kant (2000, p. xlvii). I decided to maintain "determinant" and "reflective" for the only reason that they are in line with most of the English literature.

[50] Obviously, I am here simplifying the problems behind the distinction to focus on the more restricted aims of my work. For a more subtle analysis of determinant and reflective judgments, see, for example, Garroni (1998). Kitcher (1994) and Vaccarino Bremner (2023) specify how reflective judgment enables scientific knowledge.

of the Power of Judgment tries to apply it to the empirical level: the former is interested in the particular as inscribed in a systematic unity, the latter is interested in the particular as such[51]. Granted these crucial distinctions, the Kantian forms of judgment can still help in clarifying the relationship between the constitutive and regulative dimensions by highlighting *the interplay of top-down and bottom-up procedures* in any process of knowledge—and *a fortiori* in science.

Determinant judgment refers to a top-down movement of specification, while reflective judgment refers to a bottom-up movement of induction or analogical reasoning. The two converge toward each other, thereby encompassing the whole hierarchy of possible cognitions[52]. Kitcher (1994) suggestively defines these two extremes as the *route from above* and the *route from below*. The former links "the notion of empirical law to conditions of application of the categories" (Kitcher, 1994, p. 259), while in the latter Reason seeks "to integrate generalizations about patterns in experience into a unified system, thereby bestowing lawlike status on the generalizations so embedded", so that the two routes "yield the same destination" (Kitcher, 1994, p. 259)[53].

Although they are opposed in the sense of denoting two kinds of different procedures, they are parts of the same epistemic process. As extremes of the same process, they cooperate to provide a scientific understanding of reality. This claim is also supported by some scholars, like Paul Guyer:

> when subsumption is not so simple, when more than two terms are involved, […] then perhaps reflective and determinant judgment may both be required to accomplish the single task of applying the given universal to the given particular. Determinant judgment may be set the task of applying the abstract concept to sensible particulars, but if intermediate concepts have to be discovered in order to do that, then reflective judgment

[51] Makkreel (1990; 1991), Mertens (1973), and Rajiva (2006) provide arguments to distinguish the two levels of investigation of the first and third Critique, particularly focusing on the differentiation of the regulative hypothetical use of reason and reflective judgment. They all challenge a tradition of authors who uncritically equated the two, among which August Stadler (Stadler, 1874), followed by Max Liedtke, Anselm Mödel, Rolf-Peter Horstmann, and Reinhard Brandt. The fact that Kant distinguishes between constitutive and regulative reflective judgments about purposiveness in the third Critique (CJ, 5:197) further supports a differentiation of the two distinctions.

[52] Geiger (2022) and Makkreel (1991) identify the two forms of judgement with the operations of explanation (determinant) and description (reflective), clarifying in which sense they are both required in science.

[53] Kitcher (1994) argues that the nature of the relationship between the two routes emerges in the *Opus Postumum*.

> may be needed to find those concepts and thus complete the task assigned to determinant judgment. (Guyer, 1990, p. 18)

Constitutive and regulative principles belong to a different level of analysis within Kant's framework. Nevertheless, they make possible the same epistemic process specified by determinant and reflective judgment. To be more precise, they equally point to an interplay between the two extremes of a single process of understanding reality. Constitutive principles define what counts as an object in general, and regulative principles locate objects within the ontology of a scientific theory. Constitutive principles endow concepts with empirical meaning, while regulative principles locate those concepts within a hierarchical system. The constitutive unity of the understanding is distributive, and that of reason is collective. What finally emerges is thus a synergy of equally indispensable normative requirements in order to comprehend the objects and events of reality. Note that the principles exhibit a similar relationship to determinant and reflective judgments not only in an analogical sense: understanding, reason, and judgment are characterized by Kant as different faculties of human knowledge. They all provide a priori principles without which experience would not be possible at different levels. Constitution and regulation articulate the dynamic interrelation of unifying and differentiating activities, establishing the ideal that science sets for itself and thus rendering scientific practice a rational undertaking (Wartenberg, 1992).

Many scholars have recognised the reciprocity of constitutive and regulative principles, claiming, however, that such an interrelation blurs the distinction itself (Beiser, 2006; Friedman, 1991; Guyer, 1987; Herman, 1991; Rush, 2000). For the reasons articulated above, I agree that constitutive and regulative principles are not opposed at all: they combine and merge in the concrete procedures of inquiry. And yet, Kant's analysis rightly distinguishes them since it abstracts from empirical sources, conceptually differentiating between elements that might be chronologically simultaneous. Instead of claiming that the two kinds of principles are conflated, I would rather support the idea that their integration supplies flexibility and dynamism to Kant's view of science. This claim is further endorsed by the main difference between constitutive and regulative principles that I specified: the *givenness* of the objects to which they refer. Kant acknowledges that such givenness *cannot* be securely and definitively realized in our empirical research. We, as empirical subjects, do not know whether our current list of

existing and given objects is right. Aether and phlogiston are two examples of this kind of error, exposing our historically situated activity of constituting experience as an *ongoing striving*.

Conclusion

Perhaps it is due to his development of a new way of thinking, difficult to express in traditional terminology, or maybe to the intrinsic plurivocity of some fundamental concepts; nonetheless, the fact remains that Kant rarely defines in a unique way the terms he employs, often multiplying their meanings depending on the context they are used. As shown in this chapter, the notion of constitutive makes no exception.

In the passages of the *Critique of Pure Reason* in which he employs it, Kant links constitutivity with many notions such as construction, givenness, objects in general, positing and real definitions. I have investigated all these notions in sections 1.1 and 1.2. From the analysis of the occurrences of the term 'constitutive' and of the notions to which it is related, five definitions emerged. In section 1.3, I compared such definitions. As a result, I claim that Kant intends constitutive principles as (i) establishing the criteria to posit objects as given, (ii) providing referential content to concepts, and (iii) defining what an object is—where point (iii) combines (i) and (ii). To further summarize my results in a schematic way, I proposed to call them, respectively, the (i) object-positing, (ii) meaning-conferring and (iii) object-defining dimension of Kant's constitutive.

In section 1.4, I have compared my analysis with other interpretations, raising doubts specifically about Friedman (1991) and Banham (2013). I have then completed my investigation with a brief detour into the *Critique of Practical Reason* (section 1.5.1) and into the regulative dimension described in the first (section 1.5.2) and third *Critique* (section 1.5.3).

Chapter 2: The Twentieth Century Reformulations of Kant's Constitutive Principles after the New Scientific Developments

Abstract: After the analysis of Kant's notion of 'constitutive', I investigate how the same term has been employed by three post-Kantian traditions: Marburg neo-Kantianism, Logical Empiricism, and Phenomenology. To help the reader orient herself between these various approaches, and to present at the same time my main claim, I will show that each of them has emphasized one of the three dimensions of Kant's 'constitutivity'—respectively, the object-defining, the meaning-conferring, and the object-positing dimension. This interpretative move explains why they all used the same Kantian lexicon while diverging on its meaning and application to scientific knowledge. To classify their accounts, I particularly focus on two issues, namely (i) what is the target and (ii) who is the subject of constitution.

Introduction

The present chapter is an *intermezzo* between the analysis of Kant's notion of constitutive and the reformulation of the same term in the three post-Kantian traditions that made extensive use of it, namely Marburg neo-Kantianism, Logical Empiricism, and Husserl's phenomenology. Although they all developed the same terminology in different ways and within different frameworks, I show that each of these traditions – called 'constitutive traditions' for brevity – has recovered one of the three dimensions of Kant's notion described in section 1.3—the object-defining, meaning-conferring, or object-positing dimension. This interpretative approach clarifies why, despite diverging on the meaning and application of the Kantian lexicon to scientific knowledge, they all used the same terminology.

In section 2.1, I introduce and motivate my analysis by outlining the twentieth-century debate on the validity of Kant's a priori principles after the new scientific developments in the twentieth century. Section 2.2 shows in what sense the three constitutive traditions, reinterpreted the three dimensions of Kant's notion of 'constitutive'. Sections 2.3 and 2.4 highlight two specific issues relating to the concept of 'constitution'. Indeed, once the necessity for constitutive principles is recognised, one may inquire as to *what* they

constitute and *who* underlies their constitution. These questions address the purpose and origin of the constitutive process, and both lead to fruitful cross-comparisons between the three post-Kantian traditions[54].

2.1 A priori principles and the new science

The notion of *constitutive* becomes relevant in twentieth-century philosophy of science due to discussions concerning the compatibility between the new scientific developments and Kant's *a priori*. Following the discovery of non-Euclidean geometry—developed through the works of Gauss, Lobachevsky, Bolyai, and Riemann in the first half of the nineteenth century (for an overview, see Greenberg, 1993; and Torretti, 1984)—philosophers and mathematicians began to question Kant's notion of space as an *a priori* form of sensibility, along with his alleged commitment to the necessity of Euclidean geometry.

Three main lines of thought emerged, which would later also be used to respond to the challenges posed by Einstein's theory of relativity and by the rise of quantum mechanics[55]:

1. The first position holds that Kant's framework is fundamentally committed to the necessity of Euclidean geometry and Newtonian mechanics, and thus has been refuted by the new geometries. F. C. S. Schiller, for example, wrote in his *Non-Euclidean Geometry and the Kantian a Priori* (1896) that: "When we see these facts [the existence of non-Euclidean spaces] as clearly as the development of metageometry has compelled us to see them, we must surely confess that the Kantian account of Space is hopelessly and demonstrably antiquated and can lend no support to the rest

[54] The historical details of the relationship between Kant and members of these traditions that are not relevant to the concept of constitution are beyond the scope of this work. For a reference, see de Boer (2011), Fabbianelli and Luft (2014), Ferrari (1988, 2003), Friedman (2010), Jansen (2015), Kern (1964), and Luft (2011, 2015b, 2018). Works addressing the relationship between neo-Kantians, neopositivists, and Husserl include Ferrari (2003), Friedman (1999, 2000, 2010), Luft (2011, 2018), and Neuber (2011, 2016).
[55] Bird (1998) presents two of the interpretations I summarize here. For an overview of the relationship between Kant's philosophy and twentieth century physics, see DiSalle (2006), Friedman (2001), and Ryckman (2005).

of his system." (Schiller, 1896, p. 179)[56]. This approach later became a key characteristic of Logical Empiricism, particularly in Schlick's account[57].

2. The second strategy aimed to reconcile Kant's theory of space with new scientific developments by either modifying the former or rejecting the latter's validity. Those who took the former approach included Hermann von Helmholtz and the Marburg neo-Kantians. They claimed that Kant was closely tied to the scientific understanding of his time, while also acknowledging that key elements of his thought could be revised and revitalised. This attitude also influenced the early work of Reichenbach and Carnap, and has recently sparked research into the intricate relationship between Logical Empiricism and Kant's legacy. By rejecting the validity of non-Euclidean geometry and defending the unquestionable truth of Euclidean space, Lotze (1879) exemplifies the latter approach. His attitude was famously criticized by Felix Klein (1926, p. 152)[58]. The following sections will focus on the revisionist attitude (Helmholtz, the neo-Kantians and the early logical empiricists), but I will exclude the anti-scientific stance represented by Lotze from my discussion, as it is based on an untenable rejection of well-established scientific results.
3. The third and final strategy involved the attempt to detach Kant's entire critical project from the specific scientific knowledge of his time. While recognising Kant's references to Newton's laws of motion and Euclidean geometry, advocates of this third approach emphasized the distinction between Kant's concrete examples and what he aimed to illustrate through them. The neo-Kantians Friedrich Lange and Eduard Zeller, for instance, argued that the true purpose of the transcendental method lies in exploring the *possibility of experience in general*, a task independent of any particular scientific paradigm[59]. Although the Marburg neo-Kantians were mentioned under the previous revisionist attitude, some passages in the works of Cohen, Natorp

[56] Schiller's claim is often confirmed by introductions on non-Euclidean geometry, see for example Wolfe (1945, p. 75).
[57] This first position has its roots in the numerous works of the mid-19th century (such as those of Cohen (1885) and Dieterich (1876)) that emphasised the Newtonian basis of Kant's project. However, it is important to note that interpreting Kantian experience as referring to Newtonian scientific experience does not necessarily equate to reducing criticism to a justification of classical mechanics, as some proponents of this first perspective suggest.
[58] On Lotze, see Rohr (2023, p. 4) and Torretti (1978, pp. 285-290).
[59] See Lange (1886) and Zeller (1875) as examples of the rehabilitation made on those years of Kant's method, seen as a Logic of the possibility of experience. Both these authors had deeply influenced the founders of the twentieth-century neo-Kantian schools.

and Cassirer also align with this third approach. Consider, for example, that while Cohen (1885) is one of the main sources of the intepretation of Kant's notion of 'experience' as scientific—i.e., Newtonian—he characterises the Transcendental Aesthetic as concerning only the general possibility of coexistence of a manifold, thereby criticising the reading of Kant as committed to the necessity of tridimensional, Euclidean space defended, for example, by Helmholtz (see Ferrari, 1988, pp. 54-55). Husserl's project of transcendental phenomenology—insofar as running parallel to science and not opposed to it—also fits within this third line of thinking[60].

The debate intensified after the advent of Einstein's theory of general relativity, which transformed non-Euclidean geometry from being a mathematical alternative to Euclidean geometry into a framework that represents the actual structure of the universe. Einstein's field equations, in fact, describe the relationship between the geometry of spacetime—mathematically expressed through the Ricci and Riemann curvature tensors—and the energy-momentum tensor, which represents the physical fields and masses responsible for the curvature of spacetime:

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \lambda g_{\mu\nu} = 8\pi G T_{\mu\nu}$$

This physical law characterizes the universe as a semi-Riemannian manifold with variable curvature, thereby confirming not only that multiple geometrical systems are possible, but also that the structure of the physical world is grounded in a geometry fundamentally different from the one Kant assumed in his philosophical system.

It was not just space and geometry that fueled the subsequent debate between advocates and opponents of Kant's philosophy. More broadly, the replacement of inert, absolute space and time with a four-dimensional dynamic spacetime, as well as the reinterpretation of gravity as a manifestation of the curvature of spacetime, undermines the grounding elements of Newtonian mechanics. This fact led to the idea that even laws considered fundamental—those of classical mechanics before the twentieth century—are subject to revision.

[60] Beyond his multiple claims of affinity with Kant's framework., Husserl also placed himself in the logical tradition of Lotze and Lange; see Husserl (2008, §59-61).

In the years between the two world wars, the three approaches described above developed precisely to grapple with the changing character of the fundamental principles at the basis of scientific theories. While Schlick's adoption of conventionalism broke decisively with any element of Kant's framework (Schlick, 1915/1979; 1918/1974; 1921), Reichenbach's characterisation of scientific principles as axioms of coordination — principles that are not necessarily true, but which serve as general rules for formulating empirical laws — retained the Kantian insight that there are precisely specifiable conditions necessary to endow physical concepts with meaning and objectivity (Reichenbach, 1920/1965). The interplay between these two logical empiricists influenced subsequent proposals that either revived the claim of incompatibility between modern science and transcendental philosophy — often favouring a conventionalist interpretation — or endorsed a revised version of Kant's a priori, which could better account for the evolving criteria for the foundation of scientific knowledge. Scholars such as Parrini (1983) and Friedman (1999, 2001, 2002, 2010) have exemplified this revisionist approach by advancing a relativised and dynamic version of the a priori (see also DiSalle, 2006; Padovani, 2015; Stump, 2015).

Nevertheless, the majority of contemporary Kant scholars have endorsed the third strategy mentioned above, arguing for the partial independence of Kant's work from Newtonian physics and other scientific theories (Bird, 1998; Brittan, 1978, 1994; Buchdahl, 1992; Höffe, 2010; Lugarini, 1950; Pulte, 2025; Stan, 2017; Sturm, 2022; Watkins, 2019; Wartenberg, 1992). This partial independence does not mean that Kant's framework is irrelevant when it comes to interpreting scientific theories, nor does it mean that it cannot provide philosophical insights into the structure of science (see Mittelstaedt, 2009; Pringe, 2013; and Brittan, 1978, 1986).

Within the broader discourse on scientific knowledge and Kant's a priori, the notion of constitutive principles has been emphasised and reinterpreted. Much recent literature has focused on the a priori and the necessity of Kant's principles, often presuming the clarity and unambiguous nature of their constitutive function. However, many of the aforementioned philosophers — such as Reichenbach, Cassirer and Husserl — have emphasised that it is precisely the constitutive nature of Kant's principles that must be upheld in the face of scientific innovation. Yet they have failed to provide clear and unambiguous clarification of what 'constitutive' means.

Given that the key role of constitutive principles is highlighted by neo-Kantians, logical empiricists and phenomenologists, albeit from distinct perspectives, it is unsurprising that they attributed different meanings to the same terminology. More specifically, I argue that all of the constitutive traditions inherited certain aspects of Kant's concept of constitutivity while rejecting others. The contemporary debate between Friedman, Buchdahl and others[61] reflects this plurality of definitions.

2.2 The three dimensions of Kant's constitutive in neo-Kantianism, Logical Empiricism, and Phenomenology

2.2.1 Neo-Kantians and the object-defining dimension

Within Marburg neo-Kantianism, the object-defining dimension of Kant's constitutive principles is of particular importance. The terms *constitutive* and *constitution* appear frequently in the works of Hermann Cohen, Paul Natorp, and Ernst Cassirer, both in their expositions of Kant's philosophy and in their personal interpretation of the new developments of the early twentieth century physics[62].

Marburg neo-Kantianism inherits from Kant the idea that philosophy seeks the conditions for the possibility of experience. Here, 'experience' should not be understood as a subjective state of consciousness, but rather as an objectively given state of affairs that conforms to laws and can be described using the tools of the exact sciences — what Cohen called the 'fact of science' (Cohen, 1883, p. 5; 1885[63]). Cohen reads Kant's *Critique of pure reason* as culminating with the system of synthetic principles, thus as concerning *objective knowledge*, and not our cognitive faculty: it involves science rather than consciousness (Luft, 2015b, pp. 43-47; Pringe, 2017). As a consequence, Kant's

[61] For occurrences of the notion of *constitutive* in contemporary philosophy, see Berkovitz (2020), Bitbol, Kerszberg and Petitot (2009), Bland (2011), Chang (2022), Darrigol (2020), de Boer (2010), Domski and Dickson (2010), Everett (2015), Friedman (2001; 2010), Luchetti (2021), Mormann (2021), Padovani (2015, 2017), Sanjuán (2021), Szabó (2019), Stump (2015), Toepfer (2011).

[62] For the occurrences of the terms in Cohen and Natorp, see Sokolowski (1970, pp. 215-216). The idea of constitution in Cassirer is merged with his dynamic version of the a priori (Cassirer, 1910/1953; 1936/1956); see section 3.2.

[63] Ferrari (1988, p. 34) points out that in the first edition of *Kants Theorie der Erfahrung* (published in 1871), which is still bound to an analysis of "our" experience, Cohen does not refer to the 'fact of science'. This notion, first used in Cohen (1883, pp. 5, 19), appears then in the second edition (1885), which, not by chance, is more attentive in referring to "experience in general". This suggests that the notion of the *fact of science*, often cited as the starting point of Marburg neo-Kantianism, emerged as a consequence of certain exegetical choices, particularly Cohen's emphasis on the synthetic principles of understanding as the focal point of Kant's Critique. The core chapter of Cohen's work is exactly entitled "The Synthetic Principles" and is translated in Luft (2015a).

project is reinterpreted as the establishment of the 'tools' by which the facts described by the exact sciences are produced (Ferrari, 1988, pp. 43-50).

Expanding on this perspective, Hermann Cohen and Paul Natorp describe experience as *data informed by conceptual categories*, incorporating both a priori principles and empirical laws. Within such framework, the *constitution* of objects indicates the process by which laws are applied to what we encounter in experience, rendering previously unpredictable system behaviour mathematically regulated. Constitutive are those principles that turn the *Erlebte* (subjectively experienced) into *Erfahrung* (objective experience). For example, the planets orbiting the Sun only become proper objects of classical mechanics when our observations of them are supplemented by laws governing their motion, positions, and interactions with nearby bodies.

The central problem driving the epistemologies of Cohen and, more significantly, of Natorp is the transition from subjective particularity to objective universality. The foundation for such a transition cannot lie in the positivists' notion of the given, the "here and now". This given refers merely to isolated occurrences of events without accounting for their interrelations; such a lack of relational structure precludes the possibility of knowledge understood as prediction, explanation, modeling, and the formulation of laws. Furthermore, the term *given* is inherently ambiguous, as the acts of perceiving, knowing, or determining objects invariably involve conceptual elements that extend beyond the "here and now"[64]. Although these critiques may be challenged as committing a straw man fallacy or a false dichotomy[65], Natorp's articulation of them (Natorp, 1887/1981, p. 262) laid the groundwork for subsequent discussions of empiricist approaches, such as Sellars's criticism of the myth of the given (Sellars, 1997). Indeed, if the "here and now" is regarded as containing conceptual elements, it cannot serve as the starting point of a process that leads to the acquisition of knowledge. If anything, it represents the *end result*.

[64] C. I. Lewis inherits such a neo-Kantian view when he stresses that "It is indeed the thick experience of the world of things, not the thin given of immediacy, which constitutes the datum for philosophic reflection. We do not see patches of color, but trees and houses; we hear, not indescribable sound, but voices and violins. What we most certainly know are objects and full-bodied facts about them which could be stated in propositions. […] The given is *in,* not before, experience" (Lewis, 1929, p. 54). See also Lewis (1923).

[65] Schlick (1921) accuses Cassirer, and implicitly Natorp, of setting up a false dichotomy by assuming the validity of either naïve positivism or criticism. Furthermore, Natorp assumes a radicalised version of the positivists' perspective, according to which the given is completely devoid of conceptual elements — so his argument could be considered a straw man fallacy. These points are discussed further in the following sections and in Chapter 4.

Natorp claims then that "the 'positive fact', the supposed primary given, is much more what is to be sought. One might even say it is the ultimate goal" (Natorp 1887/1981, p. 262). The 'given' becomes a task, the *factum* becomes a *fieri* (what needs to be made)[66]. Objective reality is the result of the task involving the application of conceptual elements to data. These conceptual elements are the principles and laws of scientific theories that gradually evolve by being generalized. In a word, reality does not reduce to a here and now given moment, but is rather the result of an ongoing process. Here, the concept of constitution that will influence both logical empiricists and phenomenologists enters the scene. Objects and events, insofar as not given but posed as results of a task, are *constituted*, and the set of principles at the basis of such a knowing process is called *constitutive*. However, since the neo-Kantian notion of experience refers to the fact of science, the constitutive principles of such a fact are not general requirements for knowledge—as in Kant's system. They become, instead, laws of nature and physical principles, representing the specifications of more general synthetic principles—those of Kant's system of principles of the understanding.

As in Kant's viewpoint, the constitutive process that provides the objects of experience is neither a creation of objects from scratch nor the acknowledgment of an already lawful reality, but a process of objectivation of sensations (Natorp, 1888, p. 94). Here, the neo-Kantian inheritance of Kant's object-defining dimension of the constitutive becomes visible: consciousness[67] constitutes the objects of experience by applying mathematical laws to subjective data, thereby *defining* them. Yet the nature of this definition is peculiar. Mathematical laws are *functions* that describe the relationships between properties of physical systems, expressed in terms of magnitudes. For example, Newton's second law can be read as defining *force* in terms of mass and acceleration: force is that which stands in direct proportional relation to both[68]. The ideal gas law, $PV = nRT$, can be read as defining temperature by relating it to pressure, volume, and the number of particles. In both cases, properties are not defined in isolation but through their relations to other properties.

[66] See Natorp (1910), partially translated in Luft (2015a), and Cohen (1877, p. 24).
[67] I will return to the notion of consciousness in section 2.4.
[68] It may be argued that Newton's law only relates independently understood concepts. The neo-Kantian reinterpretation is functionalist: the meaning of such concepts is exhausted by their role in the network of relations.

Likewise, physical systems themselves are frequently defined through the relations among their properties. The d'Alembert equation defines a wave not by its intrinsic essence, but by a network of relations: the second partial derivative of its displacement function *u(x, t)* with respect to time is proportional to the second partial derivative of the same function with respect to space, scaled by the square of its velocity:

$$\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$$

Another example is the electromagnetic field, which is characterized by the coupled relations between its two components, the electric and magnetic fields, as codified in Maxwell's equations. Neither field is defined in isolation; rather, their properties are specified through their interdependence. When these examples—properties defined via relations to other properties, and systems defined through the relations among their constituent properties—are considered not as relations between previously defined concepts but rather networks that represent the meaning of those concepts, they can be described as *functional definitions*. While the neo-Kantians themselves never explicitly used this label, it serves as a helpful interpretive tool for grasping both Natorp's and Cassirer's reinterpretation of Kant's constitutive principles. Whereas Kant employed constitutive principles to determine what could count as an object in general, the neo-Kantians identified them with the mathematical laws that specify the functional definitions of physical systems and their properties. Constitutive processes define scientific concept via their lawlike relations: as such they count as functional definitions[69].

The characterization of the *constitutive* process of defining scientific concepts via their *relations within laws* – regarded as a *functional definition* – is not terminologically distant from Kant himself. Kant employs the term *function* in the *Critique of Pure Reason* to express "The unity of the action of ordering different representations under a common one" (CPR, A68/B93) (see Hoeppner, 2011; Pringe, 2013; and Stang, 2021). The Marburg neo-Kantians' conceptual operation of stressing the constitutive role of laws in defining what concepts (of either properties or entities) mean aims exactly at ordering different

[69] Lotze (1989) represents a mediator between Kant's account and Marburg neo-Kantianism on this point. See Lotze's notion of *constitutive law* in the *Motivation for this work*.

items in a common relationship. They follow the path opened by Kant when they refuse to define the intrinsic essence of entities postulated by scientific theories, while characterizing them as a set of related components. The act of constitution that the neo-Kantians employ shifts the definition of objects, traditionally considered as a 'grasping' of their substantial essence, to an operation of presenting a set of elements functionally related within laws.

Consequently, the neo-Kantian epistemology reframes the concept of a *law of nature* in a new light. If objects are the results, laws are the sources of the "activity of science, which everywhere constitutes the object in law" (Natorp, 1887/1981, p. 248)[70]. Although the differences between Cohen and Natorp cannot be ignored, both philosophers focus with equal strength on this foundational claim. Cohen was the first to characterise the transcendental method as one whose objects are "not the stars in the heavens [...] but the astronomical calculations" (Cohen, 1877, 20f; translated in Luft, 2018, p. 55). According to Cohen, things, events and objects of sensation subsist only insofar as they conform to laws and ideas that govern their behaviour (Ferrari, 1988, pp. 36–43). Natorp inherited and developed the same idea in his early writings, interpreting the path from Plato to Galileo, Descartes and Leibniz as a progressive critical awareness of the lawfulness of nature (Natorp, 1882). Laws underpin the reality of empirical facts, thereby possessing conceptual priority.

Natorp does not provide many examples of his view. However, Galileo's law of free fall motion, mentioned in the previous chapter, may help in understanding his view. Free-falling bodies are defined by the law of motion $s = \frac{1}{2} gt^2$, where *s* represents the traveled distance, *g* is the acceleration due to gravity, and *t* is time. Free-falling bodies are functionally defined through this equation, as it captures the structural relations they hold with space and time. Humans can, of course, experience free-falling bodies without knowing the laws governing them. Yet, there is no *given*, crude, lawless experience of free-falling bodies that precedes Galileo's formulation of the law. Even the mere perception of such bodies already involves conceptual elements that allow us to recognise them as free-falling. Then, the formulation of a mathematical law advances our

[70] Notice that the "mathematical constitution of the real nature [mathematische Konstitution der wirklichen Natur]" (Natorp, 1958, p. 352) does not involve only the "mathematization" of sensations, but also the realization of mathematical frameworks, considered thus as systems seamlessly woven to reality and not just abstract formalisms.

knowledge of these bodies by attempting to define them independently of our sensible and fallible subjective experience. This is not to say that the law is fixed and immutable: any further specification or modification that enables its generalization to a broader class of objects contributes to the transition from subjective, local experience to universal, objective reality. What free-falling bodies truly are will only be fully understood in the long run, as the outcome of an ongoing process of their constitution through scientific laws. Once again, the constitution of objects reveals a regulative progression, as claimed in section 1.5.

A similar conception is also inherited by the most popular member of the Marburg school, namely Ernst Cassirer. Cassirer explicitly states that one of Cohen's merits was demonstrating that the focal point of Kant's first *Critique* lies in the "synthetic principles" (Cassirer, 1912), which represent the universal forms that are exemplified by the empirical laws of nature. These principles are thus characterised as 'constitutive' because they impose formal constraints on the possible candidates to become laws of nature[71]. On this basis, Cassirer reiterates and evolves the Marburg School viewpoint by claiming that "The concept of law is now regarded as prior to that of object, whereas it used to be subordinate to it" (Cassirer, 1936/1956, p. 131). Reality becomes unescapably bounded to our conceptualisation of it since the notion of object "constitutes no longer the self-evident starting point but the final goal and end of the considerations: the *terminus a quo* has become a *terminus ad quem*" (Cassirer, 1936/1956, p. 131).

The idea that nature is constituted by constitutive principles resurfaces in Cassirer's account of the laws of nature, where he vindicates them as the core of the neo-Kantian epistemology. More specifically, Cassirer addresses the determinability through laws as what "constitutes [konstituiert] physical entities, instead of merely expressing an accidental and individual feature of them" (Cassirer, 1936/1956, p. 131). I will tackle Cassirer's account of constitutive principles and his interpretation of quantum mechanics in more detail in chapter 3. For now, it suffices to bring out that the object-defining dimension of Kant's constitutive evolves, in Cohen, Natorp and Cassirer, into the idea that *it is the laws which define the object, rather than the object determining the laws*.

[71] I would like to thank Marco Giovanelli for bringing this point to my attention.

2.2.2 Logical empiricists and the meaning-conferring dimension

While the neo-Kantians inherit the object-defining dimension of Kant's 'constitutive', the logical empiricists[72] ground their understanding of constitutive principles on the meaning-conferring role. Two distinct issues concerning the neopositivist contribution to this inquiry should be kept apart. First, one may examine the explicit use of the term 'constitutive' within their works. Second, one may analyse the central concepts of their epistemology that appear to retain aspects of Kant's meaning-conferring dimension while replacing the term 'constitutive' with alternative notions such as 'coordinative principles' or 'correspondence rules'.

Let's start with the first issue. In the 1910s and 1920s, when neo-Kantianism still held a dominant position in German universities, the scholars who would later form the Vienna and Berlin Circles were beginning their academic trajectories. Within this intellectual setting, Reichenbach and Carnap do use in a technical sense the term 'constitutive'—partly under Kantian influence (Friedman, 2007). Reichenbach (1920/1965) claims that "perception does not define reality" (p. 49), since reality is only determined *via* its coordination with mathematical concepts. However, to work out how these concepts combine to form structures and processes, *constitutive principles* (*konstitutive Prinzipien*) must be formulated. Reichenbach claims that these principles "ultimately define real objects and real events" (Reichenbach, 1920/1965, p. 49)[73].

Reichenbach's examples of constitutive principles include, among the others, the principles of genidentity and special relativity, as well as the principles of covariance and the Euclidean (or non-Euclidean) nature of space. These principles determine how specific mathematical concepts are combined to establish what exists and how it behaves within our scientific theories. Reichenbach follows the neo-Kantians in shifting Kant's general analysis of human knowledge to the specific 'fact of science', but he also goes a step further: constitutive principles are always formulated within a specific theory. Building on the idea that constitutive principles always work in combination to enable

[72] In this chapter and the next, I will mainly focus on Schlick's and Reichenbach's accounts, while also adding insights from Carnap's work. Logical Empiricism was, however, a complex, multi-layered philosophical movement which included Hans Hahn, Philipp Frank, Otto Neurath, Herbert Feigl and Felix Kaufmann, among others. Wittgenstein, Gödel and Ayer also contributed to the movement. For an overview, see Mormann (2007), Stadler (2015) and Suppe (1974). For the differences between the Berlin and Vienna circles, see Milkov (2013) and Uebel (2013).

[73] For an overview of Reichenbach's early philosophy and its relationship with other traditions see Eberhardt (2011), Franco (2020), Giovanelli (2023), Padovani (2011, 2015, 2017), and Pulte (2013).

the formulation of a theory, Reichenbach claims that they are *relative* to a theoretical framework. While any individual principle may be maintained within any theory, its legitimacy always depends on its relationship with the other principles of that theory. The principle of the Euclidean character of space, for instance, is only valid in combination with the other constitutive principles of classical mechanics; conversely, it contradicts those that determine reality according to the theory of general relativity. Indeed, the principle that "at every point in the field, the theory should correspond to the special theory of relativity for infinitesimal domains" is a requirement of general relativity (Reichenbach, 1920/1965, p. 28). Reichenbach demonstrates that, in a mass-filled gravitational field described by general relativity, local inertial systems at different points cannot all belong to a single global inertial family. Consequently, it is impossible to select coordinates that render the spatial metric Euclidean at all points simultaneously. For such fields, the degree of curvature is therefore non-zero and space is not globally Euclidean.

Since Kant's constitutive principles – according to Reichenbach's reading – cannot be in contradiction one another, they should be replaced with a more dynamic framework. This move allows Reichenbach to abandon the necessity of the Kantian a priori to reframe it in scientific terms. Not only constitutive principles can change, but they also always refer to a limited domain. Kant's link of constitutivity with 'objects in general' (see section 1.1.2) has vanished. The drawbacks of Reichenbach's novel approach are the same exposed in section 1.4 against Michael Friedman whose account, not by chance, is exactly inspired by Reichenbach (1920/1965). I will return on Reichenbach's proposal and his related discussion with Schlick in chapter 4.

Alongside Reichenbach and Schlick, Rudolf Carnap's early writings also show a sustained engagement with Kantian terminology, partially justified by his working with the neo-Kantian Bruno Bauch. Although Carnap's *Der logische Aufbau der Welt* (1928/1967) marks a substantial departure from the neo-Kantian framework, it still aims at the "*constitution* of a system of concepts" (*Konstitutionssysteme*). Despite his strong differences with figures such as Cassirer or Natorp, Carnap's use of the vocabulary of constitution indicates a continuity in terminology. In a letter to Reichenbach dated 10 March 1925, Carnap revealed that the title he initially considered for what would later be published as *Der logische Aufbau der Welt* was *Prolegomena zu einer Konstitutionstheorie der Wirklichkeit* (*Prolegomena to a Theory of the Constitution of*

Reality), confirming that such a continuity in terminology with the neo-Kantians is a significant part of his work. The *Aufbau* is centered around the development of a hierarchy of concepts in which each higher-level concept can be derived from those at lower levels. In Carnap's terminology, to derive a concept from another means to transform statements containing the former into statements containing only the latter. Due to the transitivity of these reducing relations, Carnap claims that all concepts of science can be derived from the basis of the constitutional system—which contains elementary sense-experiences, in line with Schlick's epistemology.

The ambitious project of the *Aufbau* has the dual aim of clarifying the structure of scientific statements and demonstrating that all concepts can be integrated into a unified structural framework—thus underscoring the unity of science. Carnap's focus on *definitions* and on the replaceable referential contents of such definitions reformulate within a novel framework both the object-defining and the meaning-conferring dimensions of Kant's 'constitutive'. The considerations of section 1.2.2 about Kant's constitutivity aligns deeply with Carnap's framework, in which, as Coffa describes, "to constitute *X* is not necessarily […] to explicitly define it, but to give the experiential truth-conditions for each sentence where *X* occurs" (Coffa, 1991, p. 233). Thus, the early Carnap is another representative of the 'constitutive tradition', exhibiting a close resemblance to the Kantian and neo-Kantian approaches, as supported by scholars such as Friedman (1999), Haack (1977) Moulines (1985), Richardson (1997), and Sauer (1985).

As mentioned above, the neopositivist tradition provides insight into not only the occurrences of the term 'constitutive' in early philosophy of science, but also how this Kantian notion evolved while changing its name and maintaining its structural role. This claim does not require an examination of the early stages of the neopositivists' careers, as it is based on their more mature and popular theses. The core project of the Vienna and Berlin Circles is based on the idea that philosophy is primarily responsible for *distinguishing between meaningful and meaningless statements*. Their framework concerning the structure of scientific theories, known as the 'Received View' (Suppe, 1974), describes a scientific theory as a language L comprising three elements: LT, a group of terms implicitly defined by theoretical axioms; LO, a group of empirical terms associated with concrete and observable entities; and C, a set of correspondence rules that

bridge the gap between the two vocabularies by associating an empirical term (i.e. a semantic meaning) with every theoretical term. According to Logical Empiricism, all meaningful statements are of two kinds: empirical statements about the natural world, generated by coordinating theoretical terms with empirical experience via correspondence rules, or logical statements — tautologies in the case of true statements and contradictions in the case of false ones.

The set of correspondence rules recalls some significant aspects of Kant's constitutive principles, insofar as they are not merely definitions; they also 'empirically realise' theoretical terms by applying them to empirical phenomena. In Kantian terminology, correspondence rules *make concepts possible*[74] by providing them with referential content (see section 1.2.1). As Suppe stresses, "Correspondence rules serve three functions in the Received View: first, they define theoretical terms; second, they guarantee the cognitive significance of theoretical terms; third, they specify the admissible experimental procedures for applying a theory to phenomena" (Suppe, 1974, p. 17). Although the neopositivists seek to explicitly distance their account from Kant's project[75], their methodological focus on principles that connect otherwise empty concepts to otherwise blind empirical experience is more than merely similar to the Kantian system. This is precisely why they had such a lengthy debate about the most appropriate terminology to describe the fact that non-empirical principles are required to transform perceptions into scientific observations and measurements (Bland 2012, Coffa 1991, Friedman 1999, Oberdan 2022, Padovani 2015).

In developing this quasi-Kantian idea, the logical empiricists also introduce an interesting addition. As anticipated, the correspondence rules provide meaning at both a linguistic and an experimental level. At the latter level, concrete results of measurement processes realize abstract concepts. Here, an *operative nuance* of the constitutive, which was only hinted at in Kant's original account, emerges as a potential enrichment of the same notion. Objects are not merely abstractly constituted via definitions; they are also

[74] Notice that this is the very definition of Kant's constitutive principles in *CPR*, A664/B692.
[75] Although my analysis focuses on the similarities in their methodologies, this should not obscure the fact that Kant and the logical empiricists developed two profoundly different frameworks. For example, Kant's link between constitutive principles and the meaning-conferring role does not preclude domains outside the domain of constitutive principles from having meaning. Regulative principles and ideas of reason, for instance, also play a role in structuring knowledge. In contrast, logical empiricists reduce meaningful statements to those that can be coordinated with empirical experience, largely due to an erroneous interpretation of Wittgenstein's *Tractatus*.

concretely constructed in experiments[76]. Technological apparatuses play a key role in revealing physical events and enabling them to be assigned a truth value. I would therefore reject the overly simplistic interpretation that the role of scientific practice — including experimentation, analysis, and improvement of instrumentation, as well as attention to the concrete artefacts resulting from scientific knowledge — is completely disregarded within Logical Empiricism[77]. The evolution of the notion of 'correspondence rules', first described as 'explicit definitions', then as 'operational definitions' and 'reduction sentences', and finally as 'partial interpretations', demonstrates that the logical empiricists strove to provide a clear and satisfactory evaluation of the evolution of the meaning-conferring dimension of Kant's 'constitutive'. This issue can be considered one of the fundamental dilemmas that shaped their movement.

2.2.3 Husserl and the object-positing dimension

The phenomenological notion of constitution is complex and multifaceted, as Husserl employed it in many instances and with different meanings throughout the various phases of his thought – as better specified in chapter 5. For now, some preliminary remarks may suffice in showing how Husserl inherits Kant's object-positing dimension. Broadly speaking, Husserl describes constitution as the process by which we *intend* an object as both existing beyond our private experience and as presenting itself to us *as something*, i.e. structured with a specific meaning. Referring to Husserl's *Philosophy of Arithmetic* (1891), Robert Sokolowski writes that "The concept of constitution, in the form in which it is developed in Husserl's first work, does suppose that a subjective process produces a form or category which is no longer subjective, but in some way transcends the subjectivity which produces it" (Sokolowski, 1970, p. 19). The theoretical act of constitution originates in the subject, yet its outcome is the positing of a form that is not subjective.

In this context, the rigidity of my claim that each dimension of Kant's 'constitutive' can be assigned exclusively to one constitutive tradition is reduced: the positing involved in Husserl's account already includes a significant element of meaning conferral, thereby inheriting both the object-positing and meaning-conferring dimensions of Kant's

[76] Recall definition (a) and the notion of construction in section 1.1.1. The constitutive role of technological equipment in experiments will be better specified in the next subsection about Husserl and in section 5.4.2.
[77] See for example the *Practice and History Ignored Objection* in Winther (2021).

constitutivity. When Husserl speaks of the constitution of physical objects, he is not only referring to the act of attributing independent existence to them as belonging to an intersubjective world. He also refers to *recognising them as physical objects* and thereby intending their specific meaning. Ströker explicitly integrates the roles of meaning-conferring and positing in describing Husserl's concept of constitution: "According to Husserl, the productive capabilities of consciousness are solely bestowing, that is, sense-bestowing capabilities. The acts which posit being do not produce being, they *posit* being" (Ströker, 1997, p. 94). The notion of positing here should be understood in the same sense as in section 1.1.3: it refers to the attribution of existence (being) to objects or events that founds their objectivity.

Both the *Logical Investigations* (1900–1901/1970) and the three volumes of *Ideas* (1913/1982, 1952/1989, 1952/1980) trace the development of the notion of constitution. They emphasize, more explicitly than the neo-Kantian and neopositivist traditions, that constitution grounds the *correlational structure* linking subjectivity and reality. Phenomenological constitution aims to disclose objects as what they are by making their intended sense explicit. Husserl's concept of constitution is relevant to any observational procedure in the exact sciences, where data are intended to indicate a specific phenomenon. In his 1610 observations of the moon, Galileo was phenomenologically constituting the moon as an irregularly-surfaced celestial body. The fact that this observation goes well beyond simple perception is demonstrated by scientists who did not believe Galileo and interpreted the same data as telescope distortions – like Giovanni Antonio Magini (Bucciantini, Camerota and Giudice, 2015). A more recent example is the 290,000 bubble chamber photographs taken by physicists at CERN and NAL in 1973. Complex statistical analysis, theoretical explanation and conceptual justification were required to interpret these data as interactions between neutrinos and charged particles (Bogen and Woodward, 1988; Schindler, 2009). In these cases, scientists were neither actively producing nor passively registering the studied phenomena, but rather *constituting* them as specific physical systems.

According to Husserl, *consciousness* is the condition through which the sense of reality takes shape. The notable point in Husserl's analysis is that the same constitutive process that establishes objects as real *also establishes consciousness as the consciousness of those objects*. Constitution not only articulates the sense of intentional objects so that they

can be intended as what they are. It also folds back onto the intending side, shaping consciousness as the pole that relates to a given state of affairs.

A renovated and clearer description of the object-positing feature emerges here: when subjectivity is constituted *as subjectivity* through the very process of constitution, it simultaneously *differentiates itself from what it intends*. This differentiation makes it possible to regard the facticity of the intended object as transcendent, meaning that it belongs to a reality independent of the subject. This is pivotal because it allows perceptual objects to be understood as both *irreducible* to consciousness and yet thinkable only insofar as they remain *accessible* to it. Within this framework, constitution becomes the sole fundamental notion. Both the subject and reality are constituted through the same generative process.

Having concluded the preliminary—and inevitably selective—analysis of the complex and multifaceted reformulations of Kant's 'constitutive' in neo-Kantians, logical empiricists and Husserl, I will now move to their different answers to the problems of *what* is constituted and *who* constitutes in the epistemological process of constitution.

2.3 Constituting objects versus concepts

The assertion that certain presuppositions are necessary to transform mere sense data into scientific observations is trivial. What is not trivial, however, is the precise characterization of the status of these presuppositions and the subsequent accounting for the relationship between the constituting theory and the constituted reality. For example, Oberdan stresses the difference between the early Reichenbach's view of the a priori and Schlick's, stating that "On Reichenbach's understanding, the apriori constitutes the objects of experience and knowledge whereas, on Schlick's, conventions only constitute concepts, which may be applied to experiences and objects, but do not constitute them" (Oberdan, 2022). The issue of concern was then on the *target system* of the principle's constitutional activity. One thing is to claim that some logical and mathematical criteria ground scientific theories, and another is to claim that reality itself is subjected to certain principles. This distinction extends beyond the debate between Schlick and Reichenbach on the a priori and leads to a general distinction between kinds of constitutive principles.

Now, let's take a closer look at the dichotomy between concepts and objects. In Chapter 1, I demonstrated that Kant's 'constitutive' applies to both concepts and objects,

i.e. to predicates and their corresponding arguments. This follows directly from Kant's understanding of 'constitution': when an object conforms to the criteria to be posited as existing — that is, when it is subsumed under pure concepts — the pure concepts simultaneously gain referential content. In this way, transcendental philosophy connects reality to our conceptualisation of it. The revolutionary developments of twentieth-century science multiplied the ways in which the same reality — for example, the same data — can be arranged and explained. The object 'triangle' can be interpreted according to either Euclidean or non-Euclidean geometrical concepts. The interactions between celestial bodies in our solar system can be described using either the classical concept of 'force' or the relativistic concept of 'spacetime curvature'. Crucially, this multiplication of conceptual frameworks does not imply that they are all equally correct. On the contrary, both empirical evidence and extra-empirical considerations can incline us towards a more adequate concept instantiated by objects. The point remains that, in the twentieth century, the conceptual and objectual sides of the epistemic process underwent a split that led to different accounts concerning what constitutive principles refer to.

This distinction concerns the difference between the presuppositions required to formulate scientific concepts, and the presuppositions that stipulate the existence or behaviour of objects themselves. Both are non-empirical assumptions of scientific knowledge, but the former relate to the concepts used in a theory, while the latter relate to the entities that the theory is concerned with. I propose clarifying this distinction by differentiating between *concept-constitutive* and *object-constitutive* principles.

A principle is *concept-constitutive* when it enables a description of reality without directly referring to reality itself. In this sense, differential calculus is concept-constitutive of the concept of acceleration in Newton's laws of motion, as it provides the tools necessary to define acceleration as the second derivative of position with respect to time. Another example is Einstein's convention regarding the two-way speed of light, which is concept-constitutive for the notion of simultaneity (Falkenburg, 2007, p. 32). Einstein's definition of simultaneity (Einstein, 1905) can be realised in practice by sending light signals between clocks or mirrors and back again, on the assumption that light travels at the same speed in both directions. A third example is the assumption that the Big Bang represents the 'time-zero' event for defining the age of the universe. This principle does

not dictate that the universe must have begun with the Big Bang, but it is necessary in order to give meaning to the concept of the 'age of the universe' in cosmology.

Conversely, principles are *object-constitutive* when they prescribe how nature itself must behave. Examples include the assumption of the mathematisation of nature, whereby physical events, systems and empirical properties must be amenable to mathematical description – usually through differential equations; the principle of uniformity, which states that future events must resemble past ones; the strong law of large numbers, which stipulates that future research data will converge towards a specific value; and the principle of genidentity, which prescribes that "the same thing remains identical to itself over time" (Reichenbach, 1920/1965, p. 53). Although these principles form part of scientific theories and consequently involve concepts, they also define reality and stipulate how nature must behave — at least according to advocates of this kind of constitutive principle à la Kant.

The distinction between concept-constituting and object-constituting principles involves a similar contrast in the analytic or synthetic nature of the presuppositions involved. The principles that define the fundamental concepts of a theory may be considered analytic because they do not involve direct experience. Conversely, principles applied to reality itself expand our knowledge by moving beyond mere analyticity and becoming synthetic. Advocates of both perspectives not only discussed what is constituted by principles, but also the conception of 'reality' and 'conditions' that followed from their respective frameworks.

Schlick exemplifies the account of constitutive principles as analytic presuppositions defining only our concepts. Although they developed two deeply different versions of conventionalism, Schlick inherits from Poincaré the idea that the presuppositions needed to formulate our theories do not constitute nature itself. Poincaré (2018, p. 1) lists the kinds of hypotheses playing a role in scientific knowledge. Among them, freely created conventions serve as definitions of the concepts employed in a theory, like the definitions of space, time, and motion at the beginning of Newton's *Principia*, or as rules to develop the formalism of a theory, like the axioms of Euclidean geometry. However, Poincaré stresses that "while these decrees apply to our science which would be impossible without them, they do not apply to nature." (Poincaré 2018, p. 2). Schlick defends the same thesis in his correspondence with Reichenbach, where he warns against the error of confusing

"the concept of reality with reality itself… An illusion to which the Marburg neo-Kantians have fallen prey." (Schlick, 1921).

Contrary to Schlick's criticism, the Marburg neo-Kantians have not confused concepts and objects, but only merged them as integral parts of a single constituting process. They understood reality itself as inextricably bound to the principles at the basis of scientific knowledge. Hence, providing meaning to concepts and positing their objects as real become two parallel and symmetric processes. Of course, the nature or reality of neo-Kantians is not the same as that Schlick had in mind: reality is the outcome of a task according to the former, while it represents an independent ground prior to our theories according to the latter. The constitutive principles they envision are different as well: Natorp (1887/1981, p. 264) and Cassirer (1936/1956, p. 58) employ the idea of constitutive principles with reference to transcendental conditions of experience. An example of such transcendental constitutive principles is the *principle of causality*, which concerns the fact that nature can be described objectively through mathematical laws. Conversely, Schlick's example of a principle that turns perceptions into scientific data—which is his understanding of the role of a constitutive principle – is that stipulating the conventional choice of clocks over the Dalai Lama's heartbeat to define time (Schlick 1974, p. 72). Such a choice concerns how to measure time better, and not what time itself is. Thus, Schlick transposes the issue onto an empirical plane.

Beyond logical empiricists and neo-Kantians, the view of constitutive principles as targeting objects can also be found in Husserl. And yet, Husserl's notion of constitution refers more to an activity of *unveiling* rather than applying principles. We constitute objects not by projecting some meaning, but rather by grasping them as they are given. Phenomenological constitution involves the idea that consciousness plays a role in intending an object *as that object*. Since phenomenology studies multiple intentional acts — perceiving, remembering, imagining, hoping — it concerns many kinds of objects — physical, logical, imagined — investigated by what Husserl calls *regional ontologies*. Although the various objects of different regional ontologies vary in features and constitution, they are all unities of a spatial and temporal multiplicity. Spatially, objects appear in adumbrations, namely, within specific perspectives that can change, thereby gradually revealing the angles, tones, and dimensions of that object. Temporally, objects are part of a network of events, contributing to an evolving process. Objects result from

the unification of multiple spatial and temporal dimensions of phenomenological experiences. These unities are exactly the target of phenomenological constitution. In *Ideas I*, Husserl presents phenomenology as an inquiry into "how Objective unities of any region and category are 'constituted in the manner peculiar to consciousness'" (Husserl, 1913/1982, p. 209).

Not only does Husserl's constitution refer to many kinds of objects, but these objects require various kinds of constitutions. In perceiving, imagining, or remembering some content, different intentional acts shape the sense of their objects in multiple ways that cannot be reduced to a single, monolithic framework. Beyond the evident difference of Husserl's lexicon from that of the neo-Kantians and logical empiricists, their implementation of the term constitution diverges conceptually. In Husserl's late framework, objects—intended as unities of meaning—are constituted by sense-bestowing intentional acts that posit them and intend them for what they are.

A crucial lesson drawn from this subsection is that many different principles are gathered under the common label of 'constitutive'. By assuming the fundamental difference between concept-constitutive and object-constitutive principles, other differences emerge, involving the level of investigation (transcendental, empirical, or phenomenological) and the kinds of principles that are investigated (metaphysical principles, pragmatical presuppositions, or physical laws). Still, all of these uses share the common root of Kant's philosophy, which motivates their focus on the very same term — *constitution*.

2.4 Who constitutes?

The very act of constituting something intuitively presupposes a constituting agent. But who is the subject that decides upon and employs the constitutive principles articulated within the various post-Kantian traditions? Beyond the target and the scope of such principles, authors diverge significantly also on this issue—some even rejecting the question itself as meaningless.

If Kant rightly represents the starting point of this concern, his framework nonetheless proves unsatisfactory for those seeking precise and uncontroversial answers. What emerges from Kant's transcendental philosophy — and from the long tradition of scholars and commentators engaging with it — is a fundamental tension that runs through nearly

all post-Kantian reformulations of the 'constitutive'. This tension lies between, on the one hand, describing a subject that actively constitutes, and, on the other, dissolving the strong notion of a subject altogether in favor of acknowledging a set of conditions — whether self-imposed or otherwise — under which constitution occurs[78]. It is not that Kant lacks explanations about his account of subjectivity, or that he conflates the empirical and transcendental levels of investigation. As Carr stresses,

> It is the [pure], and not the [empirical apperception], that constitutes the supreme condition of our knowledge of the sensible world. […] Kant is saying that the possibility of experience requires that I be self-conscious in a special way. And it is in connection with this distinction between two forms of self-consciousness that any distinction between a transcendental subject and an empirical subject must be understood. (Carr, 1999, p. 27)

Moreover, Kant lucidly recognises the paradoxical nature of consciousness, admitting the difficulty of a precise account of the self (*CPR*, B152-B156). Allison (2004), Carr (1999, pp. 56-65), and Prauss (1974) represent some of the many attempts to provide an interpretation of Kant's concept of subjectivity. Nevertheless, I do not aim here to outline the details of Kant's own account. The inquiry into the development of constitutive principles in the post-Kantian traditions requires instead an overview of their inheritance of Kant's tension, and how they packaged their framework on constitution so that the question of who constitutes is answered or, alternatively, deflated as meaningless.

Such a shift in analysis broadens the landscape of approaches, so that both of the aforementioned alternatives—constituting subject versus impersonal constitution—admit further sub-distinctions. The claim that a subject underlies the activity of constituting experience can be specified in several ways: as a concrete human being, as a collective of individuals, or as a transcendental subject—whatever that latter term may signify. Conversely, the claim that the articulation and application of constitutive principles do not result from the deliberation of a constituting agent can be further detailed as involving rules collectively formulated within a community, a set of self-imposed criteria, or a cluster of impersonal logical and epistemological assumptions. Individual authors within the various post-Kantian traditions often oscillated between these readings, avoiding a

[78] Heinrich (1969) partially confirms such a tension in his criticism of the relationship between the empirical and the transcendental I.

straightforward characterization of 'who constitutes'. For this reason, a viable strategy to survey their approaches is to directly analyse the two options of conceiving the 'constitutor' as (i) a transcendental subject that almost dissolves into a set of impersonal conditions, or (ii) an empirical subject, part of a concrete community of individuals. The advocates of each respective view will be various authors, sometimes belonging to different traditions.

Cassirer, Husserl, and Schlick defend different accounts of subjectivity, while all employing the term '*consciousness'* to describe it. Despite their differences, they all agree in portraying consciousness as more than just 'being conscious of something'; consciousness represents instead the unity between the multiple experiences, sense data, and contents of mind.

In *Substance and Function* (1910), Cassirer underscores that reality "comes to consciousness in different ways; thus at one time we consider it in its sensuously intuitive character but in its sensuous isolation, while from the standpoint of science we merely retain those elements in it, which are at the basis of its intellectual connection and 'harmony'." (Cassirer, 1910/1953, p. 66). Consciousness is here characterized as the activity underlying both perception and a more sophisticated conceptualisation of reality, i.e., both constituting ordinary and scientific experience.

Cassirer goes even a step further, specifying that consciousness would not exist without the very interrelation between these two domains—sensation and conceptualisation. Indeed, in the section "On the Psychology of Relations", he points out that

> Consciousness *as consciousness* would be extinguished, not only if we conceived the sensuous phenomena, such as the colors and tones, the smells and tastes to be removed, but also if we conceived the 'metaphenomenal' objects, such as plurality and number, identity and difference to be removed. The existence of consciousness is rooted entirely in the mutual correlativity of the two elements, and neither is to be preferred to the other as 'first' and 'original'" (Cassirer, 1910/1953, p. 340).

This view is continuous with the previous sections: Cassirer stresses the mutual dependence of sensing and conceptualising. The very operation of making "one from many" according to rules represents Cassirer's notion of consciousness.

This argument is furthered in the first volume of his *The Philosophy of Symbolic Forms* (1923/1980). In the Introduction, Cassirer stresses again that consciousness represents the unitary invariant between a multiplicity of elements: "The synthesis by which the consciousness combines a series of tones into the unity of a melody, would seem to be totally different from the synthesis by which a number of syllables is articulated into the unity of a 'sentence.' But they have one thing in common, that in both cases the sensory particulars do not stand by themselves; they are articulated into a conscious whole, from which they take their qualitative meaning" (Cassirer, 1923/1980, p. 94). Meaning arises from the synthesis of discrete parts enabled by consciousness. Furthermore, Cassirer links in a crucial passage consciousness with the act of positing, characterized in chapter 1 as a definitional aspect of Kant's constitutive principles: "It lies in the nature of consciousness that it cannot posit any content without, by this simple act, positing a complex of other contents." (Cassirer, 1923/1980, p. 97). This recursive act of positing suggests that consciousness can provide meaning to experience in multiple ways. Here, Cassirer opens to the idea of many symbolic forms that pertain to the various domains of human knowledge, and consciousness seems to underlie the constitution of all the different symbolic domains of reality.

Two aspects of Cassirer's account remain rather obscure: which kind of subjectivity he conceives when referring to consciousness, and whether such consciousness is prior to experience or not. With respect to the first issue, Cassirer inherits the Kantian tension between empirical and transcendental subjectivity. On the one hand, he refers to consciousness as our unitary activity of sensing and knowing: such activities pertain to us as empirical subjects, with flesh, blood, sensory organs, and brains. On the other hand, Cassirer's analysis of knowledge is not psychological: he is not interested in how we actually come to know reality while growing up, in a neurological and biological sense. Insofar as it is transcendental, his methodology reveals how objects are cognised from an epistemological perspective. His subject, in this second sense, becomes an epistemic fiction—a model that abstracts from the concrete and contingent factors through which humans grasp reality, while highlighting the conditions without which knowledge would not be possible in general. This abstract model ascribes to the so-called *transcendental subject*, although Cassirer rarely employs such a term.

The second issue is strictly related to the first: while the transcendental subject might be considered the one who constitutes reality via principles (and symbolic forms), we as empirical subjects constitute ourselves while conceptualising sensations. Cassirer's account provides deep insights into the notion of consciousness and the interrelation of sensibility and spontaneity, while nonetheless remaining vague with respect to the very question of this subsection. Although his neo-Kantian framework depicts objects as the result of a task, requiring us to gradually constitute them by applying principles and symbolic forms, he does not specify *who* really does such an activity.

Husserl tackles more deeply the relationship between the empirical and transcendental subject. This is not surprising as phenomenology represents a science of *consciousness*: it studies *what it means to be a self,* to have first-person experiences. This is what already emerged in section 2.2, namely that the phenomenological constitution of objects implies a parallel constitution of the I. As the intentional activity opens to a variety of modes of constitution, the concept of subjectivity is also polyhedral in Husserl's philosophy. This is confirmed by the fact that Husserl uses various terms to refer to different aspects of subjectivity: the empirical subject, the transcendental subject, the Monad, the subjective pole, the Pure I and the phenomenological ego[79]. I will only focus on the first two notions — the empirical and transcendental subject. While Husserl distinguishes them, he also ascribes them to the very same subjectivity, so that they appear as two faces of the same coin. It may be reasonable to introduce the distinction by hinting at Husserl's anti-psychologism. Such a view enables one to avoid the weighty error of conflating Husserl's empirical and transcendental subjectivity. After this helpful clarificatory digression, Husserl's answer to the question of who enacts the constitutive sense-bestowing activity will emerge more naturally.

In the late nineteenth century, many influential positivists—such as Mill, Lipps, and Spencer—advocated psychologism, the view that logic is merely a branch of psychology. According to this position, logic studies the articulation of judgments, inferences, and thought in general, which are themselves products of human intellect. Hence, the argument goes, logic concerns psychological activities. The fact that logic prescribes how

[79] While 'subjective pole' indicates a specific moment or 'side' of the lived experience, which is opposed to the objectual side of experience, the 'Pure I' represents the non-reducible unity of these experiences. The late Husserl develops the notion of 'Monad' to specify how the Pure I acts within consciousness and is concretely embodied. For an overview of these distinctions, see Altobrando (2010).

we must think, rather than merely describing how we ordinarily think, does not, from the psychologistic standpoint, diminish its psychological character: valid arguments, true conclusions, and correct reasoning—the domain of logic—are simply a special case of the broader psychological processes of arguing and thinking (Husserl, 1900/1970, pp. 41–43).

Husserl, following Kant[80], the neo-Kantians (such as Herbart and Lotze), and Frege, opposed this view by sharply distinguishing between the "here-and-now" thoughts of empirical individuals and the categories, inferences, and concepts studied by pure logic, which are characterized by universality. The project of the *Logical Investigations*—especially Parts III–V of the Prolegomena—is devoted to separating our contingent psychological modes of thinking from the analysis of logical concepts and their ideal structures. Husserl's well-known refutation of psychologism draws on multiple arguments. Among them, he stresses that the contingent circumstances in which inferences are made have no bearing on the validity of those inferences. Psychologism, he argues, commits a categorical mistake in conflating the ideal realm of logical objects with the real realm of concrete reasoning.

Since Husserl's anti-psychologistic arguments are reiterated throughout his later works, it is important not to confuse his inquiry into the relationship between transcendental and empirical subjectivity with the claim that concepts are contingent products of human reasoning. In the *Logical Investigations*, Husserl approvingly quotes Lotze's assertion that, among the objects of logic, "Nothing relates to the thinking subject, to which concepts can only be attributed in a psychological sense, whereas the concept of Man, of Triangle, etc., is no one's property" (Lotze, in Husserl, 1900/1970, p. 136).

When it comes to phenomenological constitution, Husserl confirms his distinction between the sensible, empirical subject who lives mundane here-and-now experiences, and consciousness, which unveils the meaning of objects and whose analysis abstracts from the concrete reality. And yet, the issue is not that simple. Indeed, according to Husserl, both subjectivities belong to us. Zahavi explains this point well by stating that "The relation between the transcendental subject and the empirical subject is not a relation between two different subjects, but between two different self-apprehensions, a primary

[80] Kant's anti-psychologistic considerations on logic are quoted by Husserl himself (Husserl, 1900/1970, p. 41).

and a secondary. The transcendental subject is the subject in its primary constitutive function. The empirical subject is the same subject, but now apprehended and interpreted as an object in the world, that is, as a constituted and mundanized entity" (Zahavi, 2003, p. 49). While the transcendental subject is constitutive, the empirical subject is constituted. The transcendental subject emerges when we reflect on our experience, treating our empirical subjectivity as one among other objects of investigation. Husserl indicates the method by which ordinary experience is bracketed to reflect upon it with the label *phenomenological reduction* (see section 5.3). By suspending the belief that the world around me exists, I only focus on how the world is intended by me. Thereby, I realize that I am also a transcendental subject who posits and confers meaning with intentional acts to objects. As Carr specifies, the self splits into "the self of which I am conscious" and "the consciousness of the self" (Carr, 1999, p. 86).

Both the empirical and transcendental subjects contribute to constituting objects. The notion of empirical subject, as a concrete living body (*Leib*) with social relations, will prove crucial in the analysis of chapter 5. The notion of transcendental subject is shared by Husserl with Cassirer and the neo-Kantians, and yet Husserl's characterization is more explicit. The transcendental subject is not a thing, but a condition for the meaningful appearance of things in phenomenological experiences. As Carr stresses, "this subject can be seen as the source, not, of course, of the existence of the world or the things in it, but of their meaning, and indeed their status as objects and as world for a subject" (Carr, 1999, p. 91).

A pattern emerged in both Husserl's and Cassirer's analyses of consciousness. Indeed, their accounts of constitution point beyond the individual. Empirical subjects are not the 'constituers', but rather the inhabitants of a reality subjected to constitutive principles. For this reason, they both open to a 'subjectless' approach, in which the question of who applies the constitutive principles becomes meaningless: there is no who. Simply, reality fulfils certain conditions to be meaningful.

Cassirer does hint at such a view in some of his works. In the first volume of *The Philosophy of Symbolic Forms*, he claims that "Every particular belongs from the outset to a definite complex and in itself expresses the rule of this complex. It is the totality of these rules which constitutes the true unity of consciousness, as a unity of time, space, objective synthesis, etc." (Cassirer, 1980, p. 102). Here, consciousness does not seem to

refer to a subject that enforces rules to unify experience; rather, it refers to the set of rules themselves. This account appears to offer a clearer interpretation of Cassirer's philosophy than the previous attempt to 'embody' his notion of consciousness within subjectivity. Furthermore, this approach aligns with the Marburg School's account of subjectivity. Hermann Cohen explicitly dissolves the Kantian subject into a 'subjectless' set of conditions. According to Cohen, the subjectivity described in relation to the application of the synthetic principles of the understanding is not a specific conscious entity or a psychophysical structure, but rather a logical requirement for constructing experience (Ferrari, 1988, pp. 31-36). As Pringe outlines, "According to Cohen, the unity of consciousness is just the unity of the principles that constitute the most general laws of nature. In this unity there is therefore nothing that can correspond to an individual subject" (Pringe, 2017, p. 120).

While agreeing with Cohen's anti-psychologistic interpretation of Kant's conditions of experience, Natorp believes that the analysis of how an object in general can be cognised should relate to the actual way in which empirical subjects cognise. However, his account of internal experience does not involve a concrete human being, which could lead to accusations of subjectivism and psychologism, but rather the *general way in which objects appear*, or, alternatively, the very fact of being conscious of something (Pringe, 2017, p. 125). Therefore, Natorp departs from Cohen's approach to the problem in that he places greater emphasis on the individual correlate of the universal act of constructing experience. At the same time, however, he maintains the idea that the subjective part of the constitutive activity is not represented by a specific cognitive or psychophysical structure, but rather by a particular instance of a universal law. Without this reference to the concrete, the latter would not exist. Luft clarifies that, according to Natorp, "Subjective life cannot be directly described but only reconstructively explained. The only 'positive' and irreducible structure of consciousness (*Bewußtsein*) that one can discern is the *fact that it has (something) conscious*" (Luft, 2015b, p. 215). In other words, for Natorp the subject designates a *moment* or a *pole*—in Husserlian terms—within the process of experiencing reality, rather than a reference to human beings as organisms endowed with a specific cognitive structure. This confirms that the neo-Kantians, despite their internal differences, broadly agree in rejecting the empirical subject as the 'constituter' of experience.

Husserl's approach also opens up the possibility of impersonal constitution. Husserl characterizes the transcendental subject as the process of connecting experiences. In *Ideas*, it is described as the phenomenological ego, which coincides with the unifying activity of consciousness: "The phenomenologically reduced ego is therefore nothing peculiar, floating above many experiences: it is simply identical with their own interconnected unity" (Husserl, 1913/1982, p. 541). There is not really a duality of an intended object and an ego that applies intentional acts. Husserl is interested in disclosing the conditions of appearance of things, thereby unpacking the invariant structure of phenomenological experience. Gurwitsch (1941) and Kitaro (1987) represent two attempts to make explicit the idea of *dissolving the subject*, within a respectively Husserlian and neo-Kantian framework (see Sakakibara's and Métraux's contributions in Luft, 2017). Nevertheless, it should be noted that focusing on a set of impersonal constitutive principles of experience does not really address the question of how such a set can be established or applied by concrete human beings.

Schlick demonstrates more interest in the enactment of constitution by concrete subjects. While refuting the transcendental nature of constitutive principles and the very Kantian lexicon to label them, Schlick nonetheless admits that some principles are needed to turn mere perceptions into scientific data and precise measurements. Additionally, he does not ignore that scientific theories rest on conceptual assumptions and theoretical criteria. This group of conventional principles, which will be better delineated in chapter 4, derives generally from decisions of the scientific community: they represent shared standards that can evolve through time as technology and methods advance. However, the main character of the epistemic process of knowledge, according to Schlick, remains *the singular individual,* who receives in the first place those perceptions to which principles are applied. For this reason, multiple passages in Schlick's works point to the empirical subject as a key element in the process of knowledge.

In section §17 of his *General Theory of Knowledge*, Schlick highlights that we do not perceive, feel, or imagine unrelated contents; conversely, these contents are ordered so that they compose our experience of objects, people, and intelligible events. To pinpoint this aspect of knowledge, Schlick employs the term *consciousness* or *soul*, which is "reserved for the totality of 'contents' or mental processes that at the time are joined into a unified whole" (Schlick, 1974, p. 123). The captivating facet of Schlick's framework

consists of his attempt to demystify such terms, ascribing them to the psychological subject. On the one hand, by simply deflecting the discussion, he discards the authors—such as Hans Driesch—who associated consciousness with metaphysics and vitalism. On the other hand, Schlick describes the features of consciousness as psychological aspects needed to elaborate experience and gain knowledge, such as attention to distinguish concepts, or memory to retain ideas. These aspects of consciousness enable us to compare and connect sensations over intervals of time, thereby yielding a unitary experience. And yet, mental contents are not really things or substances, but rather the set of operations from which our knowledge of the world derives: "consciousness (mind, soul) is a process" (Schlick, 1974, p. 134).

The issue of subjectivity as the starting point of knowledge also arises in Schlick's contribution to the infamous problem of 'protocol sentences'. In the 1930s, the logical empiricists discussed which kind of propositions set out the facts on which scientific knowledge is based. As Schlick writes in the article "On the Foundation of Knowledge" (1934), "'protocol propositions' originally meant those propositions which in absolute simplicity, without any forming, change or addition, set forth the facts, whose elaboration constitutes the substance of all science, and which are prior to all knowledge, to every claim about the world" (Schlick, 1934/1979, p. 370). Schlick regards as genuine protocol sentences those that refer to the *assertions about the immediately perceived*, also called 'observation propositions' or 'affirmations' (*Konstatierungen*). Schlick outlines the form of affirmations as "Here now so-and-so" (Schlick, 1934/1979, p. 382). Crucially, these propositions are subjective, pronounced by single individuals. Schlick defines genuine protocol propositions as generalizations of affirmations that specify the time, place, and subject of the observation. His example is the affirmation pronounced by Schlick, "Here, now, blue"—while indicating with a gesture something blue—from which the protocol sentence "On *x* date, at *y* place, Schlick perceived blue" can be derived. After having formulated an assertion and derived a protocol sentence, one would then compare his protocol—treating it as a hypothesis—with those formulated by other people. When the circumstances in which the observations described in these assertions are rigorously specified and these same assertions of different individuals agree, then scientific knowledge starts to emerge (Schlick, 1934/1979, p. 381).

By considering affirmations as "the unshakeable points of contact between knowledge and reality" (Schlick, 1934/1979, p. 387), the empirical subject—as a demystified consciousness—and his cognitive ability to order experience become the only admissible 'constituer' of scientific knowledge within Schlick's epistemology. It is not that the axioms and principles of theories can be articulated by single individuals, but rather they result from a complex inductive process of comparison between hypotheses. These hypotheses, in turn, are a sophisticated generalized version of private experiences. But this means that the principles at the basis of science *indirectly rely* on these private experiences—the affirmations.

Schlick's account of meaning further supports this claim. Any synthetic statement—which means, any statement that does not pertain to logic—can be endowed with meaning only when reducible to protocol sentences. In his article "Meaning and Verification" (1936), Schlick formulates his popular principle of verification:

> Stating the meaning of a sentence amounts to stating the rules according to which the sentence is to be used, and this is the same as stating the way in which it can be verified (or falsified). The meaning of a proposition is the method of its verification. (Schlick, 1936/1979, p. 458)

The significance of this principle arises only by specifying what a method of verification consists of. Schlick's idea of verification involves the correlation of any theoretical term of a theory—or of a scientific statement—with an empirical term, which refers to our concrete experience. And yet, what are the terms that refer to empirical experience? Again, the process of knowledge arrives at the ground level of protocol propositions and, consequently, of affirmations. The spark of subjective empirical experience strikes the match of verification and, subsequently, of meaning itself. Empirical individuals end up exhibiting a *meaning-conferring role*.

Schlick refutes the very idea of constitutive principles *à la* Kant, substituting them with conventions that define the basic concepts of theories, and he suddenly finds himself with the issue of who enables such a definitional role of conventions. His only option, as an empiricist, is the empirical subject, burdened with the task of conferring meaning to concepts by relating them to immediate observations. Multiple drawbacks backfire on Schlick's attempt to set aside the vague transcendental approach of neo-Kantians: the intersubjectivity of knowledge cannot be assured, the fundamental role of affirmations

cannot be demonstrated, and the possibility of pre-conceptualised given experiences is uncritically assumed.

Schlick's effort to ground empirical propositions on qualitative statements about private experiences was countered by other logical empiricists, who considered the *quantitative* statements of physics as fundamental. Carnap identifies Otto Neurath as the first to suggest this attitude, which could also be seen as a Wittgensteinian legacy[81]:

> Neurath was also the first […] to demand constantly the rejection of formulations in terms of 'mental experience '. He rejected the comparison between statements and 'reality ', insisting that the correct mode was in terms only of statements and stated the thesis of physicalism in its most radical form. (Carnap, 1932/1995, p. 74)

Such linguistic physicalism, which supports a coherentist concept of truth rather than a corrispondentist one, enables the conceivability of *intersubjectivity* in science, recovering this notion from Schlick's more "subjective" philosophy of *Erlebnisse*, and also of a unified science (*Einheitwissenschaft*), that includes all knowledge of the individual scientific disciplines. The price to pay, on the other hand, is the abandonment of an apodictic and secure ground upon which science is built[82]. This leads to an idea of science as a fallible enterprise, famously represented by Neurath with the image of a ship that we have to repair: "There is no way to establish fully secured, neat protocol statements as starting points of the sciences. There is no tabula rasa. We are like sailors who have to rebuild their ship on the open sea, without ever being able to dismantle it in dry-dock and reconstruct it from the best components" (Neurath, 1983, p. 92).

Carnap's and Neurath's views suggest a possible alternative to the problem of who lies behind the process of constituting nature—in the sense of formulating principles and necessary conditions for objectivity. Indeed, they shift the focus from the *private* to the *public*, from the *scientist* to the *scientific community.* This shift, first suggested by C.S. Peirce, sets aside the vague notion of a transcendental subject and the solipsism of Schlick's view. Instead, it emphasises the role of historically situated groups of scientists who share assumptions, report the results of experiments and observations, and cooperate

[81] Wittgenstein sent a letter to Schlick (May 6, 1932), complaining about Carnap's non-recognition of his crucial legacy. It is, indeed, a Wittgensteinian idea the fact that the language of physics is *the* universal language. The whole dynamic is in Hintikka, Hintikka (1986), pp. 217-219.

[82] Severino (2005, pp. 427-482) stresses that Schlick's subjectivism derives from his concern for an apodictic foundation of knowledge.

in explaining and predicting phenomena. However, the attribution of the 'constituting activity' to the scientific community appears to be effective only within a limited range of principles, specifically the concept-constitutive principles considered by logical empiricists and discussed in section 2.3.

The scientific community does play a role in setting standards and criteria for measurements, experiments and observations; additionally, individuals or groups formulate hypotheses that only become scientific theories after undergoing a process of conceptual analysis and empirical verification involving the entire community. Nevertheless, assumptions such as the principles of lawfulness, causality and determinism, as well as the law of large numbers and genidentity, have been mentioned as example of constitutive principles and they appear to lie beyond the control and intention of scientists, functioning as impersonal assumptions—or, alternatively, as a priori conditions imposed within a transcendental methodology.

Consider also the assumption that a succession of discrete points in a data set representing different observations can symbolise a continuous phenomenon. Most of these principles may be considered *object-constitutive* and have a normative status that seems independent of the methodological needs and pragmatic choices of scientists. As explained in section 2.2.1, laws of nature themselves are constitutive within the neo-Kantian epistemology as they define what qualifies as an object according to specific theories. Can they be ascribed to the decisions and procedures of the scientific community? And who, in fact, is part of it? Once again, the idea emerges that some principles may be impersonal assumptions necessary for enabling knowledge in general. This raises the whole issue of the meaning and application of constitutive principles in science again, highlighting the complexity of the matter and prompting a variety of approaches and interpretations.

In this subsection, the advantages and drawbacks of various accounts concerning the subject underlying constitution have been examined. The neo-Kantian appeal to a transcendental subject provides both necessity and intersubjectivity to the constitutive process, but risks vagueness when it comes to precisely specifying its terminology. Schlick's focus on the single empirical subject offers greater clarity, yet falls prey to accusations of solipsism — namely, its inability to ground intersubjective knowledge. The developments of Logical Empiricism in the 1930s, through the works of Carnap and

Neurath, shifted the emphasis toward social groups of individuals. While this move set aside the solipsistic tendencies of Schlick (and Wittgenstein), it fails to account for the generality of most object-constitutive principles.

Husserl's writings provide a series of indications addressing both the notion of a transcendental subject and its relationship to the "flesh-and-blood" empirical subject. Furthermore, later phenomenologists and neo-Kantians (from Gurwitsch to Kitaro) sought to extend Husserl's view by referring to impersonal acts that require no underlying subjectivity. To me, the latter approach seems best suited to addressing constitutive principles as a set of impersonal conditions for scientific knowledge. This approach dissolves the issue of who underlies them.

As in the previous section, it seems reasonable to assess all these accounts as being directly tied to the particular notion of constitution they entail. Constitutive principles such as the law of causality, the fact that nature exhibits lawful regularities, or the principle of uniformity, do not appear to depend on specific communities. They can be regarded as impersonal — in the sense of being independent of empirical individuals — criteria without which nature would not be as it is. Although the notion of transcendental subjectivity lacks a precise definition, it may be plausible to assign these principles to a universal mode of cognising reality. By contrast, more empirical principles — such as the choice to measure time with clocks or the preference for simpler laws — seem to exhibit a conventional nature, insofar as they are determined within the scientific community and remain open to discussion and revision.

Does this simply mean that the various post-Kantian traditions identified different principles as constitutive — while agreeing on the respective notions of subjectivity underlying each of them — or does it indicate that they proposed different 'constituers' for the same principles? Answering this question is tricky, since in any comparison between the various post-Kantian traditions, *conceptual dissent often lurks behind terminological consensus, and vice versa*. To take a stand, I would insist that they all started with a grounding account of *how reality is constituted* — for example, through laws and a priori principles, conventions applied to sense data, or intentional acts of consciousness — and such a view had led them to subsequent divergent perspectives on subjectivity, objectivity, and modality.

Conclusion

The concept of constitution and constitutive principle plays a crucial role for Marburg neo-Kantians, logical empiricists, and phenomenologists[83]. As shown in section 2.2, many occurrences of this same notion can be found in the works by Natorp, Cassirer, Schlick, Reichenbach, Carnap, and Husserl. The neo-Kantians employed it to refer to the priority of laws to reality. Laws of nature constitute objects by defining them as what conforms to specific functional dependencies. The logical empiricists turned proper constitutive principles into correspondence rules and coordinative axioms aimed at correlating abstract concepts with concrete experience, thereby providing a method to distinguish between meaningful and meaningless statements. These non-empirical rules bestow meaning to scientific theories. Husserl intends constitution as the intentional process of intending something *as* something. To each kind of intentional act corresponds a procedure of constitution, by which objects are posited in their facticity as part of a reality that transcends the subject.

Although the three traditions employ the same idea in different ways and within different frameworks, I have shown that they all focus on one of the three dimensions of Kant's constitutive: the object-defining, meaning-conferring, and object-positing. In sections 3 and 4, I have further analysed the differences and similarities between their accounts concerning the target and source of constitution. It emerged that the notion of 'constitutive principles' is ascribed to either *assumptions that enable the construction and formalization of the concepts of a theory*—formulated by empirical individuals within a community—or *broader principles that prescribe how nature itself should be for scientific knowledge to emerge*—articulated as impersonal or attributed to a fictional subjectivity that represent the share structure of all human minds. It is now time to focus on each of the three post-Kantian traditions, one by one, to delineate more precisely how their account of constitutivity is formulated within a broader philosophical understanding of scientific knowledge.

[83] Although my analysis is limited to Husserl, I use the plural to refer to, for example, Gurwitsch, Weyl, Margenau and Kitaro.

Chapter 3: Constitutivity and Lawfulness: Cassirer's Philosophy of Quantum Mechanics

Abstract: Cassirer turns Kant's constitutivity into the idea that laws are prior to objects. This claim is developed optimally in his philosophy of quantum mechanics. This chapter offers a novel interpretation of Cassirer's account. In my reading, Cassirer's defence of causality as a transcendental principle is directly targeted against the logical empiricist epistemology, while his shift of attention from causality to the revision of substantiality is aimed at Heisenberg's conceptually poor interpretation of the uncertainty relations.

Introduction

After an initial enthusiastic reception (Antoni, 1938; Born, 1937; Einstein, 2009; Frank, 1938; Nagel, 1938; Pettersson, 1937; Weizsäcker, 1937) and a period of inexplicable indifference from the critics, Cassirer's *Determinism and Indeterminism in Modern Physics* (1936/1956, D&I henceforth) has been brought back into the spotlight over the last ten years. Multiple works have recently emphasised the relevance of Cassirer's analysis of theories in terms of various levels of statements (Cei and French, 2009; Giovanelli, 2022), his contribution to the discussion on quantum mechanics (Mormann, 2015; Ryckman, 2015; Spigola, 2024), and the relationship between Cassirer's approach to quantum theory and that of other physicists (Angeloni, 2018; Giovanelli, 2025; Ryckman, 2018).

Nevertheless, the critical aims of D&I have not been adequately addressed. Cassirer's ecumenical writing style downplays the polemical elements of his thought to the point that his later, watered-down Kantianism seems almost to merge with Logical Empiricism (Giovanelli, 2025). However, while the different phases of Cassirer's thought do indeed evolve and tend toward his opponents' view, his reiterated emphasis on the *transcendental* character of the method and principles he endorses can motivate an alternative interpretation with respect to the above quoted interpreters.

In this chapter, I argue that D&I can be better understood by identifying who Cassirer's intended audience was. More specifically, I believe that the two main claims of his book—the transcendental status of the principle of causality and the shift of focus from the revision of causation to that of substance—had been formulated by Cassirer as attacks

against, respectively, the logical empiricists[84] and Heisenberg's early thought. Far from being an unproblematic book, D&I would in this way be appropriately read as a shoulder push against a specific movement, rather than a pacifistic attempt to generally catalogue scientific theories.

Although Cassirer does not refer to the concept of constitutivity many times in D&I, the view he puts forward to contrast the logical empiricists and Heisenberg is exactly the one anticipated in section 2.2.1: our scientific knowledge develops by replacing a substantialist and essentialist view of reality with a functionalist one, in which laws take conceptual precedence over empirical experience. Consequently, while this chapter contains fewer explicit references to 'constitutive principles' and examines a principle—causality—that Cassirer explicitly characterises as *regulative*, it nonetheless illustrates Cassirer's assertion that nature is *constituted* by laws. Furthermore, analysing the principle of lawfulness will help us to gain a better understanding of the subject of this work by clarifying the relationship between the constitution of the entities of physics, regulative criteria and the transcendental method.

I will argue for my interpretation as follows. In the first section, I provide the background for understanding Cassirer's interest in causality. Beyond locating his work within the so-called "crisis of causality" of the late '20s, this section analyses Heisenberg's 1927 article in order to highlight its philosophical shortcomings. Such an overview of the debate on causality and of the vagueness of Heisenberg's early formulation of the uncertainty relations sets the stage for section 2, in which I expose the main claims of D&I. I interpret these results as directed against the logical empiricists—in section 3—and as targeted also to Heisenberg's early formulation of the uncertainty principle—in section 4. In the conclusion of the chapter, I summarize my interpretation and outline some drawbacks of Cassirer's account.

3.1 Heisenberg's 1927 article and the crisis of causality

Cassirer's D&I cannot be fully appreciated without first knowing the context in which it was written. Indeed, parallel to the development of quantum mechanics in the '20s, a philosophical debate over what was called "the principle of causality" was increasingly

[84] I will specifically refer to Schlick's and Reichenbach's accounts as representatives of Logical Empiricism. However, they do not exhaust the multifaceted approach of this movement. See, for example, Franck (1998).

unfolding. Kurt Riezler (1928), Ludwig Fleck (1929), Philipp Frank (1932), and Max Planck (1926) exemplify some of the voices that either defended the validity of causality after quantum mechanics or refuted it. Also Schlick (1931) and Reichenbach (1944) participated to the debate. However, by reading both the logical empiricists' approach to the issue of causality and, as will emerge in the following analysis, Cassirer's own standpoint, one has the impression that they never really discussed the validity of the principle of causality, but rather *how to define it* more properly.

After the advent of quantum mechanics, the confusion on the definition of basic notions does not come as a surprise. The whole development of the theory involved a reconceptualisation of classical notions, from the dynamic concept of force to the kinematic concept of motion. Most of the discussion on causality stems from Heisenberg's 1927 article "The Physical Content of Quantum Kinematics and Mechanics" (1927/1983), in which he first articulates the uncertainty principle. Not by chance, this work is itself concerned with definitions. Arguably, it represents one of the sources of the confusion that led Cassirer to write D&I.

Heisenberg (1983) represents the first formal attempt to demonstrate that the classical notion of a particle's trajectory is untenable at the atomic scale, elaborating on Bohr's earlier insights (1913) regarding the limitations of classical concepts in atomic physics. Some scholars linked Heisenberg's refusal of the idea of a definite path to quantum systems to a positivistic attitude privileging only what is observable (Aristarhov, 2023; Werner and Farrelly, 2019). Darrigol (1992), MacKinnon (1977), and, more recently, Camilleri (2009) challenged this view by showing that his suspicion toward unobservable entities was not really paramount in his development of matrix mechanics. Although the latter reading has more textual evidence, also that advanced by the former authors is compatible with the central claim that Heisenberg's revolutionary 1927 article mixed groundbreaking physical ideas with conceptual confusion.

More specifically, Heisenberg (1983) starts by highlighting the danger of uncritically employing the words "position" and "velocity" in light of the non-commutativity of quantum operators. In the matrix mechanics formalism that he introduced in 1925—and which Born and Jordan subsequently helped to formalize—conjugate quantities, such as position q and momentum p, are represented by operators that, according to matrix

calculus, do not generally commute. Their commutation relation is given by $[q, p] = qp - pq = i\hbar$ (Heisenberg, 1925; Born, Heisenberg, and Jordan, 1925).

Two crucial steps come after his introductory statement. First, he formulates the famous gamma-ray microscope thought experiment, followed by the first formulation of the uncertainty principle in the form of:

$$p_1 q_1 \sim h$$

where p and q represent the momentum and position of a particle, and h is Planck's constant. Second, he develops an operational definition of position and velocity that is compatible with such a principle.

Both steps present shortcomings. As noted by many scholars, the gamma-ray microscope thought experiment describes a *semi-classical interaction*, in which—in accordance with the Compton effect—the use of a photon to determine the position of an electron disturbs its momentum. The puzzling part of Heisenberg's thought experiment is that such a disturbance does not concern the intrinsic indeterministic behaviour of the electron. As a matter of fact, it assumes the opposite: an electron must possess a momentum and a position before the interaction if each magnitude is disturbed by the observation of the other. Moreover, Heisenberg describes the results of the whole thought experiment with a very vague account of the relation between position (q) and momentum (p).

Werner and Farrelly (2019) emphasize that such a relation is problematic for at least two reasons. First, Heisenberg does not pinpoint the meaning of "~". Second, he characterises it as deriving from the formula for de Broglie waves, namely $p = h/\lambda$ (where p is the momentum of a particle, λ its wavelength, and h is Planck's constant). Once the estimate for the precision of measuring the position q of a particle is equated with its wavelength, the de Broglie formula does indeed result in $pq = h$. Nevertheless, the very identification $\lambda = q$ should at least be justified, and Heisenberg provides no arguments for it. Without justifying the identification, Heisenberg seems to conflate the resolution of the microscope with the light's wavelength (Werner and Farrelly, 2019, p. 65).

The microscope example is then employed by Heisenberg to tackle the definitions of position, path, and velocity. Concerning the concept of "position", he operationally defines it as the observed interaction of the particle with the microscope (i.e., with the

photon). Concerning the concept of path, he rejects it as meaningless. Indeed, to measure the path of an atom we would have to illuminate it "with light whose wavelength is considerably shorter than 10-8 cm. However, a single photon of such light is enough to eject the electron completely from its 'path' (so that only a single point of such a path can be defined)" (Heisenberg, 1983, p. 65). Heisenberg's idea is that data for positions consist of mere discrete points, and not of a continuous orbit. So, as Heelan stresses, "If the classical trajectory is smooth and continuous, it is only because it does not deal directly with concrete data; the smooth curve is a constructed-theoretical norm whose essential property is that concrete data do not diverge from it systematically" (Heelan, 1965, p. 37).

Heisenberg defines operationally also the concept of velocity. For example, velocity can be measured by using red light and analysing the Doppler shift in its scattered signal (Heisenberg, 1983, p. 66). And yet, more precise measurements of velocity imply less precise measurements of position, in accordance with the uncertainty relations. Heisenberg then goes on to define the energy, referring to the experimental setups that enable us to measure it.

While the first step of Heisenberg's article raises some technical questions, especially regarding the formulation of the uncertainty relations, this second step involves a controversial refusal of the concept of 'path'. Operational definitions are often necessary for the progress of physical theories, like Einstein's concept of simultaneity. Nevertheless, the mere identification of a whole concept with the concrete operation used to measure it, combined with an ontological characterisation of the specific limits of a measuring procedure, appears too quick. The fact that Heisenberg intended to provide just a heuristic for the newborn theory and not a thoroughgoing worldview does not justify his conceptually obscure move. The concept of verification itself remains poorly defined, as stressed by Aristarhov: "Heisenberg did not question the possibility of reconstructing the trajectories once we assume their existence. He claimed that as a consequence of the UR we cannot 'verify' their existence. Hence, he claims, 'it is a matter of personal belief' to accept or to reject the results of retrodictive measurements performed under the assumption of their existence" (Aristarhov, 2023, p. 7).

After the dialogue with Bohr and a more precise formulation of the uncertainty principle, provided by Kennard (1927) and Robertson (1929), Heisenberg refined his view. Heisenberg's epistemology, sketched in his revolutionary articles and better

delineated in the later works—such as Heisenberg (1958)—focuses on what Camilleri (2009, p. 142) calls "the constitutive dimension of language". Language forms the empirical given, becoming a filter between experience and knowledge. This explains Heisenberg's attention to the definitions of classical concepts, and illuminates contact points between his epistemology and neo-Kantianism, further supported by his closeness with neo-Kantians like von Weizsäcker and Grete Hermann (see Camilleri, 2009; Monod, 2004). Nevertheless, the critical voices that were raised against Heisenberg's conceptual problems in dealing with the new theory are justified.

In addition to the conceptual difficulties raised by Heisenberg's approach to the concepts of path and verification, his 1927 article constitutes the starting point of the popular and convoluted *crisis of causality*. In continuity with the previous analysis, the key factor of Heisenberg's account would later be recognized as a definitional issue. Heisenberg defines causality as a law stating that "When we know the present precisely, we can predict the future" (Heisenberg, 1983, p. 83). Causality is here associated with two features: (i) precise knowledge of the present and (ii) exact prediction of the future. One of the main sources of this definition is Laplace's *A Philosophical Essay on Probability* (1820/1951). As will emerge later, one of Cassirer's merits is in exactly recognizing Heisenberg's definition as rooted in this work.

As Laplace wrote, "We ought to regard the present state of the universe as the effect of its anterior state and the cause of the one which is to follow. Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective situation of the beings who compose it […], for it nothing would be uncertain and the future, as the past, would be present to its eyes" (Laplace 1951, 4). Laplace's passage is useful to both define causality and to clarify its strict interrelation to determinism: according to Laplace, a cause determines its effect, so causes and effects are respectively determining and determined physical states. The relationship between determinism and causality is not uncontroversial, and recent contributions convincingly distinguish the two (Bunge, 1963; Hoefer, 2004). However, Heisenberg (1983) assumed the accuracy of the Laplacian definition, and he proceeded to deny the validity of causality in light of his formulation of the uncertainty relations.

Although the formalism that Heisenberg used to express uncertainty was problematic, the fundamental concept of this revolutionary discovery must be attributed to his work.

The uncertainty relations state that the more accurately a particle's position is determined, the less accurately its momentum can be determined. Beyond Heisenberg's formulation, it may be expressed by the fact that the product of the intervals of the values of position and momentum of a particle, $\Delta p \Delta q$, is of the order of magnitude of Planck's quantum of action h, so that a smaller range of the first factor is combined with a wider range of the second, and vice versa.

According to Heisenberg, then, it is impossible to "know the present precisely", hence the antecedent of the law of causality is false. For this reason, he stated, "Because all experiments are subject to the laws of quantum mechanics […] it follows that quantum mechanics establishes the final failure of causality" (Heisenberg, 1983, p. 83). According to Laplace's deterministic worldview, all statistical laws should be reduced to dynamical laws, insofar as the former express by definition the lack of precise information, which can only be inscribed within a range of possibilities. If such a reduction is not possible, Laplace's determinism cannot hold anymore (Cruz Ortiz de Landázuri, 2025; Mittelstaedt & Weingartner, 2005, pp. 146-147).

Other authors supported Heisenberg's assertion that, in light of quantum mechanics, the concept of causality has lost its validity. One example is Max Born, who wrote: "The impossibility of measuring all the data of a state exactly prevents prior determination of the further course of events. The principle of causality, as commonly conceived, thereby loses all meaning. For if it is in principle impossible to know all the conditions (causes) of a process, it is empty talk to assert that every event has a cause" (Born, 1969, p. 27)[85].

When reading Cassirer's work, it is helpful to bear in mind the lack of conceptual precision in Heisenberg's early articles and the 'crisis of causality' that was prevalent at that time. Cassirer's D&I does not directly challenge Heisenberg's argument. In fact, he confirms that causality would not hold *if it could only be defined in a Laplacian way*, as Heisenberg proposed. Furthermore, if causality were characterised in such a deterministic manner, it would have been rejected long before the advent of quantum mechanics. Boltzmann's kinetic theory of gases already relies on statistical laws. Cassirer's point is that the principle of causality *should be defined and formulated differently.*

In order to support this claim, Cassirer not only tackles the issue of causality, but also develops a broader philosophical framework. Within this framework, he analyses the

[85] Born's approach to causality is not equivalent with Heisenberg's; see Cruz Ortiz de Landázuri (2025).

nature and use of the Laplacian definition, together with its historical evolution, and proposes an alternative account of causality, highlighting the differences and interrelationships between the classes of statements that comprise any scientific theory. Cassirer's D&I is undoubtedly one of the earliest examples of what is now known as the *integrated History and Philosophy of Science* approach. After providing an overview of Cassirer's main arguments, I will explain why they are better understood as targeting Heisenberg and the logical empiricists.

3.2 Causality, invariance, and lawfulness

Since Cassirer's work concerns a wide amount of topics, it may prove beneficial to select the three results of D&I that I consider the most fruitful for my interpretation: (i) claiming the correlation between any account of causality and a subsequent concept of "physical object", (ii) regarding the principle of causality as the core of a hierarchical distinction of scientific statements and (iii) arguing for a non-viciously circular relationship between facts and theories.

Starting from the first point, D&I aim to show the close connection between the notions of causality and physical reality. Cassirer begins by identifying the conceptual core of the Laplacian view of causality: the idea that the past and future states of a physical system can be strictly deduced from its present state. Such strict deduction leads naturally to a mathematical characterisation of physical objects. To clarify this, Cassirer frames the Laplacian notion of causality alongside a view of physical objects as inherently mathematical, drawing on the tradition from Galileo to Leibniz. Although he acknowledges the difference between Leibniz's determinism, grounded in God's will, and other forms of determinism, Cassirer emphasizes the shared metaphysical background underlying any deterministic view of the Modern Age. His claim is that Laplacian causality is inseparable from a vision of reality as intrinsically mathematical: the certainty of predicting future states from the present—the hallmark of the Laplacian perspective—depends on the certainty of mathematical deduction, reflecting the metaphysical assumption that mathematics is a fundamental feature of nature.

Therefore, Cassirer describes the Leibnizian or Laplacean view as committed to the idea that "The same infallibility that discloses itself in the rules of mathematical thought and inference must obtain in nature, for if nature did not possess this infallibility, it would

be inaccessible to mathematical thought" (Cassirer, 1936/1956, p. 12). What is relevant here is that Cassirer, through this argument, supports that the very definition of causality or determinism is never neutral; it *rather commits us to a view of reality*. After showing that, Cassirer claims that the reality implied by Laplacean causality exhibits three drawbacks.

Firstly, it involves metaphysical elements such as fundamentally mathematical objects, and according to Cassirer, these substantial elements cannot be part of a functional science. Secondly, it blurs the distinction between determinism and predictability, overestimating the theoretical significance of the latter concept; absolute exact predictions are not part of the toolbox of scientists, according to Cassirer, not even as a guiding criterion. Thirdly, the Laplacean definition is not really a definition of causality, but rather concerns certainty or, to use a term Cassirer did not use, *entailment*.

I am not fully convinced by the first of the three criticisms, as maybe it would be possible to vindicating strict determinism without committing to a metaphysics of intrinsically mathematical objects. Anyway, even if we do not accept the first, the other two criticisms are valid. Therefore, the principle of causality should mean something different than simply the capacity to exactly predict or derive the future from the present. To better grasp Cassirer's definition of causality, however, it is necessary to introduce the second result of D&I.

To overcome the Laplacean view of causality, Cassirer identifies the kinds of statements that a scientific theory in general encompasses. More specifically, he characterizes the sphere of physical knowledge, described by Thomas Ryckman as "onion-like" (Ryckman, 2018), as exhibiting three different layers. The most external one includes the statements of the results of measurements. Cassirer describes these statements as representing "the first step in that decisive transition which leads over from the world of the given to the world of scientific knowledge, from the world of sense to the world of physics" (Cassirer, 1936/1956, p. 31). This lower-level of statements includes the data detected within the experimental settings, as well as the observations obtained through the interaction of measuring instruments and the world. The central point is that measurements are not a disordered aggregate of data: they are ordered in a structure of dependencies or systematically organized.

The same goes for the second layer, namely the statements of law. Again, laws like Schrödinger's equation do not just gather an aggregate of empirical data but rather organize them in a system of dependencies. The third layer involves the statements of principle. The Born rule or the Einstein-de Broglie relation between energy and frequency $E = hv$ may be mentioned as examples of principles, as well as the principle of least action (Giovanelli, 2022, p. 120). Exactly like the case of measurements with respect to sense data, and laws with respect to measurements, the role of principles is to guide and organize laws to compose a system, and not simply an aggregate.

Finally, the core of the sphere of physical knowledge is the principle of causality. The statements of measurements, laws, and principles have the common feature of turning an aggregate into an ordered system. The principle of causality does the same, with respect to the three statements themselves: it states that the other three classes of statements (measurements, laws, and principles) are not an aggregate but a system of mutual dependencies. As Pringe stresses, "The causality principle states that the conversion of sensible data into measurement results, their ordering according to laws and the unification of the multiplicity of these laws under principles is always possible" (Pringe, 2014, p. 59). Since Cassirer claims reality to be inextricably bound to our modes of conceptualising it, he identifies the two definitions of the principle of causality as (i) the systematicity of our levels of description (the three layers of the sphere), and (ii) the lawfulness (*Gesetzlichkeit*) and comprehensibility of nature, as two sides of the same coin.

An equivalent formulation of the principle of causality can be stated in terms of invariance. All the statements are gradually more "invariant", or independent from increasing factors: measurements are independent of our subjective feelings and sensations, but they depend on a specific portion of space and moment in time; laws then are independent of specific portions of space and moments of time, although they depend on specific scientific theories; principles are independent of specific theories, as they try to connect them, although they depend on specific "paradigms". What remains if we remove all the content of scientific statements that depend on revisable frameworks? Nothing, only the methodological (a priori) principle of investigating nature through more and more general theories, i.e., Cassirer's principle of causality. In opposition to the Laplacean view of causality, Cassirer stresses that "The causality principle can be

understood only as a 'transcendental' statement, referring, not to objects, but rather to our cognition of objects in general. Instead of being a direct statement about things, it must be viewed as a statement about our empirical knowledge of things—that is, about experience" (Cassirer, 1936/1956, p. 58). While Laplacean causality states the necessary relation between objects or events, Cassirer's principle of causality concerns our cognition of objects, our modeling of reality (Lenzen, 1959).

Cassirer's definition of the principle of causality as the general lawfulness or comprehensibility of nature should not be viewed as a rhetorical ploy. Conversely, the very etymology of the term causality, the Latin *causa*, refers to a legal case and involves the possibility of *following a rule or a law*, in support of Cassirer's critical definition. Usually, etymology is irrelevant for philosophical argumentation; nevertheless, it is relevant here, as both Kant and the neo-Kantians often employed legal terms or metaphors consciously.

Cassirer does not want only to define the principle of causality as involving the lawfulness of nature: he takes a step further, claiming also that *physical reality can be properly defined only after physical laws*. In other words, the principle of causality leads to the idea that reality is defined according to laws, and not vice versa. This claim is directly implied by the previous correlation between causality and reality that Cassirer supported. Indeed, Laplacean metaphysical determinism involves a metaphysical commitment to a mathematical reality. Conversely, Cassirer's critical determinism, in which causality represents only the conformity to laws, leads to a view of physical objects as *functional relata conforming to laws*. As Cassirer states in a dense but central passage,

> The concept of law is now regarded as prior to that of object, whereas it used to be subordinate to it. In the substantialistic conception there used to be a definitely determined entity, which bore certain attributes and which entered, with other entities, into definite relations expressible by laws of nature. In the functional viewpoint, by contrast, this entity constitutes no longer the self-evident starting point but the final goal and end of the considerations: the terminus *a quo* has become a terminus *ad quem* (Cassirer, 1936/1956, p. 131).

The theoretical determinability of an object or, in other terms, its conformity to laws, "constitutes [*konstituiert*] physical entities, instead of merely expressing an accidental and individual feature of them". The use of the verb "to constitute" aligns with the

analysis of section 2.2.1: it suggests the idea that laws *functionally define what reality is*, and the search for an essential or fundamental ground behind our theories is meaningless. Behind physical systems, "There is only a functional coordination in which all the elements, all the determining factors of physical truth, uniformly participate" (Cassirer, 1936/1956, p. 35).

This point brings us to the third and last result I mentioned at the beginning, namely that Cassirer argues for a circular relationship between facts and theories. As already explained, Cassirer claims that laws and principles need to be presupposed to prepare and organize the procedures of measurements. However, the data gained through measurements do not always confirm our theories: they retroactively enable us to organize and redefine the laws. Within Cassirer's perspective, this apparent contradiction vanishes since empirical data and theoretical principles constitute one another in a mutual and evolving relationship.

Measurements, laws, and principles are distinguished in Cassirer's analytical reconstruction of scientific knowledge, and yet in the scientific practice they merge in a synthetic process. After Duhem's (1906) fundamental contribution, also for Cassirer observations are theory-laden and theories possess a complex holistic character: "It must be admitted that in this formulation of the concept of objective knowledge, we are in a sense moving in a circle, though it is by no means a vicious one. It consists in the first place of the fact that we cannot clearly separate statements of laws and principles from experimental observations, that we cannot demonstrate the latter in their merely factual 'givenness,' independent of all theoretical assumptions" (Cassirer, 1936/1956, p. 136).

Cassirer inherits the Kantian idea of systematicity, mentioned in chapter 1, which is also emphasised in Natorp's work (Natorp, 1910, 1958): no element can be considered in isolation, as all statements are in a mutual and original interrelation. The idea of pinpointing the common idea under which a collection of elements is grouped, so that such a collection makes a 'system out of an aggregate', is a common theme in Cassirer's philosophy, which can be found already in his early work *Leibniz' System in seinen wissenschaftlichen Grundlagen* (1902/1998, p. 366), and that runs through his entire philosophical career, culminating in D&I[86].

[86] Cassirer's distinction between aggregate and system is inherited by Henry Margenau, who met Cassirer at Yale between 1940 and 1943, and who developed his subsequent epistemological view influence by the

3.3 Challenging Logical Empiricism

There are three reasons that could justify interpreting D&I as closely related to Logical Empiricism. Firstly, in the preface to the volume, Cassirer articulates two claims that appear to be consistent with the logical empiricists' approach. The neo-Kantian states that his interest was not that of "Viewing physics from the outside or in instructing it from above", but rather "To prepare the ground for a common inquiry" (Cassirer, 1936/1956, p. xxii). Furthermore, he adds that the Marburg School was never interested in respecting an "orthodox Kantianism", and that philosophers should rightly reject all dogmas[87]. Cassirer probably wrote these passages as a reply to some of the logical empiricists' accusations, yet they seem to hint at a closeness of views. Secondly, Reichenbach and Schlick made two crucial contributions to the debate on causation and quantum mechanics. Although Reichenbach published his contribution later than D&I and Schlick published his earlier, they both play the role of interlocutors with Cassirer in a diachronic analysis. Both neopositivists deny – in different ways – the validity of causality in light of quantum mechanics, a position that stands in contrast to Cassirer's and therefore calls for an examination of the reasons underlying this disagreement. Thirdly, the principle of causality that Cassirer discusses in D&I appears to be the same a priori principle that he set out in an important letter to Schlick in 1921. In those years, the two were discussing the philosophical interpretation of Einstein's theory of relativity, and Cassirer wrote to Schlick that the only synthetic a priori judgment of modern physics is "The lawfulness of experience in general [*der Gesetzlichkeit der Erfahrung überhaupt*]" (Cassirer to Schlick, Oct. 23, 1920; in Cassirer, 2009, Doc. 18). These facts prompt to consider their relationship relevant for this discussion.

Reichenbach (1944) emphasizes that the replacement of causal laws with statistical laws predates the advent of quantum mechanics, tracing back to Boltzmann's statistical mechanics. This point already appears in earlier writings by Reichenbach. In *Causality or Probability?* (1928), for example, he notes how the deterministic worldview, in which "the course of events ticks away like clockwork" (Reichenbach, 1978, p. 237), was

neo-Kantian. The aggregate-system distinction is, for example, at the basis of Margenau's distinction between correlational and theoretical procedures in science (Margenau, 1950, pp. 28-30).

[87] While Cassirer's distancing himself from "orthodox Kantianism" is here mentioned to motivate a link between his and the neopositivist's epistemology, the effective relationship between Kant, the Marburg School and Cassirer is much discussed. For an overview, see Ferrari (1988, 2010) and Kühn (2010).

overturned by Boltzmann's formulation of the second law of thermodynamics: "Instead of being a sure and strict causal law, it has only the significance of a statistical law and possesses the rank of a mere rule" (Reichenbach, 1978, p. 238). However, it is only with quantum mechanics that the proper relevance of statistical laws emerges.

Reichenbach argues that empirical observation implies only a probabilistic relation between states A and B, such that, given A, B follows with a certain probability. The laws of classical mechanics, which assert a *logical* implication $A \rightarrow B$, hold between idealized states whose variables can be determined simultaneously and with arbitrary precision. Causal laws presuppose that the inclusion of an increasing number of parameters and their more precise specification allow probabilistic empirical correlations to approximate a strict derivation ever more closely. Reichenbach therefore characterizes causal laws as limit cases: "Whenever we speak of strictly causal laws we assume them to hold between idealized physical states, and we know that actual physical states never correspond exactly to the conditions assumed for the law" (Reichenbach, 1944, p. 2). Causal laws function as idealized models, while empirical regularities can only approach them asymptotically, as in the passage to a limit. On this basis, Reichenbach defines the principle of causality as the physical postulate governing such a transitioning process: "[…] the probability p can be made to approach the value 1 as closely as we want by the introduction of further parameters into the analysis of physical states. It is in this form that we must state the principle of causality if it is to have physical meaning" (Reichenbach, 1944, p. 2).

Given this framing of the problem, it is unsurprising that Reichenbach, like Heisenberg, maintains that quantum mechanics refutes causality. The indeterminacy principle, as discussed in section 3.1, entails a fundamental limitation on measurability itself, rendering causal laws meaningless even as idealized constructs. As Reichenbach explains, "[…] we have assumed that it is possible to measure the independent parameters of physical occurrences as exactly as we wish; or more precisely, to measure the simultaneous values of these parameters as exactly as we wish. The breakdown of causality then consists in the fact that these values do not strictly determine the values of dependent entities, including the values of the same parameter at later times" (Reichenbach, 1944, p. 3).

However, it should be clear that Reichenbach's notion of causality does not coincide with Cassirer's principle of causality. Reichenbach explicitly characterizes causality as an "empirical hypothesis" (Reichenbach, 1944, p. 3). Part of their disagreement may plausibly be attributed to a difference in terminology. If causality is defined in the Laplacean sense, as both Heisenberg and Reichenbach assume, and identified with strict determinism, then it is by definition incompatible with the statistical laws of quantum mechanics and the uncertainty relations. Cassirer accepts this point, but rejects this definition of causality. For Cassirer, the principle of causality expresses the general intelligibility of nature, that is, the possibility of formulating laws that functionally relate quantities without reifying substantial entities. In this sense, which Cassirer inherits from Hermann von Helmholtz, even Heisenberg's uncertainty relations respect and indeed confirm the principle of causality. In summary, whereas Reichenbach frames the central opposition as one between causal and statistical laws, Cassirer maintains that causality and probability are compatible, insofar as both stand opposed to the myth of perfect predictability.

Moritz Schlick's viewpoint confirms that the debate between neo-Kantianism and Logical Empiricism was not on the validity of causality, but rather on *how to define it properly*. As Fox (2009) demonstrates, Schlick's reflections on quantum mechanics throughout his life centred on the issue of causality, which had already emerged as a problem for the scientific community in the 1910s, with Rutherford's law of radioactive decay and Bohr's atomic model (1913). From his initial discussion of the discontinuous behaviour of electrons in "Philosophical Reflections on the Causal Principle" (Schlick, 1920/1979), to his distinction between macro- and micro-laws in "Outlines of the Philosophy of Nature" (Schlick, 1925/1979), Schlick appears to emphasise from the outset that the 'acausal' nature of subatomic particles requires a new epistemological investigation of the notion of continuity.

However, it is only after the development of quantum mechanics in the late 1920s that Schlick returns to the issue in a more systematic way. Specifically, in "Causality in Contemporary Physics" (1931/1979), Schlick attempted to classify the various definitions of causality and propose a *pragmatic approach*. According to Schlick, the principle of causality is not a true or false statement; rather, it is a useful or useless prescription for seeking exact prediction and deterministic laws. The focus therefore shifts from truth and

validity to *usefulness* (*Brauchbarkeit*) with respect to theory construction and prediction. His perspective can be seen as a *tertium quid* between the views of Cassirer and Reichenbach, although his emphasis on verification and predictability as an empiricist contrasts more with Cassirer's transcendental approach than with Reichenbach's (the differences between the two logical empiricists is described in Padovani, 2010).

Furthermore, although Schlick's (1931) was written before D&I, it contains *in nuce* a possible criticism of Cassirer's definition. Indeed, Schlick states that causality might be defined simply as the conformity of data to laws of dependence, i.e., to functions. However, every possible set of data can be mathematically arranged in a function. Hence, according to Schlick, the mere functional dependence of data cannot be the only criterion to define causality: it is also needed to define when a functional dependence, or a regularity, becomes a law. In fact, Cassirer is not so precise on this point. While he describes causality as conformity to laws, he does not define *what a law of nature is*[88]. Schlick's specification is reasonable, although his subsequent conclusion seems inadequate in light of Cassirer's considerations. More specifically, Schlick bounds causality to prediction and exact knowledge, so his perspective exhibits the same problems that Cassirer attributes to Heisenberg's and Reichenbach's conceptions (see Dawid (2021) for further criticisms).

The divergence between the three views on causality might seem to reduce to a matter of definitions, and yet it is not that the debate was merely terminological *in a negative sense*. Conversely, behind the different definitions they gave to causality lurks a broader discussion involving the role and the status of philosophical principles in science. Firstly, Reichenbach and Schlick, *qua* logical empiricist, differ from Cassirer in where to put emphasis, since they regard prediction and verification as the touchstones of science, while the neo-Kantians consider them as consequences of a conceptually prior notion, namely lawfulness (*Gesetzlichkeit*). Notice that this opposite attitude leads to two completely different views of reality, confirming Cassirer's claim about the strict connection between the conceptions of causality and physical states. If laws have conceptual priority, reality becomes a result of our theoretical and scientific efforts, while

[88] Part of Cassirer's argument is exactly the idea that causality concerns the general faith in the possibility of discovering laws, without imposing a specific form on those laws. However, the objection remains valid: even if causality does not impose the causal or statistical nature of laws, it still assumes an understanding of what constitutes a law and how to distinguish between arbitrary functional correspondences between variables, contingent regularities, and proper laws of nature. Cassirer does not clarify this point.

it is a prior presupposition in an account based upon verifiability. According to logical empiricists, a reality of ready-made objects is for our scientific conceptualisations. According to Cassirer, reality and objects are the outputs of a prior conceptualisation of mere subjective contents.

Secondly, Cassirer stresses that the principle of causality is *transcendental*. This point should not be downplayed, as it motivates a reading of D&I as specifically targeted against the logical empiricists. Since the term transcendental is often a source of confusion, it may be reasonable to see how Cassirer himself defines it. In *Substance and Function*, he writes:

> The procedure of the "transcendental philosophy" can be directly compared at this point with that of geometry. Just as the geometrician selects for investigation those relations of a definite figure, which remain unchanged by certain transformations, so here the attempt is made to discover those universal elements of form, that persist through all change in the particular material content of experience. (Cassirer, 1910/1953, pp. 268-269)

This idea is reiterated in all of Cassirer's works. In *The Problem of Knowledge*, for example, he describes Kant's transcendental method as being based on the presupposition "that there is a universal and essential form of knowledge, and that philosophy is called upon and qualified to discover this form and establish it with certainty" (Cassirer, 1950, pp. 14-15). Although many scholars have rightly stressed the dynamic and historical character of Cassirer's version of the a priori, his remarks on the transcendental principle of causality point to a *structurally secure and fixed assumption*.

Cassirer's principle of causality pinpoints an element that remains stable in the midst of precarious theories and a fluctuating reality[89]. Scientific theories can evolve and change, but *the very fact that phenomena and events can be described according to increasingly general laws enables that same evolution and change*. The principle of causality is invariant, and it makes changes in scientific theories possible. Anyone who protests that Cassirer's principle is too abstract should not forget that the neo-Kantian is exactly looking for a principle that concerns the form, and not the content of science. He

[89] Cassirer's stress on the concept of invariance with respect to a group of transformations, which he inherits from Felix Klein's Erlangen project, grounds his idea of formal principles remaining stable accross changes. See Ihmig (1999).

wanted to formulate a *statement that cannot be true or false*, and that is not meant to describe nature but to prescribe our approach towards nature. Causality becomes a "dynamic form" (Cassirer, 1936/1956, p. 74), a flexible schema aimed at seeking and organizing the content of a theory. Its flexibility, however, does not consist in the fact that it can change, or that alternatives are possible, but only that *it can be empirically declined and applied in different ways*. Cassirer describes such a flexibility in the following way:

> The a priori that can still be sought and that alone can be adhered to must do justice to this flexibility. It must be understood in a purely methodological sense. It is not based on the content of any particular system of axioms, but refers to the process whereby, in progressive theoretical research one system develops from another. (Cassirer, 1936/1956, p. 74)

Cassirer's paradoxical characterization of causality as a principle that does not add anything to the structure of science (Cassirer, 1936/1956, p. 60) might appear as a concession to the logical empiricists, and yet the opposite is true: Cassirer vindicates the "objective significance" of the principle (Cassirer, 1936/1956, p. 58), and also links it with an "Archimedean point, some secure basis, immune to all uncertainty" (Cassirer, 1936/1956, p. 120).

Despite its merely formal nature and despite its flexibility for being applied in different ways, causality—in the sense of lawfulness and unity of nature—represents a transcendental requirement incompatible with the logical empiricists' epistemology, in which no secure basis can ground science apart from sense-data. This is one of the reasons that explain why Cassirer wrote D&I: the principle of causality is an a priori[90] that the logical empiricists cannot accept.

In their discussion concerning Einstein's relativity, Schlick challenged Cassirer to find a synthetic a priori principle in science and warned him that the mere lawfulness of nature

[90] For the record, I am not suggesting that Cassirer's concept of causality is a constitutive principle in the Kantian sense. In fact, as emphasised in Section 3.2, Cassirer characterises causality as a *regulative* principle that motivates the search for empirical laws without imposing constraints on their specific form (Giovanelli, 2022). Conversely, I am claiming that, as a regulative principle, causality is a synthetic a priori, immune to uncertainty, and this is incompatible with the neopositivist epistemology, thereby representing the final counter-objection in the dispute between Schlick and Cassirer. Cassirer's continued use of the vocabulary of "constitution" when describing his hierarchy of statements, the transcendental justification of causality, and the resulting account of quantum mechanics reiterating the idea that nature is *constituted* by laws rather than vice versa are the reasons why I still find the whole discussion relevant for a general overview of the conceptual and historical evolution of constitutive principles.

is too general and compatible with any theory (Schlick, 1921). Cassirer's D&I presents the last stage of their debate: it is exactly for its generality that causality — or lawfulness — is a regulative condition without which science would not be possible. According to the logical empiricists, the only meaningful statements beyond logical truths can be either empirical or conventional. Cassirer's principle cannot be an empirical statement, as (i) we can only observe that nature has behaved lawfully so far, and not that it must continue to do so; and (ii) we observe only regular facts, and not the lawful dependencies between them. Additionally, it cannot be a conventional prescription: there are no alternatives to it, as a refusal of causality would lead to a denial of science itself. Causality would be meaningless within the neopositivist epistemology, which would refute then the grounding statement of scientific knowledge. Cassirer's causality is synthetic, as it indicates the fact that nature is lawful, and lawfulness is not contained in the concept of nature. Yet, it is not a posteriori: we need to assume it as a condition without which scientific knowledge would not be possible in the first place. It is a synthetic a priori principle.

3.4 Causality or substance: challenging Heisenberg

Although the principle of causality is targeted to the logical empiricists and not to physicists in general, the consequences of Cassirer's view directly challenge Heisenberg's thought, as presented in section 3.1. Cassirer's criticism of the early interpretation of the uncertainty principle is threefold. First, as already suggested, it stresses the unsuitability of the Laplacian definition of causality. While Heisenberg assumed the Laplacian definition and stressed the incompatibility between its premise and the uncertainty relations, Cassirer retrieves a new meaning of causality which is both less problematic than the Laplacian one and compatible with uncertainty. Cassirer summarizes this argument by asserting that "if we express the demand of causality merely by the general requirement of conformity to law, then Heisenberg's uncertainty relations no longer constitute an exception" (Cassirer, 1936/1956, p. 123).

Second, Cassirer supports the view according to which Heisenberg's microscope experiment did not grasp the core of indeterministic phenomena. Indeed, he criticizes the ascription of indeterminism to the accuracy of single concrete measurements, shifting the focus to an ensemble of measurements that conform to the uncertainty relations. As he

states, “One can refer to a basic lack of precision in the statements of quantum theory only so long as one presupposes that statistical statements are necessarily ‘inexact’ statements. In reality they are strict statements referring, however, not to an individual thing or event but to definite collectives” (Cassirer, 1936/1956, p. 118). While the path of single particles is not part of the formalism of the theory, quantum mechanics provides precise predictions and mathematical functional dependencies when directed toward a collection of data. This point is also reflected in Kennard’s formulation of the uncertainty principle, which is now standard in physics textbooks. In quantum mechanics, uncertainty does not refer to the precision of measurements or to experimental disturbance, since the concept of a measurement error presupposes a pre-existing true value — a notion incompatible with the formalism of quantum mechanics. Rather, uncertainty quantifies the intrinsic spread of probability distributions for pairs of complementary observables (Werner and Farrelly, 2019, p. 480).

Cassirer’s defence of causality and criticism of Heisenberg lies in the fact that nature does not play dice when the focus turns from individual cases to ensembles. It is not that nature “can change its laws from case to case in a manner uncontrollable by our knowledge” (Cassirer, 1936/1956, p. 119). Therefore, Heisenberg’s link of the uncertainty relations with the refusal of causality was ill-posed. The shift from the real numbers of classical mechanics to the complex-valued matrices of quantum mechanics does not change the fact that nature is mathematically ordered, hence conforming to comprehensible rules.

Third, Cassirer suggests that, rather than the notion of cause, the uncertainty relations change our notion of *substance*. This is consistent with the first result of D&I described in section 2: concepts of causality imply concepts of reality. Although the uncertainty relations support Cassirer’s notion of causality as a general conformity to laws, they nonetheless alter the resulting image of reality. The new way to think of objects that follows from quantum mechanics is exactly that described in the second result of D&I of section 2: the priority of laws to objects.

Cassirer overturns the naively realist idea, according to which a substantial substrate of things is disclosed by our scientific analysis and laws simply describe relations between previously experienced and determined objects. Objects can be defined and determined only by laws, and since our laws evolve gradually, encompassing more

and more general phenomena, objects themselves are never definitively given, but rather posed as a task. With Cassirer's words, "The entity has thus forfeited its absolute fixation; it is, so to speak, drawn into the process of physical knowledge and can only be regarded as the limit which this process approaches but never completely reaches" (Cassirer, 1936/1956, p. 132). In contrast to Heisenberg's view, then, the real transformation provided by quantum mechanics does not concern causality but rather the notion of substance, what exists. The atom, which has always been considered the paradigmatic substantial substrate of any experience, becomes a functional network of relationships, conforming to the uncertainty principle[91].

Conclusion

It is not easy to make sense of Cassirer's D&I if we interpret it as addressing physicists in general, who can simply accept the definition of causality as the general lawfulness of nature and move on. On the contrary, Cassirer's perspective makes perfect sense as a targeted attack both against the logical empiricists, who cannot accept a synthetic a priori principle, and against Heisenberg's presentation of the uncertainty relations, which reduces them to a refusal of causality with respect to individual measurements.

After a brief overview of the conceptual problems of Heisenberg's 1927 article, which motivate the subsequent "crisis of causality" that arose, I have defended the interpretation of D&I as a targeted work in three steps. First, I have presented the main results of Cassirer's volume: (i) claiming the correlation between any account of causality and a subsequent concept of "physical object", (ii) showing the principle of causality as the core of a hierarchical distinction of scientific statements, and (iii) arguing for a circular relationship between facts and theories. Second, I have compared Cassirer's results with Reichenbach's and Schlick's analyses of causality, stressing how they diverged on *how to better define it*. Third, I have argued that Cassirer's causality, while being a flexible and merely formal requirement, is still a *transcendental synthetic a priori principle*. Hence, it is a fatal objection to the neopositivist epistemology, within which only logical truths, empirical statements, and conventions are accepted.

[91] This point should be read neither as a denial of the existence of atoms nor as a straightforward commitment to forms of structural realism. Rather, Cassirer shifts the focus from a substantialist view of physical entities to the functional role they play within scientific theories. For a comparison between Cassirer's account and structural realism, see Cei & French (2009) and Gower (2000).

Additionally, D&I presents three ideas targeting Heisenberg's view of uncertainty: (i) causality should be understood differently than the Laplacean definition, (ii) the lawfulness of nature emerges once ensembles of measurements rather than individual cases are considered, and (iii) the real conceptual revolution of quantum mechanics lies in the notion of substance.

Despite its broadness of topics and acute results, D&I is still far from being an uncontroversial book. Cassirer is not always consistent with his own approach to causality, defining it as lawfulness and then, however, linking it to the traditional category of cause and effect, thereby conflating them without justifying his terminological choices[92]. In addition, my interpretation of Cassirer's causality as a shot towards the neopositivists does not imply that he was the winner of their debate. Conversely, Schlick and Reichenbach might have reasons to insist on distinguishing causality from lawfulness and challenging the synthetic a priori character of the principle. Hopefully, reading an author like Cassirer—who is usually considered to be ecumenical—as polemic and resolute in defending the transcendental method, may fruitfully broaden the range of opinions on his work.

[92] Henry Margenau stresses this point in the Preface to the English edition of D&I, while however supporting Cassirer's view (Cassirer, 1936/1956, p. xi). See also Bunge (1963).

Chapter 4: Constitutivity and Conventionality: Schlick's Letter to Reichenbach

Abstract: In this chapter, I aim to both provide an in-depth portrayal of Schlick's substitution of constitutive principles with conventions and suggest significant shortcomings of his consequent epistemology. The text that introduces and motivates my twofold analysis is his 1920 correspondence with Reichenbach. After presenting their exchange, I describe the complexity and tensions within Schlick's conventionalism, while highlighting the influence of both Poincaré and Hilbert. Finally, I focus on nomological necessity and on the role of scientific definitions to individuate the downsides of his view.

Introduction

Schlick's philosophy is bicephalous. Insofar as he was the founder of the Vienna Circle and one of the first scientific philosophers, his arguments and writing style appear linear, transparent, and straightforward. However, from a closer look, the conceptual framework he developed during the different phases of his life is rich and multidimensional. Schlick's perspective on the status of scientific principles is an example of such complexity. This perspective occupies a central place in the history of the philosophy of science. Yet, it exhibits a hardly simplifyable framework for at least two reasons. First, Schlick embraces in almost all his writings the view that the principles at the basis of our scientific theories are *conventions*. This position already exhibits questions concerning its sources, often an unorthodox mix of Poincaré and Duhem (Bonnet & de Calan, 2009; Brenner, 2022), its precise meaning, and its compatibility with other aspects of Schlick's viewpoint, like his realism.

Secondly, Schlick considers his conventionalism as a refutation of a Kantian or neo-Kantian philosophy of science. Again, this point is contentious: while the logical empiricist explicitly rejects Kant's synthetic a priori principles, claiming to substitute them with conventions, recent contributions highlight the fact that Schlick did make use of "constitutive principles" in his epistemology (Bland 2011, 2012), a term that has at least a Kantian flavor. More specifically, Schlick accepted indeed Reichenbach's claim that some principles need to be presupposed to turn simple perceptions into scientific

observations in his 1920 correspondence with him. At the same time, the founder of the Vienna Circle could not accept the adoption of a Kantian lexicon to describe such principles. It needs to be clarified to what extent, then, his conventionalism diverged from Kant's original constitutive principles and Reichenbach's reformulation of them.

In this chapter, I will first introduce the discussion between Reichenbach and Schlick in more detail to pinpoint the difference between constitutive principles and conventions, since it grounds the subsequent discussion. Hence, section 1 is devoted to the correspondence between the two logical empiricists, and section 2 to Schlick's conventionalism and his relationship with Poincaré's epistemology. Such a relationship opens to a conceptual tension that Schlick solves by embracing Hilbert's formalistic attitude, exposed in section 3. In section 4, I present two flaws in Schlick's epistemology. First, he claimed that laws of nature are immutable, and this claim does not fit into his system. Secondly, he argued that Kant's constitutive a priori should be replaced with analytic conventions, since the principles underlying scientific knowledge are merely definitions. This assumes that definitions are always analytic. As I will show, scientific definitions often exhibit a synthetic character, which a Kantian epistemology might be better equipped to account for.

4.1 The Schlick-Reichenbach 1920 correspondence

The 1920 correspondence between Moritz Schlick and Hans Reichenbach is fascinating for plenty of reasons. First of all, the two logical empiricists started exchanging letters at a key period in their careers and in the history of the philosophy of science. Indeed, in the years after Einstein developed his theory of general relativity, Schlick published some of his most important works (most notably, his *General Theory of Knowledge* (1918/1974)), while Reichenbach wrote *Theory of Relativity and A Priori Knowledge* (1920/1965), the essay that set the stage for his career. It was exactly this latter work that motivated the correspondence. Moreover, those same years marked a transition in German philosophy from a period predominantly influenced by Neo-Kantianism to the development of the Vienna Circle and, in parallel, of Logical Empiricism. Like any other transitional period, it exhibits a complex clash between different perspectives that defies rigid categorizations and simple alignments. The letters between Reichenbach and Schlick alternate between attempts to create a united front and

recruit allies to build a philosophical movement and clashes on conceptual divergences, destined to highlight the originality of the individuals.

Another element of interest in the correspondence is the apparent linearity of the debate, which actually hides two very complex frameworks. For example, Schlick's perspective is usually considered anti-Kantian, in opposition to Reichenbach's reformulation of Kant's constitutive principles. While this schematization surely is not wrong, it should not be overlooked that Reichenbach plays the anti-Kantian against Schlick in their discussion on causality and probability (Padovani, 2010; Parrini, 2002)[93], and that before their exchange, he also criticized Schlick's use of Kant's philosophy in a review of the *General Theory of Knowledge* (Hentschel, 1991). The deep differences between the two authors, reflected also in the alleged differences between the Vienna and Berlin Circles (Milkov, 2013; Uebel, 2013), are so significant that Reichenbach states in a letter to Heinrich Scholz that "collaboration with the Vienna Circle does not mean an agreement with the number of naiveties which it conveyed to us from Vienna (and to which I also count Schlick's *Ethics*), but that this union is a result of the compulsion of the isolation in which the school philosophy put the exact philosophers" (Reichenbach to Scholz, Oct. 13, 1931; HR, 013-31-06).

Therefore, it is difficult to pigeonhole Kant's influence on the thoughts of the two logical empiricists, or how much they agreed about applying Kantian concepts to scientific knowledge. Furthermore, the claim that Schlick completely won the debate and persuaded Reichenbach to adopt conventionalism is inaccurate. Nevertheless, the mutual respect they had for each other, combined with their willingness to accept criticism and change their views, greatly enhanced the significance of their exchange.

Finally, the documents in question represent a valuable source for understanding the details of Schlick's and Reichenbach's perspectives, as well as how and why they evolved over time. All the topics crucial for the development of Logical Empiricism and the ensuing philosophy of science—including conventionalism, realism, Kantianism, and the status of physical laws and principles—emerge in Schlick's and Reichenbach's 1920 letters. In addition, it is in their correspondence that we find the distinction between

[93] Reichenbach expresses even concern for Schlick's Kantian drifts in a letter to Berliner dated 16th June 1920 (HR-015-49-25).

Schlick's conventionalism and Reichenbach's defence of constitutive principles that will be the object of this chapter.

On 25 September 1920[94], Schlick wrote the first letter of his correspondence with Reichenbach after receiving his Theory of Relativity and A Priori Knowledge. In it, he complimented the author and postponed a more detailed discussion of individual topics to a later date. In the next letter, dated 26 November 1920[95], Schlick's viewpoint on the major issues in Reichenbach's book emerges. Three issues can be highlighted to summarise Schlick's letter.

Firstly, he tackles Reichenbach's conception of the a priori. Reichenbach's argumentative strategy in his 1920 essay may be summarized in three steps:

> *Premise 1*: Kant's philosophy is committed to the claim that any set of a priori constitutive principles cannot be contradictory.
> *Premise 2*: Both Special Relativity and General Relativity show the internal contradiction of certain sets of a priori constitutive principles.
> *Conclusion*: Einstein's Relativity and Kant's concept of a priori are incompatible, and the latter should be modified in light of the former, by being relativized.

It is not relevant for the aims of this analysis to thoroughly explain all three steps (see section 2.2.2). What is crucial is that Reichenbach was the first to distinguish two different meanings of Kant's concept of a priori: "First, it means 'necessarily true' or 'true for all times', and secondly, 'constituting the concept of object'" (Reichenbach 1920/1965, p. 48). Schlick's letter starts by claiming that the two meanings of the a priori cannot be separated. Kant's principles exhibited a modal status and a constitutive role that cannot be untied. According to Schlick, Kant

> identified the self-evident general statements of natural science with the principles that constitute the objects of experience. It is here, i.e., in the identification of the two concepts of a priori that you have so properly distinguished, that I find so essential a doctrine of the critical philosophy that one cannot undermine it without placing oneself far from the

[94] I would like to thank Friedrich Stadler for allowing me to consult the texts of the letters from the Vienna Circle Archive. All quotations from the letters are taken from these manuscripts or, alternatively, from Coffa's (1991) translation.
[95] This letter can also be found in the Archives of Scientific Philosophy in the Twentieth Century, Department of Special Collections, University of Pittsburgh Libraries, as the file number 015-63-22. I refer to the copy in the Vienna Circle Archives, partially translated in Coffa (1991).

> Kantian philosophy. (Schlick to Reichenbach, Nov. 26, 1920, translated in Coffa, 1991, p. 201)

The second theme of Schlick's letter is conventionalism. After the criticism of Reichenbach's use of a Kantian language, Schlick indeed proposes to his colleague an alternative lexicon, borrowing from Poincaré the term 'convention' to describe the principles of a scientific theory. Schlick writes that he "cannot see what is the real difference between your [Reichenbach's] a priori statements and conventions" (Schlick to Reichenbach, Nov. 26, 1920, translated in Coffa 1991, p. 202).

When considered as conventions, the axioms of geometry and the principles of physics lose the burden of apodicticity and necessity that they exhibit in Kant's philosophy, at least according to Schlick. Indeed, conventions are always chosen among alternatives, keeping the option of changing the chosen ones open. Moreover, conventions are *definitions*, hence they are analytic, not synthetic, like Kant's a priori. In the letter, Schlick seems to be concerned only with the *modality* of the principles under investigation, which should not be incontrovertible. Once the necessity of principles is put aside, Schlick welcomes the possibility that they *constitute* the concept of the objects of a theory, in the sense of *implicitly defining* the theoretical terms of a theory (Bland, 2012).

As Coffa (1991) and Oberdan (2009) emphasized, a third topic emerges in the letter, namely realism. Schlick suggests to Reichenbach that conventions are employed to determine principles and theories, and not nature itself, which is autonomous. Schlick refers here to my distinction between concept-constitutive and object-constitutive principles (section 2.3).

More specifically, in his 1920 essay, Reichenbach describes constitutive principles as mediators needed to coordinate between the abstract mathematical formalism of a theory and the concrete sensory experience. However, these two realms are not both *given*. Conversely, we can only define with precision the mathematical part of a theory, choosing between various potential systems and theories, to then apply it to the empirical realm, which is *not defined* and can be defined only by the mathematical part. As Reichenbach explains,

> The coordination performed in a physical proposition is very peculiar. It differs distinctly from other kinds of coordination. For example, if two sets of points are given, we establish a correspondence between them by coordinating to every point of one set a point

> of the other set. For this purpose, the elements of each set must be defined; that is, for each element there must exist another definition in addition to that which determines the coordination to the other set. Such definitions are lacking on one side of the coordination dealing with the cognition of reality. Although the equations, that is, the conceptual side of the coordination, are uniquely defined, the "real" is not. On the contrary, the "real" is defined by coordinations to the equations. (Reichenbach, 1920/1965, p. 37)

Schlick reverses Reichenbach's claim. It is not that nature requires theories to be determined, but, vice versa, theories are determined by empirically verifying them. In the letter, he writes: "I believe that only the undefined side determines - through the mediation of perception - the conceptual side, and not vice-versa." (Schlick to Reichenbach, Nov. 26, 1920, translated in Coffa, 1991, p. 204). Nature is already "formed", and we need to empirically discover its structure. Thus, also the problem of realism enters the scene in the Schlick-Reichenbach exchange.

Given the richness of this letter and the subsequent correspondence, it is not surprising that it received much attention from commentators. After Parrini (1983, 1998), Coffa (1991), and Friedman (1999), other contributions shed light on the diverse facets of the Schlick-Reichenbach relationship, among which Ben Menahem (2006), Bland (2011, 2012), Bonnet & de Calan (2010), Oberdan (2009), Padovani (2010, 2015), Ryckman (2005), and Stump (2003, 2022). The next two sections directly tackle the main concepts that emerged in this section, i.e., conventionalism and realism, to unpack them and better understand Schlick's approach. To achieve such understanding, I will analyse Schlick's relation with Poincaré (section 2) and Hilbert (section 3).

4.2 Poincaré and conventionalism

Poincaré is often mentioned by Schlick as the source of his idea of conventions. Beyond the letter to Reichenbach, in which he explicitly points to Poincaré's conventionalism as a valid alternative to Kant's constitutive principles, he also names the French mathematician in *The Philosophical Significance of the Principle of Relativity* (1915), in the crucial section §11 of his *General Theory of Knowledge* (1918/1974, 71), in some passages of *Space and Time in Contemporary Physics* (1917/2005) and in many important articles, among which Schlick (1931, 1935).

Any attempt to reconstruct Schlick's inheritance of Poincaré's notion of convention faces two difficulties: the complexity of Poincaré's thought, which was not systematic (Gyedimin 1982, p. 1; Heinzmann 2010), and the unorthodox way in which Schlick mixed aspects of his conventionalism with other sources, most notably Mach and Duhem. Three aspects of Poincaré's epistemology should be kept in mind to assess Schlick's interpretation of his conventionalism: the inclination towards Kantianism, the reevaluation of intuition, and structuralism. Since all these three aspects are relevant to Schlick's conventionalism, I will first tackle them to then discuss the meaning of 'conventions'.

4.2.1 Poincaré's influence

First, although Schlick employs conventions to undermine the Kantian epistemology, Poincaré is very influenced by Kant's criticism and works his whole life within a Kantian environment. From Émile Boutroux, very influential in France at the end of the nineteenth century, Poincaré inherits the anti-positivist idea that scientific facts need to be constructed within intellectual frameworks that are, however, flexible and adaptable (Ferrari 2006, 2021; Nye 1970; Rollet 1999). For this reason, Poincaré's writings may be inscribed in a project of modernization of Kant's system, focused on pluralizing his functions of knowledge. The project of recovering the transcendental categories of the understanding while refusing their eternal or platonic nature, common to Boutroux, Poincaré and other French authors of the same period, is due to a variety of factors that include evolutionism, mostly interpreted in relation to Spencer's works, Comte's positivism and, finally, the constellation of authors who returned to Kant in opposition to the idealistic movement, among which Helmholtz, Zeller, and Cohen (Ferrari, 2021; Nye, 1970).

The second crucial aspect of Poincaré's epistemology, without which both his notion of convention and Schlick's interpretation of it would be incomplete, is his reevaluation of intuition as a creative process employed in mathematics and science. This point is crucial to assess his perspective on mathematical reasoning. In *Science and Hypothesis* (1902/2018, p. 8), Poincaré claims that "mathematical reasoning has in itself a kind of creative power and, consequently, that it differs from syllogism". The mathematical reasoning Poincaré has in mind is mathematical induction. This method establishes the

truth of a proposition for all natural numbers by proving a base case, typically for zero or one, and by showing that for every natural number *n*, if the proposition holds for *n*, then it also holds for $n + 1$. From a finite procedure, the truth of an infinite amount of propositions is granted. The step that licenses the indefinite extension from the base case to all natural numbers does not belong to analytic reasoning, since it is not a logical tautology, but rests instead on what Poincaré characterizes as a form of mathematical intuition. As Poincaré puts it, "This rule, inaccessible to either analytic proof or experience, is the genuine kind of synthetic a priori judgment" (1902/2018, p. 14).

Again, his reformulation of a Kantian line of reasoning may be appreciated here. Mathematical induction is not a contingent and fallible strategy, but a necessary one insofar as "the affirmation of a property of the mind itself" (1902/2018, p. 15). Although Poincaré should not be considered a strict Kantian, this specific aspect of his thought cannot be ignored, in particular, if one considers his defense of the mutual relationship between intuition and logic in the debate with Russell and Couturat (Ben Menahem 2006, Ch. 4; DiSalle 2006, p. 122; Ferrari 2006, p. 153).

The emphasis on the role of intuition and mathematical reasoning in Poincaré's works (see Folina, 1994; Heinzmann and Nabonnand, 2008; Heinzmann, 2024) exerted a controversial influence on Schlick. Two apparently contradictory considerations emerge from an inquiry into the Poincaré-Schlick relationship on this point. On the one hand, Schlick completely reverses Poincaré's project by (i) rejecting the synthetic a priori, (ii) rejecting a scientifically relevant role for intuition, and (iii) configuring a philosophical stance modeled on Hilbert's formalistic approach and on Frege's and Russell's logicism. Such a deductivist view of mathematics aligns him more with the thinking of Duhem than that of Poincaré (Bonnet & de Calan, 2010, p. 123).

On the other hand, Schlick's focus on Poincaré is partially due to Gustav Störring, one of his mentors in Zurich in 1907-1909, namely during the years in which the logical empiricists turned his attention from physics to philosophy (Ferrari, 2012; Oberdan, 2022). Since Störring's interpretation of Poincaré was less concerned with conventionalism and more with mathematical reasoning, Schlick's assessment of this latter aspect might also be subtler. Indeed, in his early article "The Nature of Truth in Modern Logic" (1910), Schlick does inherit from Poincaré the idea that our mind is at the basis of the apodicticity of mathematics (Ferrari, 2012, pp. 480-481).

The simple solution to this apparent contradiction is to separate the different phases in Schlick's thought. This strategy is surely valid, insofar as the logical empiricist clearly refutes some of his early claims in the later works. However, it may prove beneficial to keep in mind the nuanced evolution of his thought to make sense of some incoherence in his mature works and his complex relationship with Reichenbach's perspective. As already mentioned in the previous section, any reader of their correspondence is often tempted to divide them into clearly defined teams, while in reality both philosophers work in a magmatic and ever-shifting landscape, in which reconsiderations of previous thoughts are often invoked. This point will prove useful in our assessment of the complicated relationship between conventions and constitutive principles.

The third crucial aspect of Poincaré's epistemology is structuralism. As "Mathematicians do not study objects, but relations between objects" (Poincaré 1902/2018, p. 21), for the physicists as well the relations between objects "are the only reality we can reach, the only condition being that the relations between the objects are the same as those between the images standing in for the objects" (Poincaré 1902/2018, p. 115). Ivanova (2015) convincingly shows the interconnection of Poincaré's structuralism with three aspects of his viewpoint on geometry: underdetermination (our experience is compatible with more than one geometrical system), intertranslatability (non-Euclidean geometries are consistent, given that Euclidean geometry is consistent), and the epistemic status of geometry, neither empirical nor a priori. But this point leads to the next section, in which Poincaré's notion of convention and Schlick's reformulation is analysed through the conceptual instruments provided in this section.

4.2.2 The meaning of "convention"

Poincaré provides both negative and positive characterisations of what a convention is. Combining these two strategies reveals three features of conventions.

(i) Conventions respond to the untenability of both Kantianism and empiricism;

(ii) Conventions emerge when several alternatives are equally admissible; and

(iii) Conventions are not arbitrary.

Schlick's notion of convention encompasses features (i) and (ii), but not (iii). In this sense, he adopted Poincaré's epistemology while also deviating from it. First, let's examine these aspects from Poincaré's perspective, before turning to Schlick's reformulation.

In *Science and Hypothesis* (1902/2018), Poincaré emphasises what conventions are *not* by criticising both Kantianism and empiricism. He claims that if the axioms of geometry were synthetic a priori judgements, "they would then seem so self-evident that we would not be able to conceive of the opposite proposition, nor could we base a theoretical construct on them" (1902/2018, 42). There are two reasons that justify this argument. Firstly, Poincaré is referring to the development of non-Euclidean geometries, i.e. alternative conceivable geometrical systems.

Secondly, he is referring to his philosophy of arithmetic and his view of induction. The absence of such reasoning in geometry, for Poincaré, implies that no single system of axioms can compel acceptance alone. While denying its apodicticity, Poincaré also attacks the empiricist view of geometry: "If geometry were an experimental science, it would not be an exact science" (1902/2018, p. 42).

To understand this, it is important to note that, according to the French mathematician, the exactness of geometry stems from the differences between geometrical and perceptual space. While our sense of space is finite and heterogeneous, geometric space is conceived as homogeneous, infinite and three-dimensional. Such a difference implies that it is impossible to ground geometry in perceptual and empirical space. Poincaré concludes that "geometric axioms are neither synthetic a priori judgements nor experimental facts. They are conventions. Among all possible conventions, our choice is guided by experimental facts, but remains free and is limited only by the need to avoid contradiction" (1902/2018, p. 43).

In *The Value of Science* (1905/1958), Poincaré positively defines conventions, stressing that he "cannot admit that the scientist creates the scientific fact without restraint, since it is the crude fact that imposes itself on him'. [...] the scientific fact will never be anything but the crude fact translated into another language" (1905/1958, 116/120). Here, Poincaré separates two opposing levels: the domain of reality and our descriptions of it. Conventions lie in the second of these domains, namely the languages through which reality can be physically described. The linguistic aspect of Poincaré's conventionalism was crucial in influencing Schlick's perspective, but it deserves some

clarification. As Ben-Menahem (2006) highlights, Poincaré's conventionalism does not merely involve labelling the same fact: "Different geometries are different ways of articulating facts. [...] A reasonable choice of convention is informed by both experience and methodological values" (Ben-Menahem, 2006, p. 63). So can his conventionalism be characterised as linguistic?

A conceptual tension emerges at this point. On the one hand, Poincaré relates the conventional nature of the axioms of geometry and the principles of physics to the linguistic domain of our descriptions of nature. However, he is also aware that conventions are not merely different names or labels that can be applied to reality at random; rather, they give us an idea of the world and have repercussions on the image of the reality to which they are applied. For this reason, we have criteria for choosing between more or less adequate descriptions of nature; conventions are therefore not arbitrary. For example, space can be characterised as Euclidean even after Einstein's general relativity; however, this choice would have significant consequences involving the form of the equations used to describe it, the additional conjectures required to explain observed phenomena, and the relationship of the theory in question with others. The previous section is crucial for understanding the contrasting features of Poincaré's conventions, which are set in a Kantian context to develop a Kantian theme while deviating from the original solutions of Kant's epistemology and opening up a new area of research.

Other aspects of Poincaré's notion of convention should be considered, such as the sceptical strategy employed (Ben Menahem, 2006, p. 132; Friedman, 1983, ch. 7), and crucially, the difference between conventions in the geometrical and physical domains (see Ben Menahem, 2006; Bland, 2011; Heinzmann & Stump, 2024; Ivanova, 2015). However, Schlick's interpretation of these features is relevant here, as it allows us to assess the relationship between his perspective and Kant's constitutive principles.

The previous analysis showed that conventions address three problems: the untenability of Kantianism and empiricism; the existence of alternatives; and the strained relationship with nature that renders them non-arbitrary. Schlick adopts the first point wholesale. It is reasonable to suggest that his interpretation of Kant's a priori principle as being characterised by an unacceptable apodicticity is influenced by Poincaré. However, while Poincaré positioned himself within a Kantian line of research, Schlick attempted to

abandon it. Poincaré undoubtedly influenced Schlick's rejection of empiricism too, but this point will be discussed further in the next section, in reference to Hilbert.

The second point mentioned above is also adopted by Schlick, as it partially justifies the first. In other words, Kant's idea of synthetic a priori necessity must be rejected in light of alternative systems for describing nature, such as alternative geometrical systems for describing space. This raises the question: is the presence of alternatives a sufficient and necessary condition for describing the axioms of geometry, and more generally the principles of physics, as conventions? Conventions involve the possibility of choosing between alternatives: For example, length can be measured in metres or yards; a proposition can be communicated in English, Italian or French; the driver's seat in a car can be on the left or right; and, crucially, space can be described through Euclidean or non-Euclidean geometry. All of these cases present alternatives. However, the ways in which the choice is made differ. Sometimes, no factor compels the choice, which is then arbitrary, as with the position of the driver's seat. While these arbitrary cases are referred to as 'conventional' in everyday language, Poincaré characterises conventions as something different, which leads to the third feature of conventions mentioned above. In a 'technical' (non-ordinary, scientific) sense, conventions should *define* reality and inform us about its structure. For this reason, we need non-arbitrary, methodological criteria to choose an alternative. When this criterion cannot be based on experience (due to underdetermination), conventions in the technical sense are formulated.

The relationship between conventions, arbitrariness and common knowledge is complex and the subject of debate (Burge, 1975; Gyedimin, 1982; Lewis, 1969; Peruzzi, 2013). Notice that the choice of position for the driver's seat in a car and the choice of geometrical system for studying the universe may both be influenced by pragmatic reasons, which makes the two cases more similar, or by purely empirical factors, which undermines their conventionality. However, I will leave this large issue aside and limit my considerations to Poincaré's and Schlick's characterisation of conventions. Poincaré insists that conventionalism is not simply a matter of possessing different languages with which to describe the same reality. These languages shape our perception of reality, imposing a specific form on nature that aligns with our intellectual or scientific objectives. By stating that $F = ma$, Newton is not discovering the nature of force. He is defining it by using masses as "coefficients that are useful to introduce in calculations" (Poincaré

1902/2018, p. 79). This opens up a compatibility between the presence of alternatives and a neo-Kantian approach: scientists do choose creatively between alternative systems to describe and explain nature[96]. However, in doing so, they are defining the objects of experience in different ways and imposing a conceptual structure on an undefined reality. Reichenbach's 1920 essay explores this idea further.

However, this third aspect of conventionalism is controversial in Poincaré and dismissed by Schlick. Let me clarify: Poincaré stresses, in a Kantian manner, the repercussions that conventions have on reality, rendering them non-arbitrary. However, conventions do not apply directly to nature (Poincaré 1902/2018, 2). So, are conventions merely linguistic tools that describe the same reality in different ways, a reality that is independent of such descriptions? Or are they, conversely, a plurality of modes through which reality itself is constituted? Poincaré does not appear to alleviate this tension. Upon reading his works, Schlick decides to solve the same tension by tending towards realism, i.e. by assuming an objective reality that is independent of any theoretical system. Indeed, he often considers 'conventional' and 'arbitrary' to be synonymous. Consequently, the logical empiricist treats conventions as interchangeable linguistic labels that do not have a strong relationship with nature unless they are coordinated with it. In Schlick's epistemology, conventions are forms of thought that cannot be reduced to empirical data and have no genuine theoretical content; they are merely linguistic definitions (Parrini, 1983). This idea of conventionality leads to a strict separation between principles and reality. His stance on conventionalism is delineated more clearly in the next section with regard to this latter point, and the results of section 3, prepared in this section, will help to solve some of the problems outlined in section 1 concerning the Schlick–Reichenbach correspondence.

4.3 Hilbert and Realism

My analysis left two questions unanswered: why Schlick criticised Reichenbach's view, and how he dealt with Poincaré's conceptual tension. I see these as related problems that highlight Hilbert's formalistic approach to finding a solution. As Schlick writes in *The General Theory of Knowledge*, "David Hilbert undertook to construct geometry on a

[96] This interpretation of Poincaré aligns with the interpretation of the Neo-Kantian functional definitions in section 2.2.1.

foundation whose absolute certainty would not be placed in jeopardy at any point by an appeal to intuition" (Schlick 1918/1974, p. 33). Prior to this groundbreaking approach, basic geometric concepts such as points and lines were understood through intuitive rather than rigorous definitions. In Hilbert's formalisation of geometry, however, concepts are implicitly defined "just by the fact that they satisfy the axioms" (Schlick 1918/1974, 33). Thus, geometrical systems and intuitive sensory experiences exist independently of each other and can only be linked by assigning a unique correspondent experience to any sign of the formal system. According to Schlick, such a framework is valid not only for geometrical systems, but also for physical theories: "The totality of our scientific propositions, in words and formulas, is in fact nothing other than a system of signs coordinated with the facts of reality" (Schlick 1915/1979, p. 167).

Not only does Schlick provide Hilbert's formalistic approach with the fortunate denomination of 'implicit definition', but he also widens it into a broader framework. He also pinpoints a crucial consequence of such a framework:

> It is therefore all the more important that in *implicit definition* we have found an instrument that enables us to determine concepts completely and thus to attain strict precision in thinking. To achieve this end, however, we have had to effect a radical separation between concept and intuition, thought and reality. While we do relate the two spheres to one another, they seem not to be joined together at all. The bridges between them are down. (Schlick 1918/1974, §7, p. 38)

By wholeheartedly endorsing Hilbert's formalistic approach, theories and nature divorce. It is not merely a matter of characterizing the principles of a scientific theory as conventions, unrelated to any synthetic judgment or intuitive experience, but also of conceiving nature as an autonomous block that is already determined before any conceptualisation, determining by converse such conceptualisations. Although Schlick was not a naïve realist, his understanding of Hilbert and Poincaré, his early studies with Max Planck, and his anti-Kantian approach led him to a version of realism (Neuber, 2011; Oberdan, 2009; Oberdan, 2022). Schlick's viewpoint is best understood as a *ripping* between the domain of conceptualisation and the domain of empirical intuition, which

can be stitched up only through ostensive and coordinative definitions (Friedman, 1999; Friedman, 2001; Parrini, 2002, p. 68)[97].

A longstanding philosophical tradition characterizes the view of reality as a block that can be conceived autonomously of any conceptualisation with the formula 'things-in-themselves' (*Dinge an sich*). Not by chance, Schlick tackles exactly this Kantian notion in some of his works, confirming the realist claims mentioned above. In *Form and Content. An Introduction to Philosophical Thinking*, which gathers three lectures Schlick gave in London in 1932, he states that "If the 'phenomena' are appearances of something else, then the mere fact that this 'something else' is that particular reality of which that particular phenomenon is the appearance - this fact enables us to describe the reality just as completely as the appearance of it." (Schlick, 1932/1979, p. 359).

Although, for a Kantian, the initial presupposition is fundamentally flawed — Kant's phenomena are not merely the appearance of something else — Schlick's claim has a respectable pedigree. He reiterates the realist interpretations of Kant's transcendental philosophy, as represented by authors such as Heinrich Jacobi, Oswald Külpe, Benno Erdmann, and Alois Riehl (see Neuber, 2011). It should be noted that Schlick's interpretation of the term 'things-in-themselves' primarily concerns entities that are not perceived through sensory experience. In other words, he uses this term more against so-called 'immanentists', such as Mach, Avenarius and Schuppe, than against transcendental idealists (Parrini, 2002, pp. 212–213). In any case, his considerations on things-in-themselves, together with his framework of knowledge as a process of (Hilbertian) designation, his early studies with the realist Max Planck, and his remark to Reichenbach about the 'undefined side' (see Section 1), leave no room for doubt: *Schlick believes that scientific theories are coordinated with a non-conceptualised reality that pre-exists this coordination and already possesses determinate features*.

The route that starts with Kant, goes through Poincaré and ends with Schlick is now clearer, as is Schlick's dislike of constitutive principles. Kant contrasted the multiplicity of experience, or the 'rhapsody of perceptions', with the unity of the transcendental subject. Indeed, the synthesis of the 'I think' is employed to structure and organise the multiplicity of experience. However, in the nineteenth century, the unity of such a

[97] Conventions can be found both at the conceptual domain and at the coordinative level. Bland (2012) draws a distinction between mere conventions and constitutive principles based on these two levels.

synthesis multiplied: more systems of axioms or principles could be used to describe nature. The conceptual tension of Poincaré's perspective stems from this multiplication of forms. The French mathematician pitted various systems of principles against the variety of experience, attempting to uphold the notion that they are mutually constitutive.

Schlick's realism can be interpreted as the third step in this tradition. The logical empiricist realises that Einstein's general theory of relativity establishes that multiple systems of principles can be used to describe nature. Unlike Poincaré, Schlick concludes that such a variety of frameworks must be opposed to a unity of experience — namely, a pre-conceptual reality independent of any conditions of knowledge. This reality can be described using different conventional languages, in the same way that the objective content of a proposition can be translated into Italian or English.

Schlick's realist stance not only resolves Poincaré's conceptual tension, but also underpins his arguments in correspondence with Reichenbach. Once Schlick embraces Hilbert's formalistic approach and applies a strict distinction between principles and reality, together with Poincaré's notion of convention devoid of its Kantian features, reality appears to be constituted prior to any theoretical conceptualisation. Therefore, Schlick proposes a terminological transition that will reverberate throughout much of later philosophy of science: The process of constitution (*Konstitution*) becomes one of coordination (*Zuordnung*). Both terms have a rich and boundless history that cannot be covered here. For example, consider that both Cassirer and Reichenbach employed these terms within approaches that departed from Schlick's. Here, it is sufficient to observe the general difference between constitutive and coordinative principles. The difference can be illustrated using ordinary language: when A constitutes B, A is a condition sine qua non of B and B depends heavily on A to the extent that B would not exist without A. Conversely, when A is coordinated with B, both A and B are considered to pre-exist the act of coordination.

In his correspondence with Reichenbach, Schlick accepts that some principles must be presupposed to turn a perception into an observation, and he also makes use of *quasi-constitutive* principles, insofar as such principles provide some concepts of a theory with meaning (Bland 2011). In this sense, he recovers the meaning-conferring dimension of

Kant's constitutive, as argued in chapter 2[98]. However, he does not accept that nature itself requires determining principles and concepts.

4.4 Assessing Schlick's perspective: laws and definitions

In a letter dated 29 November 1920, Reichenbach replies to Schlick, objecting to the alleged arbitrariness of conventions. Reichenbach argues that it is no surprise that scientific principles – ranging from the Euclidean nature of space to genidentity and relativity – can change, yet they still align with certain requirements, particularly when considered in combination (see section 2.2.2). These combinations of principles, which occur in every theory, make it impossible to stipulate the validity of a convention arbitrarily. While the initial focus of the Schlick–Reichenbach correspondence was on how Schlick convinced Reichenbach to abandon the notion of constitutive principles, further analysis reveals that Reichenbach's criticism also resonated within Schlick's framework.

One example of such an influence is Schlick's article 'Are Natural Laws Conventions?' (1935), in which he distances himself from radical forms of conventionalism. In this work, Schlick distinguishes between the *specific symbols* used to formulate a law and the *meaning* of those symbols. He uses the terms 'sentence' and 'proposition' to differentiate between them. While a sentence is a specific group of letters and words used to express something, a proposition is the content expressed by the sentence. The various notations and kinds of equations in which laws can be formulated are *sentences* and can change arbitrarily due to their conventional nature. However, Schlick claims that natural laws are propositions — which indicates *immutable and objective facts* about the universe that remain unchanged by any arbitrary mode of formulation. Laws are not conventional, as he emphasises: "After all, we are fond of saying that natural laws are immutable, yet we are not tempted to claim that they have changed when we introduce a new notation or even a completely new geometry" (Schlick, 1935/1979, p. 443).

It is crucial to observe that, at this juncture, Schlick defends natural laws as propositions capable of being true or false: "only propositions are true or false, not sentences" (Schlick, 1935/1979, p. 444). While neopositivists often reduced laws (in the

[98] It should be stressed that Schlick does not view meaning as referential content, but rather as the rules to apply a sentence so that it refers to facts.

sense of *sentences*) to mere rules — fearing that universal statements lacked strict verifiability (see Hempel, 1950; Ferrari, 2019; and Justus, 2022) — this discussion prioritizes the propositional content of these laws, that are thus explicitly considered to possess both truth value and empirical significance[99].

The energy principle exemplifies Schlick's claim, as it "is generally considered to express that 'objective' order of facts which makes it impossible to produce work out of nothing - an impossibility which is continually impressed upon us in our daily experience and which is certainly quite independent of the manner in which we care to formulate it" (Schlick, 1935/1979, p. 443). Natural laws indicate structural facts about nature, which can be expressed in different ways. Classical mechanics invariably represents some phenomena of our ordinary experience, and yet it can be formulated in different forms with different mathematical languages—the Newtonian, Lagrangian, and Hamiltonian formulations. Similarly, Einstein's field equations represent a factual relation between spacetime and matter, but they can be formulated in various conventional ways, using non-Euclidean or Euclidean geometry with corresponding simple or less simple equations.

Now, some scepticism may be raised about the equivalence of different formulations of the same theories and laws. But even if one accepts it, a deeper shortcoming emerges: as we are about to see, in Schlick's framework scientific laws and definitions are given neither a place nor an adequate recognition. This fact motivated Reichenbach's and Cassirer's criticism of his conventionalist empiricism. By reviewing these downsides of Schlick's view, the broader relationship between conventions and constitutive principles will be clarified.

Let's start with laws. According to Schlick's epistemology, there are only three types of statement: logical tautologies, stipulated conventions and synthetic propositions about the world. To which category do the laws of nature belong? They cannot be logical analytic statements, since they impart knowledge. They are not conventions either, as Schlick (1935/1979) makes clear. They are not even mere rules, as the discussion above clarified: they are explicitly considered as either true or false descriptions of natural

[99] Schlick's identification of natural laws with truth-valued propositions rules out also interpreting laws as non-linguistic entities or facts distinct from their linguistic formulations, because only propositions are truth-bearers, while facts function, at most, as truth-makers.

facts[100]. They should therefore be empirical propositions. However, Schlick adds that laws are "immutable" (Schlick, 1935/1979, p. 443). How can a synthetic, empirical proposition be 'immutable'? Immutability might raise the necessity of Kant's a priori, which Schlick refuted.

To make sense of Schlick's account, three escape routes are viable, and yet each of them exhibits difficulties. The first option is that natural laws represent the facts to which our concrete formulation of laws gradually converges. Therefore, natural laws are the 'immutable' facts (the propositions) that can only be known approximately through our formulation of specific scientific laws (the sentences). This interpretation would motivate Schlick's criticism of Kant's attribution of necessity to Newtonian mechanics while maintaining the immutability of the ultimate, asymptotically approachable laws of nature. However, according to this conception, the content of theories results in a regulative task, and Schlick seems to criticise such a neo-Kantian view.

The second option is that: (i) the laws of nature are immutable because they represent the actual order and structure of reality; (ii) they are not an approachable, regulative polar star, but rather the laws present in our best theories; and (iii) we can still formulate them in many conventional ways, including the Newtonian approach. Four problems arise from this second option.

First, Schlick's career-making criticism of Kant's philosophy vanishes. Indeed, he would find himself, unwillingly, endorsing the idea that certain propositions about reality are necessary—although they may be expressed by different sentences. This can scarcely be regarded as a refutation of synthetic a priori judgments.

Second, Schlick should then add some internal distinctions between empirical propositions: "A perpetual motion machine is impossible" and "My kitchen's wall is orange" seem to be very different, at least intuitively. Yet, his system does not differentiate between these examples.

Third, it is far from clear how our actual laws could describe the immutable structure of reality. The incompatibility between general relativity and quantum mechanics alone can motivate scepticism, alongside the more general distinction between statistical and causal laws. Either they both represent an approximation to the ultimate laws, thereby

[100] Schlick refers to the principle of causality as a rule to seek for new laws (Schlick, 1931/1979). For the neopositivist account of laws as rules and not meaningful assertions, see Hempel (1950) and Justus (2022).

falling again into the problems of the first option, or some of our actual laws are not laws, and Schlick's conceptual toolbox seems ill-prepared to address this distinction.

Fourth, one may suggest that laws are immutable propositions that can be expressed in various sentences, and yet these sentences can be classified and even set aside due to meta-theoretical requirements, such as simplicity. Nonetheless, Schlick refutes the soundness of simplicity as a meta-requirement (Schlick, 1931/1979), and his view is generally critical of meta-theoretical prescriptions on how to classify formulations of laws.

The third option is to adopt a Humean perspective on nomological necessity (Lewis, 1986)[101]. In this view, laws are patterns that we observe in nature, i.e. regularities with no intrinsic necessity. In his *Problems of Ethics* (1939), Schlick appears to take this approach, emphasising the following:

> It is again very deplorable that the word "necessary" has been applied to natural laws (or, what amounts to the same thing, with reference to causality), for it is quite superfluous, since the expression "universally valid" is available. Universal validity is something altogether different from "compulsion". (Schlick, 1939, p. 149)

Nevertheless, this third interpretative option also has drawbacks. For example, in the quotation, Schlick treats natural laws and causality as identical. However, only natural laws are characterised as "immutable" in his works, while causality is treated as a means of seeking rules (Schlick, 1931/1979). He does not clarify the relationship between 'necessity', which he rules out, and 'immutability', which he affirms. Also consider that applying a contemporary account of laws, such as Humeanism, to Schlick's epistemology may raise doubts about its anachronistic nature. In addition to 'Are Natural Laws Conventions?', Schlick states in his *General Theory of Knowledge* that "The only things that science seeks to retain as absolutely immutable — and indeed must retain if it is to gain any knowledge at all — are laws" (Schlick, 1918/1974, p. 377). Whether such immutability is compatible with Humeanism, in which laws are contingent generalisations, is open to discussion.

[101] For an overview on the debate on nomological necessity see Dorato (2005).

Not only are laws of nature problematic within Schlick's conventionalist empiricism, but also *definitions*. Schlick explicitly identifies definitions, conventions, and analytic judgments. In §11 of his *General Theory of Knowledge*, he claims that

> definitions are to be reckoned among analytic judgments. They give us only the features that already belong to a concept. In a sense, of course, we are justified in saying that a definition effects a synthesis in that it puts various features together into a concept. But a definition is not thereby transformed into a synthetic judgment, since it does not endow the concept with any features over and above those it already possesses. A synthetic judgment, we may say, designates the uniting of objects to form a set of facts, while a definition designates the uniting of features to form a concept. (Schlick, 1918/1974, p. 76)

Schlick reiterates this idea in a manuscript written between 1923 and 1926, where he identifies definitions and analytic judgments (Schlick, 2019, p. 394). This claim is a crucial premise of his epistemology: if scientific principles are definitions—as they can be chosen among alternatives—and definitions are analytic, then scientific principles are analytic. By being analytic, scientific principles can be then described as conventions. While the argument may be valid, and the premise that principles are definitions may be accepted, Schlick does not pinpoint the fact that *definitions can be synthetic*.

To argue for his claim, Schlick again points to the distinction between concepts and objects: definitions concern features of concepts, rather than sets of facts. Do scientific definitions in fact work this way? At first, Schlick's consideration seems legitimate. In developing his theory of special relativity, Einstein defined two events as simultaneous when an observer who is equidistant from both receives a light signal from them at the same time. Thus, Einstein's operational definition of simultaneity concerns a concept, as Schlick claims.

However, it does not simply state a semantical clarification of the term, like a dictionary. It indicates, rather, *the best empirical way to define what simultaneity means*. In this way, it enables us to formulate a novel theory and to view reality itself in different terms. Indeed, Einstein's definition led to a definition of time, insofar as the equal duration of the two signals' paths must be stipulated. Such a conceptual move is at the basis of Einstein's idea of elevating the light principle and the relativity principle to the status of postulates, relativizing the notions of space and time separately considered, and

developing the theory of special relativity. As Einstein's case shows, definitions in science shape our way of looking at nature. *Contra* Schlick, this means that definitions are sometimes *about facts*, and not simply elucidations of a concept's feature.

Consider also the classifications that are central to chemistry and biology, such as Linnaeus' taxonomy or Mendeleev's periodic table. Again, they define what an item is by placing it within a system, thereby improving our knowledge and enabling predictions in a way that analytic definitions cannot do. It has been recently shown that Linnaeus's botanical and zoological taxonomy was not driven by scholastic metaphysical essentialism (Winsor, 2006). His classification was neither a collection of data nor a mere description, but an attempt to systematize living beings, gathering *species* under *genera*, based on holistic and final-causal explanatory factors (see Broberg, 2023; Müller-Wille and Charmantier, 2012; Wells, 2020). Similarly, Mendeleev's classification of the elements in his periodic table is not an arbitrary aggregate, but a powerful system that accounts for predictions and completeness (see Pulkkinen, 2019; Schindler, 2014). Linnaeus and Mendeleev employ definitions as *organizations of nature*, as what brings unity out of multiplicity. Again, they appear to concern facts and upgrade our understanding of nature, like synthetic judgments.

Schlick might reject this view, insisting on the fact that these kinds of definitions do not add features to concepts. Beyond the fact that a discussion on where a line can be drawn between adding and simply exposing features of concepts might be unproductive, the exact difference between constitutive principles and mere conventions lies in their object-positing dimension. Definitions can be constitutive in making a system out of an aggregate, in tracing functional dependencies between otherwise unrelated unities. Scientific definitions posit a reality, thereby enabling inferences, explanations, and predictions. By considering them as analytic, definitions are reduced to dictionary statements like "Bachelors are unmarried men". Conversely, they may exhibit a synthetic role by implementing knowledge, adding features to concepts, and changing them to view reality itself differently. By the act of defining, scientists "get their hands dirty": a process of constitution is at play, of *modeling*, *shaping*, and *intervening*. This is what Kant had in mind when he described Galileo's, Torricelli's, and Stahl's scientific activities as proof that "reason has insight only into what it itself produces according to its own design"

(*CPR*, Bxiii). My claim is not that all scientific definitions are synthetic, but rather that some of them exhibit a synthetic role that is not completely grasped by Schlick's account.

To sum up, Schlick's schema of scientific statements, as classified into analytic definitions and synthetic propositions, seems inadequate to address nomological necessity and the multiple kinds of scientific definitions. Part of this inadequacy may be ascribed to his refusal of constitutive principles, alongside with his sharp separation of concepts and reality derived from a synthesis of Poincaré's and Hilbert's philosophical positions.

Conclusion

In a letter to Cassirer dated 5 June 1920, Einstein states: "Not being a philosopher, the philosophical antitheses seem to me more conflicts of emphasis than fundamental contradictions". If the dispute between Schlick and Reichenbach is limited to the status of scientific principles, then Einstein's suggestion might appear appealing. Indeed, both philosophers seem to share a very similar viewpoint, expressed in a different vocabulary. In letters following those considered above, Schlick and Reichenbach even agreed to mark their disagreement as merely terminological. Partially, this choice was a mutual encouragement to build a common front against the prevailing neo-Kantianism, motivated by pragmatic and career-driven reasons. Nevertheless, the underlying difference emerges once we consider the notion of reality conveyed by their principles.

In this chapter, I have argued for this claim by first reviewing their correspondence. In section 1, I have highlighted why their exchange is so important and summarized the three main arguments it introduces, namely, Kant's a priori, Poincaré's conventions, and realism. Then, to clarify their meaning, in sections 2 and 3 I have discussed conventionalism and realism. I have stressed the three points needed to understand Poincaré's legacy to Schlick, i.e., Kantianism, the re-evaluation of the role of intuition in mathematical induction, and structuralism, to then tackle the notion of convention. Schlick inherits it from Poincaré insofar as it addresses the untenability of both Kantianism and empiricism and the presence of alternative scientific systems. However, a third aspect characterizes conventions: they structure reality, providing criteria of choice between alternatives. While this aspect is present in Poincaré, causing a conceptual tension in his framework, Schlick partially refuses it. This refusal is justified in section 3 by analysing Schlick's realism, which results from embracing and extending Hilbert's

formalistic approach. Schlick's realism, which emerges particularly in his interpretation of Kant's things-in-themselves, helps in understanding both his reformulation of Poincaré's conventionalism and his criticisms of Reichenbach in their correspondence. In section 4, I have suggested some of the problems that Schlick's view raises, related to nomological necessity and the role of scientific definitions. His anti-constitutive approach is ill-equipped to adequately grapple with these issues.

Chapter 5: Constitutivity and Realism: The Material Object in Husserl's *Ideas*

Abstract: This chapter analyses Husserl's notion of constitution and its significance for scientific knowledge. It first clarifies the basic concepts and method of phenomenology, then reconstructs constitution as a meaning-giving process that correlates subjectivity and objectivity, unfolds in static and genetic forms, retroacts on the subject, and varies according to different intentional acts and regions. The chapter then examines Husserl's account of scientific constitution in *Ideas II*, showing how scientific objects are constituted as rule-governed unities, grounded in intersubjectivity, and abstracted from relative experience. Finally, it applies these results to the Friedman–Ryckman debate, arguing that Husserl's plural and historically situated conception of constitution offers an alternative to rigid constitutive principles and provides a coherent way to relate historical contingency and a priori necessity in science.

Introduction

The aim of this chapter is threefold. First, I will clarify the meaning of Husserl's concept of constitution. Second, I will specify his related account of the formation of scientific knowledge in *Ideas II*. Finally, I will apply these Husserlian reflections to the contemporary discussion on the nature of the a priori between Michael Friedman and Thomas Ryckman, which involved phenomenology and science.

Given the significant influence that Natorp had on Husserl's philosophy (Edgar, 2008; Kern, 1964; Luft, 2011, Ch. 8), it is not surprising that the concept of constitution plays a major role in phenomenology. Its many occurrences in Husserl's writings suggest the particular relevance of such a notion, as can be seen in the subtitle of the second volume of *Ideas*. Husserl's account is also portrayed as *constitutive phenomenology* (Sandmayer, 2008) or *constitutive realism* (Smith, 2020; Tieszen, 2011; Mudri, 2021). However, the phenomenological meaning of constitution requires careful consideration. While Husserl inherits the general idea from the neo-Kantians that consciousness provides experience with objectivity and meaning by constituting it, he also enriches and reshapes this concept within a whole new framework.

The analysis of Husserl's notion of constitution raises at least two difficulties. Firstly, Husserl never provides an exhaustive and definitive definition of it. For this reason, Eugen Fink described Husserl's constitution as an "operative concept" (Fink, 1976, p. 203): a primitive term that is necessary in order to define all the others. Secondly, the concept develops alongside the progression of Husserl's philosophy. Robert Sokolowski (1970) distinguishes *four* phases in Husserl's thought, each associated with an evolution of the notion of constitution. The first period covers the late nineteenth century and is primarily focused on *The Philosophy of Arithmetic* (1891/2003). The second period encompasses *The Logical Investigations* (1900–1901/2008). The third period concerns the so-called 'transcendental turn', which culminated in the two volumes *Ideas Pertaining to a Pure Phenomenology and to Phenomenological Philosophy* (1913/1982, 1952/1989) (hereafter referred to as *Ideas*). The fourth period involves the later works, mostly published posthumously, including *Cartesian Meditations* (1931/1960) and *The Crisis of European Sciences and Transcendental Phenomenology* (1954/1970) (hereafter referred to as *Crisis*).

Regarding the first issue, in this chapter I do not intend to provide a fixed, clear-cut definition of 'constitution', but rather to emphasise the key roles of this concept and highlight the similarities and differences in its use in phenomenology and in the two other constitutive traditions of neo-Kantianism and Logical Empiricism. Regarding the second issue, my analysis will focus solely on the constitution of the material object of physics as discussed by Husserl in *Ideas*.

To further narrow down the scope of the study, the analysis of the phenomenological concept of constitution will be directed to its reinterpretation in a contemporary debate in the philosophy of physics. This debate focuses on Thomas Ryckman's attempt to integrate Michael Friedman's account of 'constitutive principles' in spacetime theories with Husserlian concepts (Friedman, 2010; Ryckman, 2010). Ryckman's suggestion to re-evaluate Husserl's historical a priori, and Friedman's considerations on phenomenology in his later works (Friedman, 2009; 2010), motivate a deeper inquiry into Husserl's understanding of the structure of scientific knowledge. The fact that neither Ryckman (2010) nor Friedman (2010) focus on the phenomenological notion of constitution and its potentially fruitful relationship with Friedman's account of constitutive principles further prompts work in this area.

However, Husserl's view cannot be specified without first clarifying his terminology and the main aspects of his method. For this reason, Section 1 provides a general outline of phenomenology, by examining the notions of intentionality (Section 1.1), essence (Section 1.2), transcendental reduction (Section 1.3) and noesis (Section 1.4). Section 2 moves on to examine the specifics of Husserl's notion of constitution, illustrating its two main features: the role of giving meaning and its retroactivity on the subject. In this section, I also highlight other key distinctions in order to evaluate Husserl's account, such as the difference between static and genetic constitution. Section 3 focuses on Husserl's analysis of material objects as it is presented in *Ideas*, particularly §18 of *Ideas II*. This section explains how Husserl conceived constitution with respect to the object of physics and science in general. Section 4 applies my analysis of Husserl's constitution of the object of physics to the debate between Ryckman and Friedman on constitutive principles, focusing in particular on the role of instrumentation and theoretical assumptions to constitute data.

5.1 The phenomenological method

5.1.1 Intentionality

In line with Kant and the neo-Kantians, Husserl's phenomenology introduces the notion of constitution as a means of describing the relationship between subjectivity and reality. More specifically, Husserl asks how a perceptual act can occur *within* subjectivity and yet be *about* something beyond it. The entire development of the concept of constitution must therefore be understood in relation to this issue: how can objects be transcendent — i.e. independent of consciousness — yet still be accessible to knowledge? The first issue that Husserl addresses in his search for an answer is the fact that acts of consciousness are always *about* something. As is well known, he does so by adopting Brentano's notion of intentionality (Brentano, 1874/1995).

Intentionality indicates the object-directedness of any act of consciousness. When I perceive, imagine, remember, wish or judge, I always do so in a transitive way, referring to an object. To better understand this notion, it may be useful to emphasise what intentionality is not (Zahavi, 2003, ch. 1). The first possible account identifies intentionality with a causal relationship. For instance, I perceive a book if that same book is causally influencing my perceptual system. However, this first view is misleading

because intentional acts can refer to absent, impossible, non-existent, future or ideal objects. I can think of centaurs and particles faster than light, and my acts are still intentional as they are directed towards such contents. The second possible account describes intentionality as a fully internal relationship between consciousness and intra-mental objects. Again, this view is problematic. If intentional acts refer to internal objects, it would be impossible for the same object to be experienced twice, or by two different subjects, contrary to what Husserl wants to claim.

According to the third possible account, 'perception' is a ternary relationship: any external object perceived creates an internal image of itself in the subject's consciousness, thereby filtered through a system of signs. Three elements are involved: the subjectivity, the mental representation of the object, and the object itself. This view has been defended by critical realists such as Hermann von Helmholtz, Oswald Külpe and Carl Stumpf. Critical realists claim that a perceiver can only infer the existence of objects beyond their representations, which are guided by physiological laws.

Although Husserl's thought has been influenced by some of the theses formulated by critical realists, his account of intentionality differs from theirs. Indeed, their entire framework merely shifts the problem further down the line, as the ternary schema does not clarify the relationship between images or representations and objects (Trizio, 2021, p. 21). As Dan Zahavi states, "The object interpreted as a representation must first be perceived. But in this case, the representative theory of perception must obviously be rejected, since this theory claimed that perception itself is made possible through representation. If representation presupposes perception and, more generally, intentionality, it cannot explain them" (Zahavi, 2003, p. 19). Therefore, Husserl's famous "return to things in themselves" should be understood as follows: it is not an invitation to believe in a realm that is completely independent of any epistemic condition, but rather a demand to consider the target of our intentional acts as real objects and not merely images of objects[102].

Intentionality designates the directedness of conscious acts towards extra-mental contents and not copies or images. These contents do not exhaust the nature of the acts; rather, they enable consciousness to relate to objects beyond itself. For this reason,

[102] Kant's epistemology is not different from this approach: the phenomenon is not an image behind which the genuine reality lurks. Allison (2003) argues against the allegedly *phenomenism* of Kant's appearances.

Husserl's account builds on Brentano's original idea. While Brentano (1874/1995) focused on the intentioned object, Husserl redirects attention to the structural features of the act itself. An act is intentional not because of the object towards which it is directed, but because of its own *noetic* structure (see below), which concerns intentional content (Lanfredini, 1994, Ch. II). Husserl transforms the critical realist triad of subject, representation and object into a phenomenological triad of intending consciousness, intentional act and object as intended in its various modes of givenness. No mediating representation, image, or copy is required, nor is any object given apart from its meaning and the ways in which it is presented to consciousness.

The concept of intentionality is helpful in understanding the process of constitution, which refers to *consciousness*[103] *intending something as something*. This means that intentionality objectifies perceptual data, referring it to a unifying object and assigning it the same pole of meaning (Mudri, 2021, pp. 6–7; Spiegelberg, 1960).

Crucially, it is not possible to employ a single intentional act to comprehend an object in all its modes of givenness. The exhaustiveness of any experience being limited leads to another aspect of intentionality that Husserl discusses in his later works: its *horizontal structure*. Any intentional object given in experience exhibits itself in *adumbrations*, revealing only part of its totality. For example, when looking at the front cover of a book, it is not possible to see the back. Although intentional acts are confined within perspectives, they presuppose the possibility of other perspectives. Saying that intentional acts are horizontal means that they refer not just to a single object, but also to the context in which it is placed. This considers not only what is present, but also what is absent, in a diachronic dimension beyond the 'now'.

5.1.2 Essence

Husserl carries forward his analysis by focusing a bit more on the intentional contents of our conscious acts. The best way to follow Husserl's argument is through an example. The musical note A♯ can be heard when played by a piano, guitar or violin, for example, and each of these instruments can play the note in a theatre at a sold-out show or in a cold basement recording studio. Clearly, then, there is a difference between the various occurrences of A♯ and the general notion of A♯. While the former are contingent

[103] For the meaning of the controversial term 'consciousness', see section 2.4.

individuals realised in spatiotemporally placed acts, the latter represents the invariant structure of all those individuals, i.e. the common target of all those acts. By analysing the intentional character of consciousness, Husserl realises that any intentioned object respects a type-token distinction: while the act of hearing may be directed towards a specific A♯, it presupposes that A♯ is a note that can occur within various experiences and be recognised as such.

Alongside intentionality, another crucial notion of Husserl's phenomenology emerges here: that of essence (*Wesen*). Essences denote the structures that remain unchanged between experiences. This notion may help to explain why Husserl formulated phenomenology as a rigorous science. His philosophy does not merely analyse what our experience is like introspectively. Rather, it attempts to reveal the non-contingent elements of our first-person experience, the essential components without which conscious experience would be impossible.

Husserl's training as a mathematician emerges here. The eidetic reduction that he articulates aims to set aside the accidental factors of experience in order to grasp its structure. This transposes the principles and attitude of set theory, which he learned from Weierstrass and Kronecker in Berlin between 1878 and 1881, into the study of consciousness insofar as it focuses on the constituting relations of an investigated system. The notion of invariance under groups of transformations remains a pivotal concept in geometry and physics today. As Constance Reid describes in her account of what geometrical systems are about, "Transformation represents change; invariance represents changelessness. When we combine the two, we are concerned with that which is changeless under change" (Reid, 2004, p. 189). This idea will be further examined in section 3.

One example of an invariant structure of experience that Husserl identifies is the adumbrated nature of perception, which was discussed in the previous section. The fact that objects cannot be presented in full, from all sides at once, is not merely a fact about how our cognitive system functions, but an essential law of experiencing reality, even in counterfactual situations (Wiltsche, 2013). By studying the essential structures of consciousness and the modes of givenness of intentioned objects, phenomenology assumes the role of first philosophy, providing the ultimate foundation for all other sciences. As Berghofer and Wiltsche emphasise, "While the individual sciences make use

of different types of experiences and reasoning, phenomenology must investigate which types of experience and reasoning confer justification and why" (Berghofer & Wiltsche, 2020, p. 10).

5.1.3 The transcendental reduction

After having clarified the aims of phenomenology, however, it needs to be clarified also the methodology that Husserl employs to achieve them. This method, mainly described in the first volume of *Ideas*, is articulated to focus the philosophical lenses into the structure of the acts of consciousness. For this reason, it requires first the *epoché*, namely the suspension of the natural attitude, bracketing the existence of a mind-independent world. Husserl does not deny the existence of an external world, quite the contrary. Nevertheless, he claims in sections §30-31 of *Ideas I* that the natural attitude, which posits the factual existence of the world around us as a theatre of our conscious acts, is unhelpful for focusing a philosophical analysis only on the structure of consciousness. For this reason, the assumptions of the natural attitude must be bracketed:

> If I do that, as I can with complete freedom, then I am not negating this "world" as though I were a skeptic; rather I am exercising the "phenomenological" ἐποχή which also completely shuts me off from any judgment about spatiotemporal factual being (Husserl, 1913/1982, p. 61).

While the exact sciences, as well as our ordinary experience, presuppose a world existing before and after the subjects who study it, phenomenology addresses the very presuppositions of any science, hence it requires to parenthesize it. By doing so, consciousness, or the Ego, "remains as the 'phenomenological residuum', as a region of being which is of essential necessity quite unique and which can become a field of a science of a novel kind" (Husserl, 1913/1982, p. 65). The transcendental reduction can be considered as a renewed version of Kant's 'Copernican Revolution': the focus shifts from how the world presents to us to how we experience the world. As Luft stresses, "The reduction 'reduces' being to being-given and the world to a phenomenon, a universal sphere of givenness" (Luft, 2011, p. 192).

Following the *epoché*, the new attitude indicated by the *transcendental reduction* consists of *reflecting* on the structure of consciousness to uncover its role in *constituting reality*. Reflection, writes Husserl, "is the name of the method of consciousness leading

to the cognition of any consciousness whatever" (Husserl, 1913/1982, p. 177). As Trizio clarifies, "By reflecting on our conscious life, we realize that all objects, from the things of immediate perception to the highest theoretical products of scientific thought, are unities corresponding to a multiplicity of acts of consciousness. By reflecting, […] we realize that any object confirms its self-identity in a multiplicity of manifestations" (Trizio, 2021, p. 76).

5.1.4 Noesis and Noema

Crucially, the transcendental reduction highlights the correlational nature of consciousness and reality. Due to intentionality, consciousness is always directed towards data that become units of meaning, or properly objects, only through intentional acts. To clarify his account, Husserl refers to sensorial material as *'hyle'*, as opposed to *'morphé'*, the form that animates it (Husserl, 1913/1982, §§85–86). The process of turning *hyle* into *objects*, or units of meaning, provides an initial understanding of the concept of constitution. Consciousness constitutes objects by providing meaning to our experiences, and this meaning consists of relating various perceptions to a single unit that portrays the specific content of consciousness.

To express the idea that consciousness discloses the meaning or sense of reality, Husserl coins the terms *'noesis'* and *'noema'*. Noesis is the intentional act and noema is the intentional object. More precisely, noesis is the directional structure of intentional acts which refers to a noema. The noema is not the object abstracted from the intentional act, but rather the object *as intended*. In the case of perception, for example, the noema is the *perceived as perceived* (Husserl, 1913/1982, §88). If I see the cover of a book, the object of my act is the book itself, while the noema encompasses all the ways in which the book is presented, including its physical characteristics, appearance, context and temporal flux of perceptions, or more concisely, its belonging to a horizon. Also notice the role of essences: by intending the book as a book, I recognise an essence or type ('book') shared by any object or token intended in the same noetic way.

The notion of constitution is beginning to unfold now, as it indicates the noetic process of transforming *hyle* into a *noema* via the intentional *morphé*. As Smith (2020, p. 172) highlights, "In Husserl's transcendental phenomenology, as detailed in Ideas I (1913), things in the world around us are 'constituted' in our consciousness insofar as they are

'intended' by virtue of appropriate forms of meaning, called 'noematic content' or 'noema', in a logical or semantic 'manifold' of meaning or sense (*Sinn*)". Constitution enables us to see a chess piece as a specific component of a game that moves according to rules. In physics, constitution enables different observation points to be gathered and modelled as a smooth curve representing the orbit of a planet or the interpretation of a mark on a bubble chamber photograph as an interaction between neutrinos and charged particles. Constitutive processes locate objects within a conceptual framework that determines their nature and role[104].

While other concepts could be added to an extensive analysis of Husserl's phenomenology, we have now examined all the necessary tools to more specifically engage with the notion of constitution and apply it to the physical sciences.

5.2 The concept of constitution

Husserl characterizes perception as an "enigma": objects cannot be reduced to consciousness, since they transcend it, while also not being conceivable at all unless they exhibit a degree of *accessibility* to consciousness. The problem of *constitution* in Husserl's phenomenology is exactly the strive to mediate between the two extremes of a weird absolute idealism and a naïve metaphysical realism, breaking free from the false disjunction fallacy that excludes a third hybrid perspective. Husserl's strategy may be summarized as an attempt to claim a *non-causal dependence* of the world from consciousness, such that reality does not need consciousness to gain existence but to acquire *meaning* or *sense*[105]. This move marks both naïve realism and absolute idealism as meaningless, insofar as they ignore the unescapable mutual interdependence of the intentional consciousness and the intentioned objects of experience: naïve realism contemplates a ready-made and meaningful reality that epistemic subjects need only to

[104] This characterization combines both Kant's constitutive and regulative dimensions, as described in section 1.5, confirming the interpretation according to which they are compatible components of a general process of constitution.

[105] Frege's distinction between sense and meaning (*Sinn* und *Bedeutung*) is not shared by Husserl. In a letter to Husserl dated 24 May 1891, Frege explicitly acknowledges that they formulated this distinction independently, although in different directions (Frege, 1974, pp. 94-98). I will use the two terms as synonymous, as better specified in section 1.4. For a comparison of Husserl and Frege see, for example, Aquila (1974) and McIntyre (1987).

register, absolute idealism holds that the subjectivity causally determines the very existence of reality[106].

Husserl specifies this general idea especially in his later works, such as *Ideas* and *Crisis*. By applying the conceptual tools developed in the previous section, namely the notions of intentionality, essences, *epoché,* transcendental reduction, noesis, and noema, two fundamental features of the process of constitution emerge: its meaning-giving role and its retroactivity.

5.2.1 Beyond realism and idealism: the meaning-giving role

One of the cardinal principles of Husserl's phenomenology is what Husserl describes in his *Crisis* as the "Correlational a priori [*Korrelationsapriori*]" (Husserl, 1954/1970, p. 159), or in the *Cartesian Meditations* as the construction of the worlds and the forms "in correlation with the constitutional a priori [*in Korrelation mit dem konstitutiven Apriori*]" (Husserl, 1931/1960, p. 154). The basic idea is that consciousness and reality are interdependent in a nontrivial way, which may be explained in two steps. As a first step, Husserl describes consciousness as conferring meaning to hyletic data (the content of intentional acts abstracted from their givenness, see Williford, 2013). The sensorial *hyle* is animated through forms, thereby constituting an object, in the way described in section 1.4.

'To constitute' means here to impute a meaning, to intend an item as something. A book, given to my experience, is constituted as a specific book, that I read for specific purposes and that I perceive in perspectival adumbrations projecting also a horizon of possibilities upon it. Similarly, some shapes of ink in a piece of paper are interpreted as letters and words and refer to some object or state of affairs that they mean, which is the result of the process of constitution. Now comes the second step*: such a constitution makes it meaningless to even talk about a given book or given shapes of ink before constitution*—which is, before intending them *as* what they are.

Of course, it is possible to abstract from the act of perception and isolate a 'first' moment in which some letters were only black shapes of ink; however, even in that case the shapes of ink would not be purely raw data, but data *intended as* (or constituted as)

[106] Depending on how 'idealism' and 'realism' are defined, Husserl can be considered a realist or idealist. I discuss this point below in more detail, criticizing both labels.

shapes of ink. Even the appeal to purely raw data presupposes the intentional act that intends some content as 'purely raw data'. In other words, the view assuming the independent existence of 'objects' that simply receive a contextual meaning from us would be an unjustified simplification for Husserl: to recognise something *as* an object, or even *as* a mere datum that has not been fully conceptualised, requires constituting it *as it*.

As Ströcker stresses, the sense-bestowing activity of constitution has the consequence that any object, "even being in itself, […] is always posited 'as in itself' and can be understood only on the basis of the sense that such a 'in itself' has for us" (Ströcker, 1997, p. 94)[107]. However, it is important to note that, although it makes no phenomenological sense to conceive of reality outside of its relationship with consciousness, Husserl is not an absolute idealist because the relationship in question is not causal. Intentional acts do not cause the very existence of objects, except for specific targets[108].

The non-causal dependence of objects on consciousness can be explained using Jaegwon Kim's notion of 'event composition', which is defined as "the way in which an event is composed of other events as its constituents" (Kim, 1974, p. 50). Applying Kim's theory to Husserl's work, consciousness is not viewed as a cause, but rather as an essential component in the emergence of objects or states of affairs. The idea is not that consciousness is part of objects in a mereological sense, but rather that a fundamental aspect of objects — the meaning that defines their essence — results from an act of consciousness. An object as intended—that is, its essence or noematic structure—is not a product of the ego, but rather the *result* of the correlation between subjectivity and objectivity (Jansen, 2015, pp. 73–74).

Of course, this framework raised multiple interpretations. It is due to the multifaceted evolution of Husserl's viewpoint and the complexity of his system that the existence of reality beyond consciousness in phenomenology is a topic still debated today. Against the authors who claim Husserl's realism and those who argue for his idealism (see Drummond, 1988, p. 87, note 1), I agree with Smith (2020) and Trizio (2021) in

[107] It is exactly for this reason that Husserl reassesses his view of constitution in the *Ideas* modifying his earlier view. In the *Logical Investigations*, constitution was strictly related to the matter-form schema, making unclear the relationship between consciousness and reality.
[108] In the *Logical Investigations*, Husserl's analysis of constitution involves also categorical objects, namely the elements of logic. In that case, Husserl claims that they exist only insofar as constituted. See Huemer (2003, p. 347).

highlighting how Husserl breaks free from the binarism of the debate[109]. As Hall (1982) claims, the very labels of realist and idealist make little sense in phenomenology, unless accompanied by additional specifications (such as Smith's mentioned 'constitutive realism'). Husserl's account attempts to suggest a *tertium quid* between a "meaning-is-already-there" realism and a "reality-is-produced" idealism. 'Constitution' is the term he employs to describe the process by which consciousness permits intentional objects to appear and unfold as what they are. In other words, consciousness makes it possible for the sense of reality to emerge[110]. Like a good teacher, who does not create from scratch the talent of a student but only motivates her and provides her with the right information to let her thrive in developing her own worldview, consciousness does not create reality but rather sets the stage upon which reality can exhibit a sense.

A significant tradition of scholars, from Fink (1952) to Landgrebe (1974), has characterized the notion of phenomenological constitution as *oscillating between creation and mere meaning-formation*. Husserl does not resolve this oscillation but rather emphasizes it as an inevitable result of the correlation between reality and subjectivity[111]. Nevertheless, the quest for a more precise characterization of constitution may not be in vain, especially in light of Husserl's effort to specify his account unambiguously. One possible route toward such clarification involves understanding how we confer meaning on empirical content. I began this section by stating that the sensorial *hyle* is animated through forms—but what does this mean?

On the one hand, the meaning-conferring dimension of constitution aims at *differentiating* things from other things, as well as concepts from other concepts. When the colors, angles, depth, and even functions of a book are distinguished from its surrounding environment, the book becomes a unity—i.e., it is intended as a single book (with an associated horizon). Such a process, therefore, endows the book with meaning,

[109] The debate over Husserl's realism develops on various levels. While some authors discuss over Husserl's metaphysical realism or idealism (Ameriks, 1977; Ingarden, 1975; Philipse, 1995; Soffer, 1990), others, among which Berghofer (2017), Hardy (2020), Harvey (1986) and Heelan (1989) defend Husserl's scientific realism, as opposed to Wiltsche (2012, 2017). The lack of alignment of the levels of the debate on metaphysical and scientific realism makes it difficult to provide a genuine review of the secondary literature, in which sometimes a realist and idealist interpretation may be so particularly characterized to even coincide. Notice also that some authors claim that Husserl's phenomenology is compatible with any metaphysical view (Carr, 1999; Crowell, 2001; Holmes, 1975), that it lacks impact on the debate *a la* Fine (Rouse, 1987), or that Husserl simply shows the impossibility of realism (Zahavi, 2003, 2010).
[110] For the role of time in the correlational structure of noetic act and noema, see Nobili (2022, Ch. 2-3).
[111] This point is continuous with my analysis of Kant's constitutive, in section 1.3.

adding a semantic dimension to mere perception. As Kaletha (2019, p. 183) notes, Husserl's identification of constitution with a procedure of differentiation has a medieval origin: Porphyry was the first to use the Latin term *differentia constitutiva* to denote the internal differentiation that defines a species[112].

On the other hand, the process of constitution confers meaning by situating objects—as unities—within temporal experience. Beyond intending an object *as* that object, thereby opening its horizon of possibilities, we also experience it within a spatiotemporal framework. An object is thus a meaningful unity not only by being intended as something, but also by persisting through time and exhibiting a structure of invariant properties (see Held, 2003). For this reason, Husserl claims in the *Crisis* that "the constitution of every level and sort of entity is a temporalization which gives to each distinctive meaning of an entity in the constitutive system its own temporal form" (Husserl, 1954/1970, p. 169).

The temporal form of the constitutive process leads to two further considerations. First, by situating objects within the flow of time, we also become conscious of that flow; hence, the constitution of reality retroacts, constituting the dimension of subjectivity itself. Second, the fact that both subjects and objects are constituted in time implies their historical dimension. The following sections clarify these points.

5.2.2 The retroactivity of constitution

What is fascinating in Husserl's line of reasoning is that the process of constitution, that makes objects truly objects, is the very same process that makes consciousness truly consciousness. In Husserl's terms: "What forms the stuff into intentive mental processes and what brings in that which is specific to intentionality is precisely the same thing as what gives the locution, consciousness, its specific sense: precisely according to which consciousness *eo ipso* indicates something of which it is consciousness" (Husserl, 1913/1982, p. 205). Therefore, not only does the constitution process provide meaning to intentional objects so that we can perceive them for what they are, but it also *retroactively creates consciousness itself*, making it the pole that is conscious of a state of affairs. This point can be fruitfully applied to scientific practice if 'object' is substituted with 'data' and 'subject' with 'theoretical hypothesis'. In this context, a collection of data can retroact on

[112] See the Motivation for this work.

the presuppositions employed to detect it, leading to improvements or changes. This point will be developed in Section 4.2.

There is another fruitful consequence of the retroactivity of constitution: if subjectivity constitutes itself as subjectivity in the process of constitution, it also *distinguishes itself* from the object[113]. Such a distinction grounds the possibility of conceiving the facticity of the object targeted by the intentional act as *transcendent*. Again, the significance of the phenomenological reduction may be appreciated here: within the phenomenological attitude, the world cannot be conceived without consciousness, and still phenomenology grounds the natural attitude of the sciences, namely the possibility of objects external to consciousness. Since constitution is not a causal dependence, the view that consciousness and reality are correlated is compatible with the view that objects are transcendent, present outside of subjects[114].

Notice that this point emerges *in nuce* in the early works by Husserl. Indeed, in the *Philosophy of Arithmetic* Husserl tries to uncover how the concept of number arises from an act of reflection on our mental acts. Husserl retraces the five steps through which mathematical concepts are abstracted from real experiences: (i) numbers refer to multiplicity, (ii) multiplicity to a group of objects, (iii) a group to a collection of elements combined through the same relationship, (iv) a collection to the mental act of collecting, and, finally, (v) reflecting on the mental act of collecting raises the concept of discrete members that form a whole, which is the basis of conceiving numbers. A great deal has been discussed on the problems and contradictions of such a view, corrected by Husserl himself after Frege's criticisms (see section 2.4), and on the relationship between this early phase of Husserl's philosophy and his more mature project. Concerning this second point, it sounds coherent with Husserl's later considerations, already described in the previous section, his allusion to reflection as a crucial activity.

However, for the purposes of this work, it is sufficient to highlight only that "The concept of constitution, in the form in which it is developed in Husserl's first work, does suppose that a subjective process produces a form or category which is no longer subjective, but in some way transcends the subjectivity which produces it" (Sokolowski 1970, 19). Despite the psychologistic flavor, this point paves the way for the more mature

[113] Some Fichtean themes might be noted here.
[114] This is a delicate point, that must be tackled keeping in mind the difference between empirical subjects and transcendental subjects. See section 2.4.

notion of constitution that Husserl develops. Constitution does not just provide meaning, or noematic content, to the objects encountered in experience; in doing so, it also constitutes the subjectivity, *making it possible for the object to transcend the subjectivity who constitutes it*. Therefore, in the resulting framework, there are no primitive concepts other than constitution itself. Besides the priority of consciousness over the world claimed by Husserl after the phenomenological reduction, which does not strictly involve constitution, neither the subjectivity nor the facticity nor the intentional act is the 'constituer' of the others, as they are all constituted within the process.

The flexibility of the schema described suggests that, beyond the general notion, Husserl is more concerned with various *processes* of constitution. This idea is expressed by Husserl with the notion of *region*. A region is a *domain of investigation*, so a set of entities subjected to eidetic analysis, such as nature. Regional ontologies are the different phenomenological analyses concerning the objects of a particular region[115]. Therefore, the study of constitution within the region of nature leads to Husserl's phenomenological approach to natural sciences[116].

5.2.3 Static and genetic constitution

Before moving to physical science, a last fundamental distinction must be drawn. The features of constitution that I have exposed in this section—giving meaning by differentiating, situating contents in time, and distinguishing subjectivity from reality—pertain to what Husserl calls *static constitution*, as opposed to another kind of constitution, namely the *genetic* one. Static constitution concerns the structure and role of consciousness in disclosing the possibility for given objectivities to exhibit a sense. The very presence of such objectivities is not inquired: their justification stems from recognising some essential structures that remain invariant in multiple acts.

Genetic constitution, on the contrary, investigates how those objectivities came about in the first place. This latter kind of constitutive process is developed by Husserl in his later works, and mostly in *Formal and Transcendental Logic* (1929/1969) (see Langrebe, 1977; Welton, 1983). Sokolowski effectively elucidates the concept of genetic

[115] A hazardous but compelling comparison could be drawn between Husserl's regional ontologies and Cassirer's symbolic forms, as both concepts are meant to multiply the layers of investigation of reality against the reductionist approach of radical naturalism.
[116] For an overview of the relationship between regions and natural science, as well as an explanation of how the notion of region challenges the Baden School of neo-Kantianism, refer to Staiti (2017).

constitution by stressing that, in Husserl's later works, "Objectivity is no longer conceived as something that can be turned on and off abruptly in our consciousness by the introduction or removal of noeses. Objectivity is now conceived as the solidifying of a part of our intentional life in a judgment. […] In this way, the sense is traced from its primitive origins in the "now instant" to its final state in judgment, where it becomes a permanent possession in our intentional life" (Sokolowski, 1970, p. 182). The methodology of genetic constitution may strike as evoking the Marburg neo-Kantianism, at least to the extent that in both frameworks the object is not the starting point but the result of an epistemological process. In the genetic constitution, the correlation between consciousness and reality redirects to the correlation between the experienced object and the experiences that justify theories about that object (Berghofer, 2022, p. 258; De Santis, 2021).

How is it possible to analyse the way objectivities come to be? Three elements are crucial for Husserl to develop genetic phenomenology: time, body, and intersubjectivity. The latter two will be tackled in the next section, but also the temporal dimension of constitution stands out as particularly noteworthy (for an overview, see Nobili, 2022). By inspecting all the main phenomenological notions mentioned in the previous section, time emerges as their grounding condition. To intend an object in perspectival adumbrations, time must be presupposed as necessary: to identify means to pinpoint a continuity in the variation, i.e. something that does not change in the flux of time. Moreover, to claim the horizontal structure of intentionality, time must be presupposed as the flowing from past possibilities to future possibilities. Even the difference between essences and facts presupposes the possibility of experiencing the same type of objects in different moments. This explains why Husserl returned to this topic first in his courses on *Time Consciousness* in 1905 (Husserl, 1991), and then in *Ideas II*.

The main claim Husserl holds is that our temporal experience is a stream of consciousness that cannot be reduced to a succession of "now-points". Our primal impression, or present living experience, must always be coupled with *retentions* and *protentions*. The former consists in the preservation of the impressional sense of what has already been; the latter consists in the (allegedly) anticipation of what is to come.

By inscribing experience within a temporal constitution, Husserl points also to the fact that our acts exhibit a *historical dimension*. This means that we do not continuously

constitute reality from scratch, but we always do so based on our previous constitutional processes and on the senses constituted by others. As Huemer states, "Husserl argued that whenever someone constitutes an object, this constitution leaves a kind of trace. If one constitutes a certain object very often, one forms a habit that shapes future constitutions" (Huemer, 2003, p. 349). This point well describes the historical dimension of science's constituting activity. In developing scientific theories, physicists try to formulate increasingly broader frameworks, so that the previous ones become approximated cases of the new ones. This asymptotically convergent process, highlighted by different authors with different denominations[117], gives a first hint of how constitutive processes have been realized in the actual history of science.

To sum up, Husserl's constitution can be clarified by the following features: first, it denotes a third alternative that undercuts the very presuppositions of the opposition between forms of realism and idealism. Indeed, phenomenological constitution almost sublate the dichotomy by stressing the correlation between subjectivity and reality. Then, constitution can be defined as consciousness' meaning-giving activity, where such a bestowal can be specified by the two sub-processes of (i) differentiating and (ii) situating objects and events in time. The temporal dimension is particularly relevant for distinguishing static and genetic constitution. Finally, constitution retroacts on the subjectivity itself, positing it as a pole opposed to the pole of objectivities. All these aspects lead to a flexible view, in which many kinds of constitutions can be recognised with respect to both the intentional act they encompass (perceiving, imagining, remembering, questioning, etc.) and the ontological region they refer to. Husserl's elaboration of constitution applied to the spatiotemporal material object leads to his account of the formation of scientific knowledge.

5.3 The material thing and scientific knowledge in *Ideas*

Although Husserl never published works explicitly addressing the philosophical interpretation of contemporary physical theories, as did thinkers like Cassirer, Schlick, and others of his time, he was nonetheless deeply familiar with and studied these theories

[117] Some relevant examples are the convergentist account of truth in Peirce (1953), the method of systematizations in Reichenbach (1920/1965, p. 69), the ultimate invariants of experience as an *aufgegeben* in Cassirer (1910/1953, p. 273), the generalized principle of correspondence in Radder (1991). See also Kitcher (1993) and Friedman (2001).

extensively. As Mirja Hartimo has recently demonstrated, a significant portion of the books in Husserl's personal library were dedicated to topics such as the theory of relativity and quantum mechanics (Hartimo, 2018). Moreover, Husserl continuously engages with the relationship between his phenomenological method and the exact sciences in his writings. One of the main reasons for his development of phenomenology may be ascribed to his view of the conceptual groundings of the exact sciences as unsatisfactory.

According to Husserl, the "empiristic naturalism", namely the account claiming that only experimental science can ground valid knowledge, falls into self-contradiction, insofar as any universal claim (like the one of the empiricist herself) cannot be grounded in experience, that provides only particular singularities and no universalities: "We need only to ask the empiricist about the source of the validity of his universal thesis (e.g., "All valid thinking is based upon experience as the only presentive intuition"), and he becomes involved in a demonstrable countersense" (Husserl, 1913/1982, p. 37). Husserl's approach is anti-naturalistic, i.e. opposed to the naturalism that claims (i) that the scientific explanatory methodology is the only epistemically valid one, and (ii) that all of philosophy needs to be developed alongside science, and not above. An example of this naturalistic attitude is Moritz Schlick (see Schlick, 1915), who indeed questioned the legitimacy of phenomenology[118]. Husserl challenges both naturalist's claims, since phenomenology (i) is articulated as a descriptive science, alternative to the scientific method, and still valid, and (ii) aims to ground the very possibility of any science (Ryckman, 2005, pp. 121-122).

Despite Husserl's methodological differences from his contemporaries who worked in close contact with the scientists of that time, the two volumes of *Ideas* raise three main claims related to the formation of scientific knowledge: (i) the definition of objects as *sets of rules* prescribed to single experiences of those objects; (ii) the scope of physics as the search for invariant elements in relative experiences; and (iii) the role of intersubjectivity and communication in providing objectivity to scientific knowledge. I will pinpoint the first aspect in the next section by analysing Husserl's use of constitution in *Ideas I*, and the other two features in sections 3.2 and 3.3 by focusing on *Ideas II*.

[118] Schlick contests both Husserl's notion of a material a priori (Schlick, 1979) and of non-physical intuition (Schlick, 1974). Husserl relegates Schlick's criticism to "nonsense" and "sense-distorting substitutions" (Husserl, 2001, p. 171), thus missing the opportunity for an enriching debate with the logical empiricists.

5.3.1 Rules and material things in Ideas I

The various occurrences of the term 'constitution' and its declensions ('constitutive', 'constituting', etc.) in *Ideas I* cannot be reduced to a single meaning. Sometimes, Husserl uses the term to simply denote the proper features of something, i.e. the aspects that constitute an item as it is. For instance, the concepts of pure logic express the "constituent determinations of an object as an object" (Husserl, 1913/1982, p. 21); practical and value characteristics "belong constitutively to the objects "at hand" as objects" (Husserl, 1913/1982, p. 53); and the typically phenomenological recourse to first-person insights involves mental processes "that are themselves constitutive of the psychological method" (Husserl, 1913/1982, p. 189). In other passages, it is not the features of objects that are constitutive, but rather the *conscious act* of attributing those features. After the transcendental reduction, pure consciousness becomes a "constitutive consciousness" (Husserl, 1913/1982, p. 134), and phenomenology investigates "the formations produced by consciousness constitutive [for determinate affairs and values]" (Husserl, 1913/1982, p. 347). While these occurrences do not always denote 'constitution' in its technical sense, they express the two meanings underlying the term: the idea of the constitutive elements of an object that are its essential features, or the process by which that object is formed.

Section 2 acknowledged the phenomenological constitution as the integration of these two uses: constitutive features of objects or the activity of consciousness that intends them. The various declinations of these two general meanings represent the oscillation between the roles of constitution in producing and providing meaning — two functions that Husserl implicitly assumes and merges. Section §149 of *Ideas I*, entitled "The Problems of the Theory of Reason Pertaining to Regional Ontologies. The Problem of Phenomenological Constitution" (Husserl, 1913/1982, p. 355), delves into this issue, examining in greater depth the application of the concept under analysis to scientific knowledge.

The starting point of §149 is the established elucidation of constitution as a process by which different sensible experiences are synthetised in an objectual unity which encompasses a "noematic composition"—that is, a set of modes of givenness and associated meanings, horizontal structures, temporal invariances, etc. Now, such a constitutional activity can refer to many kinds of 'objects' in a broad sense: perceptual objects, objects of imagination, entities in thoughts, remembered events, even objects of

desire, love, or hate. I can constitute a book like Kafka's *The Trial* by unifying various experiences in perception while leaping through its pages with my fingers, in thought while pondering on its significance, in recollections while remembering the first time I read it, in imagination while writing this essay about it. Since Husserl aims at disentangling the process of constitution *per se*, he decides to consider the most common kind of object for his analysis: the material thing of perception.

Husserl's line of reasoning is the following: if I reflect upon the mode of givenness for any material thing in perception, I do not apprehend a single, unique experience of it, but rather a sequence of experiences that progressively allow for its determination. When contemplating a material thing in general, I might initially conceptualise a celestial body, a tool, an animal, or a tree. I then select one of these alternatives and proceed to determine its details. For instance, in contemplating an animal, I first conceive of a shape and colors, then a black cat, and finally, I can mentally "move around" that cat to determine its specific properties. Although I am entirely free to choose the object of thought and the method of its specific determination, I am simultaneously constrained by the initial task of limiting my focus to the determination of material things. How does my thinking activity work from a phenomenological perspective?

Husserl highlights two fundamental aspects of this thinking process. Firstly, it is simultaneously *inadequate* but *unlimited*. It is inadequate because no single thought or experience can exhaust the concept of a 'material thing in general': I am obliged to select specific targets for determination at any given time, thus excluding others. This same inexhaustibility, however, denotes the fact that I can continue to determine or experience any object indefinitely, without ever concluding the process: I continuously convert and expand what I experience, both in perception and thought. Secondly, I implicitly follow a rule during this process of determination. Such a rule represents the constitutive form of the idea of a material thing in general. It dictates, for example, that a thing, to be material, must be capable of existing in space and time, exhibiting perduring properties, and maintaining its identity as a 'material thing' throughout all possible alterations.

This analysis leads to a key characterization of material things, which emerges from this rule-governed process:

> The regional idea of the physical thing, its identical X with its determining sense-content, posited as existing, prescribes rules governing the multiplicities of appearances. (Husserl, 1913/1982, p. 361).

Concepts of objects are the rules that their here-and-now instances obey, thereby grounding their unity. This general idea of constitution is applied specifically to the things of physics in the first section of *Ideas II*.

5.3.2 Relative and irrelative elements in Ideas II

The objective of *Ideas II*[119] is to specify the constitutive process foundational to three ontological regions: material, animal, and spiritual nature. For the purposes of my analysis, I focus on the first chapter, which details material nature as described in the physical sciences. The chapter contains three sections: the idea of nature in general (§1–11), the ontic sense-strata of the thing of intuition (§12–17), and the constitution of the objective thing of physics (§18).

Husserl begins by defining science as the study of nature, that is, of spatiotemporal objects. Yet the natural sciences do not consider all possible properties of spatiotemporal objects, such as colors, beauty, or practical utility. Scientists are theoretical subjects who objectify nature by excluding their subjective feelings and prejudices. The theoretical attitude of the scientist aims at judging, evaluating, and verifying. Scientists reduce their relationship with the world to epistemic acts directed at understanding it, purified from emotions and practical values.

After specifying nature as the target of physics and theoretical acts as the means to investigate it, Husserl examines the general features of material objects studied by scientists. Temporal determination and spatial extension are the first fundamental features of physical systems, reiterating and enriching what Husserl anticipated in *Ideas I*. The material thing is perceived through adumbrations and a horizontal structure, which alludes to a set of potential manifestations. Among these variations, however, a *scheme* inheres in the material thing, governing its modes of manifestation while allowing for change over time. The transformation of perceptions and the schemes according to which they occur follows a general principle: *under similar circumstances, similar outcomes*.

[119] I will refer to the traditional version of *Ideas II*, translated in Husserl (1952/1989). Husserl (2025) is a new German version, presenting all of Husserl's original manuscripts.

According to Husserl, this is the grounding principle of physics. The purpose of physics is to subject a system to various modifications, observe its behavior, and determine the dependence between changes in circumstances (or initial conditions) and resulting variations in the system's states and properties. Natural science is thus configured as a game of modifications and outcomes, where self-caused transformations are excluded. Husserl then phenomenologically describes this process, analysing the stages required to transition from subjective perceptual experience to objective scientific knowledge.

The title of §18 in *Ideas II* is "The subjectively conditioned factors on the constitution of the thing; the constitution of the objective material thing" (Husserl, 1952/1989, p. 60). The section contains eight paragraphs, indicating the steps to move gradually from subjective to objective experience[120]. The first three paragraphs focus on the subjective psychophysical constitution of appearances in space and time. The pivotal notion in this process is the *Leib*, an untranslatable term referring to the living body, the body that experiences the world. From physics' perspective, *Leib* might be approximated as "observer," though this translation does not capture its full semantic range; it serves to highlight a center of orientation toward phenomena. By being embodied in a living body, we are situated in a *hic et nunc*, a perspective from which it is possible to experience objects through the sensory organs (Husserl, 1952/1989, p. 61).

At the level of the living body, two kinds of sensations, which set the stage for objectification, can be distinguished: the first are sensations that constitute corresponding features of the thing by adumbration; the second are sensations that motivate apprehensions through "if–then" and "because–therefore" schemata (Husserl, 1952/1989, p. 62). While perceiving the empirical properties of surrounding objects according to sensory input and bodily movement, we also situate these perceptions within a coherent framework or "motivated order" (Husserl, 1952/1989, p. 63). For example, I do not only perceive a book to my left, but also know I am doing so by turning my head; I do not only hear a noise from the living room, but recognise it as caused by a book falling from the shelf. On the one hand I perceive, on the other I place such a perception within a narrative.

[120] Husserl's work should not be viewed as a rigid sequence of layers that constitute experience, beginning with the material thing and rising up to spiritual life. Such a stylization can sometimes appear due to the way his manuscripts were arranged by his assistants, Edith Stein and Ludwig Landgrebe, in the composition of *Ideas II.* The new edition (Husserl, 2025) restores the original structure of the manuscripts.

Husserl names these components “sensations of features” and “kinesthetic sensations” (Husserl, 1952/1989, p. 62).

The twofold articulation of perception is stressed because it arises within subjective experience but points to *regularities beyond subjectivity*. Sensations of features, relative in character, combine with kinesthetic sensations, which provide a consistent narrative, leading to the idea of non-relative features.

A second layer is added through the distinction between normal perception and anomalies (Husserl, 1952/1989, pp. 64–80). For instance, the color of an object differs from the variations it exhibits under different illumination. Husserl also notes that the Leib, while registering modifications of experience, recognises that these changes do not occur spontaneously: all modifications are caused either by bodily movement (somatological causality) or by variations in surrounding circumstances (causality linked to space, time, and motion).

This fundamental distinction between relative and non-relative elements in experience leads to the differentiation between variations and the enduring thing. Two constitutive activities operate: the constitution of the sensory thing—distinguishing its various modes of givenness from the invariant sensory thing—and the constitution of the thing of physics—distinguishing somatological changes from the invariant object.

In §18d, Husserl specifies that the transition from psychophysical constitution to the objective physical thing lies in identifying “what is non-relative among the relativities […] out of the sensuous relativities” (Husserl, 1952/1989, p. 81). Kinesthetic sensations motivate the order of feature sensations, allowing the object of physics to exhibit non-relative properties that explain its relative manifestation to living bodies. The twofold articulation of perception thus becomes the phenomenological analogue of primary and secondary qualities: once the sense-thing is constituted, it manifests geometrical determinations, which pertain to the physical object itself, and sensuous qualities, which belong to the sphere of appearances (Husserl, 1952/1989, p. 82). Establishing primary qualities requires demonstrating the possibility of non-relative elements in experience, a task Husserl addresses in §§18e–18f through intersubjectivity.

5.3.3 Trading beliefs

As phenomenology is a descriptive science, when describing the perception and constitution of physical objects, it cannot ignore the fact that such experiences never occur in isolation. I perceive, experience the world and practise physics within a community, alongside other people. Moreover, we are a "multiplicity of people who have dealings with one another" (*eine Vielheit miteinander verkehrender Menschen in die Dingauffassung eingeht*) (Husserl, 1952/1989, p. 85; see also §9 of *Crisis*), where *'verkehren'* indicates *socialising* and *trading (beliefs)* with others who can confirm or refute our viewpoint. When others corroborate the non-relative elements of my experience, these elements become part of a shared reality. However, non-corroborated experiences are dismissed as pathological hallucinations. For this reason, exchanging beliefs with others is "constitutive for the apprehension of a thing as objective and actual" (Husserl, 1952/1989, p. 85).

A key aspect of the intersubjective domain that Husserl emphasises in his later writings is its manifestation in communication, writing, and the sharing of knowledge. A scientific contribution does not become such simply by existing in a scientist's mind. It must be recorded and transcribed onto paper, often using mathematical language or other shared modes of communication. In this way, the contribution becomes a cultural artefact that can be understood, critiqued and extended by the wider community. In some cases, it may even elicit a response (*Reaktivierung*), enabling the tracing of its demonstration and an assessment of its validity by reconstructing the author's original reasoning. Consequently, the agent at the centre of the 'constitutive' process of scientific knowledge shifts from the individual researcher to a communicative framework governed by the norms that connect the scientific community.

Nevertheless, intersubjectivity should not only be understood as the presence of others with whom beliefs can be discussed. Conversely, Husserl also describes intersubjectivity as sharing an objective space and time with others. The shape and duration of a system — whether an object or an event — appears to individuals according to shifting aspects. As I move and grasp more aspects of a system, multiple perspectives capture it from different standpoints; when, from our various standpoints, we communicate our experiences, we become able to understand the properties of that system invariant under a change in perspective or reference frame. Additionally, Husserl points out that in an

intersubjective environment, my “here and there, up and down” are not someone else's “here and there, up and down”, yet I can still move and change my point of view to experience the standpoint of others. As for mathematical frames of reference, Husserl refers to an “objective system of location” (Husserl, 1952/1989, p. 88). This system cannot be experienced directly through sensory perception, but rather by abstracting and isolating the purely geometrical relations between our own body and the bodies of others.

Husserl’s approach is ingenious. While reconstructing the transition from subjective experience to objective knowledge, he articulates the phenomenological approach to defining objectivity in general. Indeed, if objectivity is defined as independence from any condition of knowability, the gulf between consciousness and reality becomes unbridgeable (thereby contradicting the methodology of transcendental reduction). Conversely, if objectivity refers to the “apprehension of a multiplicity of subjects sharing a mutual understanding” (Husserl, 1952/1989, p. 86), then it ultimately manifests as an inherent outcome of phenomenology that follows naturally from the constitution of objects within a shared spatiotemporal location and the bestowal of intersubjective meaning upon them.

Husserl describes the practical work of physicists as studying space and that which fills space. Space is a prerequisite for motion, and the relative position of physical systems within a reference frame determines their respective physical states. ‘That which fills space’ is an entity that exhibits kinetic and energetic states, conforming to differential equations and described by the laws of nature. When describing physical systems that fill space, Husserl uses the definition of objects as a set of rules, as outlined in section 3.1.

Indeed, the physical thing is not an object in the ordinary sense; the objects of our everyday experience have colours and functions and sometimes affect us emotionally. The 'thing' constituted within physical knowledge abstracts from such elements, bearing only a set of properties that can be described mathematically and independently of us. Husserl shifts the notion of an object within scientific knowledge from referring to an external substance to that which “maintains its identity within the manifold of appearances belonging to a multiplicity of subjects”, specifically “the physicalistic thing determined logico-mathematically” (Husserl, 1952/1989, p. 87). In this context, the notion of constitution reveals its inherent character as a 'process of redefinition', shifting the emphasis from the *relata* to the *correlation*. Despite differences in terminology,

method and purpose, the consistent theme of viewing constitution as a kind of definition can be seen from Kant through the neo-Kantians to Husserl.

Another central feature of phenomenological constitution emerges in the description of the 'physicalistic thing', namely its reference to an invariant structure under groups of transformations. Once the intersubjectivity of experience is considered, the subjective space and time of private perceptions is distinguished from the objective space and time of shared experiences, completing the transition from relative to non-relative elements of experience. Objective or 'real' properties emerge from what is posited in the objective space and time: "Real properties manifest themselves as real substantial-causal unities in the motion and deformation of spatial forms. These are the mechanical properties that express the causal and lawful dependencies of the spatial determinations of bodies" (Husserl, 1952/1989, pp. 88–89). The process of gradual constitution is thus complete.

Husserl concludes the chapter by setting the stage for the development of §9 of the Crisis. Indeed, the process of idealisation, moving from subjective and then objective space to the frame of physics, sets aside sense qualities: "Physical facts that correspond to qualitative distinctions such as red and green, or warm and cold, are produced without qualitative transition, appearing merely as quantitative distinctions within one domain. For instance, temperature or waves in the ether" (Husserl, 1952/1989, p. 90). However, the fact that we experience through qualitative determinations should not be dismissed as a subjective aspect of cognition that science can ignore. In fact, there is no such thing as a thing perceived and a purified thing of science; only the former refers to an actual thing in experience, while the latter is an idealisation.

As Husserl clarifies at the end of §18g, the (alleged) physical entity "is merely an empty, identical entity that serves as a correlate of identification possible according to experiential, logical rules, and is grounded through them" (Husserl, 1952/1989, p. 92). Primary qualities, insofar as they are mathematically idealised, will always replace our perceptual experience, but will never be our perceptual experience itself (see Trizio, 2021, pp. 128–137). This point is relevant to the arguments of the *Crisis*: while science rightly employs the formidable methodology of idealising nature in order to grasp its structure, elevate our knowledge and strengthen our modes of intervention in the world and society, it cannot ignore the fact that the origin of such idealisation is the realm of our ordinary

experience, the *Lebenswelt*[121]. Science is a rational progression of historical frameworks and should not forget the steps through which it arrived at the present moment.

5.4 Friedman, Ryckman and Husserl's philosophy of physics

5.4.1 Ryckman's criticism and Friedman's reconsideration of phenomenology

Michael Friedman's three-layered account of scientific knowledge (Friedman, 2001; 2002; 2010) has been criticised from various perspectives (described in the *Motivation for this work*). Since his proposal is based on Reichenbach (1920/1965), almost all authors who discuss it suggest reconsidering another author's work for a more adequate approach to contemporary philosophy of science. For instance, Everett (2015) and Ferrari (2012) advocate Cassirer's neo-Kantian epistemology as a robust means of rehabilitating the a priori in modern science, whereas Uebel (2012) proposes Carnap's analytic principles as a potential solution to certain issues within Friedman's framework. Nordmann (2012), meanwhile, suggests addressing Friedman's lack of attention to technology by considering Heidegger's work. Mormann (2012), for his part, emphasises the contribution of the pragmatist tradition to the issues Friedman addresses. Finally, Dimitrakos (2016) and Stump (2015) advocate incorporating the relativized a priori within a naturalistic perspective.

Ryckman (2005; 2010) could also be added to this list, as he suggests that Friedman should reconsider Husserl's phenomenology. More specifically, Ryckman (2010) criticises Friedman's Hilbertian conception of mathematics. In his account, Friedman characterises constitutive principles as *coordinative*, since they are meant to mediate between the abstract formalism of a theory and the concrete phenomena that the theory describes. This approach is directly inherited from Reichenbach's formulation of the axioms of coordination (Reichenbach, 1920/1965). The shortcoming of such a view is that it assumes that an abstract formalism exists independently of experience. The mapping procedure that applies mathematical notions to reality assumes that these notions exist in an abstract way prior to application.

[121] This notion represents the horizon of all our possibilities. For an overview of the development of this concept in the *Crisis* and its relationship with scientific knowledge, see Berghofer, Goyal and Wiltsche (2020), Hyder and Rheinberger (2009), Luft (2011), Staiti (2017), and Trizio (2021, Ch. 5).

Ryckman questions this assumption for two reasons. Firstly, he asserts that this perspective is based on an over-simplification of the formalistic accounts of Hilbert and Frege, neither of whom ever conceived of mathematics as being entirely independent of the intuitive process of applying it (Ryckman, 2010, pp. 457–458). Secondly, the autonomy of mathematical formalism, which Friedman and the logical empiricists assume, is not obvious. Shifting the emphasis from the neo-Kantian constitutive role of principles to the coordination between two autonomous sources of knowledge — empirical experience and abstract formalism — ignores how formalism itself is constituted.

Ryckman then stresses that "if one proceeds from Husserl's critique of psychologism in logic rather than Frege's, then logic and mathematics are not to be accepted 'at face value' in the constitution of physical objects. Rather, each is a form of objectification that, like all such forms, is an achievement of what Husserl somewhat mysteriously termed 'transcendental subjectivity', the source of all objective meaning" (Ryckman, 2010, p. 461). Crucially, Husserl's approach transforms the duality inherent in the coordination process into historically situated, pre-predicative experience, constituting both empirical experiences and objectivities. In line with the core of this chapter, Ryckman states that such an approach "avoids the Scylla and Charybdis of scientific realism and instrumentalism" (Ryckman, 2010, p. 460): neither does reality emerge as already constituted, nor do our scientific methods fail to represent phenomena from an independent reality.

Despite the phenomenological basis of his criticisms, Ryckman (2010) does not elaborate further on his reference to Husserl's philosophy. Indeed, Ryckman's subsequent specification of his criticisms of Friedman focuses primarily on the work of Hermann Weyl. Drawing on his phenomenological studies, Weyl made a direct contribution to the development of mathematical tools and physical concepts.

The main insight that Ryckman puts forward is that Weyl's development of a purely infinitesimal geometry translates in mathematical terms the idea of embracing the phenomenological perspective of consciousness. The restriction of the space of analysis to what is given to the cognising subject is geometrically transposed into considering only the tangent space (a neighboring space) to an arbitrary point in space-time (the subject). By employing this framework, Weyl develops the formal toolbox to incorporate

Maxwell's laws of electromagnetism in the metric of spacetime. To locally rescale such a metric, Weyl introduces an affine connection, namely a mathematical structure to transport vectors along a curved space. The fundamental idea is that electromagnetic phenomena exhibit local variations (for example, the intensity of the field on a body decreases as the body moves away from it), and representing these effects using only the metric tensor of general relativity is insufficient for a unified description. Weyl introduces an affine structure in which gauge symmetries are fundamental, allowing these symmetries to be incorporated into the spacetime geometry. This structure can be projected into the spacetime metric to describe the influence of an electromagnetic field within the framework of spacetime.

While Ryckman's emphasis on Weyl is well justified in the context of the debate with Friedman, it has tended to overshadow Husserl's contributions. Moreover, despite the fact that Friedman acknowledged the relevance of Ryckman's suggestions, he failed to integrate phenomenological ideas fully and satisfactorily in his subsequent contributions. Although Friedman (2009, 2010) engages with the notion of the *Lebenswelt* and several of Husserl's later reflections, he emphasises the differences between his project and phenomenology. Indeed, Friedman is interested in reconstructing the specific principles and criteria that have historically contributed to the formulation of theories and theory changes. Crucially, his issue is "how to reconcile the necessity and priority demanded by transcendental philosophy with the unavoidable contingency of history" (Friedman, 2010, p. 698). According to Friedman, this problem was *not salient* to Husserl, who aimed to delineate "the transcendental conditions of historicity in general, constitutive of the immediately given life-world, rather than providing a transcendental explanation of particular concrete developments that may occur against the background of these general conditions". (Friedman, 2010, p. 698).

Friedman is correct in that Husserl's phenomenological constitution involves a general level that abstracts from concrete occurrences in the history of science. However, this does not mean that Husserl was not interested in the issue that Friedman raises, nor that the tools he developed cannot be applied to the same domain that Friedman addresses.

5.4.2 Reconsidering Husserl: scientific observation as constitution

One shortcoming of Friedman's conception of 'constitutive principles' is that he groups together a wide variety of statements under this common label. In his account, it is not always clear why certain fundamental scientific principles are best described as constitutive rather than axioms, postulates, premises, conventions, coordinative principles or logical presuppositions. The examples he provides — calculus, the light principle, and the principle of equivalence as constitutive of classical mechanics, special relativity, and general relativity, respectively — seem to refer to different elements with different roles. Although Friedman distinguishes between mathematical and physical presuppositions, he ultimately collapses this distinction by forcing both into the Procrustean bed of the label 'constitutive'. The image of constitution that emerges, provided by different kinds of principles, is thus monolithic: it refers solely to the role of coordinating between an abstract formalism and concrete phenomena.

Another related drawback of Friedman's framework is the so-called problem of *uniqueness* (Friedman, 2010, p. 801, n. 353). Often, alternative formulations can validly constitute the same theory: for example, Newtonian mechanics can be expressed in either Hamiltonian or Lagrangian formulations, and algebraic formulations of general relativity diminish the significance of Riemannian geometry (Ashtekar, 1987). Similarly, general covariance, considered constitutive of general relativity, can be applied to any spacetime theory (see Norton, 2003). If multiple alternative principles can constitute the same theory and a single constitutive principle can constitute multiple theories, how can the formulation of a theory be considered impossible without such principles? Do these necessary elements need to be unique, or can they constitute a set of alternatives?

The unfolding of the phenomenological notion of constitution into a plurality of distinct constitutive processes and acts offers a potential solution to both problems. As emerged especially in Section 2, this concept has multiple modes of application in at least three senses. First, Husserl distinguishes between different constitutive intentional acts and different kinds of constitution (active or passive; predicative or pre-predicative; static or genetic). Second, he differentiates between the regions in which these acts can be applied (physical nature; the psychological or spiritual self; culture). Finally, the constitutions of these regions, based on different acts, are situated within a historical process through the transition from studying the static domain to studying the genetic

domain. While Friedman is correct in noting that Husserl shows little interest in the concrete development of physical theories, each of the three aforementioned elements plays a role in the history of science by specifying the relationship between transcendental conditions and empirical contingency.

Just as Husserl distinguishes between perception, imagination, memory and other processes of consciousness, the community of physicists articulate the understanding of reality in different ways and through different acts without a fixed formula. Klein and Poincaré, for instance, emphasise *visualization* and the *intuitive* dimension through which mathematicians depict algebraic relations using geometric images and physicists apply mathematical frameworks to phenomena (Klein, 1896; Poincaré, 1902, 1905). Furthermore, there has been a recent shift in the philosophy of science toward recognizing *imagination* as a constitutive – in Husserl's sense of sense-bestowing – rather than merely instrumental dimension of scientific reasoning (see Levy and Godfrey-Smith 2020).

Perceptual acts also assume multiple forms in scientific practice. Observation and measurement, which can be considered two intentional acts through which empirical content is detected and interpreted, operate in various ways, thereby exemplifying Husserl's concept of different constitutions. Theoretical models work alongside experimental models and engineering considerations regarding how to design and implement the necessary experimental setup.

Consider the first observations of Sagittarius A*, a supermassive black hole at the centre of the Milky Way, made by the Event Horizon Telescope (EHT). These observations are not empirical in the traditional sense; they are the result of a global network of synchronised radio observatories working together. Therefore, capturing the image of the black hole would not have been possible without specific technological equipment, continuous communication among expert communities, and the sharing of aims, methods, and conceptual frameworks. In line with this consideration, Doboszewski and Elder (2025) show that general relativistic assumptions play a substantive role in simulations used in black hole observations. The LIGO–Virgo observations, for instance, rely on what they call "ampliative simulations," namely numerical simulations of the dynamical evolution and gravitational-wave emission of binary black hole systems. These simulations function as standards against which other models are tested and calibrated, thereby fixing expectations about how genuine signals should appear in the data. As

Doboszewski and Elder argue, ampliative simulations "unlock connections between the properties and dynamics of astrophysical sources […] and how these features are encoded in observational data," with the result that "theoretical assumptions about the dynamics of binary black hole mergers are baked into the observation methods" (2025, p. 836).

The point is not that observations of black holes are trivially theory-laden. I am referring to the multifaceted role of theoretical assumptions in constructing empirical data here because it exemplifies exactly what Husserl calls "phenomenological constitution". Consistent with the process described by Husserl in §18 of Ideas II, the contemporary cosmology of black holes does not rely on data that is given autonomously, nor on artificial images that lack objectivity. Instead, groups of scientists share conceptual assumptions, exchange ideas, compare results and identify common factors in order to understand the noematic structure of their observations — namely, that the resulting image represents the black hole. By simulating expected results and comparing data models with theoretical assumptions, cosmologists do not merely record or create black holes and their properties arbitrarily; rather, they constitute them by playing the game of modifications and outcomes described in the previous section[122].

The fact that black holes are constituted rather than simply given independently of subjectivity is confirmed by the relevant role of conceptual and theoretical assumptions in enabling, comparing, and interpreting observations. Giere (2006) has famously defended the idea that scientific observations require a hierarchy of models to assess instrument reliability, gather and organise data, interpret outcomes and place them within a theory to explain and predict relevant phenomena. All these modelling activities realise, in different ways, Husserl's concept of constitution, as they are steps towards *intending an object as it truly is*, thereby grasping its invariant structure.

The same is true according to several philosophical reconstructions of experiments in particle physics. The detection and organisation of subatomic particles occur across multiple sites and communities in communication. These results are not merely given,

[122] The notion that experiments are guided by theory in a meaningful way was not alien to Kant himself. In the First Introduction to the *Critique of the Power of Judgement*, he writes that "the principles in accordance with which we set up experiments must always be derived from knowledge of nature, and therefore from theory" (CJ, 20:199). Wartenberg (1992, pp. 243–244) emphasises Kant's interest in providing theoretical guidance for experiments. The relationship between the way scientists constitute objective experience and technological or experimental equipment is also discussed in Section 2.2.2 in relation to the Neopositivist operational interpretation of the correspondence rules.

but constituted — endowed with meaning — through a set of assumptions and theories. The shared body of assumptions that allows the scientific community to tackle joint inquiries emerges for example in Antoniou's description of the practices in High-Energy Physics, according to which "The overall design and operation of the track reconstruction and particle identification systems at the LHCb [Large Hadron Collider beauty] (as well as of any other large scale experiment) is based on a number of physical principles that are considered to be fundamental and are expected to hold in any possible new physics theory to be constructed based on these data" (Antoniou, 2021, p. 101).

In addition to demonstrating that "perception"—in the sense of detecting data via observations and experiments—occurs in a variety of ways, experimental work in particle physics clearly reveals that observational data are constituted as units on the basis of multiple theoretical models and, conversely, *retroactively influence these models*, encouraging their modification and improvement. This is emphasised, for example, by Bauchemin (2017), Antoniou (2021), and Ritson and Staley (2020), who describe Large Hadron Collider (LHC) experiments on the interactions between hadrons and the nucleus of the material forming a calorimeter in which different competing models, although empirically equivalent, "Affect the simulation of detector effects and thus the unfolding transformation performed in the measurement procedure" (Bauchemin, 2017, p. 299).

The constitutive—in a Husserlian sense—role of measuring instruments emerges not only in their imbuement in theoretical assumptions and in their retroactivity: the very procedure of measurement raises the Husserlian notion of *essence*. This point is beautifully explained by Fjelland (1991, p. 272):

> In a certain sense measuring instruments presuppose ideal objects. When we measure length, we use a measuring rod. When we measure temperature, we use a thermometer, etc. However, like Plato, any scientist knows that there is a discrepancy between the ideal and the material world. The actual measuring rod which we use, expands when heated, and is deformed by external forces. In the same way there are numerous possibilities of malfunctioning of a thermometer, but we try to construct the material measuring rod and the thermometer so that it is as close as possible to the ideal measuring rod and the ideal thermometer. When there remains a discrepancy between the material and the ideal instrument, we try to make corrections to compensate for this fact.

Husserl extends this argument to the general methodology of science in *Ideas I*, where he describes the nature examined by the natural sciences as corresponding to "an Eidos that can be apprehended purely, the 'essence' *Any Nature Whatever,* with an infinite abundance of predicatively formed eidetic affair-complexes included in the latter" (Husserl, 1913/1982, p. 19). In summary, specific observations in cosmology, experiments in particle physics, and conceptual assumptions in measurement procedures reveal that data detection involves—in some cases—a process of phenomenological constitution in at least three ways: it endows empirical data with theoretical concepts, providing meaning and categorising it as data relating to a specific target; it involves retroactive effects of the data on theoretical assumptions; and it presupposes ideal essences against which actual measurements are compared to determine them.

Consistently with these considerations, some commentators have highlighted Friedman's lack of attention to the technological equipment, theoretical framework and essential ideals required for detecting and organising data in general (see, for example, Nordmann, 2012). The significance of measuring tools and data-modelling is crucial to several accounts developed to overcome Logical Empiricism[123] and has clear Husserlian roots: a process of phenomenological constitution is at play in conferring meaning to data and modifying theoretical models on the basis of the retroactivity of those data.

Moreover, the variability of observational procedures and the theoretical apparatus required to construct, guide and interpret data aims to identify structural elements of reality about which intersubjective agreement can be achieved. The Husserlian approach proposes shifting the focus from the abstract description of scientific theories based on a set of 'constitutive' principles, to the actual scientific practice of employing a variety of *constitutive procedures* to isolate essential and invariant structures of reality.

5.4.3 Necessity and contingency

One could argue that these considerations are unrelated to Friedman's issue as they do not focus on the role of specific principles. Nevertheless, I would point out that shifting attention from the principles of a theory – which often exhibit roles that cannot be reduced

[123] Among the others, Bachelard (1984) and Suppes (1962) deserve a mention: while the former emphasises that objectivity should be linked to a specification of the methods to objectify nature, which involve technical instrumentation and apparatus, the latter articulates the notion of 'data model' to describe the need to regiment, order and interpret any collection of data. See Tal (2013; 2023) for a recent model-based approach to measurements and data detection.

to a single characterisation – to the *different modes in which data are gathered and interpreted*, is not merely an integration of Friedman's approach, but a rethinking that may more accurately resolve the above-identified problems of uniqueness and plurality of principles. Indeed, given the threefold pluralisation of phenomenological constitution relating to various intentional acts, regions and diachronic unfolding, there is a sense in which the very *core* of Husserl's philosophy aligns with what Friedman denies Husserl addresses, namely "to reconcile the necessity and priority demanded by transcendental philosophy with the unavoidable contingency of history" (Friedman, 2010, p. 698).

The key point is this: if the focus of enquiry is on the constituting subject and the principles she employs to order nature, then science becomes a one-way activity in which the contingency of the world appears to be ruled out or governed by subjectivity. Within this non-Husserlian view, which is dominant in Friedman's analysis, any emphasis on the contingency of reality risks reducing a priori presuppositions to the relativised postulates of a specific theory. This can result in the entire disappearance of the transcendental level of investigation.

On the contrary, Husserl separates constitution from the subject. Objects constitute themselves as meaningful entities within experimental procedures, while subjects constitute them in various types of synthesis, such as active or passive[124], predicative or pre-predicative, and operational or speculative. Subjects themselves are constituted by the retroactive influence of constituted nature, and a collection of data may lead to the modification of those same set of assumptions that made possible to detect them. Scientific communities shape their practices, constraints and schedules in response to natural events that they had previously sought to explain. Transcendental constitution is thus *inherently linked with temporal unfolding* and, consequently, with historical contingency. Husserl transforms the monolithic notion of constitution — arguably incapable of accommodating contingency — into a collection of constitutive acts and processes that are better able to represent the various ways in which scientists both order nature and are compelled to acquire scientific knowledge.

Although the dynamism of Husserl's constitution already emerges in *Ideas*, it is especially in the late Husserl that the concept of historicity, alongside the notion of life-world, is thematised. Langrebe claims that Husserl's late reflections (such as those in the

[124] On passive constitution, see Landgrebe (1981)

Crisis) constitute even a "transcendental theory of history" (Landgrebe, 1982, p. 100). Indeed, the late Husserl expands the dynamic exposed in section 3—which includes our personal differentiation between relative and non-relative elements of experience, the 'trading' of our beliefs with others, the process of communal constitution of nature via communication and reaction to others claims—to a historical horizon. Since we coexist in a shared life-world, where our personal life-worlds — that is, our collections of experiences and beliefs — can be compared, we can consider also the life-worlds of earlier people, primarily through their writings. As Landgrebe stresses, "The invariant element in different life-worlds is not only valid for those who live during the same time with their respective worlds; it is also valid for the worlds in the past of which we have gained knowledge" (Landgrebe, Chaffin and Welton, 1981, p. 127). In this way, phenomenology embraces historicity, and the process of constitution becomes genetic. The constitution of any cultural product, and *a fortiori* any scientific modelling of nature, is based on earlier constitutive processes (Landgrebe, 1982; Luft, 2011, pp. 103-124).

Jansen (2015) clarifies how Husserl integrates necessity and contingency through the historical dimension of constitution. The idea is that, within any contingent multiplicity of contents situated at 'now-points' in history, general features emerge that render those contents coherent — a unity arising from multiple modes of givenness. These conceptual generalities, embodied in contingent occurrences, are freed from their specific contexts, portraying concrete experience as a mosaic of different levels of contingency and necessity. Jansen stresses that "even on the most basic level of originary association, understood as a synthesis of the similar with the similar, the given is imbued with an air of generality insofar as this association already implies disregarding the differences between the associated moments, as well as a sense of affinity amongst them" (Jansen, 2015, p. 72). At the same time, any object projects a multitude of possibilities in terms of how it can be perceived and how it can evolve over time. Thus, the conceptual necessity embedded in contingent experience opens up a horizon of possible consequences and new experiences. Consequently, no contingent experience or object exists without intending it as itself and grasping its essential nature. In parallel, no transcendental constitution exists without projecting new contingent possibilities. This is how Husserl reconciles transcendental constitution and historical contingency.

The interplay between contingent possibilities and the constitution of unity frames the history of science as an infinite process — an ongoing effort to order nature under increasingly general laws which, however, can never fully exhaust the horizon of reality. Beyond resembling Cassirer's neo-Kantian view of the progress of scientific knowledge as a regulative task, Husserl's perspective aligns also with Nozick's (2001) view that there is no single kind of necessity, but rather a plurality of statements exhibiting *varying degrees of necessity and contingency* in function of their location and role within the historical process. Necessity is that which remains invariant under possible transformations, yet it is possible to conceive of principles whose necessity is not entirely detached from contingency: the more necessary a constitutive principle *P* is, the further it stands from historical events in which *not-P* occurs. Furthermore, the assignment of degrees of necessity and contingency to principles and laws, which may also vary over time, occurs within a community and an intersubjectivity that enables the objective study of nature through 'trading beliefs'.

Once objectivity is understood as identifying invariant elements in experience — achieved through dialogue and the norm-governed practices of the scientific community — it becomes possible to reconcile historically situated scientific practices, experimental discoveries and the formulation of laws and principles with a plurality of constitutive processes that bring manifold elements into an essential, transhistorical unity. This is something that Friedman's perspective does not allow.

This shift is indicated paradigmatically by Husserl's discussion of the historical a priori in *The Origin of Geometry* (Husserl, 1954/1970, p. 369). As Husserl asserts: "We stand, then, within the historical horizon in which everything is historical, even though we may know very little about it definitively. But it has an essential structure that can be revealed through methodical enquiry. This inquiry prescribes all the possible specialised questions, thus including, for the sciences, the inquiries into origin that are peculiar to them by virtue of their historical nature." Contrary to a monolithic transcendental epistemology, Husserl claims that the principles and modes of investigating nature are always historically situated. Contrary to historicism, which reduces the results of mathematics and the natural sciences to historical occurrences that lacks necessity, scientific concepts would be meaningless, he emphasises, if they did not attempt to transcend contingent 'here-and-now' moments in order to achieve generality across past, present and future instances.

The historical a priori constitutes the absolute presupposition according to which concepts such as the 'triangle' and proofs such as that of the Pythagorean theorem are formulated within a specific historical context, yet claim validity and necessity independently of historical occurrences. The same applies to scientific definitions, classifications, laws, theoretical formulations and modelling procedures.

Husserl acknowledges that the notion of a historical a priori may seem oxymoronic: "One might object: what naïveté to seek to display, and claim to have displayed, a historical a priori with absolute, supertemporal validity when we have obtained such abundant testimony for the relativity of everything historical." (Husserl, 1954/1970, p. 373). Nevertheless, he clarifies that it emphasises the flexibility of conceptualising nature, while recognising the inescapable need to intend it as it is: "All not-knowing concerns the unknown world, which yet exists in advance for us as a world — as the horizon of all present questions and thus also of all specifically historical questions." (Husserl, 1954/1970, p. 374).

As given objects cannot escape constitution, contingent and historical facts likewise cannot avoid being intended as what they are. History presents contingent facts that may contradict our theories or even the a priori principles meant to organise knowledge; yet such facts must still be constituted *as contingent facts*. I do not claim that Husserl resolves all the issues Friedman addresses. An alternative, potentially non-phenomenological analysis in Friedman's style, aimed at pinpointing the role and evolution of specific principles within specific theories, remains valuable. However, through Husserl's notion of constitution, Friedman's attempt to reconcile the contingency of history with the a priori of transcendental philosophy, along with criticisms regarding the uniqueness of his principles and the Procrustean fallacy of his approach, can be addressed and unpacked productively.

Conclusion

In this chapter, I have clarified Husserl's general notion of constitution by highlighting five aspects (section 5.2). First, constitution alludes to a description of knowledge that eludes both realism and idealism by pinpointing the correspondence between subjectivity and objectivity. Second, I have clarified in which sense a constitutive process 'provides meaning': it does so by differentiating objects and by situating them in time. Third, I have

specified that the temporal dimension delineates two kinds of constitution: static and genetic. Fourth, constitution retroacts on the subject, making her the pole which intends with conscious acts. Fifth, I have distinguished a plurality of constitutions, which vary on the basis of the intentional act they involve and the region they apply to.

Subsequently, I have focused on how Husserl applies the general concept of constitution to scientific knowledge (section 5.3). By investigating mostly the first chapter of *Ideas II*, three further aspects of constitution emerged: (i) it depicts objects as rules that their multiple occurrences follow; (ii) it works as *scientific* constitution mainly by grasping the "irrelative" elements in relative experiences; and (iii) it emphasises intersubjectivity as the grounding for objectivity.

In the final part (section 5.4), I employed some aspects of Husserl's notion of constitution—both in general and with respect to scientific knowledge—to address some shortcomings of Friedman's view. This move was motivated by Ryckman (2010), who invites Friedman to reconsider the role of phenomenology without however deepening Husserl's thought, and by Friedman (2010), who fails to integrate Husserl's insights within his account. Specifically, Friedman claims that Husserl did not reconcile historical contingency and a priori necessity, as he aims to achieve. I have argued that Husserl did tackle this issue, and that phenomenological constitution can offer an alternative and fruitful framework.

This is because Husserl shifts the rigid notion of constitutive principle into a plurality of constitutive processes. Constitution can be realized through various intentional acts—which, in science, can be identified with modes of measurement, observation, imagination, creative thought, etc.—and it leads, in my interpretation, to the mutual relationship between assumptions that enable to detect data and data that lead to a refinement of those same assumptions—a concrete example of the meaning-giving and retroactivity features of Husserl's constitution. Finally, this plethora of constitutive processes points to contingent procedures, situated in history, that nonetheless refer to essential structures of objects, meant to exhibit a transhistorical necessity.

Concluding Remarks: Classifying Constitutive Principles

In contemporary philosophy of science—largely due to the influential work of Michael Friedman—the concept of ‘constitutive principles’ refers to those fundamental presuppositions that establish the spatiotemporal framework required to formulate the empirical laws of a theory. As outlined in the *Motivation for this work* and Chapter 1, the objections to this view are many; however, two may be mentioned here as particularly significant. First, critics argue that such principles become functionally indistinguishable from related concepts such as postulates, axioms, or coordinative principles. Second, the "Kantian flavor" of the term—originally intended to be salvaged from the rigidity of Kant’s transcendental system—loses its distinctiveness when applied merely to physical statements within specific scientific theories (Allison, 1994; de Boer, 2011; Everett, 2015).

In contrast to existing conceptual analyses of constitutive principles (Luchetti, 2023; Stump, 2015; Sus, 2024), which are often prone to counterexamples or the conflation of distinct scientific assumptions, this work adopts a historical approach. My investigation reveals that the evolution of this term has not been linear; no single, clear-cut definition emerges across the surveyed authors, nor can a unified account be easily synthesized from such diverse methodologies. Nevertheless, I have established specific guidelines to help navigate the plurality of the term's occurrences.

For Kant, constitutive principles are those that apply pure concepts (categories) to schematized appearances. They function as the criteria for *positing* something — a technical term standing for the assertion of the existence of something within an intersubjective reality. For instance, the three Analogies of Experience prescribe that only appearances exhibiting a permanent, invariant structure — and which are causally related to other appearances — qualify as genuine objects or events. Conversely, the "experience" of an immaterial ghost or spirit (of the kind Kant mocked in his critique of Swedenborg in *Träume eines Geisterseher* (1766)) fails these criteria and must therefore be excluded from the domain of possible experience.

Consequently, constitutive principles define the conditions of "objecthood" while simultaneously providing referential content to concepts. This is the essence of Kant’s

claim that constitutive principles “make possible the concepts without which experience would not be possible.” Crucially, these principles refer to objects in general, rather than the specific empirical laws of a physical theory. While Kant viewed his system as inherently related to scientific knowledge, this link is not maintained by constitutive principles in isolation; rather, it requires their interaction with regulative ideas (such as systematicity) and reflective judgment.

Following Kant’s original account, three distinct philosophical paths emerged.

Firstly, the Neo-Kantian interpretation, according to which constitutive principles are the set of functional definitions and laws that transform subjective experience into objective facts. Our focus on Cassirer’s philosophy of quantum mechanics added to this general picture the example of the principle of lawfulness. What emerged as relevant was especially its transcendental character: it must be valid if we want to do science.

Secondly, the logical empiricist interpretation. I have distinguished Reichenbach’s and Carnap’s use of the Kantian terminology –in section 2.2.2 and 4.1 – from Schlick’s one. According to Schlick, constitutive principles are reduced to a subset of the conventional assumptions necessary to formulate any mathematical or physical theory. In chapter 4, I have focused on Schlick’s characterization of principles as conventions, highlighting his account of coordination as grounded on an underlying realism—developed by combining insights from Poincaré and Hilbert. This chapter was also helpful to raise some possible shortcomings of an epistemology that sets aside the notion of constitutivity.

Thirdly, the Husserlian interpretation, where the single notion of constitution is substituted by a variety of constitutive processes. Husserl treats constitutive principles as the underlying rules of different types of "constitutions"—intentional acts directed toward specific "regions" of objects (e.g., the material, the psychological, or the formal). This chapter was also useful to tackle some objections to Friedman’s account, marking more than the others the claim that scientific knowledge involves an interrelated process in which theories constitute nature and nature constitutes theories.

One possible consequence of this study is the functional reclassification of the fundamental assumptions underlying scientific theories. Rather than treating constitutive principles as a homogeneous class, the analysis showed that they could be systematically organised by intersecting two independent distinctions.

The first distinction, that emerged in the various criticisms to Friedman's account, separates theory-independent assumptions from theory-dependent ones. Theory-independent assumptions include principles such as lawfulness, general covariance, and broad forms of the principle of causality. Apel (1971), Chang (2008) and Falkenburg (2007) present other examples of such principles, among which the uniformity of nature, the existence of mind-independent facts that can be intersubjectively recognised and the principle according to which physical systems can be analysed into parts and causally relevant factors. Their validity does not depend on any particular scientific theory, since they are conditions of scientific knowledge itself. They play a stabilising role across episodes of theory change, ensuring continuity and rational intelligibility.

By contrast, theory-dependent assumptions are specific to particular theories. Examples include the light postulate in special relativity and the Euclidean nature of space in classical mechanics. These assumptions perform the specific coordinative work required to connect a theory's formal structure to empirical phenomena within a given framework. The specificity of these assumptions refines, rather than limits, the generality of theory-independent ones. However, this specification makes them more susceptible to empirical comparison and increases the likelihood of them being discarded.

The second distinction, developed in Section 2.3, is between concept-constitutive and object-constitutive principles. Concept-constitutive principles provide the formal or mathematical resources necessary to define and manipulate theoretical concepts. By contrast, object-constitutive principles are responsible for conferring ontological commitment, i.e. for determining what kinds of entities a theory posits as existing.

Combining these two distinctions yields a fourfold taxonomy of scientific assumptions:

1. The first category encompasses theory-independent and object-constitutive principles, which are paradigmatically Kantian constitutive principles that specify the general conditions under which objects of experience are possible.
2. The second category comprises theory-independent and concept-constitutive principles, which are broad metaphysical, heuristic or regulative requirements such as simplicity, systematic unity or parsimony. These principles constrain theory

construction without fixing a specific ontology, and they sometimes involve conventional elements[125].

3. The third category includes theory-dependent and object-constitutive principles, which are ontological commitments and classifications internal to a given theory that identify the specific bearers of properties that exist. Examples include the assumptions concerning the existence of fields and spacetime structures, the classification of particles in the standard model, and the taxonomy of organisms in biology.
4. The fourth category includes theory-dependent and concept-constitutive principles, which are relativized a priori principles in the sense developed by Reichenbach and Friedman. These coordinative principles—among which Newton's laws of motion, the light principle in special relativity, and the fact that any observable is represented by a linear operator in quantum mechanics—mediate between the abstract formalism of a theoretical framework and the empirical phenomena that it seeks to represent.

In Kant's sense, I would consider *only the principles at the first level to be properly constitutive*. I suggest maintaining the narrow, specific meaning of 'constitutive' (as theory-independent, object-constitutive presuppositions) and characterising the principles at the second level as *regulative* or *methodological*, at the third level as *ontological* and *classifying* assumptions and at the fourth level as the specific *axioms* and *physical principles* of a theory. However, the other levels also present assumptions that could be (and have historically been) considered *constitutive* in different specified senses according to the aforementioned distinctions. My framework is thus compatible with the claim that they all exhibit some constitutive uses in a broad, non-Kantian sense which, however, needs to be specified on a case-by-case basis. This taxonomy clarifies that principles which are often presented in the literature as mutually exclusive alternatives, such as conventions, coordinative principles or metaphysical commitments, occupy different functional levels within scientific theorising. These principles are not competitors, but rather distinct forms of assumptions that typically coexist.

[125] In line with the results of Chapter 4, I would include non-conventional principles in this second category, as well as considering those with a conventional status as not necessarily analytic. This means that they would have to exhibit non-arbitrary reasons for acceptance by the scientific community (i.e. conventions à la Poincaré rather than Schlick).

The four levels can be further distinguished along three dimensions: *status*, *justification* and *revisability*.

With respect to status, only the fourth level straightforwardly includes physical principles, while the others comprise methodological, metaphysical or transcendental presuppositions. However, this distinction is fluid. For example, a metaphysical assumption such as determinism may acquire the status of a physical principle following a theoretical revolution, while a physical principle such as the principle of least action or the principle of relativity may become so general that it no longer appears tied to any specific theory.

In terms of justification, relativized a priori principles are justified instrumentally by the role they play in enabling theory construction and empirical coordination. By contrast, theory-independent assumptions are usually backed up by transcendental arguments or methodological considerations rather than direct empirical success (Chang, 2008).

In terms of revisability, all four levels exhibit some degree of flexibility. Theory-independent principles can be revised in their empirical articulation while retaining their general validity, thereby supporting the rational continuity of science. On the other hand, theory-dependent principles can be entirely replaced as theories change, making them more easily revisable.

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