Entity Realism Meets Perspectivism

Abstract: Relying on the notion of 'overlapping perspectives', this paper argues that entity realism and perspectivism are complementary. According to entity realism, it is justified to maintain a positive attitude toward the existence of unobservable entities with which multiple experimental interactions are possible. Perspectivism also explains that our beliefs about these entities are bounded by historically contingent theoretical and instrumental perspectives. The argument of the paper is developed through a discussion of Ronald Giere's versions of realism: entity realism, constructive realism, and perspectival realism.

1 Introduction

Various brands of scientific realism have thus far been proposed in the literature, including entity realism, structural realism, constructive realism, referential realism, transcendental realism, perspectival realism, and the like. The differences between these views are sometimes confusing for outsiders, and even for philosophers of science. One might argue that there is no consensus among realists about which scientific knowledge deserves realist commitment. This state of affairs makes a commitment to any realist view somewhat precarious. That said, realists can respond that versions of realism are in many cases compatible and complementary. Thus, one of the tasks of the realist is to synthetize realist views. In this regard, for instance, Chakravartty (2007, chapter 2) argues for an integration of entity realism and structural realism, and Ronald Giere explains that constructive realism and perspectival realism focus on two facets of one view (see the next section). Analogously, the present paper argues that perspectival realism and entity realism are

complementary. Thus, contemporary perspectivists and entity realists can benefit from each other's valuable ideas for the purpose of acquiring a more comprehensive and compelling view.

Given that most proponents of perspectivism, such as Ronald Giere (1999; 2006a), Michela Massimi (2022), and Paul Teller (2020), subscribe to realist attitudes, it is quite straightforward to claim that perspectivism and realism are compatible. But the paper defends a more specific claim: perspectivism and entity realism complement each other. This is significant to the scientific realism debate because, first, to my knowledge, entity realists such as Ian Hacking, Nancy Cartwright, Matthias Egg, Markus Eronen, and Bence Nanay have not discussed perspectivism (on entity realism, see Egg 2018; Khalili 2023). Second, there are perspectivists who explicitly deny (entity) realism. Bas van Fraassen, who is sympathetic to perspectivism in his *Scientific Representation: Paradoxes of Perspective* (2008), notoriously has issues with (entity) realism. Also, Michela Massimi, who defends perspectival realism, has criticized (an early version of) entity realism in her 2004 paper. A further benefit of synthesizing entity realism and perspectivism is that their integration solves problems the two views cannot handle separately. In particular, the paper argues that perspectivists should take seriously the epistemological role of 'overlapping perspectives' in order to explain the cases in which an underlying nature transcends a number of perspectives, thereby resulting in an entity realist version of perspectivism. In addition, my answers to the criticisms of entity realism are in agreement with perspectivism, implying a perspectivist reading of entity realism.[1]

[1] Khalili (2022b) argues for the integration of perspectivism and entity/experimental realism on the basis of phenomenological-hermeneutical approaches. The present paper does not pursue these

What is more, thus far Giere's versions of realism have not been studied in any detail. The paper fills this gap by discussing his entity realism, constructive realism, perspectival realism, and their mutual relations. His views on scientific realism provide a basis to reconcile entity realism and perspectivism. In this regard, the concept of 'overlapping perspectives' is of central importance. This concept, which surprisingly does not play an essential role in Giere's epistemological view, can epistemically ground our beliefs in the reality of entities. Moreover, it allows us to see a significant affinity between entity realism and perspectivism.

The paper proceeds as follows. Sections 2 provides an account of Giere's contribution to the scientific realism debate. Sections 3 bridges the gap between the concepts 'robustness' and 'overlapping perspectives', and accordingly it distinguishes between three meanings of objectivity. Section 4 explains the relationship between perspectivism and entity realism. It also briefly discusses Chakravartty's criticism of perspectivism and compares my proposal with Massimi's perspectival realism.

2 Giere's Versions of Realism

Chapter 5 of Giere's *Explaining Science: A Cognitive Approach* (1988) argues that the scientific knowledge that results from appropriate experimental uses of unobservable entities such as protons and genes deserves realist commitment. This view has been considered to be an early development of 'entity realism' (Chakravartty; 2017a, section 2.3; 2017b, p. 29, n. 9). At the same time, Giere

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approaches, but supports the same proposal. This paper, instead, relies on the notion of 'overlapping perspectives'.

supports 'constructive realism' in chapter 4 of *Explaining Science*. In *Science without Laws* (1999), he advances the case for constructive realism, and also suggests the notion of 'perspectival realism', which is further developed in *Scientific Perspectivism* (2006a). One may ask about the relationship between Giere's entity realism, constructive realism, and perspectival realism. In what follows, I explain his versions of realism and their relations with each other.

In chapter 5 of *Explaining Science,* Giere studies the Indiana University Cyclotron Facility (IUCF), where scientists investigate "the structure of the nucleus by bombarding various nuclei with rapidly moving light nuclei, mainly protons, and seeing what comes out" (1988, p. 111). He argues that particles such as protons are real entities because they are produced and used as research tools. Protons with roughly the properties that physicists attribute to them are employed as tools in other research. They are as real as other technologies employed in exploring the nuclear structure. Scientific knowledge of protons is indeed embodied in technologies that contemporary experimenters use to investigate other particles. If we take it that protons with their properties are not real, we should also be skeptical about the correctness of what is happening in other investigations that use protons as research tools.

> These nuclear physicists are producing protons with desired characteristics, such as energy, and then using them, together with other particles, to investigate the properties of various nuclei. To say that they are "producing" and "using" protons implies that protons exist. … The judgment about protons seems to me one whose correctness we should take as a basis for further explanations of what is going on in the laboratory. The judgment is not itself problematic. (1988, p. 125)

Giere criticizes those authors who ignore or downplay the distinction between entities used as "research tools", such as protons, and the "objects of current study", the objects that are still under investigation. For instance, the details of nuclear structure, as an object of current study at IUCF, is investigated by means of protons, as research tools. We might not be justified in our consideration of the objects of current study as real and might count them as "theoretical"; however, the entities that are used as research tools are justifiably real. Ignoring this distinction, according to Giere (1988, p. 127), shows the "empirical failing of both empiricism and constructivism" in that they neglect *the distinction that is central to the actual scientific practice*. As a result, he (1988, p. 128) counts Bas van Fraassen's (1980) account of science, in which this distinction is not taken seriously, as empirically inadequate. This distinction is so critical that scientific progress (at least partly) depends on the use of the objects of current study as established research tools in novel future investigations.

> The proton was once among the most theoretical of particles. Scientists had real questions about the reality of any such thing. Now the proton has been tamed and harnessed to the equipment used to investigate other particles and structures: quarks, gluons, and the shell model of the nucleus. Thus, some of what we learn today becomes embodied in the research tools of tomorrow. That is undeniable progress of a very different, and very important kind. (1988, p. 144)

Giere's study of experimental work provides an epistemological criterion for establishing real entities. Besides, he develops 'constructive realism' so as to show that his realist view "can be

formulated as a coherent thesis that is neither vacuous nor obviously false" (see 1988, p. 92).[2] He describes constructive realism as a realist alternative to Van Fraassen's constructive empiricism (see Giere 1985; 1988, p. 93; 1999, p. 150). Constructive realism is in agreement with constructivism, the view that scientists (socially) construct scientific models. "Nature does not reveal to us directly how best to represent her" (1988, p. 93), but nature manifests itself through human-*made* models. The result is "constructive realism", a realist view that takes into account the fact that model building is a deliberate activity (1988, pp. 92-93). Accordingly, scientific categorization is a human process. At the same time, it may represent the real differences of things in nature.

> The categories we use are to some extent constructed by us. Nevertheless, scientists can sometimes legitimately claim genuine similarities between their logical constructs and aspects of reality. That makes me some kind of realist rather than a social constructivist. (Giere 1999, p. 150)

Giere's main point in his constructive realism is that scientific models are constructed yet still representations of reality. A material model such as the metal model of DNA replication originally proposed by Watson and Crick is built in the same way as a material object such as a table is built. However, a table does not represent something else, but Watson and Crick's model does. Furthermore, compare abstract models (such as the Bohr model of the atom) with abstract social constructs such as money or the concept of currency. Money, despite the material existence of

[2] Theo Kuipers (2000) has also developed a (different form of) "constructive realism".

banknotes and coins, is not concrete.[3] Many mathematical models used in physical or biological sciences are similarly abstract constructs. The difference between money and these models is that there are things in reality that are (at least claimed to be) represented by the elements of the models, while money does not (or is not even claimed to) represent something else. Please note that there is no controversy over the fact that constructs are themselves real (they are not unreal, illusory, or hallucinatory). The point is that some of these constructs, namely models, represent reality, but others do not.

Thus, scientific models are built actively, and at the same time they *represent* reality. According to Giere, the representational character of models supports realism. There is some degree of *similarity* between models and aspects of the objects of inquiry. Aspects of similarity exist not only between models and observable phenomena, but also between models and unobservable entities such as protons: "scientists legitimately make claims also about the hidden causal structure of the world. Thus, constructive *realism*" (Giere 1999, p. 150).

The argument for this claim is the same as the one that supports *entity* realism. Those unobservable aspects of models that are used as research tools should be considered to be real in order for experimenters to rely on the results of their further investigations. In my view, a kind of transcendental argument is deployed here. That is, the condition of possibility for the reliability of the results of experimental investigations is that contributing research tools work well. An

[3] My interpretation of money assumes the credit theory, which says that "coins and notes are merely tokens of something more abstract: money is a social construction rather than a physical commodity" (De Bruin et al. 2020, section 1.1).

unobservable entity, as a research tool, cannot be effective in the laboratory if it is non-existent or merely mental.

More generally, Giere invokes the many successes of technologies against (social) constructivists' antirealism. Those scientific representations that are used significantly in the process of producing successful technologies manifest aspects of reality. For instance, engineers make use of scientific representations of electrical paths for manufacturing computers: "The success of these endeavors, and the reliability of the product, prove beyond any reasonable doubt that there has got to be something right about these representations" (1999, p. 60). This argument is similarly transcendental: the condition of the possibility of successfully manufacturing computers is that the representational character of electrical paths is to some extent right. In other words, working computers cannot be manufactured if there is nothing right about the representational character of electrical paths (provided that these representations genuinely contribute to manufacturing computers).

Although I prefer to understand Giere's argument as transcendental, it can also be reconstructed as a kind of No-Miracle Argument, according to which realism is the only philosophical interpretation that can explain the successes of modern science. Giere insists on the *technological successes* of scientific research. According to this interpretation, it would be miraculous if, say, scientific representations of electrical paths were not similar to aspects of reality but technologies based on these representations worked successfully nevertheless.

Giere's perspectival and constructive realism are similar views which emphasize different points. The emphasis of the latter is on the *constructive* features of scientists' model-building, whereas the former stresses that *aspects* of the world are *represented* by constructed models.

> *Perspectival Realism*, finally, is a later development of constructive realism. The constructive element remains as before. The difference is the insistence that our theories do not ever capture the totality of reality, but provide us only with perspectives on limited aspects of reality. Scientific knowledge is not absolute, but perspectival (Giere 1999, p. 150; see also 2006a, p. ix; p. 118, n. 13).

Scientific perspectivism also entails what is *unavailable* for human beings as a result of their scientific practice: the 'totality of reality' is inaccessible, a 'complete' image of the world that represents 'all aspects' of real things is unattainable, an 'ultimate' knowledge of reality that avoids any historical contingency is beyond human conditions, one cannot present things from 'no perspective whatsoever', scientific knowledge that is 'independent of all perspectives' is unreachable. Still, perspectivism, or at least a *realist* version of perspectivism, concludes that it is reality that is presented from one or several perspectives. The point is that these representations are bounded by instrumental, theoretical, and historical conditions. In the following, I explain three interrelated types of perspectivism that are visible in Giere's work: (1) instrumental perspectivism, (2) theoretical perspectivism, and (3) historical perspectivism.

First, instrumental perspectivism maintains that human knowledge of reality depends on the mediation of bodily-sensory apparatuses and technological instruments. The way that human beings ordinarily experience the world is colored by specific perspectives. That is, the way we ordinarily perceive the world is bounded by the biological conditions of our eyes, which are sensitive to, e.g., three colors, and to the conditions of our neural system that contribute to analyzing input signals. If we possessed different apparatuses, we would experience the world differently. If human eyes evolved like a fish called Skate, whose eyes have no cone photoreceptors, we would see only in black and white. If human eyes had only two types of cones,

we could distinguish colors in the way dogs and cats do. Our experience would also be different if our eyes had four types of cone cell. As a result, our ordinary vision is conditioned on the instrumental characteristics of our visual system. In like manner, the outputs of scientific instruments are conditioned on their specific features, such as what they are sensitive to or how they analyze input data to produce outcomes. For example, a gamma-ray telescope is responsive only to gamma rays, or a CAT scan only shows the structure, rather than the function, of the brain. The analyzing processes of different instruments may also be different. For instance, the statistical analyses employed in producing neuroimages from noisy signals are different from the machine learning techniques employed in the analysis of astrophysical detector data. Thus, since humans always experience the external world by means of (embodied or technological) instruments, they can experience neither ordinary objects nor scientific entities without the mediation of this instrumental perspective (Giere 1999, pp. 79-81; 2006a, chapters 2 and 3).

Second, according to theoretical perspectivism, scientific knowledge is conditioned on qualified models. For this reason, a representation of all aspects of a real object is impossible. Scientific models are similar to maps. Different maps, for instance a subway map, a flat map, a neighborhood map or a geological map, are deliberately constructed, each from a different perspective, to represent specific aspects of a territory (1999, pp. 26, 81-82 and 214-215; 2006a, pp. 73 and 76-78). In a similar fashion, different models of an entity can be constructed to represent different aspects of a single entity. Reality is complex, and no model can fully represent all aspects of a real entity. Scientists create different theoretical models of entities, depending on the distinct problems they encounter. Take water, for example. A molecular perspective, in which water consists of particles, is employed to account for its Brownian motion. However, water is a continuous fluid according to the hydrodynamic model, which accounts for the flowing behavior

of water. These two inconsistent models represent two different behaviors of water from different perspectives. Each model fits specific aspects of water. Neither explains all behaviors of water (Giere 2006b, 33-340).

Finally, historical perspectivism is usually based on an interpretation of Thomas Kuhn's historicism (see Giere 2013). Michela Massimi describes this form of perspectivism thus: "our scientific knowledge is *historically situated*, that is, it is the inevitable product of the historical period to which those scientific representations, modeling practices, data gathering, and scientific theories belong" (Massimi 2018, p. 164). Giere acknowledges a realist version of historical perspectivism, according to which we should see neither the outputs of contemporary instruments nor scientific representations of current models as ultimate images of reality, even though scientific instruments and models do manifest aspects of reality. Thus, scientific knowledge is always bounded by historically available instruments and models, and future instruments and models augment our current knowledge of reality.

Historical perspectivism can provide an answer to the pessimistic induction, an objection to realism according to which current theoretical concepts do not refer to real entities, just as abandoned theoretical concepts such as the ether have turned out to be non-referring (Laudan 1981). According to Giere, the fact that the ether does not exist does not imply that ether models are not, in some respects, similar to reality. "Whether the ether exists or not, there are many respects in which electromagnetic radiation is like a disturbance in an ether." (1988, p. 107) Current perspectives are more advanced than past ones in manifesting aspects of reality. However, abandoned models are successful to the extent that they represent aspects of reality.

Thus far I have explained different facets of Giere's realism. He is realist about the scientific representations of entities employed in designing technologies, hence his entity realism. Giere's

realism is not extreme but modest, and it is consistent with constructivism inasmuch as scientific models are (socially) constructed by scientists. It is also compatible with perspectivism insofar as the construction of scientific knowledge is bounded by historically available instrumental and theoretical conditions. Below I will further discuss entity realism and perspectival realism. As stated, perspectival realism is a development of constructive realism. Accordingly, a separate discussion of constructive realism is no longer necessary. Section 3 explains how the concept of 'overlapping perspectives' helps avoid criticisms against both entity realism and perspectival realism, hence adding this concept contributes to a more resilient account of realism.

3 Overlapping Perspectives

3.1 Reality and overlapping perspectives

A criticism of entity realism is that it is only realist about those entities that can be used as manipulable research tools. Thus, Hacking (1989) is antirealist about astronomical entities that cannot be used as such tools. However, one can argue that to be realist in cosmology, biology, neuroscience, and so on, one does not need to presuppose that real entities can always be used as manipulable research tools (see Radder 1996, pp. 91-92). In general, there are real entities, which we have good reason to believe in, but some of these slip through the net of entity realists (Shapere 1993).

In response, entity realists can employ the criterion of reality as *robustness*, a more inclusive epistemological criterion that can be applicable to claims about astronomical, biological, neurological, or other scientific entities. The same idea forms the basis of Hacking's argument from coincidence, according to which, for instance, when a number of microscopes whose working

is based on different mechanisms detect a microscopic entity, one is justified to believe in the entity (1983, p. 201; 1985, pp. 146–147). Hacking does not develop this argument in order to further support realism, e.g., about astronomical entities. However, scholars such as William Wimsatt (2007) and Markus Eronen (2015) have significantly advanced the idea of robustness. According to Eronen, "X is robust in the relevant scientific community at a certain time insofar as X is detectable, measurable, derivable, producible, or explanatory in a variety of independent ways" (2015, p. 3967; see also 2017). X is a thing, including an unobservable entity, a property, a phenomenon, or even an ordinary object.[4]

A fairly similar concept to robustness, which can be found in Giere's *scientific perspectivism*, is the notion of 'overlapping perspectives'. When several independent instruments manifest the same fact, 'overlapping instrumental perspectives' are available (2006a, pp. 57-58). When assuming that a fact plays an explanatory role in several theories, 'overlapping theoretical perspectives' are at work (2006a, p. 92). Giere considers the evidence achieved from overlapping perspectives as good evidence, which is still perspectival.

> the same object can often be observed from several different perspectives, such as a nearby galaxy observed by both optical and radio telescopes. This is indeed good evidence that there is "something" there, but that is scarcely knowledge in the objectivist sense. The knowledge we get comes from one perspective or

[4] It is 'evidence' that is usually described as 'robust' in the literature. However, 'entities', 'properties', 'phenomenon', and 'ordinary objects' can also be called 'robust' when they are supported by robust evidence.

> another, not from no perspective at all. Multiplying perspectives does not eliminate perspectives. (2006a, p. 92; see also pp. 57-58)

The role of robustness or overlapping perspectives is not essential to the *epistemology* of Giere's realism. He introduces overlapping perspectives as an "important *methodological* strategy" (2006a, p. 58; emphasis added). He discusses overlapping perspectives not to develop his epistemological thesis, but to argue against the claim that overlapping perspectives provide the condition of being viewed from nowhere.

I suggest that Giere's criterion that real entities should be employed in designing technologies should be understood as a specific case of the criterion of robustness. When an entity is produced and used in a technological facility, the entity is probably real. Our confidence in the reality of the entity increases if the entity is produced in a variety of independent ways. Giere agrees that using protons in the cyclotron facility should not be considered to be "a single isolated action", but that we should take account of

> the process of designing and performing hundreds of experiments, the process of designing, building, and maintaining a cyclotron facility over a period of years, and so on and on. As a result of this continuing and varied experience, contemporary nuclear physicists never even think about questioning the existence of protons or wonder whether they have adequate evidence for their beliefs about protons (1988, p. 129).

Accordingly, protons are real not merely because one can produce and use them in one specific kind of experiment, but their production is based on a variety of mechanisms provided by independent perspectives. In other words, protons are robust, so they are justifiably real.

I agree with Giere that humans cannot perceive or know independently of perspectives. In other words, to be perspective-independent, a thing should be observed or known independently of any instrument, (theoretical) concept, and historical contingencies. Human beings are embodied, so they cannot perceive without the mediation of any (embodied or technological) instrument. Their (scientific) knowledge is conceptual, so they cannot be free from (theoretical) concepts. And they are temporal beings, so they cannot be independent of historical contingencies. Thus, although overlapping perspectives together provide a broader perspective than each of their constituent members, they still depend on some common instrumental, theoretical, and historical conditions of their constituent perspectives. In other words, perspective$_1$ and perspective$_2$ jointly provide a broader perspective which does not exclusively depend on the particular conditions of perspective$_1$ and perspective$_2$, but is still conditioned on the common features of these two perspectives.

After all, the *validity scope* of several perspectives is still bounded. Let me explain this by the concept of 'nonlocal patterns'. Radder (1996, p. 84) argues that the observational/experimental results are not 'universally' valid. The results may still be bounded by some conditions that are 'nonlocal'. This is similar to the view that overlapping perspectives do not present 'non-perspectival' knowledge. Further, according to Radder, observational/experimental results are not local either, since the results of replicable experiments/observations transcend local circumstances (see 1996, section 5.4). In perspectivists' terms, replicable observations/experiments provide overlapping perspectives and not simply a single perspective. All in all, observational/experimental results are neither local nor universal. The fact that they are not universal implies that they do not provide a non-conditional or non-perspectival image of reality.

While our knowledge of an entity is always bounded by perspectives, the concept of 'overlapping perspectives' can provide an epistemological criterion for our confidence in the

reality of entities and their properties *in the nonlocal scope provided by overlapping perspectives*. This bounded criterion is a matter of degree. The degree of our confidence in the reality of the entity depends on the degree of robustness that different perspectives, from which the entity is detectable, provide.[5] According to the criterion of overlapping perspectives (or robustness), one can show that entities in astronomy, biology, neuroscience, and so forth, can be real. It might be impractical to make use of all real entities to design and manufacture technologies, but it is highly practical to explore an entity from independent perspectives. Evidence obtained from independent perspectives can justifiably demonstrate whether or not an entity is real.

Another common objection to entity realism is that it is incoherent to believe in an entity without also believing in the theory describing the entity (see, for instance, Psillos 1999, pp. 248-249). Accordingly, one cannot separate knowledge of the existence of scientific entities from their theoretical descriptions, because the properties of scientific entities are always described by theoretical concepts. On the other hand, Giere (1988, p. 124) would respond that entities should be separated neither from their properties nor from the theoretical models describing them. For instance, protons possess mass, charge, and momentum, which are described by the Standard Model of particle physics. This response is compelling *if it also maintains the perspectival features of scientific knowledge*. A robust entity or property is real inasmuch as nonlocal overlapping perspectives support it. Still, the theoretical descriptions of those entities and their properties

[5] I stress that 'overlapping perspectives', 'robustness', and different meanings of 'objectivity' (which I will define in the next subsection) are all *epistemological* terms in that they provide a criterion for our *confidence* in or a *justification* for the reality of things.

depend on some theoretical perspective. The justified yet fallible belief that an entity or its properties exist is obtained on the basis of overlapping perspectives. Nevertheless, the entity or its properties always need to be described by some specific theoretical perspective.

3.1 Objectivity and overlapping perspectives

This subsection clarifies the relationship between 'overlapping perspectives' and 'objectivity'. For this purpose, the different meanings of the notion 'objective' should be distinguished. I call the first notion objective$_1$, which implies being viewed from nowhere, or in other words: being universal in the sense of being independent of all local conditions. However, according to perspectivism this kind of objective observation or belief is unavailable forever, because our observations and beliefs are always bounded by a range of instrumental, theoretical, and historical perspectives.

'Objective$_1$' is quite different from Alan Chalmers's (1990, chapters 4 and 5) conception of objective, which I call 'objective$_2$', according to which observation is *achieved* as a result of practical activities of observers, hence his term 'observation objectified'. Chalmers's objectified$_2$ observation either is achieved or not achieved. If objectifying procedures that help observers to purify their beliefs from subjective errors have been correctly employed, the observation is objectified$_2$. To be reliable, experimental/observational results should be objective$_2$. Chalmers maintains that objectified$_2$ results are fallible due to the theory-ladenness of observation, but this leads neither to subjectivism nor to relativism. It only shows the fallibility of objectivism$_2$. The requirement that experimental/observational results should be objectified$_2$ is compatible with the

rejection of objectivism$_1$, because an objectified$_2$ belief or observation is still conditional on the validity of a number of presupposed theories and employed instruments.

I suggested that the concept of 'overlapping perspectives' or 'robustness' can be used to develop perspectivists' *epistemological* criterion for reality. In this regard, I introduce a third notion of objective, that is, objective$_3$: 'being confirmed by a variety of different perspectives'. Inasmuch as an observation transcends the particularities of single perspectives, the objectivity$_3$ of the observation, and accordingly our justification for the belief in the thing observed, increases. Although the observations or beliefs that are confirmed by multiple independent perspectives can still be false, we can justifiably rely on them to develop scientific knowledge.

Although Giere does not speak of the epistemological criterion of 'overlapping perspectives', textual evidence suggests that he *would* accept that additional perspectives can increase the objectivity$_3$ of an observation. About seeing a building from different angles and distances, he asserts: "Additional objectivity can be built into this example by imagining a series of photographs taken from different viewpoints" (1999, p. 80). Here, he is indeed ascribing objectivity$_3$ to *observations*. Objectivity$_3$ can also be ascribed to *experiments*; and subsequently to our *beliefs* in the things observed/detected in observations or experiments. Furthermore, when experiments or observations are performed in a variety of independent domains, the plausibility of *theories* that are tested also increases (see Radder 2012[1984/1988], p. 76).

Objectivity$_3$ is a matter of degree. The more our observational/experimental results transcend local conditions, the broader perspective the local perspectives together provide, the more objective$_3$ our beliefs in the represented things is. In sum, although our belief in a thing cannot be objective$_1$, it should be objective$_2$, and it can (and should) satisfy a (high) degree of objectivity$_3$. See the following table for three meanings of objectivity regarding beliefs (and observations).

Objectivity$_1$ (which Giere denies)	Being viewed from nowhere or being independent of all local conditions
Objectivity$_2$ (which Chalmers supports)	Being purified from subjective errors and biases
Objectivity$_3$ (which I suggest based on "overlapping perspectives")	Being confirmed by a variety of independent perspectives

4 Entity Realism Meets Perspectivism

The affinities between 'robustness' and 'overlapping perspectives' help to understand entity realism and perspectivism as two complementary theses. Entity realism specifies which aspects of our knowledge claims deserve realist commitment. whereas perspectivism sheds light on the role of theoretical, instrumental and historical conditions and contingencies in scientific discoveries. In other words, entity realism maintains that the experimental interaction with the world supports realism. Thanks to the epistemological role of 'overlapping perspectives', perspectivism can agree with entity realism. Perspectivism can also further explain the conditions and boundaries of how humans interact with (physical) reality.

First of all, instrumental perspectivism explains that instruments provide perspectives to represent aspects of entities by observing, detecting, or producing their properties. If the observation or detection is made by means of a number of independent perspectives, (the property of) the observed or detected entity is robust and thus real, even if the observational or experimental results are still bounded by nonlocal conditions of the relevant observation or detection.

About theoretical perspectivism, let me first make two statements in a Kantian vein: experimental interactions with entities are blind if the entities are not theoretically interpreted by concepts and models; conversely, theoretical concepts and models that are not, ultimately, connected to reality are empty. Theoretical perspectivism insists on the first statement that discovered entities are always described and interpreted by concepts and models. Entity realism and the idea of 'overlapping perspectives' emphasize the second side: theoretical terms refer to entities inasmuch as observers or experimenters rely on multiple interactions with reality.

Finally, experimental results and theoretical interpretations are bounded by historically available perspectives. Accordingly, "robustness is clearly a fallible criterion that is relative to a certain scientific community at a certain time" (Eronen 2015, p. 3966). This is explicitly sympathetic to the spirit of historical perspectivism. A relevant point is that historical perspectivism should not be understood in a relativist way, because according to the idea of 'overlapping perspectives', there can always be a certain degree of continuity or persistence among historical perspectives. Another point is that current perspectives are typically broader than past ones, hence scientific progress.[6] Therefore, if a scientific community at a given period of time lacks the technologies necessary to manifest an entity, or is bereft of the theoretical concepts necessary to describe it, the entity remains either unrecognized or unarticulated at that period. Future instruments may manifest that entity or its other properties. Future theories may also

[6] See Giere (2006a, p. 94). See also Davis Baird's and Thomas Faust's 1990 paper, where they argue that scientific progress relies on the advancement of technological instruments and the accumulation of instrumental techniques.

describe aspects of the entity differently and better than current ones (see also Khalili 2022a, chapter 6).

According to our current scientific knowledge, robust entities will probably be acknowledged as real in future science. However, there is "no guarantee that things that are considered robust based on the current state of science are real, as arguments such as pessimistic induction purport to show" (Eronen 2015, p. 3966). Thus, realist claims are made about those entities and properties that satisfy the criterion of robustness. Be this as it may, one should not expect that the epistemic warrant the criterion of robustness provides will be without any future defeaters. According to historical perspectivism, the strongest prospective claim an entity realist can make is that we are justified to think that robust entities may remain in the future of science. The least risky bet one can make on the future of science is betting on the reality of highly robust scientific entities, which have been explored through independent perspectives.

Another consequence of historical perspectivism is that the level of our confidence in an entity's existence differs in different periods. Since more technological facilities and theoretical resources are available today than in the past, current scientists are (and should be) more rigorous than past ones when recognizing the reality of entities. Still, it does not follow that current scientists can determine the reality of entities beyond any perspective, because, after all, current science is conditioned on current (and past) technological and conceptual resources.

In the remainder of the paper, Chakravartty's (2017b, section 6.3) criticism of perspectivism is addressed, and then, Massimi's (2022) perspectival realism is briefly compared with my proposal. According to Chakravartty, perspectivism about ontology is implausible because of three concerns: instability, irrelevance, and incoherence. First, 'perspectival ontology' collapses under scrutiny into non-perspectivist views. Second, although there are ways in which scientific practice

is considered to be perspectival, they are irrelevant to ontology. Third, some interpretations of perspectivism requires believing in incompatible realities, which is implausible.

In the first place, my entity realist version of perspectivism is not unstable. In particular, it does not collapse into a realist view that considers our beliefs in real entities to be objective$_1$. Still, it clearly incorporates entity realist attitudes, and for this reason it agrees with the following criticism against a non-entity realist version of perspectivism.

> The outputs of telescopes which are sensitive to radiation emanating from distant galaxies are represented in glorious color images that are produced by arbitrarily assigning colors to different wavelengths of radiation. But once again, if the visual images formed in either case, though variable, are taken to represent one and the same thing, it follows that belief in the existence of that thing is not context-relative … A more pressing mater is whether anything can be said about what these objects of detection and measurement are like, and here we have an illustration of the sort of instability and collapse suggested above. In some cases we have underlying or background knowledge that allows us to infer from different representations of things to an underlying nature that transcends perspectives (Chakravartty 2017b, p. 183).

In case of the representation of 'one and the same thing' by different instruments or that of 'an underlying nature that transcends perspectives', perspectivists should take seriously the epistemological role of 'overlapping perspectives' or 'robustness', which results in an entity realist

version of perspectivism. After all, first, antirealist perspectivism is problematic,[7] and second, realist perspectivism is inspired by entity realism. At the same time, the objectivist$_1$ version of realism can be avoided. The 'underlying nature' transcends *available* perspectives; it does not transcend all perspectives whatsoever. Chakravartty seems to equate "a way that goes beyond the perspective in which it is generated" with "perspective-independent" (2017b, pp. 183–184). However, the way that goes beyond the perspectives in which a number of representations are generated does not result in perspective-independent observations or beliefs. Inasmuch as we are bounded human beings, we can never determine whether something is independent of *any* perspective whatsoever. There may always be some theoretical or instrumental conditions that have not been taken into account. In this sense, therefore, it makes little sense to claim that something is perspective-independent. For example, different earth-based or astronomical setups have so far measured the speed of light in a variety of independent ways. These measurements demonstrate that the constancy of its speed is a 'robust' property of light. However, this constancy is valid only *within the validity scope of* special relativity theory. The speed of light is not constant in any perspective whatsoever. The broader perspective of general relativity theory enables us to see the bounded validity of the constancy of the speed of light. Similarly, prospective theories may

[7] Van Fraassen's perspectivist ideas (see, for instance, 2008, pp. 69–72, 84–87, and 175–176) and their role in his sophisticated philosophical view about science, which is also empiricist and structuralist, need to be studied in detail elsewhere. However, insofar as his perspectivism falls short of taking account of 'overlapping perspectives', it could be criticized.

provide broader perspectives, revealing some perspectival features or bounded validity of the general theory of relativity (see Khalili 2021; 2022a, section 7.5).

My view does not collapse into a deflationary account of scientific ontology either. This account regards metaphysical presuppositions of scientific theories to be indicative of something other than ontology, such as conventions (see Chakravartty 2017b, section 1.2). In my view, however, robust entities and properties can be justifiably considered to be real. Be that as it may, our beliefs in these entities are bounded by conditions. And thanks to historical perspectivism, our ontological beliefs in real entities change inasmuch as the construction of technological instruments and theoretical models broadens our perspectives in the course of history.

In reaction to the concern that perspectivism is irrelevant to ontology I should first stress that my view is primarily epistemological. It concerns our justification to believe in theoretical entities and their properties. Our beliefs have no influence on, and in this sense it is irrelevant to, independent reality. On the other hand, my view carries implications for onto*logy,* as the philosophical *study* of reality. A perspectivist denial of objectivity$_1$ implies that the notion of 'non-perspectival ontology' is problematic. Although reality is independent of human perspectives, our beliefs about reality are always conditioned by available perspectives. Thus, our ontological study of reality is also perspective-dependent, which means that onto*logy* relies on objective$_3$ (and not objective$_1$) observations and beliefs.

Finally, my proposal does not entail 'incompatible realities'. According to the criterion of 'overlapping perspectives' or 'robustness', realist attitudes are maintained only toward those entities and properties that are manifested compatibly through independent perspectives. Incompatible representations cannot justifiably be taken as those of real entities and properties.

Let us now briefly discuss Massimi's view. In spite of her earlier (2004) dissatisfaction with early entity realism, *Perspectival Realism* (2022) has affinities with the 'robustness' version of entity realism, and thus with the proposal of the present paper. She writes: "My case for perspectival realism rests ultimately on the ability to assess reliable scientific knowledge claims *across a plurality of scientific perspectives*" (2022, p. 5). This statement can be reconstructed in harmony with my proposal: the plurality of scientific perspectives constitute 'overlapping perspectives' and the knowledge claims that stand up across these perspectives enjoy 'objectivity$_3$'. What is more, the very concept of robustness is incorporated in Massimi's realism, which primarily concerns "*modally robust phenomena*" (2022, pp. 74-75; see also chapter 6). A phenomenon is *modally* robust when we can know its possibilities and conceivable scenarios in different contexts (on modal knowledge, for instance, see her 2022, pp. 123–125). A variety of historically and culturally situated scientific communities help to infer a modally *robust* phenomenon from a diverse range of datasets over time (2022, pp. 12–16).

Massimi advocates 'a phenomena-first approach to ontology' (2022, subsection 6.7.2), asserting that "the realism emerging from perspectival modelling is not realism about unobservable entities or similar. It is realism about phenomena" (2022, p. 15; see also p. 70). This realist attitude about *phenomena*, rather than entities and properties, might seem to make an essential difference between her perspectival realism and my entity-realist-perspectivism. The difference can be reconciled, however. My repudiation of objective$_1$ beliefs and observations agrees with her Kantian stance that takes phenomena, and not 'things in themselves', as the objects of scientific ontology (Massimi 2011; 2022, chapter 6). Nevertheless, I also suggest that from the empirical evidence obtained in a variety of independent ways of observation, which constitutes 'modally robust phenomena', objective$_3$ beliefs about unobservable entities can be inferred (see also Khalili

2023), which makes possible a fallible and dynamic ontology. Thus, we can employ empirical evidence (or datasets) to infer modally robust phenomena, whose metaphysical presuppositions allow us to infer ontological beliefs about unobservables. In this regard, modally robust phenomena are seen as the primary, and not the only, objects of scientific ontology. They allow us to know which entities and properties may be taken as real. Provided that Massimi's approach is just phenomena-*first* (and epistemology-*first*, see 2022, pp. 15 and 330) and not phenomena-*only* (and epistemology-*only*), the secondary, metaphysical inferences from phenomena to entities and properties are permissible. Arguably, an ontology that suits entity/experimental-realism-cum-perspectivism is that of potentialities (see Khalili 2022a, chapter 2).[8] And, interestingly, this ontology fits the epistemology of modally robust phenomena well. Accordingly, ontologically speaking, reality consists of *potentialities* that can be realized differently in different conditions, and epistemologically speaking, scientific knowledge is *modal* in the sense that it describes the possible scenarios of these potentialities.

The paper has argued that understanding the relationship between the concepts of overlapping perspectives and robustness will help to bridge the gap between perspectivism and entity realism. The experimental exploration of an entity from different perspectives justifies the reality of a given entity. Entity realism explains that (multiple) experimental interactions with entities and their

[8] Chakravartty (2010; 2017b) defends dispositional ontology as a rival to perspectivism. I, however, support a realist ontology about dispositions or potentialities and a perspectivist epistemology regrading instrumentation and modeling. For a criticism of Chakravartty's non-perspectivist account of dispositional ontology, see Khalili (2022b, section 7; 2022a, pp. 213–214).

properties support realism. Perspectivism emphasizes that experimental interactions are bounded by embodied or technological instruments, and are described by means of theoretical concepts. Accordingly, scientific beliefs are made possible by, and at the same time they are bounded by, historically contingent instruments and theories.

The conflict of interest statement

There is no conflict of interest.

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