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ARTICLE

# A Dialogue among Recent Views of Entity Realism

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## Abstract

This paper concerns the recent revival of entity realism. Having been started with the work of Ian Hacking, Nancy Cartwright, and Ronald Giere, the project of entity realism has recently been developed by Matthias Egg, Markus Eronen, and Bence Nanay. The paper opens a dialogue among these recent views on entity realism and integrates them into a more advanced view. The result is an epistemological criterion for reality: the property-tokens of a certain type may be taken as real insofar as only they can be materially inferred from the evidence obtained in a variety of independent ways of detection.

## 1. Introduction

Some portions of our successful scientific theories have turned out in the past to be non-representational. *Selective realists* seek to determine which are the trustworthy parts of our scientific theories, i.e. those that probably represent real entities. An example of selective realism is *entity realism*, according to which certain experimental interactions with unobservable entities, such as electrons and genes, can bring about knowledge that deserves realist commitment.[1] Whether an entity is manipulable, is used as a research tool, or is the cause of an observable effect, are all determined through experimental practice. Therefore, "experimental realism" is sometimes used as another name for entity realism, thus insisting on the entity realists' analysis of the *methodology* of science, which relies on experimentation. In contrast, the term "entity realism" emphasizes the *epistemological* aspect, the fact that we can consider knowledge of entities to be true. Because my discussion is epistemological, I employ the term "entity realism" in the following.

Ian Hacking (1982, 1983), Nancy Cartwright (1983, essay 5), and Ronald Giere (1988, chapter 5) constitute the first generation of entity realists. Hacking first coined the

[1] My use of the term "entity" may differ from how the notion is employed in metaphysics. As will be clarified, entities are considered concrete particulars in this paper.

term entity realism. He suggests that if one can causally manipulate an entity by intervening in other phenomena, one is justified to believe in the existence of that entity. Hacking's slogan is that when one can spray entities (such as electrons), they are real (see, e.g., Hacking 1983, 23). In the second half of his *Representing and Intervening* he develops a complex network of arguments in order to underpin this slogan. His main claim is that our knowledge of an entity's existence can survive even if the theoretical concepts that interpret the instruments or experimental results change. Hacking's argument for this claim is that experimenters can manipulate the entity under investigation to observe its effects. Explicit examples of manipulable entities are those that can be used "as tools, as instruments of inquiry" (Hacking 1989, 578). Cartwright (1983, essay 5) is also known as an entity realist. She makes a distinction between theoretical and causal explanations. Theoretical explanations are based on laws, which can be explanatory without being true. Causal explanations, by contrast, cannot work without being true: "to accept the explanation is to admit the cause" (1983, 99). Accordingly, an entity can play its causal, explanatory role only if it actually exists. Accordingly, Cartwright "believe[s] in theoretical entities" (1983, 89, see also 92) whose causal roles can be established in "direct experimental testing" (1983, 98). In this regard, she agrees with Hacking that "we manipulate the cause and look to see if the effects change in the appropriate manner" (1983, 98).[2] And finally, Giere's (1988) entity realism is fairly similar to Hacking's. He argues that particles like protons are real entities because they are produced and used as research tools. For example, 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. 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.

Below, I discuss the views of Matthias Egg, Bence Nanay, and Markus Eronen, who belong to the current generation of entity realists. My definition of entity realism (i.e., that experimental interactions with unobservable entities can bring about knowledge deserving realist commitment) is inclusive enough to encompass all versions of entity realism. I have not included the concept of "manipulation" in the definition, although it is essential to some accounts of entity realism. A more general concept, such as "experimental interaction," which I have employed, takes into account the views of all entity realists, in particular Eronen, whose view does not primarily depend on manipulation. Note that "experimental interaction" should not be understood too broadly either. That is, *theory* realism—the realist attitude toward most aspects of scientific theories and models that rely somehow on empirical evidence—is not included under the definition of entity realism.

Surely, there are other scholars who are somewhat sympathetic to entity realism as well: for instance, Anjan Chakravartty's semirealism (1998, 2007, chapter 2) and dispositional realism (2017b, section 4.2), Hans Radder's referential realism (1984/2012, part II), and Shannon Vallor's (2009) phenomenological support for realism all have some affinities with entity realism. Nonetheless, my focus in this paper is on those scholars who explicitly consider their views as developments of

[2] Cartwright's later views on causation, and their relations to her entity realist view, could be studied in a future work.

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entity realism. In his chapter on entity realism in *The Routledge Handbook of Scientific Realism*, Egg describes his causal realism as "a modified version of Cartwright's [entity] realism." (2017, 129); Eronen asserts that "I formulate a new robustness-based version of entity realism" (2017, 2341); and Nanay also argues that "the only way entity realists can resist the pull of straight scientific realism about theories is by endorsing ... [his] singularist semirealism" (2019, 499).

A merit of the current accounts of entity realism is that they begin from the promising but vague insights of early entity realists and make them precise by drawing conceptual distinctions, by discussing the implications of the claims, by providing further arguments, and by developing the theory in a way that avoids earlier objections. The development of entity realism is valuable because, despite quite a few realists who have dismissed the insights of entity realism, sometimes rather quickly, recent entity realists acknowledge and advance these insights. In the following sections, I will explain how a modified version of entity realism can circumvent usual criticisms. In particular, I address the criticism that it is incoherent to separate our causal knowledge of an entity from the theories that describe the entity (see Morrison 1990; Resnik 1994; Chakravartty 1998; Psillos 1999, 247–249; Clarke 2001), and the criticism that entity realism cannot be realist about those entities, such as astronomical objects, that are not used as manipulable instruments of inquiry (see Shapere 1993; Radder 1996, 91–92).

A drawback of the mentioned recent accounts of entity realism is that none of them have sufficiently discussed each other's views. Thus, it is significant to open a dialogue among them. I intend to synthesize the current accounts of entity realism into a maximally supportable view. For this purpose, I will perform three tasks. First, problems with each formulation of entity realism will be identified and avoided. Second, tensions between the three versions of entity realism will be revealed and resolved. My general strategy is to render all the acceptable accounts of the three entity realists fully consistent with each other, in such a way that the final account does not result in inconsistencies. Third, the strengths of one account will be used to make up for the weaknesses of the others, in order to finally develop a more advanced view of entity realism. As a result, I integrate the valuable elements of the existing variants of entity realism into a consistent, unified view.

Sections 2, 3, and 4 explain Egg's causal realism, Nanay's singularist semirealism, and Eronen's robust realism, respectively. Section 5 discusses the implications of Nanay's singularism for causal and robust realism. Section 6 addresses the relationship between robust and causal realism. Section 7 concludes the paper by providing a criterion for the reality of property-tokens. The criterion is based on the arguments of recent entity realists and on the additional points I will make.

## 2. Causal realism

Egg's (2012, 2014, 2016) "causal realism" is based on a distinction between causal and theoretical warrants. This distinction is inspired by Cartwright's distinction between causal and theoretical explanations. According to Egg (2014, chapter 4), an explanation is *causally warranted* if and only if it fulfills the following three conditions. Each is a necessary condition, and the three together are sufficient to provide a causal warrant.

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I) Non-redundancy: The hypothesis that explains the relevant empirical evidence is the *only* hypothesis that can account for the evidence, thus the hypothesis is "non-redundant." In other words, other hypotheses, if any, cannot provide a serious explanation for the empirical evidence (Egg 2012, section 4.1, 2014, 50–53).

Egg distinguished between a strong and a weak sense of non-redundancy. The former requires that no other empirically adequate hypothesis (known or unknown) is conceivable. The latter implies that no alternative hypothesis that explains the empirical evidence is known. If met, condition I supports the weaker sense of non-redundancy. In addition, Egg claims that hypotheses that fulfill conditions I, II, and III "are likely to be non-redundant in the strong sense" (2014, 91, 2016, 127).

II) Material inference: Below I first examine Egg's presumptions about this condition, and then I present his definition of material inference.

III) Empirical adequacy: If the observable (in Van Fraassen's [1980, 16] sense) implications of the causal explanation are true, then the explanation is empirically adequate (Egg 2012, section 4.3, 2014, 59–61).

The concept of "material" in the second condition implies that a concrete matter of fact, rather than an abstract theoretical law, should explain the phenomenon. To explain the concept of "concrete matter of fact," Egg draws on Chakravartty's (2007, 41–42 and 107–111) notion of "causal properties" as the sources of capacities. Properties such as masses, charges, and temperatures confer on the entities that have them certain capacities, which manifest certain behaviors in certain circumstances (see also Cartwright 1999, 59–64). Entities with "detectable" properties, that is, with causal properties that can be detected by scientific instruments, may deserve realist commitment. However, "auxiliary" properties, those attributed to entities only by theoretical models, are not trustworthy (Egg 2014, 57, n. 8, 2016, 126; Chakravartty 2007, 47). Accordingly, a concrete matter of fact is a detectable property of a concrete entity.

Egg follows James Woodward in supporting a *manipulability/interventionist* account of causation, according to which "for something to be a cause we must be able to say what it would be like to change or manipulate it" (Woodward 2003a, 112). Throughout this paper, I also characterize causation in line with Woodward's view: If C is a cause of E, then C can be manipulated such that E is changed in turn. Thus, causal claims are tested through manipulating the presumed cause by modifying it in order to see the change in the presumed effect.

A characteristic of Woodward's account, which is crucial for my argument, is that it is not necessary that human agents manipulate a cause to see the effect. Thus, his account avoids the anthropomorphism of some manipulability accounts of causation, and allows for natural experiments, that is, "the occurrence of processes in nature that have the characteristics of an intervention but do not involve human action or at least are not brought about by deliberate human design" (2003b, 94, see also 2003a, 103–04). Furthermore, his view allows for hypothetical intervention: "it makes sense to speak of hypothetical interventions on X, of what would happen to Y under such interventions, and hence of X causing Y, even if manipulation of X is not within the technological abilities of human beings, and indeed even in circumstances in which human beings or other agents do not exist" (Woodward 2003a, 128, see also 2003a, section 3.2, 2003b, 95).

According to Woodward's account, it is necessary to have a well-defined notion of what it would mean to manipulate the cause (Woodward 2003a, 128, see also 2016,

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section 12). There is a well-defined notion of what it means to modify a property when it is clear what difference we would expect in our observations if hypothetical modifications were made. A well-defined intervention thus allows us to "have some sort of basis for assessing the truth of claims about what would happen if an intervention *were* carried out" (2003a, 130). Consider this causal relationship (examined by Woodward 2016, section 10, 2003a, section 3.5): "The gravitational attraction of the moon causes the motion of the tides." Although it is not technologically possible for humans to modify the gravitational attraction of the moon to see the actual effects, there is a well-defined notion of what it means to modify it: If we changed the mass of the moon or its distance from the earth, we would observe that the tides change. In this case, Newton's theory of gravitation allows us to specify the changes clearly. However, in Egg's view, it is not always necessary to use well-developed theories or models to have a well-defined notion of the modification of a property: "In everyday life, we constantly engage in counterfactual reasoning without employing formal theories, and I think something similar is going on in the kind of experimentally-oriented (somewhat non-theoretical) reasoning" (Egg, personal communication, 6 September 2022).

One might argue that a hypothetical intervention refers to a counterfactual fact, that is, a fact that did not concretely occur, so it cannot be a concrete matter of fact. However, in Egg's view, the concrete fact is understood as a detect*able* fact, that is, either it has actually been detected or it is in principle detectable but has not been actually detected. In the latter case, the concrete fact is inferred according to a hypothetical intervention (this inference is causally warranted provided that the other conditions, that is, non-redundancy and empirical adequacy, are also fulfilled).

Egg accordingly defines a material inference as "one that results in ascribing to a concrete entity a property for which there is a well-defined notion of what it means to modify it" (Egg 2014, 58, see also 2016, 12, 2012, 65–66). His discussion of material inference implies that a property for which there is a well-defined notion of what it means to modify it is nothing but a "detect*able*" or a "material" property, in the sense that "we can *in principle* establish some causal contact" with it (2014, 90). Accordingly, a material inference is one that results in ascribing to an entity a detectable property. Still, it should be made clear what is inferred from what. In causal inference, in general, a cause is inferred from an effect. In material inference, in particular, the cause is a detectable property of an entity, which is inferred from the result of an actual or a hypothetical intervention. Altogether, the following definition can be stated:

> Material inference: the inference from the result of an actual or a hypothetical intervention to a detectable property of an entity.

Egg's (2012, section 4) discussion of the detection of neutrinos provides a concrete example for what is meant by material inference. In 1930, Wolfgang Pauli postulated the neutrino hypothesis to account for how beta decay could conserve energy. Pauli assumed that an undetected particle (i. e., the neutrino) may carry away some energy. Niels Bohr, on the other hand, had proposed a statistical version of the conservation law, implying that energy conservation is not always valid at the nuclear level. This proposal is clearly theoretical/formal. Although it saves the phenomenon, it does not

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specify the cause of the energy waste in the beta decay, and accordingly it does not fulfill the material inference criterion. On the other hand, the neutrino proposal employs a well-defined notion about the modification of the neutrino's ability to carry energy. There was a well-defined notion of what it means to modify this property. Therefore, the ability to carry energy is a detectable property of the neutrino, and the neutrino proposal satisfies the material inference criterion.

A contrasting example, which meets non-redundancy and empirical adequacy but not the criterion of material inference, concerns a property of a purely formal or theoretical character such as "being accurately described by QED [that is, quantum electrodynamics]" (Egg 2012, 265, see also 266). This general property is described by a well-grounded theory, and this description is non-redundant. However, the property is not detectable; it is unclear how this property could be modified in practice or what change we would expect in our observations if hypothetical modifications were carried out.

Note that, according to Egg, a property of an entity is not *real* merely because it is materially inferred. In order for the property to be justifiably considered real, or in other words, in order to actualize the possibility of establishing causal contact with the property (see Egg 2016, 126, 2014, 90), the conditions of empirical adequacy and non-redundancy should also be fulfilled. That is, all the observable implications of the hypothesis that the property exists should be true, and only that property should explain all the relevant empirical evidence. I agree that causally warranted explanations need to fulfil the conditions of material inference and non-redundancy. I will, however, suggest in section 6 that instead of his criterion of empirical adequacy, the stronger condition of robustness should be used. Furthermore, in section 5 I will reformulate Egg's definition of material inference to clearly include the positive aspect of Nanay's singularism that in experiments particulars are manipulated.

## 3. Robust realism

Another current entity realist account is "robust realism," developed recently by Eronen (2015, 2017, 2019). His argument for realism is a specific example of the argument from corroboration or consilience (see Chakravartty 2017a, section 2.2). It is based on the following criterion.

> Robustness: "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" (Eronen 2015, 3967, 2017, 2345–46).

In this criterion, Xs are primarily entities, properties, and phenomena. Robustness is primarily an epistemological criterion, which provides *justification* for an ontological commitment.[3] This commitment is a matter of degree. More independent ways of accessibility indicate a higher level justification for our beliefs in entities and their properties (Eronen 2015, 3970, see also Eronen 2012).

[3] According to Eronen (2017, 2352), robustness provides a sufficient justification. In sections 6 and 7, I will argue that robustness is not sufficient for a realist commitment. An employment of a causal account and the condition of non-redundancy are also needed.

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Eronen's view is inspired by William Wimsatt (2007), and moreover, the criterion of robustness is comparable with Hacking's view that the experimenters' belief in an entity increases when they can investigate the entity through different mechanisms, hence his "argument from coincidence." For instance, when different microscopes—the working of which is based on other mechanisms—detect a microscopic entity, one is justified to believe in the entity (see Hacking 1985, 144–46, 1983, 201).

According to Eronen, real entities are accessible by independent experimental mechanisms or can be derived from several independent models. Different means of detection, measurement, or production of an entity in experimental situations, or of deriving the entity from independent hypotheses, justify believing in the entity's reality. Unless an entity really exists, it is unlikely that the entity is accessible in multiple ways, none of which depends on the others.

We are justified in relying on the criterion of robustness, but this criterion is not infallible. "Robustness is clearly a fallible criterion that is relative to a certain scientific community at a certain time" (Eronen 2015, 3966). Prospective technological instruments or theoretical resources may demonstrate that a currently postulated robust entity is not really robust and real. Nevertheless, as long as there is no defeater for believing in a robust entity, we are justified to consider it to be real.

## 4. Singularist semirealism

As mentioned in my introduction, a criticism of entity realism is that it is incoherent to separate our causal knowledge of an entity from the theories that describe the entity. Scientists need theories to describe the properties of entities and their lawful relationships with each other. These theoretical descriptions are required to manipulate unobservable entities in experiments. Therefore, to be a realist about entities, one is also forced to be a realist about theories (see Nanay 2019, section 3).

In response, Nanay (2013, 2019) argues that entity realists should be realist only about "singular representations," which attribute "property-tokens" to particulars (in particular, to entities). Concrete property-tokens, rather than abstract property-types, are manipulable in experiments (Nanay 2019, 510), and accordingly are known via singular representations. However, non-singular representations, which attribute "property-types" to particulars or to other property-types, are not literally representational, because property-types are only products of us humans; they do not exist out there, independently of us (Nanay 2013, 380, 2019, 508).

Nanay advocates a kind of nominalism,[4] according to which property-types do not exist but are the products of grouping property-tokens in a useful way. Property-types should not be seen as real essences, but as pragmatically useful categorizations of property-tokens. More useful categorizations provide better explanations and predictions. Laws (as general relationships between property-types) or models (which include non-singular representations) are derived ultimately from

[4] See also Nanay (2010, 2011). Also, it should be clarified that there are two different yet interrelated questions. (i) Do abstract entities, including properties, exist? For instance, is there such a thing as redness, or are there just red things? (ii) Are the types/kinds to which our scientific generalizations refer natural/real or conventional/constructed? My discussion on "nominalism" in this paper is primarily about (ii), although (i) is also considered.

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singular representations (Nanay 2019, 512). Although property-types, laws, and models are useful epistemic tools, they do not refer to real kinds or essences.

Nanay does not accept that general causal claims are true. He is a realist only about singular causal claims, which are about particular entities and their property-tokens. Accordingly, our realist knowledge is restricted to singular representations and singular causal claims (Nanay 2019, 508). According to him, experimenters are not required to be realists about property-types, laws, or models used as epistemic tools to guide the manipulation of property-tokens of particular entities. They learn how to perform an experiment from previous attempts:

> "... there is no reason to think that the experimenter would need to be realist about any of the property types of the electron (or of the niobium ball or anything involved in this experiment). All she needs is some knowledge of previous attempts at spraying niobium balls with electron[s]. Some of these attempts were successful, some others, no doubt, unsuccessful. She should try to spray the niobium ball in a way that is more similar, in the relevant respects, to the previous (token) successful attempts." (Nanay 2019, 510)

Nanay calls his view singularist semirealism, which is realist only about singular representations of property-tokens and their singular causal relations. The view is not realist about property-types, laws, or models. Singularist semirealism provides an answer to the criticism that entity realists are supposed to be realists about theories. In this view, singular representations are interpreted in a realist way, but the theories constructed based on the singular representations are not. This does not mean that the singular representations are not dependent on theories in any way, because the singular representations are theory-laden. In spraying niobium balls with electrons, experimenters interact with the niobium and electrons described by theories. But a realist interpretation of the theories involved is not necessary to use them in the descriptions of the singular representations. One can be a realist about a singular representation of "niobium balls sprayed with electrons" without accepting that the theories that describe niobium balls and electrons are true. In the future, the theories that describe electrons and niobium may change, but the fact that something concrete that is currently described as niobium balls is sprayed in experiments with something concrete that is currently described as electrons will probably remain true. In this sense, one may simultaneously be a realist about singular representations generated in experiments and still not be a realist about theories describing them.

Nanay's reply to the objection that entity realism necessarily reduces to a full-blown realist view is comparable to that of Egg (2014, 62), according to which the detectable properties of entities may be trustworthy, while other parts of theories may not be true. In section 5, I will interpret Egg's detectable properties as property-tokens, so his reply to the objection would become very similar to Nanay's. The only difference is that for Egg detectable properties are more inclusive than those actually manipulated in experiments. In this regard, I agree with Egg. The next sections will clarify how I develop Egg's conditions to argue that detectable property-tokens are justifiably real if they can be exclusively inferred from the evidence obtained in multiple ways of detection.

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Eronen's (2017, 2348) reply to the objection that entity realism leads back to theory realism can strengthen Nanay's and Egg's reply. When property-tokens of a certain type are detectable by independent mechanisms, our confidence in their existence increases. If each of these mechanisms relies on a different model or theory, we will understand that the property-tokens are real even if the models and theories describing them are untrue or inconsistent with each other.

Thus far, I have briefly discussed recent entity realists, each of whom has developed his view independently of the others. My discussion of their replies to the objection that entity realism is reducible to theory realism entails that their accounts can be integrated into a unified, stronger view. In the remainder of the paper, I suggest further exchange of views between these recent entity realists. The following section discusses the implications of Nanay's distinction between property-tokens and property-types for material inference and for robustness. It also argues that Nanay's nominalism is not necessary for entity realism.

## 5. Implications of singularism

According to Egg, "a concrete matter of fact" is "opposed to a law" (2014, 56). If we accept from Nanay that theoretical laws are relationships between property-types, it follows that concrete properties which are examined in experiments are indeed property-tokens rather than property-types. Entities are also concrete particulars. Accordingly, the definition of material inference can be rewritten as follows.

> Material inference': the inference from an actual or a hypothetical intervention to a detectable property-token of an entity.

By actually or hypothetically intervening in the property-token as the putative cause, an actual or a hypothetical change in its effect takes place. The change allows us to infer the property-token from the effect.

There may be two conflicts between Egg's causal realism and Nanay's singularist semirealism. First, Nanay might argue that a merely hypothetical intervention is not enough to infer a real property-token. Only an actual intervention in a real experimental situation brings about knowledge of real property-tokens. In response, Egg could argue that if the (hypothetical or counterfactual) claim that a property-token is detect*able* is true and his other two conditions (non-redundancy and empirical adequacy) are satisfied, the property-token is indeed detect*ed* and real.

The three conditions are, according to Egg, well suited to support a realist commitment. I agree with Egg that realism should not be restricted to actually manipulated properties. Nevertheless, in section 7, I shall provide a more sophisticated criterion for reality than the three conditions Egg suggests. According to that criterion, even if not *actually* manipulated, property-tokens should be considered real if they can be exclusively inferred from the evidence obtained in various independent ways of detection.

Second, Egg might argue that the fact that *property-tokens* are being manipulated in actual experiments does not imply that a real property-token does not belong to a real property-type. Indeed, the realist can hold on to real property-*types*, as long

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as these are restricted to the right kind of properties, namely detectable ones that satisfy the three conditions.

A reason for realism about property-types concerns the fact that science is not interested in exclusively individual tokens. Experiments need to be reproducible in some sense and to some extent. Realism about types takes account of the issues of reproducibility by the original experimenters or by other experimenters. Even a *particular* detection process (apart from its replication through different processes) needs to be itself reproducible (about reproducibility and replicability, see Radder 1996, 11–26 and 78, 1984/2012, chapter 3). Reproducing an experiment seems to presuppose that the tokens which are tested belong to the same type.

The significance of reproducibility in scientific practice is clearly acknowledged by Eronen, whose view is that if there are several independent ways of manifesting an entity, the entity may justifiably be claimed to be real. In his view, replicating an experiment in which a robust entity is manifested is central to scientific practice. Reproducing an experiment in almost the same way as the original one brings about a low degree of robustness. Replicating the experiment in several different ways brings about a high degree of robustness.

Can Nanay's singularist semirealism take into account the issues of reproducibility? I think it can, but only in a complicated way. According to Nanay's view, an experiment is almost never reproducible *in the exact way* it is conducted the first time. The entities (e.g., electrons, genes, black holes) examined in an experiment are not the entities examined in the next, reproduced experiment. Nevertheless, the reproduction of the experiment helps to check if *similar* entities, those being classified in a type, behave similarly in certain circumstances. A variety of independent experimental techniques assure scientists that *similar* property-tokens (that is, members of a nominal property-type) can be ascribed to *similar* entities (that is, members of a nominal entity type). In other words, if a property-token of an entity is materially inferred in an experiment, the property-token is real. If the experiment in which the property-token is inferred is reproduced, the nominal property-type is derived. The nominal property-type can be ascribed to a nominal type in this sense: in reality, similar entities have similar property-tokens. That is, $\text{entity}_1$ has $\text{property-token}_1$, $\text{entity}_2$ has $\text{property-token}_2$, $\text{entity}_3$ has $\text{property-token}_3$ and so on, such that $\text{entity}_1$, $\text{entity}_2$, $\text{entity}_3$ and so on are similar particulars belonging to a nominal type; and $\text{property-token}_1$, $\text{property-token}_2$, $\text{property-token}_3$ and so on are similar property-tokens belonging to a nominal property-type. The entity type and the property-type are epistemic tools that help replicate experiments in a useful and reproducible way. However, they are not real.

Accordingly, singularist semirealism can explain the replicability of scientific practice and, at the same time, argue that we are not justified to be realist about epistemic tools such as the types that are used in replicating experiments. We are justified to be realist only about property-tokens that are manipulated in particular experiments.

Put differently, Nanay does not have to disagree with the view that the theoretical concepts abstracted from the material realization of replicable experiments have nonlocal meanings; their meanings are not (fully) determined by the particularities of each experiment.[5] For Nanay, abstract theoretical concepts are derived from

[5] This view is developed in detail in Radder's (2006) book.

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concrete tokens; however, their nonlocal meanings do not necessarily refer to *real* types. Instead, they are useful ways of grouping real tokens. Replicating experiments helps scientists in a useful way to eliminate arbitrary, subjective, or irrelevant factors from the process of categorizing similar tokens.

However, Nanay's nominalism is problematic in that it is not really parsimonious. Instead of the commitment to property-types, it may need to postulate a brute relation of similarity between property-tokens in order to account for successful generalizations from one experiment to the next. Consider the equation for Newtonian force, $\mathbf{F} = \mathrm{m} \times \mathbf{a}$. According to singularist semirealism, one should be realist only about the singular representations of the equation, e.g., about $\mathbf{F_1} = \mathrm{m}_1 \times \mathbf{a_1}$, $\mathbf{F_2} = \mathrm{m}_2 \times \mathbf{a_2}$, ... $\mathbf{F_n} = \mathrm{m}_n \times \mathbf{a_n}$, which are all acquired from a series of experimental practices. To explain why the general equation $\mathrm{F} = \mathrm{m} \times \mathbf{a}$ is successful, the singularist semirealist should presuppose that some real similarity exists between $\mathbf{F_1}, \mathbf{F_2}, \ldots \mathbf{F_n}$, between $\mathrm{m}_1, \mathrm{m}_2, \ldots \mathrm{m}_n$, and between $\mathbf{a_1}, \mathbf{a_1}, \ldots \mathbf{a_n}$, and so on and so on. In contrast, the realist about types simply presupposes that **F**, m, and **a** are real types, whose instances stand in a certain relationship with each other. Singularist semirealism is (partly) correct in that, in actual experiments, tokens are manipulated. However, this view cannot sufficiently motivate realists not to commit to the knowledge of types ontologically. The nominalist view is not the simpler, more parsimonious one. At least, Nanay's argument does not convince us that it is.

I do not claim that nominalism is incorrect, but that, from an entity realist point of view, nominalism is not preferable to realism about types. After all, we should distinguish between (Nanay's) singularism and nominalism. I agree on the deployment of singularism in addressing the objection that entity realism is reducible to theory realism (see section 4), and also in the reformulations of Egg's and Eronen's accounts (in this section). A central idea of entity/experimental realism, which ought to be incorporated in the final, integrated formulation of entity realism, is that our experimental interactions with reality are indeed with particular entities rather than with types. Experimenters interact with particulars, but this does not answer the question of whether these particulars belong to real or merely constructed types. As a result, the idea that experimenters interact with particulars does not, despite Nanay's claim (2019, 511), have to be combined "only" with nominalism.

Still, an entity realis*t* might become a realist about (certain cases of) types thanks to independent arguments and case studies presented in the realism-nominalism debate. However, this further step is not required by entity realis*m*. This entity realis*t* is not a realist about types (or about certain cases of types) on account of entity realis*m*, but because of other arguments and case studies that that entity realis*t* agrees with. For example, the property of being an electron is an example of a property-token that may justifiably belong to a real type. According to basic quantum physics, electrons are strictly identical in the sense of being all of the same type. Non-identity would have substantial, empirically testable implications. Because the identity of similar tokens has an explanatory power, one may (justifiably) believe those tokens to be instances of a real type. However, this belief is not an implication of entity/experimental realis*m*, which relies on singular causal interactions in experiments.

Let me now redefine the criterion of robustness by incorporating Nanay's singularism (rather than his nominalism).

> Robustness': a property-type X is robust in the relevant scientific community at a certain time insofar as the property-tokens belonging to the property-type are detected, measured, derived, produced, or explanatory in a variety of independent ways.

In robustness', X is specified as a "property-type." It is a "type" because several ways of exploring (similar or identical) property-tokens lead us to speak about the (nominal or real) type of those tokens. In this way, robustness' is still neutral about the debate between nominalism and realism about types. A type is robust if its tokens (i.e., its members) are real, irrespective of whether the a posteriori evidence obtained in a variety of independent ways requires that those tokens are essentially identical. According to the criterion of robustness, other concrete members of a robust property-type, including not-yet-experimentally-examined property-tokens that are expected to behave similarly/identically in certain circumstances, are justifiably considered to be further real property-tokens of the robust property-type.

X is a "property" because (as Chakravartty, Egg, and Nanay rightly assume) entities are primarily detectable through their properties. That is, epistemologically speaking, an entity manifests itself through its properties. This is true both about ordinary objects and about scientific entities. For instance, we do not see the "table-ness" of a table, but we experience its shape, color, and so forth. Similarly, when scientists discover an entity, they indeed detect one or more properties of the entity. If at least one property of an entity is accessed, the entity itself is also accessed.

I have used "detected," "measured," "derived," and "produced" instead of detectable, measurable, derivable, and producible in robustness' because using the latter concepts might imply that a possibility of being detected, measured, derived, and produced is enough for X to be robust. As discussed in section 2, this possibility is admitted when we simply have a well-defined notion of what it means to intervene in (a property of) an entity. To be robust, however, an entity should in actual fact have been detected, measured, derived, and produced in several ways.

In material inference' and robustness', while avoiding Nanay's nominalism, I have made use of his simple but insightful account that particulars (entities and property-tokens) are what can be experimentally explored. The next section aims to reconcile material inference' and robustness'. Section 7 further pursues this aim by using material inference', robustness' and non-redundancy to provide a sufficient criterion for reality.

## 6. Causality and robustness

In this section I first show the need for a causal account of the realist interpretation of robustness and then suggest that the criterion of robustness' should be employed instead of that of empirical adequacy.

Eronen maintains that "[causal] criteria are entirely compatible with the robustness approach. For example, one could argue that the ultimate metaphysical criterion for what is real is the causal criterion, but the source of justification for science-based ontological commitments is robustness" (2015, 3973, n. 15). Elsewhere, nevertheless, he claims that the advantage of his view over causal realism is "that it moves beyond causal motivations for realism, and is based on the notion of *robustness*

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instead" (2017, 2342). If what Eronen means by the causal criterion/motivation for realism is that the metaphysical claim that "X is real" is equivalent to "X is a cause or an effect," then there is no serious conflict between this claim and his epistemological account of robustness. But if the causal criterion/motivation is an epistemological thesis, as in the case of Egg's three conditions for causally warranted explanations, it is less than obvious if and how the robustness approach is compatible with the causal account. In the first place, in Eronen's robustness criterion (and in robustness'), "or explanatory" should be removed since it is merely theoretically motivated—it does not concern causal interaction in experiment. A realism based just on explanatory robustness moves beyond the scope of entity/experimental realism, toward a more general realist view. Apart from this, it should be explained how the robustness approach is compatible with the epistemological causal account (of Egg's), as I will do in what follows.

My claim is that if the criterion of robustness is to be employed in a realist view, it should be explicitly joined with a causal account. After all, an antirealist such as Bas van Fraassen (1980) would agree that evidence obtained via different, independent ways enables scientists to accept models and theories empirically, but he disagrees that realism follows from this kind of evidence. In reaction to Hacking's (1985, 144–45) argument from coincidence and his specific case about using different microscopes to see blood samples, Van Fraassen writes:

> "We refer to two different sorts of instruments, so the sameness in the outputs must be attributed principally to similarities among the inputs. But no one doubts that it is in each case *blood samples* and not different kinds of physical systems that were fed into the machines. This conclusion warrants no inference about the reality of the imputed unobservable structure." (1985, 298)

He rightly demands a warranted *inference* about the reality of the unobservable structure. What distinguishes robust realism from robust antirealism is the fact that robust empirical evidence is the effect caused by a real unobservable entity. The cause, or more precisely the unobservable entity's causal property, is *inferred* from the empirical evidence. Therefore, a realist view of robustness cannot avoid explicitly employing a causal account of inference.

To put it another way, the properties of unobservable entities are not directly accessible. Empirical evidence of properties is obtained through technological instruments. In Chakravartty's words, trustworthy properties "are *causally* linked to the regular behaviors of our *detectors*" (2007, 47, my emphases). Experimental results are detected by means of instruments; accordingly, property-tokens of an unobservable entity, as the cause of the experimental results, are justifiably inferred (by material inference'). Even if evidence of the property is obtained in several independent ways, the *inference* from the evidence to the reality of the property is necessary for a realist. Due to the prevalence of technological instruments in scientific practice, knowledge of unobservable entities is mostly based on inferences from empirical evidence obtained by instruments, as the effect of the entities' causal properties.

To further clarify my realist account, I briefly discuss Nora Boyd's (2018) recent view of empirical evidence. She employs "enriched" concepts such as "empirical

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results" or "empirical evidence" instead of "observables" or "experience." The former concepts are more faithful to the results gained by means of "intricate instruments and techniques prevalent in scientific research today" (2018, section 2). Her view that empirical evidence can accumulate, be merged, and constrain rival models allows us to understand current science, in which a large volume of data is gathered and analyzed to test scientific models. Boyd also speaks of "a causal story connecting the target of interest to the generation of the results." The role of the causal connection between empirical evidence made available by the instrument and "the target of interest" could be developed so that it results in realism. My main point here is that the causal connections with reality that scientific instruments provide can enable us to distinguish evidence of real entities from unreal results and support a *realist* view. Empirical evidence is causally connected to properties of real entities. This connection cannot be found in what Van Fraassen calls a "public hallucination" such as the experience of a rainbow (2008, 101–09). After all, it is not necessary to presuppose a colorful object in the sky to explain the rainbow. In explaining a rainbow, we do assume the existence, composition, and dispersion of (white) light rays in the presence of water drops. Therefore, we consider these rays to be real; however, we do not presuppose the existence of a colorful object. The explanation of the rainbow does not depend on a causal relationship between some colorful object and our experience. For another example, ions do need to exist to bring about the trace in the cloud chamber as their effect. Or astrophysical entities such as gravitational waves need to exist to bring about the evidence detected by instruments, of course on the condition that the evidence is detected by *several* independent means (thanks to "robustness").

A key point that should be highlighted is that instrumentally mediated empirical evidence—i.e., the effect of an unobservable cause on a technological instrument—is either produced or not produced but potentially available to be detected. Sometimes, the effects are actively *produced* and then detected. For instance, in the experiment where Donald Eigler and Erhard Schweizer employed xenon atoms to inscribe "IBM" on a nickel surface, "our ability to *produce* such pictures testifies to our knowledge about atoms" (Egg 2014, 102, my emphasis). The pictures produced are indeed effects to be explained by the properties of atoms, as their causes. In this case, and more generally in experimental particle physics, detectable effects are deliberately produced by actually modifying their causes. Sometimes, however, the evidence is not produced by actually manipulating entities. For instance, in observational astrophysics, the evidence of gravitational waves or black holes is not produced by modifying the waves or holes. Still, it is *potentially available* on or near the Earth, and can be actively detected by our observational apparatuses. Evidence is always evidence regarding a hypothesis, so in these cases suitable instruments are prepared to detect the empirical results relevant to the hypothesis, and therefore can be used to acquire evidence for or against the hypothesis. We cannot actually modify the origin of black holes or gravitational waves in order to observe the changes in their effects. To be a realist about astronomical entities, it is enough to detect their signals by multiple means of detection. In sum, although the role of the production of effects in controlled experiments should not be ignored, such productions do not play a part in all experimental/observational practices.

I have argued 1) that a *realist* view of robustness requires the active employment of a causal account of inference; and 2) that the evidence of a real unobservable entity is not always produced as a result of an actual manipulation of the entity; it may be potentially available to be detected by instruments experimenters actively prepare and use. These two points are consistent with each other, since according to the manipulability/interventionist account of causation, an actual interference in the cause, and therefore the production of the evidential effects, is not necessary. Rather, there must be a well-defined notion of what it means for the cause to be manipulated. To consider the cause to be a *real* property-token, other necessary conditions should also be fulfilled. According to Egg, the presupposed cause should also be non-redundant and empirically adequate.

To establish highly empirically adequate hypotheses, I suggest that the criterion of robustness' is employed instead of that of empirical adequacy. This allows realists to be committed, more cautiously, only to the empirical evidence gained from a number of independent ways or perspectives. Suppose evidence is gained only through one particular kind of instrument. In that case, strict realists may be reluctant to place their ontological trust on the hypothesis confirmed by the evidence, even if the hypothesis satisfies the conditions of non-redundancy and material inference' as well.

This suggestion of mine explains better Egg's own example of the detection of the neutrino as well. First, Egg insists on "the importance of the neutrino's direct experimental detection." He criticizes philosophical views, such as constructive empiricism, that downplay this significance (2012, 274–75). I quite agree that the *detection* of neutrinos is epistemically crucial. However, Egg's three criteria (non-redundancy, material inference, and empirical adequacy) cannot demonstrate this importance. A non-redundant proposal may not result in experimental detection. Material inference requires detectability rather than detection. Empirical adequacy does not necessarily include experimental detection either. On the other hand, the significance of detection is appreciated in robustness' (and in my criterion for reality in the next section).

Moreover, as said in section 5, replicating detection through different processes is central to scientific practice. The replication of detection techniques assures the scientific community that the detected property/entity is real. In the detection of neutrinos, in particular, a variety of detection techniques have been developed. In the experiment designed by Frederick Reines and Clyde Cowan (mentioned in Egg 2012, 276), two scintillation detectors are employed. Protons absorb neutrinos and transform into neutrons and positrons. The resulting positrons are annihilated by electrons in an electron-positron collision process, which produces photons. These photons are detected by the two scintillation detectors above and below the target, and accordingly the (properties of) neutrinos are materially inferred. The detection technique of this very experiment is not the only one that has so far been implemented to detect (the properties) of neutrinos. Radiochemical methods, Cherenkov detectors, and racking calorimeters are among other familiar detection mechanisms. The Sudbury Neutrino Observatory, for example, is a Cherenkov detector designed in Canada to detect solar neutrinos (neutrinos originated from the core of the sun). When heavy water reacts with neutrinos, the so-called blue Cherenkov light is produced, which signals the detection of neutrinos (for a recent review of the variety of the neutrino detection techniques, see Nath and Francis 2021). The replication of detection techniques cannot be explained merely by the criterion of empirical adequacy, but it can be explained by that of robustness'. Hence, my suggestion to substitute the condition of empirical adequacy with robustness'.

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Suppose, according to what has been argued in this section, that only certain property-tokens (all belonging to a property-type) can explain the relevant experimental evidence, and that a variety of independent means of detection provides the evidence of the property-tokens such that the evidence could not have been detected by independent means unless the property-tokens exist. In that case the property-tokens are the real causes of the evidence obtained. In other words, the property-tokens would be the *real causes* of detected evidence, on the condition that *only* they explain the evidence, and the evidence is obtained through *a variety of* independent means. In the following section, I will provide a more fine-grained version of this criterion for reality.

## 7. A criterion for reality

This section incorporates all the convincing aspects of the recent views of entity realism into a criterion for reality. Eronen suggests that a specific kind of evidence associated with robustness supports a realist commitment. However, as I have argued, for a realist view of robustness, it is necessary to *causally infer* reality from this kind of evidence. Egg's material inference, or more precisely, its refined version, i.e., material inference', could explain the causal part. While Egg employs the three conditions to single out the specific kind of evidence that justifies a realist commitment, as argued in the previous section, the condition "empirical adequacy" should be substituted with the kind of evidence associated with "robustness."

What matters here is indeed the cogency of the criteria proposed both by Egg and by Eronen. It seems inappropriate to see either criterion as superior. Instead, the strengths of recent entity realisms can be employed to provide a more compelling criterion for reality. By taking into account these insights and the points I have made, I suggest the following criterion for the reality of property-tokens.

> The property-tokens of a certain type may be taken as real insofar as only they can be materially inferred from the evidence obtained in a variety of independent ways of detection.

This criterion acknowledges Nanay's distinction between a property-type and its particular members (the property-tokens) and his point that property-tokens of unobservable entities are what can be experimentally detected. "Property-tokens" play a justifiable explanatory role in concrete experiments, and consequently they can be real. On the other hand, Nanay's nominalism is not assumed in the criterion, which remains impartial regarding the nominalism versus realism debate about types.

The criterion is primarily a criterion for the reality of property-tokens. Nonetheless, it can also imply that a property-type can be robust, in the sense that its concrete members are real property-tokens, regardless of whether or not a posteriori evidence suggests that those robust property-types are real essences.

Although I have employed the concept of property-tokens in the criterion, it is completely plausible to use instead more general notions, such as (unobservable) entities or properties. In particular, the following criterion could be useful when one is aware that the experimental detection of (unobservable) entities always

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concerns their particular properties, while preferring not to be couched in metaphysical jargons such as property-tokens and types.

> (Unobservable) entities may be taken as real insofar as only their properties can be materially inferred from the evidence obtained in a variety of independent ways of detection.

Our confidence in the reality of property-tokens is a matter of degree, hence my use of the qualifier "insofar as." Also, I agree with Eronen's qualification that a thing is considered to be robust in the relevant scientific community at a certain time, which alerts us to the fact that the manifestation of property-tokens depends on historically contingent technological instruments and conceptual theories provided by the scientific community. Experimental results are fallible and are conditioned on instrumental and theoretical resources.[6] Because of these qualifications, the property-tokens "may be taken as" real. Still, this expression is in sharp contrast with the anti-realist attitude that unobservables cannot be taken as real. Accordingly, it should not be understood as a mere possibility, but as an epistemological permission: one is justified to take the property-tokens that satisfy the criterion as real. And the reliance of the criterion for reality on scientific communities should not be understood in an unreasonably relativist way. Although the property-tokens are taken as real in the relevant scientific community at a certain time, their reality may be acknowledged by other communities as well.

The criterion provides a sufficient (and not a necessary) condition for reality. There may be real property-tokens and entities that do not fulfill the criterion. However, if similar property-tokens meet the criterion they are probably real.

The word "only" is added so that the criterion complies with Egg's condition that a causal hypothesis should not be non-redundant. If different types of property-tokens and entities can explain the evidence, the criterion is not satisfied.

The "evidence" is "obtained" by making experimental efforts. The evidence may be produced in the experiments or it may consist of potentially available signals whose causes are not actually manipulated.

The criterion concedes that causal property-tokens are not non-inferentially known. Knowledge of them is justifiably "inferred" when only they can explain the evidence. Being explanatory is not an independent way of having access to a property apart from being detectable. If only the existence of a specific property-token can explain the empirical evidence, the token exists. Our confidence in the existence of other property-tokens, all of which belong to a property-type, increases when a variety of independent ways of detection present evidence that is explainable only by the existence of those property-tokens that belong to the property-type of which the previously examined property-tokens are members.

The inference from evidence to the property-tokens of a certain type is reasonable when "a variety of independent ways" of detection agree that the property-tokens make the evidence happen. The reproduction of a detection in almost the same way that the original one is conducted does result in some degree of justification

[6] For this reason, entity/experimental realism is compatible with perspectivism (see Khalili 2022b, 2021, section 3).

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for the reality of the property-tokens, but replicating the detection in several different ways results in a much higher degree of justification. Here, the notion of "detection" should not be understood narrowly. It includes scientific observation, measurement, derivation, and production.

It is virtually impossible to actually manipulate astrophysical objects. Still, we are justified to consider them to be the real causes of the evidence, provided that several independent means of detection confirm the inference from the evidence.

The emphasis of entity realists on the causal connection of property-tokens (as causes) with empirical evidence (as the effects of the causes) distinguishes their realist view from antirealism. I have argued that that entity realists are required to presuppose a causal relationship. The manipulability/interventionist account of causation (used in material inference') and robustness' allowed me to explain the causal inference of property-tokens from the evidence obtained in a variety of independent ways.

In concluding this section, I illustrate the criterion by applying it to these unobservable cases: dark matter, digamma particles, Higgs bosons, and gravitational waves. Dark matter is a hypothetical entity, presupposed to account for approximately 85% of the matter in the universe. Calculations show that galaxies would have appeared differently if they had not contained a large amount of invisible, dark matter. However, as Niels Martens (2022) argues, the properties of this entity have not yet been defined well. We do not even know whether it is really matter or not, or whether the dark matter part of the universe consists of one or several types of entities. As a result, there is no well-defined notion of what it means to intervene in property-tokens of this entity, and thus it—at least currently—does not meet the precondition of detectability. In other words, property-tokens that should be materially inferred in order for experimenters to detect dark matter have not yet been specified. Therefore, dark matter may not be justifiably taken as real.

Another case that cannot be considered to be real is the putative digamma particle, which was presupposed to explain an anomaly in data collected in 2015 at the Large Hadron Collider (built by CERN in Geneva). A property that is attributed to this hypothetical entity concerns its capacity to decay into two photons. This property is specific enough to be materially inferred. However, further analysis and the data collected in 2016 by the Collider combined with the previous data did not result in the detection of the property-tokens of this hypothetical entity. Experimenters concluded that the anomaly in the 2015 data had been a statistical fluctuation rather than evidence for a new kind of particle.

On the other hand, Higgs bosons may be taken as real. An important property of this boson is its mass, which explains why particles such as W and Z bosons are massive, whereas photons and gluons are massless. This property was not sufficiently specific in the mid-1960s, when it was first predicted by physicists. However, the historical course of events clarified that this boson should have a mass of around 125 GeV/$c^2$, which was finally detected in 2012. After that, the mass of the boson was again detected in other experiments. Still, the Higgs boson has been produced so far only as a result of proton-proton collisions. The justification for the boson will increase provided that its evidence is obtained in different ways.[7]

[7] On the detection of the Higgs boson and for a comparison between the Higgs boson and the hypothetical digamma particle, see Khalili's (2022a, sections 2.4 and 2.6) dissertation.

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Gravitational waves may also be taken to be real since only their property-tokens can be materially inferred from the (big) data obtained in (at least) these two ways of detection: direct and indirect. First, the radio telescopes employed by Russell Hulse, Joseph Taylor, and Joel Weisberg interact with electromagnetic radiations from the binary pulsar, and on the basis of these interactions gravitational waves are inferred. Second, the interferometers of Virgo (in Italy), LIGO (in the US), and KAGRA (in Japan) interact with the gravitational waves directly, and as a result the data recorded indicates the strain of the gravitational waves (on the direct and indirect detection of gravitational waves, see Elder 2022). We are quite justified to take them as real, because their evidence—potentially available on or near the earth—has been discovered according to (at least) two different ways of detection.

Entity realism can expound the experimental detection of neutrinos, Higgs bosons, and gravitational waves, and also the lack of detection in the cases of dark matter and digamma posits. Each entity realist can shed light on some aspect of these examples. The version developed here incorporates all the valuable insights of the existing accounts of entity realism, and thus it gives a more comprehensive grasp of the examples. In the detection of neutrinos, as I explained in section 6, Egg's three criteria cannot demonstrate the importance of obtaining the evidence of neutrinos in a variety of independent ways of detection, while the account of this paper, thanks to its reliance on Eronen's robustness, can. On the other hand, Eronen's robust realism is unable to sufficiently explain why dark matter cannot be justifiably considered to be real. He might claim that we cannot currently consider dark matter to be real simply because it has not been detected in a variety of independent ways. This claim, however, fails to notice that, thus far, dark matter has not even become conceptually well-defined. This nuance is appreciated in the developed entity realist account of this paper, in which Egg's material inference is deployed. Finally, Nanay's singularism lacks the conceptual resources for developing an epistemological criterion for reality. Yet this paper agrees with its observation that we should believe more firmly in the detected property-tokens of neutrinos, Higgs bosons, and gravitational waves than in property-types and theories that are abstracted and constructed from the detected property-tokens.

The paper has not aimed to convert antirealists or other selective realists to entity realism, but to open a dialogue among recent entity realists, which has culminated in the proposal of a criterion for the reality of property-tokens. An attractive feature of entity realism concerns its focus on the implications of experimental detection for our epistemology of unobservables. I have explained that robustness and replication, material inference, and the idea that experimenters interact with concrete entities and property-tokens should be central to our understanding of experimental science. Antirealists and other modest realists could also come up with more sophisticated views of themselves by seriously considering these central concepts. The development of such sophisticated versions signifies advancement in the debate on scientific realism.

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