Accepted by the European Journal for Philosophy of Science.
Preprint (not copyedited or formatted).

From Phenomenological-Hermeneutical Approaches to Realist Perspectivism

Mahdi Khalili[*†]

Abstract: This paper draws on the phenomenological-hermeneutical approaches to philosophy of science to develop realist perspectivism, an integration of experimental realism and perspectivism. Specifically, the paper employs the distinction between "manifestation" and "phenomenon" and it advances the view that the evidence of a real entity is "explorable" in order to argue that instrumentally-mediated robust evidence indicates real entities. Furthermore, it underpins the phenomenological notion of the horizonal nature of scientific observation with perspectivism, so accounting for scientific pluralism even in the cases of inconsistent models. Overall, realist perspectivism is proposed as the way to go for (phenomenologically-hermeneutically minded) philosophers of science.

Keywords: Scientific Realism; Perspectivism; Robust Evidence; Scientific Instruments; Phenomenological-Hermeneutical Approaches

---

[*] Postdoctoral Fellow at the School of Philosophy of the Institute for Research in Fundamental Sciences, Tehran, Iran (mahdi7khalili@gmail.com; mahdi.khalili@ipm.ir)

[†] I am grateful for extensive and constructive feedback on this work from Hans Radder, Lieven Decock, and two reviewers for this journal. I would also like to acknowledge useful comments from Javad Akbari, Alireza Kazemi, and Ave Mets.

1 Introduction

During the last decades of the twentieth century, philosophers such as Theodore Kisiel (1970), Gary Gutting (1978), Patrick Heelan (1983; 1986; 1997), Joseph Rouse (1987), Don Ihde (1991), Robert Crease (1993), and Joseph Kockelmans (1993) have discussed scientific practice from phenomenological and hermeneutical viewpoints. In their analysis of science, they address ideas both from analytical history and philosophy of science and from works of Edmund Husserl, Martin Heidegger, Maurice Merleau-Ponty, Hans-Georg Gadamer, among others. I call these kinds of reflection on science the phenomenological-hermeneutical approaches to philosophy of science.

In recent years, philosophers such as Shannon Vallor (2009), Don Ihde (2011; 2016), Harald Wiltsche (2012; 2017a; 2017b), Philipp Berghofer (2018a; 2020a; see also Berghofer et al. 2020), and others (see Wiltsche and Berghofer 2020, chapter 1) have advanced these phenomenological-hermeneutical approaches. In this paper, I would like to contribute to the debate among these philosophers. The focus is on disagreements between Vallor, Ihde, and Wiltsche. Due to the reliance of Ihde and Vallor on Heelan's account of instrumentation, Heelan's view is critically discussed as well. I also make use of ideas from Kockelmans to support my arguments. The scope of the paper is confined to the scientific realism debate, in particular to the role of instrumentally-mediated empirical evidence.

I argue both *against* the antirealist claim that theoretical entities – such as protons and ions, which cannot be perceived by the unaided senses of humans – cannot be considered to be real, and *against* the realist claim that these entities become directly perceivable by using scientific instruments. Instead, I support the realist view that mediated access to theoretical entities is possible by means of evidence provided by technological instruments and interpreted by

theoretical concepts. I then complement this realist view with perspectivism. Several phenomenological-hermeneutical ideas lead to my realist yet perspectivist view.

There is not much work on the relationship between phenomenology-hermeneutics and perspectivism. Berghofer's 2020a paper is an exception. He demonstrates the close affinities between perspectivism and phenomenology. For instance, he explains that Husserl's accounts of horizonal intentionality and the lifeworld fit well with perspectivism. He also discusses the relationship of perspectivism with Merleau-Ponty's claim that the first-person perspective should be incorporated into science and with his ontological claim that reality is (partially) dependent on observers. Furthermore, he draws a parallel between Merleau-Ponty's interpretation of quantum mechanics and a QBist ontology, in which an objectivist representation of quantum states is denied. According to Berghofer, Merleau-Ponty's "partial realism" perfectly agrees with the "participatory realism" of Christopher Fuchs, the main proponent of QBism, and these two realist views are in agreement with perspectivism. The present paper is fairly sympathetic to these claims, but it has a different aim and therefore it focuses on different topics. The aim is to develop a realist perspectivism that helps to resolve disagreements between phenomenologically-hermeneutically minded philosophers of science. To fulfil this aim, the paper includes new discussions of the phenomenological-hermeneutical approaches that are not addressed by Berghofer. In particular, it critically discusses Heelan's claim on knowledge of theoretical entities, Vallor's view that empirical evidence is explorable, and Kockelmans's distinction between "manifestation" and "phenomenon" and his Heideggerian conception of truth. These new topics help me both to display novel affinities between perspectivism and phenomenological-hermeneutical approaches and to develop my realist perspectivism.

An argumentative surplus of this paper consists in the novel affinities that it shows between the phenomenological-hermeneutical approaches and realist perspectivism. Those approaches support realist perspectivism; conversely, realist perspectivism enables me to elaborate on several phenomenological-hermeneutical ideas. The other surplus of this paper concerns the explanation of the way realist perspectivism can settle certain disagreements among the advocates of the phenomenological-hermeneutical approaches to philosophy of science.

Realist perspectivism constitutes the main thesis of the paper. Two concepts are of central importance in this view. 1- Perspectivity: scientific knowledge is *perspectival* inasmuch as it is conditional on instruments and theories/models. According to perspectivism, non-perspectival knowledge of reality, or a view from "nowhere", is unattainable. 2- Explorability: the empirical evidence of a real entity is "explorable". Inasmuch as the evidence for claims about a theoretical entity is explorable through independent perspectives, we may have reason to support realism about that entity. As section 6 will further clarify, realist perspectivism draws on major themes from (phenomenological-hermeneutical approaches to) experimental realism and perspectivism. The paper's thesis is novel in that a similar combination of experimental realism with perspectivism can be found neither in the phenomenological-hermeneutical approaches to philosophy of science nor in the mainstream literature on scientific realism.

The thread that leads the reader through the discussion in this paper is as follows. Sections 2 and 3 critically review the relevant literature regarding scientific realism. Section 2 discusses the debate between Ihde and Wiltsche about Husserl's view of the lifeworld. Section 3 explains the phenomenological defense of realism. Vallor argues for the explorability of empirical evidence. Ihde and Heelan argue that instrumentally-mediated observations are perceptions of theoretical entities. My more direct contribution to the debate starts in section 4, which questions the realist

claim that theoretical entities are perceivable by means of instruments. After that, I argue in section 5, with the help of the concept of "exploration" and the distinction between "manifestation" and "phenomenon", that scientific observation differs from "public hallucination". Although a theoretical entity may not be perceivable, it may be real inasmuch as *its evidence* is successfully explorable through several instrumentally-mediated processes. Explorability is necessary for a realist claim. This supports realism but, as section 6 argues, based on phenomenological-hermeneutical ideas this realism should at the same time be perspectivist. The result is a realist perspectivism that acknowledges the role of theoretical concepts and inferences in science (as the hermeneutical character of science), agrees with Vallor's analysis that scientific observation is horizonal, confirms Heelan's and Ihde's emphasis on the key role of instruments in science, denies "scientific objectivism" (which Husserl and Wiltsche attack), and is consistent with Kockelmans's Heideggerian conception of truth. In concluding the paper, I reevaluate the criticism of Ihde against Husserl and account for scientific pluralism even in the cases of inconsistent models.

2 Debate about the Lifeworld

In *The Crisis of European Sciences and Transcendental Phenomenology*, Husserl challenges an objectivist understanding of science. According to him, the main problem of this understanding is that it forgets that the origin of the scientific worldview is in the "lifeworld" – the world of our everyday views and experiences. The false assumption of the objectivist view is that the truly

objective image of reality is the one provided by science alone.[1] Husserl considers Galileo as the founding father of this view. Galileo, as Husserl claims, developed the metaphysical view that quantitative, measurable objects form the fabric of reality, so the only approach to truly understand the world is that of the mathematical sciences.

Husserl himself believes that what he calls the basic "fundament" of knowledge is formed by subjectively given experiences, on the basis of which "the mathematically substructed world of idealities" of scientific models is formed. The "only real world", as stated by Husserl, is "the one that is actually given through perception, that is ever experienced and experiencable—our everyday life-world" (Husserl 1970, pp. 48–49). Science without pre-given perceptions is impossible. Science is constructed by idealization and mathematization of the complex perceptual experiences of the lifeworld. The main problem of the Galilean metaphysics, Husserl believes, is that if it is true, science loses its foundation. Following Wiltsche (2012; 2017a) I call this the problem of scientific objectivism.

It is necessary to see that "scientific objectivism" is not the position that scientific objects exist human-independently. In the context of the current paper, scientific objectivism should be understood as the position that (only) science can deliver a purely objective view on the world. The view that the current scientific image is close to the ideal truth is a form of this objectivism. Against this, critics of scientific objectivism argue that scientific knowledge is bounded by specific conditions (or perspectives) and is not ultimate. Scientific objectivism is not a strawman because

[1] Wilfrid Sellars echoes the objectivist view when he says that "science is the measure of all things, of what is that it is, and of what is not that it is not" (1963, p. 173).

all those philosophers, scientists, science journalists and ordinary people who maintain that scientific knowledge is "approximately true", in the sense that it nearly corresponds to the world in itself, presuppose this kind of scientific objectivism.

Let us now review Ihde's view of science. He (2011; 2016, chapter 2) argues that Husserl gets both Galileo and science wrong because, according to Ihde, Husserl neglects the role of instruments in science in general, and in Galileo's work with the telescope in particular. Husserl, Ihde believes, focuses exclusively on the mathematical side of Galileo's work, while Galileo was also a "lens grinder", "the user of telescopes", "the fiddler with inclined planes", and "the dropper of weights from the Pisa Tower" (Ihde 2011, p. 78). This aspect of Galileo's practice makes a huge difference for Ihde, since "Galileo with a telescope is considerably more than a calculator or mathematician, Galileo with a telescope is also a perceiver and a practitioner within a now technologically mediated, enhanced world" (Ihde 2011, p. 80). Ihde claims that if we consider Galileo's work in practice (rather than only his words), we understand that he "never leaves the lifeworld", but "makes dimensions of the newly enhanced lifeworld open to perceptual-bodily experience" (Ihde 2011, p. 80). The reason is that the lifeworld is not limited to what is observed by bodily perception, but it also includes what is perceived by technological instruments. Instruments, according to Ihde, enrich human perception; Galileo's telescope, for instance, made previously invisible objects such as mountains on the moon intersubjectively visible. Instruments extend the bodily-sensory capacities of human beings (Ihde 1991, p. 75; 1979, pp. 35–39), and therefore they extend their perceptual (life)world. All in all, Ihde contends that as a result of this instrumental embodiment of science, "science remains thoroughly immersed in the lifeworld" (2011, p. 69; see also Ihde 1991, pp. 102–103).

In his account, Wiltsche accepts that, from a historical point of view, Husserl's discussion of Galileo does not include the "hands-on" character of Galileo's work. He also concedes that the practical aspects of scientific activity "are largely absent in the *Crisis*" (2017a, p. 157). However, he complains about the one-sidedness of Ihde, who only focuses on Galileo's work in astronomy and neglects such areas of science as mechanics and kinematics, in which *idealization* and *model building* play seminal roles. According to Wiltsche, if one scrutinizes the work of Galileo on straight, accelerated and projectile motion, one can recognize Galileo's technique of idealization, by which he "impose[s] a geometrical grid" on "the complexity and messiness of the Lifeworld" in order to exclude what he assumes as irrelevant factors and to reduce the complex lifeworld we initially perceive to what the model represents. Accordingly, Galileo built his mechanics through idealization of what was perceivable by unaided senses. The objects of Galileo's mechanics are, for instance, a frictionless plane or a point mass that moves along a perfect projectile trajectory. These are the idealized forms of the observable states of affairs. Thus, Wiltsche argues that, because of this idealization, Galileo's mechanics is applicable only to objects of his ideal model rather than to the complex reality.

According to Wiltsche, considering the role of instrumentation in science does not preclude an analysis of Galileo's idealizations (2017a, p. 165). What is observed through instruments is not simply used in scientific models. It is their idealized results that are used in models. For instance, Galileo did not simply deduce from his experimental results that the phenomenon of fall is independent of features of bodies other than their masses and distances, but he employed interpolation and extrapolation techniques "in order to advance an *ideal limiting case*" (2017a, p. 169). Wiltsche concludes that studies of experiments and instruments or other practical aspects of scientific activity cannot ignore the role of idealization in constructing scientific models. This

idealization is, according to him, the main factor that distinguishes the objectively understood scientific worldview from that of the human lifeworld.

Among philosophers of science, Nancy Cartwright (1983) argues that reality is messy and complex, and no idealized concept can perfectly describe a real thing. Also, natural laws are only true in controlled experimental situations and by considering some sorts of approximation. Yet, from the fact that science uses idealizations it does not follow that scientific knowledge is conceptually imprecise. The more tenable idea is that the complexity of the world in the face of our limited computational abilities is the reason why we need idealizations. But in contemporary physics, several appropriate corrections are routinely made to eliminate simplifying physical assumptions and idealizations. For instance, in the measurement of light speeds in a perfect vacuum, corrections for the fact that, in experimental reality, the vacuum is not completely perfect are routinely made (see Khalili 2021, subsection 3.1). Accordingly, it is fairly controversial to argue for the imprecision of scientific knowledge, and then for antirealism, merely on the basis of idealizations.[2]

Still, Wiltsche claims that "only" the antirealist "line of argument prevents the problem of [scientific] objectivism" (2017a, p. 172). To avoid misunderstanding, in this paper my point is not to assess Wiltsche's interpretation of Husserl's view of science, but to argue against his defense of antirealism. This defense is based on a reading of Husserl's principle of principles [PP], according to which

[2] Michael Weisberg (2007) discusses three kinds of idealization and concludes that they are compatible with a sophisticated definition of realism.

> every originary presentive intuition is a legitimizing source of cognition, that everything originarily (so to speak, in its 'personal' actuality) offered to us in 'intuition' is to be accepted simply as what it is presented as being, but also only within the limits in which it is presented there. (Husserl 1983, p. 44)

An item X is intuitively presented when the "intention towards X is fulfilled by the direct, immediate presence of X" (Wiltsche 2012, p. 108). With the term "originary" Husserl emphasizes that the presentive intuition of X is given directly to me, so it is different from a recollection of X or an imagination of X, in both of which I intend X indirectly (see Zahavi 2003, p. 95).

Wiltsche tries to clarify PP by referring to Husserl's definition of a physical object as "the possible object of a *straightforward* percept" that is "capable of being perceived" (in Wiltsche 2012, p. 110; and 2017b, p. 818). But might this "possibility" or "capability" not be a merely logical possibility that is applicable to any object of imagined worlds? Wiltsche does not think so. He believes that Husserl's concept of a "motivated possibility" can be an indicator of the possibility of a straightforward percept. An "assertion about an object" enjoys motivated possibility if "the object *could* become present in appropriate intentional acts" (Wiltsche 2017b, p. 821, emphasis added). Indeed, Wiltsche tries to understand PP in the sense of Bas Van Fraassen's (1980, p. 16) principle of observability. That is, if there is a possible circumstance in which an object is at least *potentially* observable for an actual person, i.e., a "bodily situated subject" (Wiltsche 2017b, p. 818) rather than "an empty logical possibility" (Wiltsche 2012, p. 111), that object is observ*able*. For instance, there is no possible circumstance in which we as actual observers can see ions, and so they are unobservable. One may object that ionized particles can be observed with the aid of cloud chambers. Again following Van Fraassen (1980, p.17), Wiltsche responds that what is observable in this case are the silver-grey lines, whereas scientists *infer* that

ions—as theoretical entities—are responsible for these lines. Thus, ions themselves are not observable; rather, their supposed effects are. Unlike Ihde, Wiltsche asserts that scientific instruments should not be considered as the extensions of our body, but they are the "engines that produce new observables for us to apprehend" phenomena through model building and theorizing (Wiltsche 2012, p. 117; 2017b, p. 823; cf. Van Fraassen 2001, p. 154; 2008, chapter 4). I agree with Wiltsche and Van Fraassen that microscopic entities are not perceivable/observable, and therefore our knowledge of them is inferential. Furthermore, sections 4 and 5 argue that even if such entities are not perceivable, the empirical evidence obtained by instruments possesses perceptual characteristics, which makes it possible to acquire inferential knowledge of theoretical entities. In addition, section 6 argues that this view results in a realist yet perspectivist view. But first I will further evaluate Wiltsche's view and critically review the realist motivations of philosophers such as Vallor, Ihde, and Heelan.

3 Motivations for Defending Realism

3.1 Inferential reasoning for theoretical entities

Wiltsche restricts his realist view to those objects whose existence is not justified by an act of inference. By so doing, he maintains his antirealist view about unobservables, those entities "merely given by means of inferential reasoning" (Wiltsche 2012, p. 114). However, this restriction is inconsistent with Husserl's foundationalism, according to which we are justified to believe both non-inferentially justified beliefs (i.e., basic beliefs such as perceptual beliefs) and the beliefs inferentially depending on them (i.e., non-basic beliefs, which are deductively, inductively or abductively inferred from basic beliefs). "[T]here is convincing textual evidence

that Husserl needs to be interpreted as a moderate foundationalist" (Berghofer 2018b, p. 3; on perceptual beliefs, see also his 2020b).[3] Husserl's epistemology, accordingly, allows us to believe in objects whose existence is justifiably inferred. Thus, one need not restrict one's realist view to those objects whose existence is (claimed to be) non-inferentially justified.

Wiltsche might respond that only those objects whose existence *can be* non-inferentially justified may count as justifiably inferred. That is, in order for an object to be real, it should be possible that our knowledge of the object is a basic belief. This response is implausible, because it is unclear why justified beliefs need to be restricted to those that possess the possibility of being basic. A mathematical equation (say, $(a^2+b^2)(x^2+y^2) = (ax+by)^2+(ay-bx)^2$) may be justified, even if it cannot be a basic belief. Similarly, a belief about a microscopic entity need not have the possibility of being basic in order to be justified.

According to Husserl's moderate foundationalism the knowledge of theoretical entities *can be* inferentially justified. For instance, atoms are not experiencable but one can justifiably infer a claim to their existence, as a non-basic belief, from empirical evidence of atoms, as a basic belief. Along these lines, section 5 argues that the knowledge of real entities can be inferentially justified, so we are justified to consider them real. But first, in subsections 3.2 and 3.3, I critically discuss

[3] According to *moderate* foundationalism, basic beliefs are adequately justified, but they are not infallible, indubitable, or incorrigible. They can be defeated by other justified beliefs. *Moderate* foundationalism is also compatible with the view that (basic or non-basic) beliefs can get extra justificatory support from their coherence with other justified beliefs (Berghofer 2018b, section 1.2).

the phenomenological views of philosophers such as Vallor, Ihde, and Heelan, who argue that the knowledge of theoretical entities rests on a perceptual basis. The insightful, acceptable part of their views, as section 4 further clarifies, results in the claim that empirical evidence of theoretical entities (obtained by instruments) possesses perceptual characteristics, even if the entities are not perceivable by naked eyes.

3.2 Explorable perceptual horizons

Vallor's (2009) argues for a form of experimental realism. That is to say, she supports Hacking's experimental realism but also modifies his criterion for determining real entities. Hacking (1983) restricts his realist claims to the existence of the entities that can be (instrumentally) manipulated by being used as tools to interfere in other phenomena. However, this criterion leads to antirealism about entities that are not manipulable. This is why Hacking (1989) is antirealist about astronomical entities such as black holes; furthermore, according to Vallor, his criterion cannot sufficiently explain the engagement with microscopic entities that are perceptual in the phenomenological sense but not manipulable in Hacking's sense. Two examples of such engagements are the case of "Rutherford's encounter with the nucleus" and "Leeuwenhoek's encounters with microorganisms" (Vallor 2009, p. 19). In addition, Vallor maintains that her account can acknowledge that posits like Gelfert's (2003) "quasi-particles" are unreal, although they are manipulable in Hacking's sense (Vallor 2009, p. 20).

Vallor's argument is mostly based on Husserl's (1960) view of the horizonal nature of perception, on Merleau-Ponty's (1968) view of "empirical pregnancy", and on Heelan's view that scientific instruments are extensions of human embodiment. Husserl argues that a real thing is perceived in a "horizon". The foregrounded thing on which one focuses is surrounded by and

contrasted with other things in a larger (background) context. In addition, it possesses other aspects, or "profiles", which can be disclosed by further explorations. Accordingly, any feature of the present context of the thing and also all of its (other) possible profiles are included in the horizon of a thing (more on this horizonal account of observation below). Merleau-Ponty's idea that real things are "empirically pregnant", in a non-metaphorical sense, means that a real thing enjoys *possibilities,* which provide *actual* experiences when the perceiver actively engages with the thing. The engagement or encounter with the real thing takes place through our embodiment, or what Merleau-Ponty calls the "flesh". According to Heelan, this embodiment can be extended to instruments used in observations and experiments.

A central point of these accounts of perception is that objects cannot be observed through passive sensation. Instead, they are manifested through active explorations. Indeed, as a result of the "pregnancy" of a real thing, its perceptual horizon is explorable. That is, one can actively keep exploring different profiles of the thing.[4] According to this view, experimental experience of microscopic entities also has perceptual status. Profiles of a microscopic entity are fulfilled when one starts, and proceeds with, the experimental exploration of the features and profiles of a microscopic entity by means of scientific instruments.

> When experimenters employ instruments in complex performances directly revealing empirical horizons pregnant with new features and profiles to be bodily explored, such performances are perceptions in every epistemically important sense of the term. (Vallor 2009, p. 16)

[4] On the active and passive dimensions of perception, see Gallagher and Zahavi (2012, p. 111).

If one takes the active, engaged aspect of perceptual experience seriously, one admits that a theoretical entity is real insofar as it is practical to experimentally engage with it in order to explore its various profiles. The sign or evidence of a microscopic entity "becomes manifest to the experimenter in a perceptual style" (Vallor 2009, p. 15). If the exploration of a theoretical entity continues, insofar as the profiles of the entity are explorable through our different engagements, we may have reason to support realism:

> robust grounds for realism emerge only when the data are manifested in a perceptual style, that is, belonging to a horizon pregnant with kinaesthetic-sensory possibilities revealing the thing in an open but concordant series of explorable profiles. Cells, electrons and protons, unlike phlogiston, were revealed in experimental praxis as pregnant with such profiles (Vallor 2009, p.19).

The profiles of a microscopic entity are instrumentally explorable. The view that the perceptual horizons of things are explorable is insightful, and in section 5 I shall benefit from it in my argument for realism. Before that, it is necessary to discuss the claim that experimental instruments extend human embodiment.

3.3 Instrument use as extended embodiment

This subsection explains the view that the use of experimental instruments can be seen as an extension of embodiment. To do so, I first clarify the notion of embodiment. Phenomenologists argue that embodiment is the condition of the possibility for perceiving ordinary objects:

> spatial objects can only appear for and be constituted by embodied subjects. ... the body is a condition of the possibility for the perception of and interaction with spatial objects …. every worldly experience is mediated by and made possible by our embodiment. (Zahavi 2003, pp. 98–99)

Three important concepts are used in the quotation: "constituted by", "mediated by", and "made possible by". Each emphasizes an aspect of a single idea: the mediation of the body makes possible the constitution of the object. The concept of "constitution" can be further clarified as follows.

> Constitution must be understood as a process that allows for manifestation and signification, that is, it must be understood as a process that permits that which is constituted to appear, unfold, articulate, and show itself as what it is. … As Heidegger was to observe: "Constituting" does not mean producing in the sense of making and fabricating; it means *letting the entity be seen in its objectivity*. (Zahavi 2003, p. 73)

Perceptual experience is disclosed or brought to awareness through embodiment. That is, embodiment is a necessary condition for the manifestation of an object.

Heelan claims that embodiment is not limited to human embodied organs. Technological instruments can also make possible perceptual experiences: "The possibility of embodiment in readable[5] technologies … follow[s] from deep roots in *the conditions of possibility of* perception" (Heelan 1983, pp. 210-211, emphasis added). Merleau-Ponty's account of perception is usually

[5] In section 4, I will explain the meaning of this "readability".

employed to support the view that instruments are the extensions of human embodiment. A blind person's cane constitutes the person's perceptual experience (see Merleau-Ponty 1962, p. 143; Heelan 1983, p. 150). When the blind person is using the cane, or in Heidegger's terminology when the cane is a "ready-to-hand" tool (1927, section 15), it is not seen in an objective way, but considered as part of the people's embodiment that discloses their world. The so-called tactile-visual sensory substitution (TVSS) technology can similarly help a blind person to acquire a vision of the environment by sensing tactile stimuli.

> Once the subject is habituated to the tactile stimulation the technology itself ceases to be an object and is incorporated into the body in a way that discloses the world. Such technologies … become part of the body that we live. (Gallagher and Zahavi 2012, p. 157; see also Heelan 1983, pp. 200-201)

It is similarly argued that experimental instruments extend human embodiment and, therefore, make possible the manifestation of theoretical entities that are not perceivable by human sensory organs alone. The heart of Ihde's "instrumental" realism is the idea that "what has previously been thought of as "theoretical" becomes replaced with the instrumentally "observable", and in differing degrees, this observability in turn becomes part of a new perceptual region" (Ihde 1991, p. 107). This basic idea of Ihde's realism can originally be found in Heelan's work.

> Now the position I have been defending is that theoretical states and entities are or become directly perceivable (alternatively, "observable," in the stipulated sense) because the measuring process can be or become a "readable technology," a new form of embodiment for the scientific observer. In this view, the term "observation" no longer means unaided perception. It implies that theoretical

> states and entities are real … because (and to the extent that) they are perceivable in the perceiver's new embodiment. It also implies that the nature and aim of scientific explanation is to make manifest the processes and structures of the real. (Heelan 1983, p. 203)

Heelan argues that a scientific instrument

> does not change the essential structure of the perceptual act, neither with respect to its phenomenological characteristics, (particularly directness), nor with respect to the physical and causal relationships between the embodied perceiver and the object. (1983, pp. 210-211)

Firstly, the physical aspect of the human observational apparatus is by its nature instrumental. Although it is specific to our species, and so it is different from that of other animals, it basically works by means of the same physical laws as scientific instruments do. But, secondly, there is an intentional act that makes a difference between humans and scientific instruments. According to Heelan, this intentional act is embodied in human observational apparatuses. Adding new instruments to our inborn apparatuses provides an "extended embodiment", in which new intentional acts are embodied. In unaided perception, the intentional act is mediated by our inborn apparatuses. In instrumentally-aided perception, the intentional act is mediated by inborn apparatuses joined with instruments.

It is correct that the physical condition of observation depends on the causal relationships between the perceiver and the object. However, Heelan's view that we have non-inferential knowledge of theoretical entities is problematic. In my view, we can only have non-inferential

knowledge of ordinary objects, but our knowledge of theoretical entities and their properties are *inferred*, as I will explain in the next section.

4 Non-Inferential Knowledge of Theoretical Entities?

According to Heelan, an experimental instrument is 'readable', in the sense that the response of the instrument is "in a position of 'text' to be 'read' in the 'context' of a scientific horizon" (1983, p. 206). Heelan's controversial claim is that instruments "make manifest to perception the constituent parts or hidden structures" of theoretical entities (1983, p. 206). That is, the process of 'reading' is non-inferential.

> I now claim that this 'reading' is a perceptual process, since *it fulfills all the characteristics of perceptual knowledge*.
>
> Perceptual knowledge is (1) direct, not mediated by inferences, nor is it just knowledge of an "internal representation" or "model" constructed, perhaps, out of sensations, or in some other, perhaps, mathematical, way. (1983, p. 198)

For example, in the measurement of the temperature by a mercury thermometer, our knowledge of the thermodynamic temperature is non-inferential:

> the position of mercury on the scale functions as a 'text'; this 'text' has the character of information$_1$. Through a 'reading' of this 'text,' one gains knowledge of the current thermodynamic temperature [information$_2$]. The expression of this knowledge takes the form of a judgment, "The present ambient temperature is (say) 70°"; this judgment is empirical, direct [i.e., non-inferential and non-

> representational], and uses scientific terms descriptively of the World (1983, p. 198).

However, a 'reading' of the "position of mercury on the scale" is possible only by an act of inference. What is non-inferentially known, or "information$_1$" in Heelan's words, is not the thermodynamic temperature but the length of the column. We know that there is a (linear) relation between the length of the (mercury) column and the thermodynamic temperature, so the temperature, as "information$_2$", is justifiably *inferred* from the length observed. Therefore, Heelan's claim that the knowledge of thermodynamic temperature is "not mediated by inferences" is untenable.

More precisely, we should distinguish two levels of discussion: perceptual and epistemological. Heelan speaks of "knowledge" that takes the form of "judgment", so his discussion is epistemological. At this level, one's *knowledge* of the thermodynamic temperature relies on (usually unconscious) inferences. For this reason, if we ask whether one's judgment is correct, we need to address the relevant inferences. Thus, a correct analysis of the thermodynamic temperature example is as follows. We perceive the length of the column on the thermometer. This perception, which is conceptually interpreted by the terms "length", "column", etc., constitutes our basic belief that "the length of the column is (say) 3 centimeters". This belief is a perceptual, a basic one – it is non-inferentially justified (on basic beliefs, see subsection 3.1). But the belief/judgment that "the present ambient temperature is (say) 70°" is not basic anymore. If we are asked why we believe in it, we should justify the belief/judgment as follows:

(1) we have the perceptual, basic belief that the length of the column is (say) 3 centimeters.

(2) there is a (linear) relation between the length of the (mercury) column and the thermodynamic temperature, such that the length of 3 centimeters corresponds to the temperature of 70°

(3) it is inferred from (1) and (2) that the temperature is 70°.

Suppose that we are inside a warm house but the thermometer measures the temperature of the cold outside of the house. We perceive the warm inside by our embodied sensors, hence our non-inferential knowledge of the warmness. At the same time, we know the temperature of the outside inferentially. The fact that we have learnt to know the temperature of the outside through a thermometer without making conscious inferences does not entail that it is really non-inferential from an epistemological perspective.

Now consider Heelan's assertion at the perceptual level of discussion: "theoretical states and entities are or become directly perceivable". First, our observation of theoretical entities is mediated through instruments and theoretical concepts.[6] For this reason, it may be confusing to assert that theoretical entities are "directly" perceivable. Second, Heelan seems to endorse a kind of "direct realism", according to which our intentionality is *directed* to things and not to their mental representations or replica. I agree that we engage with things themselves and not with their mental representations, but this engagement is mediated through instruments and interpretations.

[6] About the conceptuality of perceptual experience, see McDowell (1994); Brewer (1999); Noë (2004, chapter 6); Radder (2006, chapters 6 and 7). The conceptual interpretation of perception is not necessarily propositional (see Gallagher and Zahavi 2012, p. 121, n. 2) or conscious (see Radder 2006, p. 84).

Direct realism is compatible with (realist) perspectivism. The former is at odds with "(mental) representational realism" but not with perspectivism. In this regard, Giere rightly argues that the perspectivist interpretation of instrumentally-mediated observation is in line with direct realism.

> Direct realists argue that we perceive objects themselves. Representational realists argue that we experience not the object itself, but a mental representation of the object. For instruments, the direct realists are closer to the mark. Instruments clearly do not form representations of objects, which they then detect. Instruments interact directly with objects in the world. … Observation is thus always mediated; not, however, by a representation, but by the perceptual apparatus of the observer. (Giere 2006a, p. 126, n. 7)

In view of these two remarks, a preferable alternative to Heelan's assertion at the perceptual level is thus: the conceptual interpretation of instrumentally-mediated empirical evidence directs our intentionality toward theoretical entities themselves and not to their mental representations. (The role of "evidence" in this statement will be elaborated in section 5.)

Let us now consider the case of cloud chambers. Van Fraassen and Wiltsche are right that our knowledge of ions is inferential. A "trace" in the cloud chamber is perceived, and then it is interpreted that the trace is that of ions. The cloud chamber is thus the condition of the possibility for the perception of the "trace" that is interpreted as evidence of ions. The apparatus does not present the perception of the ions. Instead, it produces signs or empirical evidence of ions, and thus the knowledge of their existence and properties is inferred on the basis of the empirical evidence.

One might argue that the cloud chamber is not the only or the latest technology or practical technique scientists have invented to study ions. For instance, techniques of laser cooling and

trapping have been devised since the 1980s. They also enable experimenters to make manifest ions and atoms. In this technique, ions or atoms are cooled and slowed down through collisions with laser light, and then they are "trapped" by electromagnetic fields (on the laser cooling of trapped ions see Eschner et al. 2003). By performing the relevant manipulations, the ions or atoms are "prepared" to be manifested by the mediation of a microscope such as a scanning tunneling electron microscope. Still, atoms or ions are not "perceived". Although the intentionality of the experimenter(s) is directed at the atoms or ions (and not at their mental representations), the intentionality is mediated by instruments and conceptual interpretations. Furthermore, to count our knowledge of the outcomes of the microscope as images of atoms, inferences are necessary. These inferences should be justified if they are to result in scientific knowledge of cooled and trapped ions.

As Joseph Pitt rightly illustrates, "seeing through a microscope is not the same as … seeing a tree in front of me" (2005, p. 25). One should be trained specially to see through any instrument. Observation is a skill and training is necessary to observe correctly.[7] Michael Polanyi (1973, p. 101) illustrates this claim by explaining the perceptual experience of a medical student who is being trained to inspect an X-ray picture. During the processes of learning, the learner will gradually "see" the details of the picture. When the observer becomes skilled and experienced, his/her intentionality is promptly directed to the objects of inquiry, hence there is no need for

[7] The necessity of training applies as well to seeing a tree by young children (for instance, concerning the difference between a tree and a bush). But in scientific observation, a specialized, technical kind of training is necessary to observe correctly.

conscious interpretation or inference. Still, this observation is made possible by the mediation of instruments and relevant conceptual interpretations. In the case of the scanning tunneling electron microscope, at the perceptual level the signals produced by *means* of the microscope need to be *interpreted* in order that the observer's intentionality is *directed* to the objects under inquiry. At the epistemological level, the *justified* results rely on valid *inferences*, even if observers do not usually make these inferences explicit.

Other more complex instruments, such as particle detectors at the LHC or the Virgo and LIGO detectors, should be studied carefully to determine what is really presupposed and detected by each of them. Nevertheless, a cursory examination of their operation suggests that various statistical and computational inferences are employed to provide evidence of the relevant theoretical entities. Big data should be analyzed and interpreted to be used as evidence for the existence of complex theoretical entities, such as gravitational waves or a binary black hole merger.

Instruments extend our empirical evidence. The evidence provided by scientific instruments can change the epistemic status of theoretical entities from a mere theoretical postulation to empirically justified entities. Our knowledge of the latter is still inferential. Again, the fact that the inference from available evidence to (the properties of) an entity is mostly made *unconsciously* does not mean that no inference is made.

Van Fraassen agrees that the use of instruments in experiments may extend our (perceptual) knowledge *of observables*, but he emphasizes that this extension (or "enlargement" in his words) should not be expressed in a metaphorical way:

> It will serve … to think of experimentation in terms of a literal *enlargement of the observable world*, by the creation of new observable phenomena, rather than a metaphorical *extension of our senses*. (2008, pp. 98-99)

I share Van Fraassen's concern that the metaphorical concept may bring about epistemological misunderstandings. Accordingly, I would prefer the non-metaphorical term "the extension of perceptual evidence by instruments" to the term "the extension of body/embodiment by instruments". The former term is consistent with Heelan's and Ihde's emphasis on the key role of instrumentation in constituting new perceptual horizons, without employing a metaphorical expression. The importance of instrumentation is such that scientific progress depends on the empirical evidence that technological instruments present, and in turn, on the availability of technological instruments, or what Isaac Record (2013) calls "technological possibility". The term "the extension of perceptual evidence by instruments" is also compatible with Vallor's Merleau-Pontian definition of "perception as an embodied engagement with an empirically pregnant horizon" (2009, p. 20). During the process of instrumentally-mediated observation, the empirical evidence of a theoretical entity is manifested in a perceptual style. Empirical evidence enables scientists to investigate theoretical entities.

The next section explains my arguments for realism concerning these entities with the aid of the concept of "exploration" and the distinction between "manifestation" and "phenomenon". Please note that I use the notion of "manifestation" in an active sense, as the becoming manifest of non-manifest entities (this usage should not be confused with the so-called "manifest image", which is often contrasted with the "scientific image").

5 The Manifestation of a Theoretical Entity through Robust Evidence

Based on Heidegger's phenomenological method (1962[1927], section 7), Kockelmans distinguishes between "manifestation" and "phenomenon". This distinction helps to better understand the epistemic status of empirical evidence generated by instruments. A phenomenon is

observed, and then it is used as a sign or evidence of a theoretical entity that is manifested through the phenomenon.

> Let us call a *phenomenon* that which shows itself directly. Taken in the narrow sense, the set of phenomena is then the totality of all entities that are actually manifest to human beings without mediation through something else. Taken in the broad sense, the set of phenomena is the totality of all entities that *can* be actually manifest to human beings in the manner indicated. … An *appearance or manifestation* is something that does not manifest itself *directly*; rather it is something that *announces* itself without showing itself directly. What appears announces itself by means of something that shows itself immediately. In this case we often speak of indications, symptoms, signs, symbols, etc. (Kockelmans 1993, pp. 249-250)

The fire in the wood-burning stove, as a manifestation, announces itself by the smoke coming out of the chimney, as a phenomenon. Similarly, scientific instruments produce empirical evidence, which constitutes indications or signs of real entities. The main difference between the fire-smoke example and scientific cases is that we may see the fire by using our unaided senses, but theoretical entities cannot be observed in this way. Thus, Kockelmans's distinction genuinely works only for theoretical entities. They announce themselves only through what he calls phenomena, indications, symptoms, signs, symbols, or in sum: empirical evidence, which is a more common term in current scientific practice (see Boyd 2018).

Multiple means of gathering empirical evidence provide robust evidence that indicates real things. We know that perceiving a rainbow does not provide robust evidence of some colorful object in the sky. At first sight it might provide some evidence because even non-veridical

perceptual experiences can provide some prima facie evidence, but this evidence is falsified by other pieces of evidence. A piece of evidence may be mistaken, and thus evidence is fallible (see Berghofer 2019). Other pieces of evidence can falsify a piece of mistaken evidence. Thus, perceiving a rainbow provides prima facie evidence for believing that there is a colorful object in the sky, but this evidence is discovered to be misleading thanks to other sources of evidence. This mistaken evidence may offer illusory experience to someone unaware of further, more robust pieces of evidence. However, multiple sources of empirical evidence allow us to falsify mistaken evidence.

The rainbow phenomenon can be explored from the lifeworld and the scientific points of view, both of which can establish that no colorful object exists in the sky. One (for instance, an uneducated child) might first be under the illusion that there is a colorful object in the sky when he/she experiences the rainbow phenomenon by his/her ordinary perception, but one can easily change the positions and angles of observation to finally learn that there is no colorful object in the sky. Also, from a scientific perspective we know that perceiving a rainbow does not offer robust evidence of some colorful object in the sky, even if it provides evidence of the refraction of light rays of different frequencies. Similarly, in the case of the cloud chamber the trace perceived is evidence of ions, as entities. It may be the case that what has appeared to us (ordinary people or scientists) is an unknown illusion or hallucination. In general, veridicality is not guaranteed. Some of our justified beliefs may still be wrong and some robust evidence may still be mistaken. However, to the extent that our experience or evidence relies on *several modes* of our bodily or instrumental engagements, we are justified to consider the experience or evidence to be that of real

things.[8] In the case of ions, we are justified to claim that ions refer to real things, because multiple processes of obtaining empirical evidence indicate that we have justification for believing that they are real. In the case of the rainbow, multiple ways of encountering the phenomenon, that is, its ordinary perception from different angles and positions or its investigations through different scientific methods, make it obvious that there is no tangible colorful object in the sky.

As embodied subjects we are not brains in vats. We can use our different modes of engagement with things and perform multiple exploratory actions to distinguish robust evidence *of* real things from illusions and hallucinations, which do not indicate real things.[9] Unlike real entities, to which robust evidence or signs testify, the supposed objects of illusions and hallucinations will sooner or later be dispelled after multiple and active bodily or instrumentally explorations. We can actually approach a mirage and see it from different angles to become confident that its manifestation is different from the robust experience of an actual lake. Similarly, scientists devise various practical methods to distinguish robust evidence from merely artificially created illusions and hallucinations.

---

[8] See also Eronen (2015). Both things and evidence can be described as robust. According to Eronen, we are justified in believing in a robust *thing* (including theoretical entities). According to my discussion in this section, we can similarly attribute robustness to *evidence* that relies on several modes of embodied or instrumental engagement with the same thing. Robust evidence provides justification for believing that a (robust) thing is real.

[9] On the role of "exploratory action" in determining illusion, see also Merleau-Ponty (1962, pp. 296–297).

Vallor's criterion for reality is applicable in differentiating empirical evidence of real things from mistaken evidence, illusions, and hallucinations: A real entity is explorable indirectly through its evidence or signs.[10] My usage of the term "explorable" implies that theoretical entities are explorable through several independent ways of obtaining evidence. Detecting, measuring, deriving, and (re)producing are different modes of "exploring". When the empirical evidence of a thing is explorable in several independent ways, one is usually justified to reject the claim that the thing is a mere artefact of the experimental instruments. The replication of an experiment in different conditions justifies the conclusion that the results of the experiment do not depend on the specific circumstances of the instruments. In contrast, the supposed object to which an illusory or hallucinatory phenomenon seems to refer does not provide evidence that is explorable through several different modes of investigation.

The view I am defending is different from Van Fraassen's, which does not take seriously the fact that robust evidence indicates something real. He does not differentiate between robust and hallucinatory "observables", equating an image made by a microscope with a public hallucination.

[10] Vallor employ's Heelan's concept of 'reading'. However, she does not discuss whether 'reading' is inferential or not. Heelan explicitly states that the direct perception of the hidden structures of reality is possible by means of instruments but without any act of inference. However, it seems that for Vallor only the *signature* or *evidence* of a real entity (rather than the entity itself) is perceivable: "the pregnant signature of that particle becomes manifest to the experimenter in a perceptual style" (Vallor 2009, p. 15).

> It is accurate to say of what we see in the microscope that we are ‘‘seeing an image’’ (like ‘‘seeing a reflection’’, ‘‘seeing a rainbow’’), and that the image could be *either* a copy of a real thing not visible to the naked eye or a mere public hallucination. I suggest that it is moreover accurate and in fact more illuminating to keep neutrality in this respect and just think of the images themselves as a public hallucination. … [W]hat are the practical implications? To keep neutrality in this respect does not prevent us from gathering empirically attestable information. (2008, p. 109)
>
> [W]e can report on our sightings made by means of a microscope in the same way as we report our rainbow-observations. (2008, p. 110)

However, scientists do (and should) not stay neutral about robust evidence and hallucinatory experience. Multiple methods enable scientists to determine robust evidence *of* real entities. On the other hand, although illusory results or mere artefacts of instruments can teach experimenters something about the possible problems of the instruments, they are not robust evidence of entities inasmuch as multiple processes demonstrate that they are illusory results or mere artefacts.

The view that explorable empirical evidence indicates theoretical entities supports realism. Nevertheless, this realism is not objectivist. We humans, as situated, bounded beings, cannot acquire knowledge of reality independently of our instrumental and conceptual conditions. Empirical evidence is always provided by instruments whose validity scopes are qualified. Also, theoretical and interpretive inferences, as the hermeneutical side of scientific knowledge, are necessary. In the next section, I discuss the perspectival nature of scientific observation and knowledge in order to support a realist perspectivism.

6 Realist Perspectivism

On the basis of the explorability of perceptual horizons, Vallor supports experimental realism. The shortcoming of experimental realism, and its phenomenological defense, is that it does not properly take into account the theoretical/mathematical side of physical sciences. This sometimes results in not acknowledging the crucial theory-dependence of scientific observation (for instance, in Hacking 1985, p. 137). The underestimation of the role of theorizing in science is also a basic problem of Ihde's instrumental realism, in which one hardly find a discussion of model building or the formal features of physical science.

However, experimental realism and perspectivism can augment each other, and hence result in *realist perspectivism*. This section argues for a realist perspectivism that is compatible with but not limited to experimental realism. My realist perspectivism, as we shall see, takes into account both the practical/experimental aspects and the mathematical/theoretical sides of scientific practice. In the following, I support realist perspectivism with the aid of phenomenological-hermeneutical ideas.

Husserl's view that physical objects manifest themselves *perspectivally* is an initial, insightful idea to argue for perspectivism. Husserl maintains that when we perceive an object, we always see it from a perspective. Only one profile[11] of the object is actually presented; its other profiles are

[11] Perception is always a mixture of presence and absence. The present parts are called profiles. Some scholars distinguish the concepts of "side", "aspect", and "profile"; see, e.g., Sokolowski (2000, p. 19). I, nevertheless, use these concepts as roughly equivalent. Further on, I will expand the notion of a profile to include the perspectival dimension of empirical science.

co-given in a horizon: "a *core of* '*what is actually presented*' is apprehended as being surrounded by a horizon of '*co-givenness*'" (Husserl 1983, p. 94). He argues that

> there belongs to every external perception its reference from the 'genuinely perceived' sides of the object of perception to the sides 'also meant'—not yet perceived, but only anticipated …[T]he perception has horizons made up of other possibilities of perception, as perceptions that we *could* have, if we *actively directed* the course of perception otherwise. (Husserl 1960, p. 44; see also Zahavi 2003, pp. 95–97; Radder 2006, chapter 6; and Smith 2016, section 3.2)

In criticizing Van Fraassen's (1985) view that observation is only about actual objects, Vallor supports Husserl's perspectival account of perception, and admits that perception is always based on an object's "profiles", and an "anticipatory horizon" is always needed to bring about a complete perception (Vallor 2009, pp. 4–5). Perception is always about a whole, only a part of which is presented in the actually perceived profile of the object; other parts are added in an anticipatory horizon: "the most epistemically significant component of a perception is the projected horizon of the *non*-actual" (Vallor 2009, p. 7). This horizon helps to provide a complete understanding of the object from a limited number of perceptual profiles. Non-actual parts of perception are anticipated, based on a limited, discrete set of actual profiles.

Vallor's view needs further clarification and development. I have argued in the previous section that a theoretical entity manifests itself through phenomena used as evidence, and that robust evidence justifiably indicates the theoretical entity. Now I suggest that profiles of an entity consist of empirical evidence obtained by means of the relevant instruments. The evidence which has thus far been collected constitutes the a*ctual* profiles of the entity. All prospective evidence of the entity

constitutes its *non-actual* profiles. Actual profiles have been perceived, but there should always be an *anticipatory horizon*, which helps to complete the currently actual profiles of the entity by anticipating non-actual profiles. The role of the completion of the horizon rests on the shoulders of scientific theories. We can understand this role better with the help of *realist perspectivism*.

In phenomenological terms, instruments provide us with the perceptual profiles of an entity and we actively complete the anticipatory horizon with the aid of theoretical assumptions that rely on scientific theories to provide a complete image of the thing. For example, the main assumption of the PET scan is that neural brain activities can be understood in terms of the blood flow (or the metabolic changes) of a particular area of the brain. More generally, the proper interpretation of neuro-images is always theory-dependent. In addition, statistical analyses are always necessary to produce a "complete" outcome from signals. Thus, a scanned brain image is not simply a photograph of the real brain (Klein 2009; Roskies 2007), but it consists of signals obtained from the brain that are completed with the aid of anticipatory assumptions. As a result, our access to the brain substantially depends on how brain scanners work and how their results are interpreted. "One has images *as produced by CAT or MRI or so forth*. One cannot detach the description of the image from the perspective from which it was produced" (Giere 2006a, p. 56).[12] According to this view, the perspective is provided by the specific sensitivity of the instrument and by the theoretical assumptions that help us actively complete the initial profiles we gain by means of the instrument.

[12] This does not contradict the point that replicated experimental results are reliable. Robust or replicated results achieved from "overlapping perspectives" are not non-perspectival (see Giere 2006a, pp. 57-58 and p. 92).

One might argue that in the case of ordinary perception, we can easily "direct the course of perception otherwise" to check if "we could have" the actual perception of the other aspects of the object, those aspects that were previously anticipated, while it is hardly possible to check if the theoretical assumptions that anticipatorily constitute the result of an instrumentally-mediated observation are correct. In response, even if we accept that it is often hard *in practice* to check the validity of the anticipatory assumptions, there is no *in principle* hindrance to conduct experiments in order to investigate other evidence of the entity, the evidence that was previously anticipated merely theoretically. The evidence obtained by means of instruments determines if the previous theoretical assumptions were acceptable. In this way, non-actual, anticipatory profiles of the entity can become actual.

One should also take into account that a scientific experiment is not limited to the practice of an individual experimenter. The justification of experimental results is a *collective* enterprise. An experimenter may rectify the empirical evidences provided by other experimenters. Also, an experimenter may reproduce the experiment in a different way to provide new signs of an entity which is under investigation. Experimenters in a scientific community revise and complete evidence collected by the experimental processes of one another, which makes the empirical results reasonably reliable.[13]

Let us return to perspectivism, according to which not all aspects of a real thing can be represented simultaneously. The phenomenology of perception (discussed in subsection 3.2 and earlier in this section) entails that only one profile of an ordinary object can be actually presented.

[13] Cf. De Boer et al. (2018).

In scientific investigations, similarly, different profiles of a theoretical entity cannot be disclosed in one experimental exploration, which employs certain instruments and techniques. Nor can a number of experimental explorations disclose all aspects of the entity, which might have other features that will not be disclosed unless further explorations take place. Moreover, quite a few case studies demonstrate that scientific models can only reveal limited features of their objects of inquiry. The next section discusses several of these cases and pursues the line of argument that perspectivism can explain the plurality of scientific models.[14] These and similar cases show that models do not provide isomorphic images of objects/entities (cf. Suarez 2003). They are similar to maps. Various maps, such as a subway map, a flat map, a neighborhood map or a geological map, represent specific aspects of a territory. However, they cannot generate a complete, unqualified image of the territory (see Giere 1999, pp. 26, 81-82 and 214-215; 2006a, pp. 73 and 76-78). Likewise, different models of an object/entity represent its specific aspects. These models cannot be claimed to represent all aspects of the object/entity, because other models may still be constructed to represent its other aspects. An implication of this view is that scientific

[14] Note that I do not claim that science should or should not strive for unification of existing knowledge. My claim is not prescriptive, but rather descriptive and explanatory. It is descriptive in the sense that the study of actual scientific practice shows that there is a plurality in scientific models of an object of inquiry. It is explanatory as the concept of perspectives helps to account for this plurality. Those who disagree with the use of this concept, or similar ones such as conditions or contexts, run into difficulties with the explanation of the plurality in models actually built by scientists.

representation is always qualified. Scientific models constitute perspectives within which the world is represented. According to Giere,

> the strongest claims a scientist can legitimately make are of a qualified, conditional form: "According to this highly confirmed theory (or reliable instruments), the world seems to be roughly such and such." There is no way legitimately to take the further objectivist step and declare unconditionally: "This theory (or instrument) provides us with a complete and literally correct picture of the world itself." (2006a, pp. 5–6)

Realist perspectivism is in sharp contrast with objectivism. Accordingly, it does not lead to the problem of scientific objectivism, as the major motivation of Wiltsche to defend antirealism. It also takes into consideration the role of scientific instruments in providing perceptual evidence, which is sympathetic to Ihde's argument for realism. Thus, realist perspectivism can help to resolve disagreements between an antirealist such as Wiltsche and a realist such as Ihde. This view, inspired by several ideas from phenomenological- hermeneutical approaches to scientific practice, is the way to go for phenomenologically-hermeneutically minded philosophers of science.

The perspectivist view that the strongest true claim to be made should be qualified is also akin to Kockelmans's statement that "it is very difficult to subscribe to the view that scientific theories are true without further qualification" (Kockelmans 1993, pp. 135). In general, Kockelmans's (1993, chapter 3, §2, 6) Heideggerian view of truth is in harmony with a perspectivism, according to which scientific knowledge is always made possible within conditions. Depending on certain contexts and purposes, scientists construct models that represent the object in a qualified way.

Heidegger's (1962[1927], section 44) account of truth is based on his reading of the Greek word "aletheia" as the antonym of lethe, meaning concealment. Accordingly, aletheia means un-

concealment, and truth is un-concealedness (Heidegger's word is *Unverborgenheit*). When a thing becomes un-concealed, some aspect of it in a context becomes evident. The process of un-concealment begins and continues in a background or context of meaning. A truthful statement reveals some aspects of the thing that can be un-concealed in that context, and at the same time, the statement conceals other aspects of the thing.

Similarly, according to perspectivism, the manifestation of an entity always concerns profiles of the entity in a theoretical and technological context. The process of discovery occurs in the historically situated background of theoretical concepts and models as well as that of available technological instruments. In a specific context, some profiles of the entity are discovered through empirical evidence, while some other profiles remain covered. Discovered profiles may be interpreted differently in the future, and covered profiles may become uncovered in the future. Nonetheless, even in the future, uncovered profiles will be conceptually interpreted – they are not theory-free. Also, there may still be further uncovered profiles – the entity will hardly be discovered from all possible perspectives. Accordingly, scientific knowledge is always *qualifiedly* true. It is

> impossible for us to claim that in our judgments we state how things are "in themselves," comprehensively, exhaustively, definitively, and absolutely. We can claim only that our judgments state how things are as seen from some limited context of meaning or, in the final analysis, from the perspective of the whole of meaning of which we can conceive. Thus, every form of revealment implies for us also some form of concealment. (Kockelmans 1993, pp. 145)

This section has argued that realist perspectivism, as a comprehensive way of understanding practical and theoretical dimensions of science, can expound several phenomenological-

hermeneutical ideas. Realist perspectivism could in general be favored in the debate about scientific realism. In particular, it is preferable over sophisticated versions of antirealism. This paper has criticized Van Fraassen's antirealist neutrality between hallucinatory experience and robust evidence of real things. More generally, the shortcoming of antirealism is that it does not preserve the intuition that, although in a qualified way, science represents *reality*, and specifically in the cases that robust evidence is available, science investigates *real* entities.[15] The following section discusses a further explanatory power of realist perspectivism: it can explain pluralism in science.

7 Scientific Pluralism

Let us examine Ihde's criticism of Husserl once more. Ihde argued that Husserl's distinction between the world of science and that of the ordinary lifeworld is unjustified, because both are provided on the basis of perception. Ihde, however, does not take into account that different *perspectives* disclose different *aspects* of reality. Thus, he (1991, pp. 11–44) employs the concepts

[15] It can also be argued that realist perspectivism is compatible with other modest forms of realism. Section 6 has argued that perspectivism complements experimental realism. Likewise, an advanced version of structural realism would take seriously perspectivist ideas, and realist perspectivism would agree with compelling cases for structural realism. Wolff (2020) uses models of measurements to support the idea that perspectivism and structural realism are complementary. Also, Khalili (2022, section 6.6) develops a realist perspectivism that draws on ideas from structural realism. A detailed discussion of (the compatibility of) different versions of realism detracts from the main purpose of of this paper.

of "paradigm", "episteme", and "macroperception" (suggested respectively by Thomas Kuhn, Michel Foucault, and himself) to explain the way we see the world. These concepts, however, do not allow for *synchronous* ways of discovering an object.[16] There is more than one available perspective not only across history but also in specific periods of time.[17]

Husserl is right that science and ordinary perception present different images of the world, but this difference is not restricted to the two images Husserl mentions. There are also synchronous perspectives in science itself which present different images of a particular object. Therefore, there may be *more than two* images of objects. About water, for example,[18] there are at least three images: the one ordinary perception presents, the continuous substance that hydrodynamics

---

[16] On the distinction between diachronic and synchronic perspectives, see Massimi (2018)

[17] Another reason why I prefer the concept of "perspective" to, particularly, "paradigm" is that the origin of the word *perspective* implies that we basically *look*, but this looking is *bounded by* the instrumental and theoretical means *through* which the looking has been possible for us as human beings. Thus, perspectives are our basic means for discovering reality, although they are bounded by their contingent conditions. A paradigm, on the other hand, only helps us to solve puzzles. However, there is no implication that we discover reality by solving problems with the aid of a paradigm's possibilities. For other comparisons between the notion of paradigm and perspective, see Giere (2006a, p. 82; 2013) and Massimi (2015).

[18] The case of water is examined in Morrison (1999, pp. 53–60), Teller (2001, pp. 401–402, 408–409), and Giere (2006b, 33-34).

describes, and the discrete elements that statistical mechanics characterizes. Each of these images is presented from a perspective. Although none of them is believed to describe water as a thing-in-itself, each of them is presented from a perspective that expands human knowledge about water. In many cases, our perspectival knowledge concerns different aspects of the same object. For instance, in her discussion of cancer theories, Anya Plutynski (2020) argues that each cancer theory provides bounded knowledge about cancer. For another example, Margaret Morrison (2011, section 2) holds that turbulence models provide complementary understanding about different features of one phenomenon. In these and similar cases, it is unproblematic to claim that none of the models is more original than the others; each complements our understanding of the same thing by presenting a different aspect of the thing (see also Rueger 2005; Mitchell 2009; 2020; on perspectival disagreements in science, see Massimi 2019).

On the other hand, there are cases of theories/models that do imply inconsistent claims about reality. For example, that water is a continuous substance (hydrodynamic model) is inconsistent with that it consists of discrete elements (the statistical-mechanical model). For another instance, it seems inconsistent to believe that light consists of waves and particles at the same time. Morrison (2011, section 3) provides a further example: there are more than 30 different models of the nucleus, many of which attribute incompatible assumptions to the same thing, thereby challenging the commitment to any realist claims, including Giere's account. According to Morrison, perspectivism

> isn't a satisfactory option because none of these "perspectives" can be claimed to "represent" the nucleus in even a quasi-realistic way since they all contradict each other on fundamental assumptions about dynamics and structure. In this case perspectivism is simply a re-branded version of instrumentalism. Given that

> we assume there is an object called "the atomic nucleus" that has a particular structure and dynamics it becomes difficult to see how to interpret any of these models realistically since each is successful in accounting only for particular kinds of experimental evidence and provides very little in the way of theoretical understanding. (2011, p. 350)

However, Morrison's assumption that "there is an object … that has a particular structure and dynamics" is problematic. Objects do not have particular structures and dynamics independent of their relations to observers/experimenters (see also Berghofer 2020a, pp. 18ff). The properties of a real thing are not already realized in a "particular" way. Rather, a more tenable ontological view, which fits epistemological perspectivism, is that a real thing consists of potential properties that can be realized differently in different conditions (see Bhaskar 1978, Harré 1986, Cartwright 1989, and Radder 1996, chapter 4). As a result, the realizations of the potentialities of a thing in different conditions may result in attributing inconsistent properties to the thing.

Thus, I (partly) agree with Anjan Chakravartty (2010, section 3) that inconsistent models can be explained on the basis of a dispositional ontology. For instance, depending on the circumstances (such as temperature) salt may dissolve in water or it may not. Similarly, light behaves both wave-like and particle-like, depending on which experimental settings it is subjected to. The difference of my view and Chakravartty's is that he defends dispositional ontology as a rival to perspectivism. However, I think that human-independent potentialities are realized in instrumental and theoretical perspectives, hence a realist ontology about potentialities and a perspectivist epistemology regrading instruments and models/theories are fully compatible. On this basis, it is questionable that "scientific investigation [into the nature of light] has revealed perspective-transcendent facts about how light behaves in different conditions" (Chakravartty 2010, p. 410). If the facts are

perspective-transcendent they should be true independently of any condition. But light behaves wave-like in certain conditions and thus our knowledge that light behaves like waves is subject to these specific conditions. Our knowledge that light behaves particle-like is not correct under these conditions. Accordingly, the conditions in which our knowledge is valid should always be stated, and in this sense our knowledge is conditional and perspective-dependent. A critic might argue that the dispositional knowledge that light *can* behave like waves (or like particles) is perspective-transcendent. In response, we should distinguish between epistemological and ontological issues. When it comes to the latter I do agree that human-independent potentialities exist, e.g. light *exists* and consists of the *potentialities* of behaving like waves and particles. At this level, a mere dispositional account might be adequate. However, at the epistemological level there are several problems that certainly are not addressed unless the concept of perspectives, or similar concepts such as conditions or contexts, are used. In the first place, our truthful beliefs are not limited to dispositional facts. The scope of the validity of an (observational/experimental) statement that is expressed in a non-dispositional language (e.g., light behaves like waves) depends on (instrumental) perspectives. That is, without considering the perspectives in which our statements are truthful, we cannot address the epistemological question of what constitutes the *boundaries* of our knowledge. Furthermore, as Michela Massimi rightly argues, the *justification* of our knowledge always depends on perspectives. For instance, the problem "*under what conditions* we are justified to believe that electrons have electric charge" cannot be solved if we do not use perspectives (2012, p. 41). Moreover, as has been argued in this paper, our knowledge of entities and their potentialities is interpreted according to theoretical perspectives.

This paper has connected phenomenological-hermeneutical approaches with work on perspectivism. The latter is realist inasmuch as the evidence gathered by multiple ways of

instrumental exploration suggests that the entity is real, rather than illusory or hallucinatory. This view is perspectivist inasmuch as scientific knowledge is bounded by instrumental and conceptual conditions. This perspectivism expounds on several phenomenological-hermeneutical ideas and can, as a middle ground, reconcile the disagreements among an antirealist such as Wiltsche and a realist such as Ihde.

References

Berghofer, Philipp. 2018a. Transcendental phenomenology and unobservable entities. *Perspectives* 7(1): 1–13.

Berghofer, Philipp. 2018b. Why Husserl is a moderate foundationalist. *Husserl Studies 34*(1): 1–23.

Berghofer, Philipp. 2019. On the Nature and Systematic Role of Evidence: Husserl as a Proponent of Mentalist Evidentialism?. *European Journal of Philosophy* 27(1): 98–117.

Berghofer, Philipp. 2020a. Scientific perspectivism in the phenomenological tradition. *European Journal for Philosophy of Science* 10: article number 30. Https://doi.org/10.1007/s13194-020-00294-w.

Berghofer, Philipp. 2020b. Motivating and defending the phenomenological conception of perceptual justification. *Inquiry: An Interdisciplinary Journal of Philosophy*. https://doi.org/10.1080/0020174X.2020.1712232

Berghofer, Philipp, Philip Goyal and Harald A. Wiltsche. 2020. Husserl, the mathematization of nature, and the informational reconstruction of quantum theory. *Continental Philosophy Review*. Https://doi.org/10.1007/s11007-020-09523-8.

Bhaskar, Roy. 1978. *A realist theory of science*. Hassocks: Harvester Press.

Boyd, Nora M. 2018. Evidence enriched. *Philosophy of Science* 85(3): 403–421.

Brewer, Bill. 1999. *Perception and reason*. Oxford: Oxford University Press.

Cartwright, Nancy. 1983. *How the Laws of Physics Lie*. Oxford: Clarendon Press.

Cartwright, Nancy. 1989. *Nature's capacities and their measurement*. Oxfored: Oxford University Press.

Chakravartty, Anjan. 2010. Perspectivism, inconsistent models, and contrastive explanation. *Studies in History and Philosophy of Science Part A* 41(4): 405-412

Crease, Robert P. 1993. *The play of nature: experimentation as performance.* Indianapolis: Indiana University Press.

De Boer, Bas, Hedwig Te Molder and Peter-Paul Verbeek. 2018. The perspective of the instruments: mediating collectivity. *Foundations of Science 23*(4): 739–755.

Eronen, Markus I. 2015. Robustness and reality. *Synthese* 192(12): 3961–3977.

Eschner, Jürgen, Giovanna Morigi, Ferdinand Schmidt-Kaler and Rainer Blatt. 2003. Laser cooling of trapped ions. *Journal of the Optical Society of America B* 20(5): 1003-1015.

Gallagher, Shaun and Dan Zahavi. 2012. *The phenomenological mind*. London and New York: Routledge.

Gelfert, Axel. 2003. Manipulative success and the unreal. *International Studies in the Philosophy of Science* 17(3): 245-263.

Giere, Ronald N. 1999. *Science without laws*. Chicago: University of Chicago Press.

Giere, Ronald N. 2006a. *Scientific perspectivism*. Chicago: University of Chicago Press.

Giere, Ronald N. 2006b. Perspectival pluralism. In *Scientific pluralism*, edited by Stephen Kellert, Helen Longino and Kenneth Waters, pp. 26-41. Minneapolis: University of Minnesota Press.

Giere, Ronald N. 2013. Kuhn as perspectival realist. *Topoi* 32(1): 53-57.

Gutting, Gary. 1978. Husserl and scientific realism. *Philosophy and Phenomenological Research* 39(1): 42–56.

Hacking, Ian. 1985. Do we see through a microscope? In *Images of science: essays on realism and empiricism, with a reply from Bas C. van Fraassen*, edited by Paul Churchland and Clifford Alan Hooker, pp. 132–152. Chicago: University of Chicago Press.

Hacking, Ian. 1989. Extragalactic reality: the case of gravitational lensing. *Philosophy of Science* 56(4): 555–581.

Harré, Rom. 1986. *Varieties of realism*. Oxford, UK: Blackwell.

Heelan, Patrick A. 1983. *Space-perception and the philosophy of science*. Berkeley: University of California Press.

Heelan, Patrick A. 1986. Interpretation and the structure of space in scientific theory and in perception. *Research in Phenomenology* 16 (1): 187–199.

Heelan, Patrick A. 1997. Why a hermeneutical philosophy of science?. In *Hermeneutics and the natural sciences*, edited by Robert Crease, pp. 1–27. Dordrecht: Kluwer.

Heidegger, Martin. 1962[1927]. *Being and time*, translation by John Macquarrie and Edward Robinson. Oxford: Basil Blackwell.

Husserl, Edmund. 1960. *Cartesian meditations*, translation by Dorion Cairns. The Hague: Martinus Nijhoff.

Husserl, Edmund. 1970. *The crisis of european sciences and transcendental phenomenology*, translation by David Carr. Evanston: Northwestern University Press.

Husserl, Edmund. 1983. Ideas pertaining to a pure phenomenology and phenomenological philosophy, first book, general introduction to a pure phenomenology, translation by Fred Kersten. The Hague: Martinus Nijhoff Publishers.

Ihde, Don. 1979. *Technics and praxis: a philosophy of technology*. Dordrecht: Reidel Publishing Company.

Ihde, Don. 1991. Instrumental realism: the interface between philosophy of science and philosophy of technology. Bloomington: Indiana University Press.

Ihde, Don. 2011. Husserl's Galileo needed a telescope!. *Philosophy and Technology 24*(1): 69–82.

Ihde, Don. 2016. *Husserl's missing technologies*. New York: Fordham University Press.

Khalili, Mahdi. 2021. Perspectivism and special relativity. *Theory of Science* 43(2), 191-217.

Khalili, M. (2022). *Reality in perspectives*. Doctoral dissertation, Vrije Universiteit Amsterdam. Digitally available at https://research.vu.nl/en/publications/reality-in-perspectives

Kisiel, Theodore. 1970. Merleau-Ponty on philosophy and science. In *Phenomenology and the natural sciences*, edited by Joseph Kockelmans and Theodore Kisiel, pp. 251–73. Evanston: Northwestern University Press.

Klein, Colin. 2009. Images are not the evidence in neuroimaging. *British Journal for the Philosophy of Science 61*(2): 265–278.

Kockelmans, Joseph. J. 1993. Ideas for a hermeneutic phenomenology of the natural sciences. Dordrecht: Springer.

Massimi, Michela. 2012. Scientific perspectivism and its foes. *Philosophica* 84(1): 25-52.

Massimi, Michela. 2015. Walking the line: Kuhn between realism and relativism. In *Kuhn's structure of scientific revolutions - 50 years on*, edited by William J. Devlin and Alisa Bokulich, pp. 135-152. Switzerland: Springer.

Massimi, Michela. 2018. Perspectivism. In *The Routledge handbook of scientific realism*, edited by Juha Saatsi, pp. 164–175. New York: Routledge.

Massimi, Michela. 2019. Realism, perspectivism, and disagreement in science. *Synthese*. Https://doi.org/10.1007/s11229-019-02500-6.

McDowell, John. 1994. *Mind and world*. Cambridge, MA: Harvard University Press.

Merleau-Ponty, Maurice. 1962. *Phenomenology of perception*, translation by Colin Smith. London: Routledge and Kegan Paul.

Merleau-Ponty, Maurice. 1968. *The visible and the invisible*, translation by Alphonso Lingis. Evanston: Northwestern University Press.

Mitchell, Sandra D. 2009. *Unsimple truths: Science, complexity and policy*. Chicago: University of Chicago Press.

Mitchell, Sandra. D. 2020. Perspectives, representation, and integration. In *Understanding perspectivism: scientific challenges and methodological prospects*, edited by Michela Massimi and Casey D. McCoy, pp. 178-193. New York and London: Routledge.

Morrison, Margaret. 1999. Models as autonomous agents. In *Models as mediators*, edited by Mary S. Morgan and Margaret Morrison, pp. 38–65. Cambridge: Cambridge University Press.

Morrison, Margaret. 2011. One phenomenon, many models: inconsistency and complementarity. *Studies in History and Philosophy of Science Part A* 42(2): 342–351.

Pitt, Joseph C. 2005. When is an image not an image? *Techne: Research in Philosophy and Technology* 8: 24–33.

Plutynski, Anya. 2020. Cancer modeling: the advantages and limitations of multiple perspectives. In *Understanding perspectivism: scientific challenges and methodological prospects*, edited by Michela Massimi and Casey D. McCoy, pp. 85-108. New York and London: Routledge

Polanyi, Michael. 1973. *Personal knowledge*. London: Routledge and Kegan Paul.

Radder, Hans. 1996. In and about the world: philosophical studies of science and technology. Albany: State University of New York Press.

Radder, Hans. 2006. *The world observed / the world conceived*. Pittsburgh, PA: University of Pittsburgh Press.

Record, Isaac. 2013. Technology and epistemic possibility. *Journal for General Philosophy of Science* 44(2): 319-336.

Roskies, Adina L. 2007. Are neuroimages like photographs of the brain?. *Philosophy of Science* 45(2): 231-250.

Rouse, Joseph. 1987. Husserlian phenomenology and scientific realism. *Philosophy of Science* 54: 222–232.

Rueger, Alexander. 2005. Perspectival models and theory unification. *The British Journal for the Philosophy of Science* 56(3): 579–594.

Sellars, Wilfrid. 1963. *Science, perception and reality*. London: Routledge and Kegan Paul.

Smith, Joel. 2016. Experiencing phenomenology: an introduction. London: Routledge.

Sokolowski, Robert. 2000. *Introduction to phenomenology*. Cambridge: Cambridge University Press.

Suarez, Mauricio. 2003. Scientific Representation: Against Similarity and Isomorphism. *International Studies in the Philosophy of Science* 17(3): 225–244.

Teller, Paul. 2001. Twilight of the perfect model model. *Erkenntnis 55*(3): 393–415.

Vallor, Shannon. 2009. The pregnancy of the real: a phenomenological defense of experimental realism. *Inquiry: An Interdisciplinary Journal of Philosophy* 52(1): 1-25.

Van Fraassen, Bas C. 1980. *The scientific image*. Oxford: Oxford University Press.

Van Fraassen, Bas C. 1985. Empiricism in the philosophy of science. In *Images of science: essays on realism and empiricism, with a reply from Bas C. van Fraassen*, edited by Paul Churchland and Clifford Alan Hooker, pp. 132–152. Chicago: University of Chicago Press.

Van Fraassen, Bas C. 2001. Constructive empiricism now. *Philosophical Studies 106*(1): 151–170.

Van Fraassen, Bas C. 2008. *Scientific representation: paradoxes of perspective*. Oxford: Clarendon Press.

Weisberg, Michael. 2007. Three kinds of idealization. *Journal of Philosophy* 104(12): 639–659.

Wiltsche, Harald A. 2012. What is wrong with Husserl's scientific anti-realism? *Inquiry: An Interdisciplinary Journal of Philosophy* 55(2): 105-130.

Wiltsche, Harald A. 2017a. Mechanics lost: Husserl's Galileo and Ihde's telescope. *Husserl Studies* 33(2): 149-173.

Wiltsche, Harald A. 2017b. Science, realism and correlationism: a phenomenological critique of Meillassoux' argument from ancestrality. *European Journal of Philosophy 25*(3): 808-832.

Wiltsche, Harald A. and Philipp Berghofer. 2020. *Phenomenological approaches to physics*. Cham: Springer.

Wolff, Johanna. 2020. Representationalism in measurement theory: structuralism or perspectivalism? In *Understanding perspectivism: scientific challenges and methodological prospects*, edited by Michela Massimi and Casey D. McCoy, pp. 109–126. New York: Routledge.

Zahavi, Dan. 2003. Husserl's phenomenology. Stanford, CA: Stanford University Press.