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Facts and objectivity in science

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ABSTRACT

There are various conceptions of objectivity, a characteristic of the scientific enterprise, the most fundamental being objectivity as faithfulness to facts. A brute fact, which happens independently from us, becomes a scientific fact once we take cognisance of it through the means made available to us by science. Because of the complex, reciprocal relationship between scientific facts and scientific theory, the concept of objectivity as faithfulness to facts does not hold in the strict sense of an aperspectival faithfulness to brute facts. Nevertheless, it holds in the large sense of an underdetermined faithfulness to scientific facts, as long as we keep in mind the complexity of the notion of scientific fact (as theory-laden), and the role of non-factual elements in theory choice (as underdetermined by facts). Science remains our best way to separate our factual beliefs from our other kinds of beliefs.

KEYWORDS

Objectivity; facts; theory-ladenness; underdetermination; realism; values; aperspectival view; faithfulness to facts

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1. Introduction

The goal of this chapter is to present the concepts of fact and fact-based objectivity (as the most intuitive conception of objectivity, among several others) in science. It intends to show that facts are not just ‘out there’ in the world, or that they do not ‘tell a story’ just by themselves, but that they are always embedded in an experimental, theoretical, social, etc. context. While it does not intend to downplay the importance of facts or objectivity in science – quite the contrary – it intends to show some of the potential

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problems and limits associated with simplistic claims to factual reporting or ‘following the science’ often to be found in the general public, politicians and even scientists. By introducing the reader (especially the early-career scientist) to some of these subjects (in a necessarily partial and superficial way given the breadth of the subject and the limited scope of this article), it hopes to make her more aware of the need for critical assessment when dealing with them, and encourage her to look deeper into the issues (or other relevant ones) mentioned here.

The plan is the following. The introductory section presents the various meanings of objectivity, a characteristic of the scientific enterprise. The second section defines the notion of fact in everyday experience and then in science, and contrasts it with opposite or adjacent notions. The third section then expands the related concept of objectivity as faithfulness to facts, and shows its limits. Finally, the conclusion summarises the discussion and reaffirms the importance of facts and objectivity for today.

Before going forward, note that ‘science’ in this article means all the sciences in the large (German) sense, including the humanities and the social sciences (Hansson 2017b), but, obviously, only the *empirical* (i.e. *factual*) disciplines or parts of disciplines within that set. That means that (some, or part of the) sciences bearing on our mental constructions (such as mathematics, logic, linguistics, literary studies, philosophy, etc.) are excluded from the scope of this article.¹ Section 3.2 bears more specifically on natural science (which is more amenable to laws and models).

1.1. Objectivity as a characteristic of science

Objectivity is a characteristic feature of science – probably the most important one alongside that of truth. Science aims at objectivity, and is deemed objective, or at least the most objective mode of inquiry into the world.² Objectivity is the source of the authority which science enjoys in society, and a precondition of public trust in science: it is one of the main reasons (alongside truth) why we value science. Thus, objectivity can be conceived more precisely as (one of) the defining aim(s) of the scientific enterprise (together with the pursuit of truth), if considered in itself, intrinsically; and/or as a value, if considered in relation to us, who value it (in pretty much the same way truth can be considered either as an aim, or the aim, of science, or as a value, see Hicks 2014, 3272–3273).

Objectivity is a quality which can be used to qualify (as ‘objective’) knowledge claims (i.e. results of scientific inquiry, or of observations or measurements), methods (processes of scientific inquiry), or even people (scientists performing the inquiry). Objectivity has much to do with truth (especially when it qualifies knowledge), but is nevertheless a different concept (it would not make much sense to say that a method, and even more a scientist, is ‘true’). It is focused on the way knowledge is gained, rather than on its final formulation in a statement – which is subject to truth (or not).

Because of its central importance for science, understanding objectivity is necessary to understand science itself, as well as its relationship with society. Objectivity is linked to

¹I leave aside the issue as to which extent, or which parts of, these disciplines can be considered theoretical.

²Of course, science or scientists do not have the monopoly of objectivity (for example, a judicial inquiry can also be said to be objective), but this article is limited to this scope.

many issues of the philosophy of science: realism; induction and confirmation; theory choice and scientific change, to name just a few.

1.2. Different conceptions of scientific objectivity and common core

Historically, scientific objectivity has been a changing, culturally situated concept (Daston and Galison 2021). In the last decades, many different conceptions of objectivity have been proposed, and the multi-faceted nature of the concept is generally acknowledged. Without pretending to be exhaustive, we can try to recapitulate some important conceptions of objectivity as follows:

- Objectivity as faithfulness to facts (Reiss and Sprenger 2020, §2): this is the most intuitive, natural notion of objectivity, and the one which will be studied here.
- Procedural objectivity (Bedessem and Ruphy [2020, 635] who call it ‘Baconian’ objectivity): it has to do with the epistemic quality and reliability of all the experimental and cognitive techniques and processes deployed in a scientific inquiry.
- Objectivity as freedom from extra-scientific (i.e. social, political, economic, etc.)³ values (both individual and collective ones): in other words, freedom from *explicit* non-cognitive biases, preferences or interests (related for example to ideological preferences, conflicts of interest or research misconduct).
- Objectivity as freedom from individual or collective *implicit* or hidden biases (such as Longino’s (1990) ‘background assumptions’, which, according to her, any scientific community implicitly holds, and which are imbued with extra-scientific values).
- From the collective point of view, objectivity as a feature of scientific communities and their practices (Reiss and Sprenger 2020, §5), sometimes called intersubjectivity in this respect (because the focus is on the knowing subject rather than on the object of knowledge). Merton’s (1938, 1973) sociological norms⁴ constitute a famous example. In the same vein, for Longino (1990) transparent, critical discussions between epistemic agents enable a better identification of errors, or situations in which personal preferences or interests might override evidence. Such collective conceptions of objectivity are also instrumental to all previous understandings of objectivity, including objectivity as freedom from personal implicit biases, since the confrontation with other perspectives enables to correct one’s own.

In the following, only this first understanding of the complex concept of objectivity – objectivity as faithfulness to facts – will be analysed. To do so, we will first need to discuss the notion of fact on which it is based. All other conceptions, which are not directly

³In general, intra-scientific (or epistemic, or cognitive) values (i.e. related to the pursuit of knowledge), such as internal or external coherence of a theory (within itself or with other theories), empirical adequacy, simplicity, fruitfulness, etc., are not controversial, and their influence is taken to be a normal part of scientific work (for example when deciding to accept or reject a scientific hypothesis).

⁴These norms, which concern the social aspects of scientific inquiry, are: ‘universalism’ (scientific claims are assessed according to impersonal criteria which do not depend on the personal or social qualities of the scientists); ‘communism’ (scientific findings are openly shared in the scientific community, and are not the property of specific individuals or groups); ‘disinterestedness’ (scientists should not follow personal or extra-scientific – ideological, financial or other – interests: the only things that matter are the advance of knowledge and peer acknowledgment); ‘organised skepticism’ (in science skepticism is a virtue and the scientific community does not accept a claim without due assessment and subjects it to ‘detached criticism’, without consideration for tradition, religion or ideology).

defined with respect to facts, will be left aside. The reason for this, apart from the fact that it would be impossible to properly cover all these conceptions in the scope of one chapter, is that all these latter conceptions of objectivity more or less indirectly rely on the notion of fact.

1.3. Objectivity and scientific realism

More precisely, all these conceptions (even, to some extent, the last one, with the issue of reproducibility⁵) have in common the core idea – present in the word objectivity itself – that what is objective *does not depend on us* (the subject), but describes something characteristic of the ‘object’⁶ of our investigation (that which exists independently from us, from our knowledge of it). This intuitive conception is nicely captured by Whewell ([1840] 1847, 30):

[...] the part of a man’s knowledge which belongs to his own mind, is *subjective*: that which flows in upon him from the world external to him, is *objective*. And as in man’s contemplation of nature, there is always some act of thought which depends upon himself, and some matter of thought which is independent of him, there is, in every part of his knowledge, a subjective and an objective element.

Even social understandings of objectivity (as intersubjectivity) aim at identifying this common (objective) feature of our knowledge, by ‘cancelling out’ our personal idiosyncrasies, correcting our errors, enlarging our point of view, etc.⁷ The very possibility of such social conceptions of objectivity would be mysterious if there was not an independent object towards which they are directed.⁸

Such core idea presupposes a minimally *realistic* stance, which acknowledges the independent existence of the ‘objects’ – or rather, facts – which we study, independently from our perceiving or thinking them (in other words, they are not pure constructions, they do not depend solely on the subject of knowledge).⁹ This, however, is only true to some

⁵The reproducibility of empirical research results requires that the idiosyncrasies of individual researchers are irrelevant to reaching them, and that instead, an impersonal protocol enables any researcher to reproduce the empirical results of another one.

⁶This term is not to be taken in the restricted, ontological sense of object (as an entity), but rather as the state of affairs, the relationship between objects – in other words, the facts – which we investigate (see Section 2).

⁷Another way to put it is to say that a diversity of perspectives takes the place of the absence of perspective (the ‘view from nowhere’, see below), in order to have at least the best possible replacement of the latter (increasing the number of points of view decreases the probability of personal bias).

⁸If we exclude radical idealistic or relativistic conceptions, according to which scientific theories, instead of reflecting reality, are nothing but projections of the structure of human mind onto reality, or social constructs reflecting power (or interest, or other social) relations.

⁹The issue of (scientific) realism is different from, though clearly related to, that of scientific objectivity. It is a central issue in the philosophy of science, which has given rise to an enormous literature (with many different definitions of what scientific realism in fact means) and which lies outside the scope of this chapter (for an overview, see Chakravarty 2017). In a nutshell, scientific realism is realism about what is described by scientific theories, about their content and what they say about the world. Scientific realism and anti-realism come in various types and degrees (for a classification and ordering of various strands of scientific realism and anti-realism, see Stamenkovic 2015, §4.4.1). Very roughly, realism about scientific theories claims that they aim at the truth and get closer to it, while realism about scientific entities (such as atoms or genes) says that they really exist. Anti-realism about theories says they should not be believed literally but are rather useful ways of prediction. Anti-realism about entities says they are useful intellectual fictions (Hacking 1983). Here is not the place to argue for a particular stance in the realism debate. Let us just note that, while some acceptations of scientific objectivity (such as freedom from hidden biases, or feature of scientific communities) do not necessarily presuppose scientific realism *stricto sensu*, they nevertheless rely on a minimal realistic stance (if we exclude unreasonable radical idealistic stances), acknowledging that science investigates subject-independent

extent, since we know (as Kant would put it) that we generally do not have access to objects ‘in themselves’, but only in relation to ourselves, our senses, apparatuses, languages, theories, etc. As Whewell ([1840] 1847, 24) says,

[...] a Fact is a combination of our Thoughts with Things [of the external world] in so complete agreement that we do not regard them as separate.

[...] Facts involve Thoughts, for we know Facts only by thinking about them.

Therefore, a more proper way to define objectivity may be to say that what is objective, rather than (completely) not depending on us (since it does so in part), *imposes itself onto us* in some way, independently of a *particular* subject, but not of *all* subjects who investigate the *same* world.

2. The concept of fact

In general a fact – a rather large and imprecise notion, which we will try to narrow down to a more accurately defined concept – refers to something which happens in the world, independently of us (this is what we will call a *brute fact*).¹⁰ In science a fact is generally established thanks to experimental and theoretical means (and of course, thanks to our sense data) – and therefore cannot generally be said to be completely independent of us (this is what we will call a *scientific fact*).

2.1. In everyday experience

‘Fact’ is an ordinary word, designating everything that really happened or happens (possibly on a regular basis). It is somewhat synonymous with ‘event’ – but the term ‘fact’ insists on the reality of the matter: we thus talk of ‘matter of fact’. For example, we can say that ‘it is a fact that we are in Paris now’, ‘it is a fact that days and nights alternate at the surface of the Earth (except in polar latitudes)’. In general, we talk of facts to denote single occurrences in space and time, but we can also use the word to designate (somewhat abusively) generalisations (including physical laws). Rarely, and even more abusively, one can also talk of a fact to designate a valid conceptual or logical – i.e. not empirical – statement (for example, ‘it is a fact that this argument is contradictory’, or ‘it is a fact that $2 + 2 = 4$ ’).

A fact does not designate an object (like a stone) but a relationship between objects (‘this stone lies on the ground’), in other words, a state of affairs. Semantically, a fact is designated by a sentence (in logic, a proposition), and not a single noun (in logic, a subject) as an object is. This sentence (proposition) is true if it indeed corresponds to a fact. Thus, the epistemological notion of fact is linked to the semantical notion of truth, and is indispensable in the classical theory of truth as correspondence with the world, according to which a proposition (first kind of entity) is true or false according to whether or not it corresponds to a fact (second kind of entity).

facts (what will be called *brute facts* hereafter, the facts which science conceptualises being themselves called *scientific facts*).

¹⁰Note again that acknowledging the existence of brute facts represents only a minimal commitment to scientific realism, which says nothing of our belief in the content of scientific theories or models, in scientific entities or laws, etc.

In everyday life it is usually possible to identify facts directly through our senses (for example the fact that it is raining now at our place). In science, however, (scientific) facts cannot generally be directly established by the unaided senses (see below). As we said above (following Kant and Whewell), any fact identification already involves our mind – and this applies to everyday facts as well. However, this is done *immediately* from our sensations in everyday experience (where facts are directly perceived), in contrast to science where establishing facts may be *mediated* by various experimental, instrumental and theoretical means (more about this below). A good analogy, taken and adapted from Whewell (38),¹¹ to illustrate fact identification in everyday experience and in science, is that of reading a familiar language or deciphering an ancient, incomplete inscription. If the letters or signs are the ‘observed facts’, to read and interpret them into meaningful words and sentences (in other words, to establish the facts) requires in both cases ‘a mental act’ (based on background knowledge represented by the alphabet and language, what in science is the ‘theory’), but in the first case, this act is ‘unconscious’ and immediate, whereas in the second case it is conscious and iterative, we are clearly aware of the gap between what we see and how we interpret it. Anyone can establish immediately, thanks to her senses and without any specific knowledge, the fact that it is raining now at her place – but it requires instruments and/or background knowledge to make observations about the population of a given species in a given area, or to make a measurement in a physical experiment, and to process this information for further scientific work (e.g. in ornithology or particle physics).

Identifying facts and separating them from our attitudes towards them (e.g. our preferences, values (see 2.3.1), or intentions about what to do with these facts¹²) is an essential requirement for us to be able to act in the world (Hansson 2017a, 2018). Thus, in our minds, we distinguish our factual beliefs (what we believe to be facts) from our other types of beliefs and feelings. If we mixed up our factual beliefs with our other types of thoughts, we would have no way to separate facts from our reactions to them. This may be what certain animals do (although we do not know much about how they think), and what we might have done in the absence of language. As Hansson remarks, such a conception is so natural to us that it is difficult to envisage something else. We apply principles of theoretic rationality to these facts (we reason about them), in order to reach practical rationality (to be able to act in the world), both at the individual and collective level. According to Hansson, the ability to separate (what we believe to be) facts, and reason about them in relative isolation from other components of our minds, makes us more successful in our practical dealings with the world and with each other, has a survival value for us, and was probably developed because of the evolutionary advantage it provided us with. While we do not know much how other animals think, and in particular if they are able to separate factual from other kinds of beliefs, this

¹¹This analogy is inspired from Whewell (1840/1847), but he insists on the ‘conjectures’ which we make and which are ‘separate from the observed facts’ to which they are confronted, and to which they are ‘united as elements of one act of knowledge when we ha[ve] hit upon the right conjecture’. This looks like hypothesis testing, whereas I just want to show the difference between everyday facts and scientific facts (the latter explicitly requiring a theoretical interpretation). Note that an everyday fact, which can be asserted directly by the senses, is not the same as a brute fact which I mention hereafter, which is a fact happening independently of us, not necessarily directly ascertainable by the senses.

¹²In other words, distinguishing what depends from us from what does not (see above).

ability seems to be present in all kinds of human societies, in tribal as well as in modern ones.

Separating factual beliefs is even more important at the collective level (in society) than at the individual level. For beings like us who isolate factual components of their thoughts, it seems advantageous to have a common repository of factual beliefs which we share, in order to communicate, reflect and coordinate our actions. In an organised process of collective decision-making such as the legislative process or the elaboration of policy, this characteristic is particularly developed (Hansson 2018, 210), or should be. In particular, this is what we (try to) do in science, which provides us with ‘a common repository of reliable factual beliefs’.

Thus, distinguishing facts from our attitudes towards them represents the basis of our everyday life and is also central in science. A science based on facts (further generalised in the form of laws and principles) represents the ideal of scientific inquiry.

2.2. In science

In the same way as in everyday language, in science the term ‘fact’¹³ can designate either:

- An individual event (located in space and time, except if we consider quantum phenomena) – hence, it does not designate an object, but a relationship between objects. For example can we say that ‘it is a (historical) fact that Napoleon died in 1821 on the island of Saint Helena’ (in history), or ‘it is a (physical) fact that the object we dropped hit the ground of the lab at 13:36’ (in mechanics).
- More rarely, and somewhat abusively, a regularity between individual events (described by a general statement or a law) or a general property. For example, ‘it is a fact that two identical electrical charges exert a repulsive force on each other’ (in electromagnetism) or ‘it is a fact that a molecule of (normal) water is made up of two atoms of hydrogen and one atom of oxygen’ (in chemistry).¹⁴

In science, a fact can be observed, recorded, certified, i.e. can be the object of intersubjective agreement following a measurement, or a verification (Lecourt 2006, 486–491). The identification of facts represents a central goal of science – and is instrumental in achieving objectivity, a higher-level goal: science has to do with uncovering, and establishing, the facts. Science can be described as a ‘fact-finding [and we should add, fact-based] practice’, and the scientific corpus as ‘a social repository of factual statements’ (Hansson 2017a, 2018). The increasing diversity of facts discovered implies the increasing diversity of scientific disciplines, as the history of science testifies, which is a history of the division of labour of the human mind applied to the knowledge of reality.

¹³One can sometimes find the rather unclear expression of ‘scientific fact’. It would be more accurate, and less misleading, to say a *scientifically established* fact. Such expression makes clear that facts are established in science thanks to an experimental and theoretical apparatus, and are not just ‘out there’ waiting to be discovered. However, for the sake of simplicity, I will often use the former expression. There is also the idea, in the expression ‘scientific fact’ (or scientifically established fact), of the *authority* conferred by science to this fact, whose reality has been validated or confirmed by science – but this is an aspect left aside here.

¹⁴Here I just consider the level of generality of statements designating ‘facts’, and leave aside the question of their epistemological status (obtained by induction, from purely perceptive facts or theoretically and instrumentally laden facts, etc.).

A *scientific fact* – i.e. a scientifically established fact – is measured, corrected, stated, elaborated in a rigorous language, and the statement of its reality and its meaning presuppose its link with other facts, laws, theories, etc. i.e. its insertion in a(n) (experimental, instrumental, theoretical, linguistic, etc.) system. Scientific facts are not established through immediate sense data but are, to some extent, instrumental, experimental, theoretical, etc. constructions – of course they are not *only* that. They can be established only once the scientist has elaborated a research perspective, with the help of already available experimental and theoretical frameworks. Scientific facts depend on their correct interpretation in order to be understood: for example, if you cannot read the relevant instrument(s) and/or interpret the results theoretically, you cannot understand the fact in question (Duhem [1906] 1981).¹⁵

Note that the description of science as a fact-finding,¹⁶ and fact-based, activity is not contradictory with the claim that there is generally no (scientific) fact independent from any (experimental, theoretical, etc.) presupposition. Of course, (brute) facts exist independently of us, even if we do not observe or measure them. This does not contradict the claim that (scientific) facts are only ascertainable thanks to some experimental and theoretical apparatus. In other words, it is just a matter of distinguishing *brute* facts from *scientific* facts, with the latter referring to the former (this is what we mean when we say that observations represent, or give an account of, the facts). The state of affairs originally measured exist independently of us (the brute facts), only *we* have access to them in a mediated way (the scientific facts). For example, if a star explodes somewhere in the Universe and we are aware of it, clearly *something happens* independently of us (the brute fact); nevertheless we have (cognitive) access to it only through our measuring instruments (and ultimately our sensory data provided by, e.g. our eyes), observational set-ups and theories (this is the scientific fact). In general, ‘fact’ used without further specifications means brute fact, that which happens independently of us and from which we try to give an account.

2.3. Related notions

2.3.1. Fact vs. value

A fact is classically to be distinguished from a value. Although some authors put into question this distinction (a subject lying outside the scope of this article), this distinction nevertheless remains necessary both in science and in everyday life (see 2.1). Classically, judgements (or statements) of fact can be right or wrong, according to whether they match what is observed in the world (e.g. ‘I am in Paris now’). On the other hand, judgements of value are normative judgments which stipulate a norm, a rule of conduct (e.g. ‘you should not steal’) or evaluative judgments which evaluate (i.e. blame or praise) someone or something in reference to a norm (e.g. ‘Donald Trump was not worthy of being President of the United States’).¹⁷ These two types of judgment belong to two fundamentally different realms, what there *is* (factual statement) and what *should be*

¹⁵We will see this in more detail below, with the concepts of theory-ladenness as well as underdetermination.

¹⁶To establish and describe the facts is not, of course, the sole aim of science – which also aims at their systematisation, causal explanation and prediction, among other things.

¹⁷Some authors equate judgments of value with evaluative judgments (which presuppose normative judgments), and consider normative judgements as a separate category.

(normative statement), respectively. If we maintain the classical distinction between fact and value, there is no way to derive the one from the other, either way (Hume [1739-40] 2009; Weber 1949; Bueter 2021):

- from *is* to *should*: what the world is like does not justify what the world should be (a thing being the case does not mean that it should be the case);
- from *should* to *is*: what the world should be is independent from what the world actually is (the world is not necessarily what we would like it to be).

Transposed to science, this distinction means that:

- science (which tells us what is) cannot ultimately tell us what should be (even if it can inform our reflection for doing so, for example in public policy making);
- we should not let our preferences illegitimately influence our scientific practice (even if values can have a legitimate influence in some cases).¹⁸

2.3.2. Neighbouring notions

Since a fact refers to that which happens in the world (either completely independently of us, in the brute sense; or as identified by our experimental and conceptual means, in the scientific sense), it has to do with the empirical, with that which is real (this is what we mean when we use the adjective ‘factual’). Thus any notion related to this idea more or less overlaps that of fact. We can mention very briefly some neighbouring notions:¹⁹

- Experience: our perception of the world through our sensations (hence the expressions ‘perceived’ or ‘sensory’ experience), or the practical knowledge gained by it.²⁰
- Observation: the acquisition of information through the senses and/or through scientific instruments.
- Data: any kind of information stored in whatever form; when we talk of empirical data, we mean data coming from experiments, and data refers to the recorded result (typically numerical values).
- Evidence: a complex notion (see Kelly 2016), much used in the philosophy of science, as well as in judiciary contexts; when we talk of evidence we have in mind the idea of proof, we refer to the fact that we will use this material to justify our belief. It usually means any kind of empirical data.

Although they should be *stricto sensu* distinguished, the notions of observation, data and evidence happen to be used more or less indistinctly, especially regarding (empirical)

¹⁸The question of values in science has given rise to a specialised literature which lies outside the scope of this article (for an overview, see Elliott and Steel 2017).

¹⁹Note that, as everything in the philosophy of science, these notions are debated and do not have consensual definitions.

²⁰ cannot go into the details of these notions here. In brief, sensation is the process of sensing our surroundings using the five senses while perception is the process of interpreting the acquired sensations. In philosophy, experience is often taken in the sense of a higher-level knowledge rather than just sensations or perceptions. For example, according to Aristotle experience comes from generalisation of repeated memorised perceptions.

data and (empirical) evidence. Since these terms relate to the core idea of empirical information, such confusions do not seem to be misleading.²¹ Similarly, the notion of (scientific) fact can, according to how it is used, designate any of these notions, by more or less abuse of language. For example, we can typically:

- talk of theory-ladenness²² of (scientific) facts (instead of theory-ladenness of observation);
- talk of underdetermination of theory by fact (instead of underdetermination by evidence or data);
- say that we rely on facts to make up our minds (instead of evidence or data).

Nevertheless, the notions of observation, data and evidence *stricto sensu* designate specific *aspects* of scientific facts, and of how they are used in scientific inquiry. Thus, it would be more correct to say that they *represent* (various aspects of) facts.

3. The concept of objectivity as faithfulness to facts

As we have seen, the most intuitive definition of objectivity is based on facts: as Reiss and Sprenger (2020) aptly put it, objectivity is conceived as ‘faithfulness to facts’ – by which we mean brute facts. What is objective in this sense is what is factual, i.e. that which exists independently of us, of our thinking or knowing it (Lecourt 2006, 819). It is a positive definition of objectivity, insisting on giving an account of the facts, as opposed to negative definitions insisting on avoiding the influence of particular perspectives, values, goals, biases and interests.

3.1. The *aperspectival view*

The conception of objectivity as faithfulness to (brute) facts presupposes that facts are ‘out there’ in the world, that they can be ascertained independently of any particular perspective. It is a very natural conception, the one which we all rely on in our everyday experience, as well as in science – which is ‘nothing more than a refinement of everyday thinking’ (Einstein 1936, 349; see also Hansson 2020, §1). In science, this conception presupposes that facts can be discovered, analysed and systematised independently of the perspective of the individual scientist. The following three conceptions all illustrate this idea (which has also been endorsed by several empiricist philosophers of the twentieth century, such as Rudolf Carnap, Carl Hempel, Karl Popper, or Hans Reichenbach), as indeed their names illustrate.

3.1.1. The ‘*point of view of no one in particular*’

Reflecting on the new theory of relativity, physicist Arthur Eddington (1921, 30–44) introduces this expression to designate an objectivity which would make abstraction of:

²¹By contrast, there is an abundant literature in epistemology and the philosophy of science which carefully distinguishes between all these different notions and studies their mutual relationships. For the present discussion, it is sufficient to take these notions as more or less interchangeable.

²²For this notion, as well as underdetermination, see section 3.2.

- the position of the observer: for example, we can think of a chair seen from all perspectives, and get a mental aperspectival picture of it. In everyday experience, this is achieved thanks to our two eyes which enable us to perceive relief. In physics, this is achieved thanks to the three-dimensional instantaneous Newtonian space. It is the point of view from nowhere in particular, from a super-observer who can see all locations at once (Fine 1998).
- the motion of the observer: according to Eddington, we could perhaps see this intuitively, combine it into one mental picture, if we had two eyes moving with different velocities with respect to each other. In physics, taking into account all possible motions of the observer is performed through integration of time with space, in the four-dimensional manifold of relativity theory.
- the magnitude (size) of the observer: for Eddington, we could perhaps intuitively see this if we had two eyes of different sizes. In physics, this is achieved through gauge transformations in Weyl's (1918) unified field theory, intended to unify electromagnetism with gravity.

This mathematised conception of objectivity is of course particularly suited to physics. Indeed, Eddington warns that it is valid only in physics, and that more points of view may be needed to reach an even fuller appreciation of objectivity.

3.1.2. *The 'view from nowhere'*

This expression, taken from the title of Thomas Nagel's (1986) book, has become famous in the philosophy of science. It corresponds to the intuitive conception of objectivity according to which what is objective (the objective qualities) is that which does not vary according to the perspective. Our everyday experience constantly presupposes, and motivates, such a distinction between qualities which vary with changes of perspective and qualities which remain constant through changes of perspective – the objective qualities – and can therefore be considered as intrinsic to the object. For example, although the apparent size of the house towards which I am walking changes, I assume that the intrinsic size of the house does not. If I close my eyes and do not see the house anymore, I assume it is still there nevertheless (Reiss and Sprenger 2020).

According to Nagel (1986, 14), objectivity is gradually reached in three steps:

1. we realise that our perceptions are caused by the action of things on us, through our bodies;
2. we realise that since the same things can also produce effects on other things and can exist without producing perceptions at all, 'their true nature must be detachable from their perceptual appearance and need not resemble it';
3. we then 'try to form a conception of that true nature independent of its appearance either to us or to other types of perceivers'.

Nagel's conception starts with, and is grounded in, our perceived, everyday experience (in contradistinction to Eddington's), but can also be extended to science. Indeed, Nagel's conception is not only 'centerless' (abstracted from our particular point of view), but also 'featureless' in the sense that it abstracts from any perceptions (not only ours, but any human perception), i.e. it abstracts the 'secondary qualities' of the world ('how it

looks, feels, smells, tastes or sounds’) and keeps only the ‘primary qualities’ (such as ‘shape, size, weight, and motion’) which are thought of ‘structurally’ (1986, 14).²³

3.1.3. The “absolute conception” of the world

A similar view is expressed by Bernard Williams’ ‘absolute conception’. It ‘represent[s] the world in a way to a maximum degree independent of our perspective and its peculiarities’, the world ‘as it is independent of our experience’, as opposed to ‘as it seems to us’ (1985, 138–139). As Williams remarks, such a conception of objectivity can meaningfully explain ‘a convergence characteristic of science, [...] a convergence on how things (anyway) are’. It can also ‘explain how it itself, and the various perspectival views of the world, are possible’ (1985, 139). Like Eddington, Williams also makes it clear that this conception applies only to scientific knowledge (as opposed to any type of knowledge, and, most importantly, to ethical thought).

3.1.4. Strengths and limits of the aperspectival view

The aperspectival view illustrated by the previous conceptions is linked to various degrees²⁴ with scientific realism, the view that science really describes the content of reality. It corresponds to our everyday worldview, and is often endorsed by scientists. It is natural to endorse this conception, inasmuch as it provides a unique and unified account of the world (against pluralism), and a basis for articulating different perspectives and arbitrating between conflicting viewpoints. The aperspectival view seems the most intuitive and efficient conception to explain the world, predict phenomena, manipulate and control them, and settle disagreements, as Reiss and Sprenger (2020, §2.1) remark.²⁵ For the layman as well as the working scientist, it is understandable not to put into question this simple, commonsensical picture, because it is indeed efficient, to a large extent justified, and, more prosaically, by lack of time or interest.

However, while acknowledging the main (realistic) claim of this aperspectival view – that science represents facts – it is also important to understand its limitations. More precisely, two well-known issues in the philosophy of science limit the claim that science provides an aperspectival picture of the world, an objectivity as faithfulness to (brute) facts: the theory-ladenness (or theory-dependence) of observation, and the underdetermination of theory by evidence. These issues show that the relationship between scientific

²³The terminology here is Nagel’s. In philosophy, since Descartes the notion of primary quality is often defined as a mode of the *res extensa*, that is: shape, position, motion, extension – but not weight. Descartes and his direct followers (the inventors of the distinction primary/secondary qualities) believed that the only properties that could be formalised or mathematised were the chrono-geometrical ones (according to Descartes), or a little more (for Newton: also: mass, force ...). Since nineteenth-century psychology and psychophysics, and thanks to contemporary neurophysiology and phenomenology, we know that the so-called ‘secondary qualities’ (like colour, taste, etc.) can also be studied with structural and mathematised methods.

²⁴While Nagel’s and Williams’ conceptions are compatible with a strong scientific realism, Eddington’s and Weyl’s conceptions illustrate a weaker conception, which, following Kant, can be called ‘empirical realism’ and is associated with ‘transcendental idealism’. Roughly speaking, that means that, while they do not put into doubt the existence of a mind-independent reality and (to a more or less great extent) mind-independent facts, they consider scientific theories as a cognitive way for the knowing subject to apprehend reality rather than as designating external, mind-independent aspects of this reality.

²⁵Conversely, their anti-realist objections seem far-fetched and implausible. According to them, the aperspectival view is ‘at best sufficient but not necessary’ to fulfil these goals. They propose for example to ‘settle disagreements by imposing the rule that the person with higher social rank or greater experience is always right’. One sees immediately that such strategies belong to unrealistic armchair philosophy. The last domain (manipulation and control of phenomena) even more requires a realistic approach.

theories, hypotheses or models²⁶ on the one hand, and empirical facts on the other, is not simple and unambiguous, but complex.

As Reiss and Sprenger (2020, §2.3) remark, the fact that this relationship is problematic should not surprise us, inasmuch as scientific theories contain highly abstract claims remote from sense experience: since they pretend to provide an aperspectival view of the world, and since sense data is always perspectival, they must describe a world different from sense experience. Such a view, however, presupposes that facts themselves are ascertainable by sense experience, but we have started to see above (with the notion of scientific fact) that this is generally not the case. The experimental facts used in science are not ascertainable directly through sensations: rather, they are often unobservable to the unaided senses, and/or established through complicated procedures of measurement and experimentation, which require knowledge of the underpinning theories.

3.2. Theory and facts

It is generally granted that scientific knowledge grows by gradually approaching the truth, by becoming more objective, more faithful to facts. Indeed, no scientific theory is definitive: scientific theories change, are replaced by better ones, in order to provide the best account of facts. Empirical scientific knowledge is never definitively ‘proven’ as is purely logico-mathematical knowledge, it is only more or less confirmed or corroborated and thus always in principle liable to revision (although in practice, we consider the vast majority of it as beyond reasonable doubt, in order to focus our inquiry on the small, uncertain part of it which we intend to investigate).

This conception of scientific progress and change presupposes the concept of scientific objectivity as faithfulness to facts. Between competing theories, we select the one which best represents facts. To do so, we test theories by comparing their implications with observations, and we verify which one is correct. This verificationist view was very popular in the first half of the twentieth century (with the philosophical movement known as logical empiricism). In this conception, observations (which would allegedly be stated in a neutral, theory-independent language, as logical empiricists hoped) should enable us to verify which theory is correct, and to decide between competing theories.

3.2.1. Theory-ladenness of observations

However, against this conception, many authors have shown the reciprocal interactions between observations and theory: observations do not only influence theory (in the sense that they enable to choose which one is correct), but theory also influences observations (in the sense of making observations possible in the first place). The most famous proponents of this conception are Hanson (1958) and especially Kuhn (1962). In his seminal *Structure of scientific revolutions*, Kuhn argues that scientists’ daily work of ‘puzzle solving’ (or ‘normal science’, in contradistinction to what he calls ‘scientific revolutions’, where paradigms are replaced) takes place within ‘paradigms’ (from the Greek

²⁶In the following, I will only talk of theories, in a very general sense including hypotheses and models (namely, as a statement or system of statements intended to explain and predict facts).

parádigma meaning example, model). A paradigm is a specific (scientific) conception of the world which comprises theoretical and methodological presuppositions, but also experimental techniques, relevant problems to be solved, etc. It also has a sociological role: the adhesion to a paradigm constitutes a given scientific community. Kuhn's original concept of paradigm was criticised for its numerous meanings. Kuhn subsequently focused its meaning in the restricted sense as a (set of) problem(s), together with its (their) solution(s), which serves as an 'exemplar' or model of problem solving,²⁷ in analogy with which further research must be pursued.²⁸

Such paradigms are not easily invalidated by observations because the latter are theory-laden: according to Kuhn, any observation is already laden with theoretical assumptions part of the ruling paradigm, which a scientist has in mind when studying reality. This means that:

1. The meaning of observational concepts is already influenced by theoretical assumptions. For example, the concepts of mass or length have different meanings in Newtonian or relativistic mechanics. In other words, there is no neutral, theory-independent observation language (as logical empiricism thought). Thus observational reports cannot serve as impartial, purely factual arbiters between different theories to decide which one is faithful to reality.
2. What is more, according to Kuhn, the very perception of a scientist also depends on the paradigm she is working in: our own sense data are structured by a theoretical framework. For example, Tycho Brahe, who lives in a world structured by the geocentric paradigm, sees the Sun rise, whereas Kepler, who lives in a world transformed by the Copernican revolution, sees the Earth rotate around an immobile Sun.²⁹ This makes even more remote the possibility of assessing which theory or paradigm is more faithful to facts, more objective.

Ultimately, Kuhn (and Feyerabend) go as far as to claim the 'incommensurability' of (literally, the absence of common measure between) different paradigms, and in particular, scientific theories. This is due to that fact that one cannot judge a paradigm from an absolute vantage point: all one can do is leave one paradigm to embrace another. Since we necessarily experience reality through 'paradigms', there is no direct, absolute knowledge of it. All we can do is take off the 'glasses' of one paradigm for the ones of another paradigm, we cannot look directly at reality. This very strong, relativistic claim is criticisable, of course. Taken literally,³⁰ it would mean that we are not able to compare different

²⁷Kuhn mentions as paradigms Aristotle's analysis of motion, Ptolemy's computations of planetary positions, Lavoisier's application of the chemical balance, or Maxwell's mathematization of the electromagnetic field. Such paradigms are typically to be found in classical articles or books, such as Aristotle's *Physica*, Ptolemy's *Almagest*, Lavoisier's *Traité élémentaire de chimie*, or Newton's *Principia Mathematica*. Such texts contain not only new theories and laws, but also their applications to the solutions of exemplary problems, together with the required mathematical and/or experimental techniques for doing so.

²⁸For Kuhn, 'normal' science (which is a product of the community, not the individual researcher) is learned, and then practised, through problem solving, in analogy with the ruling paradigmatic problem, which is accepted dogmatically by the community. This enables scientists to focus their efforts on elaborating the details of the research avenues in line with the paradigm (which is more general), instead of questioning it.

²⁹Of course, we must object that Kepler sees the Sun rise just as Tycho Brahe does, but that he can *think* that this movement is only apparent, and that in fact, the Earth rotates around the Sun. The former action is immediate perception, the latter is an intellectual reflection (which requires some intellectual effort).

³⁰Kuhn and Feyerabend later on took care to clarify and moderate this claim (Oberheim and Hoyningen-Huene 2018).

scientific theories (for example, to take Kuhn's typical example, Newtonian and relativistic dynamics) and that we cannot identify any progress between them – which in fact we can, as scientific practice constantly illustrates.

Kuhn's work illustrates the fact that there are two types of theory-ladenness which must be carefully distinguished:

- the theory-ladenness of experimental facts or observations (which is uncontroversial);
- and the theory-ladenness of perception (a controversial and more radical thesis).

Since the seminal work of Duhem ([1906] 1981), the theory-ladenness of experimental facts or observations has become commonplace. Duhem identifies two stages in a physics experiment: pure passive observation of the phenomena, which can be performed by the layman even if he does not understand the experiment; and their interpretation, which requires knowledge of the underlying physical theories, and which is required in order to understand the experiment. Thus,

A physical experiment is the precise observation of a group of phenomena, accompanied by the INTERPRETATION of these phenomena; this interpretation substitutes the concrete data really gathered by observation with abstract and symbolic representations which correspond to them in accordance with the theories admitted by the observer. (Duhem [1906] 1981, 221, my translation)

Note that the theory-ladenness of experimental facts or observations should not be seen as a threat to scientific realism, as various authors have shown (see e.g. Popper [1934/1959] 2005; Shapere 1982; Hacking 1983). The theory-ladenness of experimental procedures is not a problem for theory testing, since the theoretical assumptions underlying experimental procedures are some of the best verified theories that science has produced. As Whewell ([1840] 1847, 46) writes, 'Theories become Facts, by becoming certain and familiar: and thus, as our knowledge becomes more sure and more extensive, we are constantly transferring to the class of facts, opinions which were at first regarded as theories.' In general, theory-ladenness is not a problem as long as the theory doing the testing (presupposed by experimental facts/observations) is independent from the theory being tested (present in the theoretical claim under scrutiny). For example, Hacking (1983, 209) has convincingly shown that the way we control and create microscopic phenomena, how we use instruments based on entirely different physical principles to observe the same structures, our good understanding of the physics underlying our building of the microscope, the converging observations from other disciplines, all lead us to believe in the reality of the microscopic phenomena observed.

While the thesis of the theory-ladenness of perception is more controversial and has been criticised from different viewpoints, it is not considered to be a problem for theory testing neither. Hacking recalls that many important observations in the history of science were not theory-laden. In modern science, we seldom observe with the unaided senses – but rather with instruments. Today science does not rely anymore (or only marginally) on perceptual experience, as the empiricist tradition claimed, but rather on evidence and data (see e.g. Shapere's (1982) account of a particle physics experiment). The efficacy of a laboratory for acquiring data does not depend on observant experimenters (as in nineteenth-century science), but rather on its powerful technical

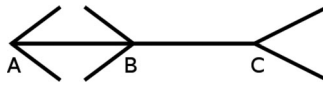


Figure 1 Müller-Lyer illusion.

and information technology means, which enable a proper treatment of data (far from a purely passive interaction with nature, see Barberousse, Kistler, and Ludwig 2000). Other arguments, coming from cognitive science, cast doubt upon Kuhn's and Hanson's thesis of theory-ladenness of perception. According to Fodor (1983), the mechanisms responsible for our perceptions (whether visual, auditive, tactile or kinaesthetic) are modular, i.e. they are influenced neither by background assumptions of the subject, nor by any information not coming from the sensory modularity in question. The Müller-Lyer illusion (see Figure 1) is a famous example of the fact that our background knowledge does not influence our perception: although we know the two lines have the same length ($AB = BC$), we still perceive the illusion that they do not. Although the empirical debate about the modularity of human vision is still open, many results in various disciplines tend to show the functional specialisation of human vision (Barberousse, Kistler, and Ludwig 2000).

3.2.2. Underdetermination of theory by evidence

There is a second issue jeopardising the idea that our theories faithfully represent facts. Evidence never completely determines theory. Neither positive results (when the theory's predictions are verified) nor negative results (when they are not) allow unambiguous inferences about (the verification or the falsification of) the theory (Reiss and Sprenger 2020; Stanford 2021):

- A *positive* result can obtain even if the theory is false, due to some alternative theory that makes the same predictions³¹: this is 'contrastive underdetermination' (also known as the underdetermination of theory by data). For any given body of evidence *confirming* a theory, there might be other theories which are also well confirmed by that same evidence. Schematically, we start from evidence and infer a theory from there.
- A *negative* result might be due not to the falsehood of the theory but to the falsehood of auxiliary assumptions³²: this is 'holist underdetermination' (also known as the Duhem, or in its radical version Duhem-Quine, thesis). Our inability to test hypotheses in isolation leaves our revision of the theory underdetermined in response to *disconfirming* evidence. Here, we start from a theory and confront it to new evidence.

Holist underdetermination illustrates the claim that hypotheses or theories can only be tested in groups, never in isolation – a position called holism, from the Greek *hólos*

³¹In other words, two different (even contradictory, to some extent) theories can account for the same facts: they can be logically incompatible but empirically equivalent.

³²Note that while contrastive underdetermination can be seen as a theoretical, rarely encountered problem for scientists (mostly encountered in highly sophisticated mathematised physics), holist underdetermination is a common methodological problem which they can encounter in their daily practice.

(all, whole, entire). According to Duhem (1981), this is because we can derive empirical consequences from a hypothesis or theory only if it is conjoined with many other hypotheses or beliefs (about the world, how measuring instruments operate, interactions between objects in the original field of study and the wider environment, etc.). For this reason, when an experiment fails, we do not know whether the fault comes from the hypothesis to be tested or from an auxiliary hypothesis or belief. For example, if we want to test Newton's laws of motion for the planets of our solar system by comparing them to observations, we need to assume the number of planets, their masses (and the Sun's), some conditions of observation related to the Earth's atmosphere and the working of our telescope, etc. Any of these assumptions may be false. This is why, according to Duhem, there is no 'crucial experiment' enabling to decide between two competing hypotheses or theories in physics (instead, Duhem recommends to use one's 'good sense' for establishing, on the basis of empirical results, the truth or falsity of a theory or hypothesis).

Duhem's holism has been extended by Quine (1951): not only can no isolated hypothesis be tested experimentally in science (here Quine takes inspiration from Duhem), but any statement (even the laws of logic) can be revised. According to Quine, all of our theories in the mathematical, natural, social and human sciences form a 'corporate body' which is confronted to experience as a whole, and

which impinges on experience only along the edges. Or, to change the figure, total science is like a field of force whose boundary conditions are experience. A conflict with experience at the periphery occasions readjustments in the interior of the field. [...] But the total field is so underdetermined by its boundary conditions, experience, that there is much latitude of choice as to what statements to reevaluate in the light of any single contrary experience. (Quine 1951, 42–43)

Without going into the details of the Duhem and Duhem-Quine (holist) underdetermination theses, it is clear that the latter, amplified version is not only very abstract but also very radical – something Quine himself later regretted, who instead promoted a 'maxim of minimal mutilation' of our system of knowledge, particularly excluding revision of mathematical knowledge, which would reorganise the system of knowledge much too drastically (see Zammito 2004, 23). We usually know what to do because we try to preserve some epistemic virtues such as simplicity, scope, in addition to conformity with experience, and we try to minimise the number and importance of beliefs we need to abandon and we are reluctant to sacrifice central, core beliefs.

In fact, the radical anti-realist implications of holist underdetermination are countered essentially for the same reasons than for theory-ladenness: the testing theory (the one relied upon in our instruments and/or auxiliary hypotheses) is different than the theory being tested, and the former is generally well established. Furthermore, there is a reciprocal interaction and support between them (Hacking 1992). Thus, while history of science does provide some examples of auxiliary hypotheses modified in order to salvage a theory, 'it simply cannot be presumed that there will always be some logically possible formal accommodation of an anomaly which preserves evidential equivalence between competing explanatory theories' (Greenwood 1990, 568).

Regarding contrastive underdetermination (or underdetermination of theory by data), Quine alternates between two versions, a weak one and a strong one (see Zammito 2004,

25-33). The weak version (of empirically equivalent and logically incompatible theories) holds that for a given theory compatible with a given body of evidence, one can always conceive of another theory also compatible with that body of evidence but logically incompatible with the former theory. This weak version is unproblematic in a sense illustrating the fallibilism of empirical science, of scientific theories in the making. But the strong version (of global underdetermination of theory by data) extends the previous version to *all* possible evidence. The strong version is therefore illegitimate since it postulates *a priori* an end to scientific inquiry which is by definition open-ended (Murphey 1992), and since it equates logical and semantic possibility with epistemological possibility, and neglects actual scientific practice, where the superiority of a theory over its rivals can be established (Laudan 1990; Laudan and Leplin 1991). The stakes are high since the underdetermination thesis has been used (often in its weak version then unduly used to support consequences from the strong version) by many post-positivist philosophers in support of a relativistic stance where every theory is as well supported by evidence as any of its rivals (Zammito 2004, 30-33). In the end, it is an empirical – not *a priori* – matter whether underdetermination of theories occurs.

To sum up, contrastive and holist underdetermination show that there is a kind of gap between evidence and the theory supposedly supported by it.³³ However, this gap can be bridged thanks to values, which supplement evidence. Indeed, theory appraisal is a complex form of value judgment – be it cognitive values such as internal coherence of a theory or external coherence with other theories, simplicity, fruitfulness, etc. (e.g. Kuhn 1977; McMullin 1982), or non-cognitive values such as social or political values (especially for sciences which are policy-relevant, such as medical or climatic science). Thus, the ideal of scientific objectivity as *aperspectival*, as pure faithfulness to facts, is untenable: scientific theories are a joint product of factual and non-factual elements – the scientists' value judgements. This does not mean that facts are not important in theory choice, or that value judgments have more importance than facts, but it does mean that value judgments are inescapable to some extent. This, in turn, does not necessarily represent a threat for the objectivity of science (e.g. Hansson 2017a, for a rigorous model of incorporating non-cognitive values in science while preserving its integrity). In particular, it should not be taken as a proof – as various social interests-driven theorists of science (in the sociology of scientific knowledge, feminist critics of science, social studies of science, etc.) claim³⁴ – that extra-scientific, social considerations (always more or less related to power: career interests, political values, gender biases, etc.) ultimately explain theory/hypothesis choice (see Stanford 2021, §2.2)

4. Conclusion: the importance of facts and fact-based objectivity

Let us summarise what has been said previously by defining the concepts of fact and fact-based objectivity:

³³This gap is larger than the so-called problem of induction (which can be seen as a special case of it, see ChoGlueck 2018), which refers to the (logical) gap between a limited series of occurrences (observations) and the generalisation of them (in the form of laws or principles), which virtually concerns an infinity of occurrences.

³⁴Such claims often make use of holist underdetermination (which requires that something else than empirical evidence makes the job of singling out which claim is kept or abandoned in the presence of conflicting evidence), and are usually based on case studies of particular episodes of the history of science, which can hardly be generalised.

1. A (brute) fact is an event which happens in reality, independently of anyone thinking it. Nevertheless, the 'brute' fact becomes a 'scientific' fact once we take cognisance of it – or produce it – through the means made available to us by science. A scientific fact generally presupposes complex observational/instrumental/experimental/theoretical/etc. assumptions in order to be ascertained (as opposed to a fact from everyday life, which can generally be ascertained through direct sense data). This is not contradictory with the fact that the brute fact still happens independently of us – only our cognisance of it is mediated by this experimental and conceptual apparatus.
2. Because of the complex, reciprocal relationship between scientific theory (or hypothesis) and scientific facts, the concept of objectivity as faithfulness to facts does not hold in the strict sense, i.e. of an aperspectival faithfulness to brute facts. Nevertheless, we can maintain the definition of objectivity as faithfulness to facts in the large sense, as long as we keep in mind the complexity of this relationship, i.e. as long as we understand the complexity of the notion of (scientific) fact itself (as theory-laden), and the role of non-factual elements in theory choice (as underdetermined by facts).³⁵

In spite of these limitations, it is important to recall the importance of separating our factual beliefs from our other, non-factual, beliefs (including our reactions to these factual beliefs), and to reaffirm that science remains our best manner to do so. Notwithstanding the sophisticated philosophical debate about scientific realism (see Chakravartty 2017),³⁶ it is obvious that science captures some facts about reality, and that it does so better and better. Such debate may be justified in the philosophical context, but in everyday life as well as in science one cannot do without factual beliefs which have been (at least provisionally) 'fixed' (Hansson 2018), and which refer to brute facts which happen (ed) independently of us (for example, the fact that such animal species has disappeared or not, that such battle took place at such date, that this drug is efficient, etc.). We have to 'fix our belief' on most things in order to study the remaining ones.

Finally, the question of the consequences of such philosophical issues on the trust the general public puts in science also arises. The philosophical debate on facts and objectivity surely is more difficult to understand for the layman than for scientists or philosophers of science, and may have a detrimental effect on public trust in science. This concern about potential public misunderstanding and backfire effects is all the more true in our current 'post-truth' or 'post-facts' predicament, where people choose to believe facts according to whether they fit their personal or political preferences, and where emotions take precedence over truth and objectivity. There is a true danger that focusing only on the limits of scientific inquiry (in order to prevent uncritical scientism), on issues such as the theory-ladenness of observations or the underdetermination of

³⁵A simple way to summarise the complex relationship between (scientific) facts and theory can be to talk of *overdetermination of facts by theory and underdetermination of theory by facts* – provided we can recall the precise meaning of these somewhat abusive expressions. In the first case we are interested in establishing the facts – and to do so we necessarily have recourse to our currently admitted theories, in order to interpret raw empirical data. In the second case (itself divided into two subcases) we are interested in establishing the (correct) theory – and to do so we have recourse to the available facts (which can either confirm or disconfirm our theory), in order to infer a theory from them.

³⁶Let us mention, for example, the 'no-miracle argument', according to which it would be a miracle if scientific theories weren't at least approximately true representations of the world, given the great empirical success of science; or the 'pessimistic meta-induction', according to which the history of science shows that theories taken to be true at one time are later considered false, and become replaced by new theories. Both arguments are defended and attacked in the philosophical literature.

theory by evidence, may lead to ‘science pessimism’, epistemic relativism and mistrust of science (Bussmann and Kötter 2018, 89). By so doing, one forgets the accomplishments of the scientific enterprise, and the limits and dangers of relativism are, conversely, ignored.

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