**Robust Realism for the Life Sciences**

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**Abstract**

According to entity realism, we are warranted in believing that some entities studied by science are real, but not that scientific theories are true. In discussions of scientific realism, entity realism is usually quickly dismissed due to serious objections that appear to make it untenable. In this paper, I formulate a new robustness-based version of entity realism, and show that this version has resources to answer the classic objections raised against the original version. I also show that, in contrast to the currently popular (ontic) structural realism, robustness-based entity realism provides a plausible account of realism for the life sciences.

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**1. Introduction**

The core idea of standard scientific realism is that we ought to believe that the best scientific theories are (approximately) true. Antirealists deny this. Entity realists accept the antirealist tenet that we are not required to believe in the truth of scientific theories, but also defend limited realism, as they argue that we are warranted in believing that at least some entities that appear in scientific explanations are real. Thus, entity realism (ER) appears to lead to an appealing middle path between standard scientific realism and antirealism.

However, in discussions of scientific realism, ER is usually quickly dismissed (see, e.g., Devitt 2005; Ladyman and Ross 2007; Psillos 1999). This is probably due to two main factors: the ambiguity and inconclusiveness of the arguments for ER, and several serious counterarguments that have been raised against it. In this paper, I will formulate a new robustness-based version of ER, and show that this version has resources to answer all the classic objections raised against original ER. I will also show that, in contrast to the currently popular (ontic) structural realism, robustness-based ER provides a plausible account of realism for the life sciences.

In the next section, I will briefly go through ER and its main problems. In Section 3, I will present the robustness argument for ER, and in Section 4, I will argue that robustness-based ER has resources to answer all the main counterarguments raised against original version. In Section 5, I briefly consider the relationship between robustness-based ER and (ontic) structural realism.

**2. Entity Realism**

The most important accounts of ER are in Nancy Cartwright’s (1983) *How the Laws of Physics Lie* and Ian Hacking’s (1983) *Representing and Intervening*. I will mainly focus on Cartwright’s version of ER here, as it is more compact, and for the purposes of this paper, the differences between the accounts are inessential.

Cartwright’s (1983) starting point is inference to the best explanation (IBE), which is one of the classic strategies to argue for scientific realism. The core of the IBE argument is that if theories or laws are extremely successful at explaining and predicting phenomena, we can infer that they are also (approximately) true. This strategy has been forcefully criticized by a broad range of authors, most prominently Bas van Fraassen (1980). Cartwright mostly agrees with the critics, but argues that there is one exception: causal explanation. In the context of causal explanation, IBE is justified: “To the extent that we find the causal explanation acceptable, we must believe in the causes described” (Cartwright 1983, 5). In other words, she states that “to accept the explanation is to admit the cause” (ibid., 99). To illustrate, she gives the following example (ibid., 91). The lemon tree in her garden is sick, and the leaves are falling off. She comes up with an explanation: Water has accumulated at the bottom of the pot, which has made the tree sick. According to Cartwright, accepting this explanation as correct requires believing that the cause (water at the bottom of the pot) is real.

Importantly, Cartwright (1983, 75-76) also argues that accepting a causal explanation and the reality of the cause does not require accepting any theory or law as true. According to her, there is theoretical “redundancy” in science in the sense that the same causal process can be embedded into different theoretical frameworks, and consequently the reality of the causal process does not imply the truth of any theory. However, causal explanations themselves are “non-redundant”, as only one causal story for a given phenomenon can be accepted as satisfactory.

Cartwright (1983) and Hacking (1983) also appeal to scientific practice and experimentation for support. Hacking famously argues that the best evidence for the reality of electrons is that we can use them to create and study other phenomena – “if you can spray them, they are real” (Hacking 1983, 23). Cartwright claims that experimentation can give causal explanations a degree of objectivity that is impossible to reach for laws and theories, referring for example to a laser-making company that runs numerous test lasers to death each year to make sure that the lasers produced have exactly the effects that they are supposed to have (Cartwright 1983, 3).

Also transcendental or indispensability arguments for ER can be extracted from the accounts of Cartwright and Hacking (Morrison 1990; Miller forthcoming). The idea is that successfully manipulating and controlling nature with scientific means *requires* accepting the reality of the entities involved. As Hacking puts it, scientists cannot help being realists about (experimental) theoretical entities (Hacking 1983, 262).

Finally, an important consideration in favor of ER is that entities seem to be more stable and resistant to scientific revolutions than theories and laws. For example, the electron entered the ontology of physics in the late 19th century, and has remained there since, although theories in physics have gone through such dramatic changes as the discovery of quantum mechanics and the relativity theory (Hacking 1982). Thus, ER appears to be less susceptible to the pessimistic induction argument than standard scientific realism.

ER is an attractive position, as it seems to amount to “defensible middle ground” between antirealism and standard scientific realism (Clarke 2001). However, ER has few proponents nowadays. This is probably due to two main reasons: the elusive nature of the arguments presented in favor of it, and serious counterarguments that can be raised against it. The elusiveness of the arguments for ER should be clear from the above summary. There is no compelling master argument, just several interconnected strands of reasoning presented in its support (see also Clarke 2001 and Miller forthcoming). I will now proceed to discuss the main counterarguments.

First of all, the notion that accepting a causal explanation as correct implies accepting the reality of the cause can be questioned. An antirealist along the lines of van Fraassen (1980) could argue that when a scientist accepts a causal explanation, she does not have to accept the reality of the cause, but merely that there is a causal story that is empirically adequate (Hitchcock 1992). Another strategy for an antirealist would be to argue that if Cartwright is correct that statements of the kind “P causally explains Q” imply the reality of P, then we are not warranted in believing that such statements are true (ibid.). There seems to be no compelling reason why accepting the scientific practices of causal explanation would require accepting the reality of the causes (see Clarke 2001 and Hitchcock 1992 for more).

A second problem for ER can be formulated as a dilemma: Either ER is too minimal to be interesting, or it leads to a form of standard scientific realism (Morrision 1990; Psillos 1999, 249). More specifically, if ER amounts to just being warranted in believing that some entity X exist, and nothing more than that, it is questionable whether it constitutes a substantial and interesting form of scientific realism. At least, a realist also has to accept the reality of some key properties of the entity, for example, that the electron has a negative electric charge. However, the only scientifically acceptable way to attribute properties to entities is to do this on the basis of the most state-of-the-art scientific theories. This, in turn, seems to require believing that those theories are to some extent true (Chakravartty 2007, 30; Psillos 1999, 248-249). But accepting that the best scientific theories are to some extent true is not very far from accepting standard scientific realism. Thus, if entity realism is extended to cover also the properties of entities, it may not be so different from standard scientific realism after all.

A third and related problem is that, in spite of appearance, ER may not fare any better than the alternatives against the argument from pessimistic induction (Morrison 1990; Chakravartty 2007, 32). Although it may be true that, for example, the electron as such has withstood several scientific revolutions, views about its properties have considerably changed. Thomson and Rutherford believed very different things about electrons than scientists do today (ibid.). For example, they did not believe that the electron is a fermion or that it exhibits wave-particle duality, which are nowadays seen as fundamental properties of electrons. If the views about the nature and properties of the electron have dramatically changed since it was discovered, the same presumably holds for entities as well, and the continuity that ER provides is only illusory.

In sum, the main problems of ER can be paraphrased as follows. (1) The success of causal explanation does not warrant inferring the reality of the cause. (2) Realism about entities only (without their properties) is too weak to be interesting, but the properties of entities are attributed to them by the best scientific theories, so accepting their reality involves accepting that the best scientific theories are to some extent true, leading to a form of standard scientific realism. (3) The properties of entities cannot in general be expected to survive scientific revolutions, and thus any interesting form of ER fails to avoid the pessimistic induction argument. In the next section, I will formulate a new robustness-based version of ER, and in Section 4 I will show that it successfully tackles these problems.

**3. Robustness**

As we saw above, Cartwright and Hacking present several interconnected arguments in support of ER: causal considerations, arguments from experimentation, indispensability arguments, and so on (see Clarke 2001 and Miller forthcoming for more). These arguments clearly have not convinced the philosophical community, as ER remains an unpopular position. However, there is a further argument for the reality of scientific entities, which can be extracted from different debates in philosophy of science, and is far more promising for defending entity realism. This is the argument from robustness: Roughly, if there are several independent way of measuring, detecting or deriving something, then we have good reasons to believe that that thing is real.

Robustness in its different manifestations has been extensively discussed in recent years (Eronen 2015; Kuorikoski, Lehtinen, and Marchionni 2010; Kuorikoski & Marchionni forthcoming; Raerinne 2013; Schupbach forthcoming; Soler, Trizio, Nickles, and Wimsatt 2012; Woodward 2006). It is also often briefly referred to in discussions of scientific realism, including those of Cartwright and Hacking (Cartwright 1983, 84; Hacking 1981; 1983, 201; see also Chakravartty 2007, 65-66). However, it has not been developed to a full argument for scientific realism, with the exception of the work of William Wimsatt (1981, 1994, 2007), which I will take as the starting point here.

Wimsatt (1994) explicitly argues that we should adopt robustness as a criterion for what is real, and that this leads to scientific realism that is less metaphysical and more local than the standard forms. The idea is that if there are many ways of measuring, detecting, producing or deriving something, and those ways are sufficiently independent, then it is very unlikely that all of them turn out to be mistaken or erroneous. Thus, things that are robust in this sense are very likely to be real. For example, electrons can be measured, detected and produced with many different techniques and setups relying on different theoretical assumptions, and they can be derived from various models and theories. Consequently, they are robust and extremely likely to be real.

Wimsatt’s rough idea is prima facie plausible, but is in several respects unsatisfactory or at least incomplete, and needs to be further refined (see also Eronen 2015). First of all, in order to avoid the implication that robustness itself makes things real (leading to some kind of constructivism), we should not see it as *criterion* for what is real in any strong sense, but rather as a source of justification or warrant for ontological commitments. This can be formulated as follows: *Robustness confers justification for believing that X is real, and the degree of this justification corresponds to the degree that we have robust evidence for X*. Furthermore, as robustness depends on currently available methods of measuring, detecting or deriving something, it is clearly a feature that is relative to a certain scientific community at a certain time. This needs to be incorporated into any definition of robustness. For similar reasons, we should take into account that robustness is a matter of degree: for example, we have more robust evidence for electrons or DNA molecules than we have for the Higgs boson. With these considerations in mind, we can give the following working definition of robustness (based on Eronen 2015):

(Robustness) The relevant scientific community at a certain time has robust evidence for X insofar as X is detectable, measurable, derivable, producible or explanatory in a variety of independent ways.

The notion “explanatory” has been included in the definition for the reason that it is very plausible that things that appear in many independent explanatory generalizations or models are more robust[[1]](#footnote-1) than things that do not (see also Eronen 2015). For example, electrons are very robust partly because they appear in a broad range of distinct models and explanatory generalizations in physics, whereas D-branes only appear in certain string theory models, and are in this respect less robust. It is also important to note that none of the dimensions mentioned is by itself necessary for robustness: The moon, for example, is an extremely robust entity, although there is no clear sense in which we can produce it, and properties or phenomena can be highly robust even though there are no accepted explanatory generalizations or models involving them (e.g., gamma-ray bursts).

The notion of independence is crucial for robustness: If different ways of measuring something are not independent from each other, but are based on the same assumptions and methods, then they all lose their value if those assumptions and methods turn out to be false or mistaken, and the robustness that they confer is only illusory. One problem for robustness-based realism is that spelling out the nature of this independence is far from trivial, and if it is unsuccessful, the plausibility of the whole account can be questioned (Hudson 2014; Stegenga 2009). However, in recent years much progress has been made in defining the right kind of evidential independence. What is certainly not required is statistical independence, as two distinct ways of measuring the same thing will be often correlated, and this should not prevent them from contributing to robustness (Schupbach forthcoming). The idea is rather that two ways are appropriately independent if their characteristic errors and biases are independent from each other (Kuorikoski and Marchionni forthcoming). For example, cloud chamber experiments to detect electrons are based on different causal processes and theoretical assumptions than cathode ray tube experiments, and thus they cannot involve the same biases or systematic errors. Ways of detection that are independent in this sense make it more likely that the entity or phenomenon is real, and thus contribute to robustness (see Kuorikoski & Marchionni (forthcoming) for more, and Schupbach (forthcoming) for an alternative proposal).

For the purposes of this paper, let us assume that the account of robustness presented here is roughly correct, so that we can examine what consequences it has for the issue of entity realism. In fact, the consequences are rather straightforward. First, it is clear that many entities in science are detectable, measurable, derivable, producible, or explanatory in a variety of independent ways, and thus we have a high degree of robust evidence for them. From this it follows that we have a high degree of justification in believing that many entities in science are real, which amounts to a form of ER. Thus, if we understand the role of robustness as I have proposed here, it directly leads to ER.[[2]](#footnote-2) In the next section, I will clarify this robustness-based entity realism (from now on, RER) further, and show how the criticism raised against original ER fails to undermine it.

**4. Neurons and Robustness-based Entity Realism**

The main example that I will use here to elaborate on RER is the neuron. This is a suitable case, as the neuron is a “theoretical” entity in the sense that it is not directly observable, and in the 19th century the existence of neurons was still just a hypothesis, but nowadays there is overwhelmingly robust evidence for their reality. Here it suffices to mention just some examples of the variety of independent evidence for neurons: they can be observed with a broad range of staining techniques; they can be seen with light microscopes and imaged with electron microscopes; their activity can be recorded with various single-cell and multi-unit recording setups; they can even be produced with the help of stem cells; they play an important role in explanatory models and generalizations concerning animal and human behavior, and so on. Even if broad categories of these sources of evidence would turn out to be mistaken, plenty of other independent sources would still remain, and we would still have highly robust evidence for the neuron.

With this example in mind, let us go through the four objections to ER outlined in Section 2. The first problem was that accepting a causal explanation does not require accepting the reality of the cause, *contra* Cartwright (1983). However, in contrast to the original ER, RER does not appeal to any special features of causal explanation. In the picture I have sketched above, the fact that an entity or a property appears in a causal generalization can contribute to its robustness (as “explanatory” is one of the dimensions in the definition of robustness), but just as one possible factor among many others. A robustness-realist can accept that causal explanations are as fallible as any other explanations in science.

However, even though RER evades this particular problem, an analogous anti-realist objection can be formulated for robustness. A constructive empiricist in the vein of van Fraassen could insist that there is no compelling reason why anyone would be required (as opposed to permitted) to believe in entities for which we have robust evidence (see also van Fraassen 1985, 297-300). This may be strictly speaking true, but in the case of entities like neurons, such suspension of belief comes close to outright skepticism. It could be argued that someone who has access to all the robust evidence for neurons is just as justified in believing in the reality of neurons as in the reality of the table in front of her (see also Hacking 1981). However, as I have pointed out above, RER does not require accepting any particular theories as true, or accepting IBE as valid, so many aspects of the constructive empiricism of van Fraassen (1980) are in fact compatible with RER.

The second problem for ER was the that realism about entities only is too weak to be interesting, but realism about the properties of entities seems to require accepting that the best scientific theories are to some extent true, leading to a form of standard scientific realism. First of all, RER can and should be extended to properties as well.[[3]](#footnote-3) The electrical conductivity of iron is detectable, measurable, derivable, producible and explanatory in a broad range of independent ways, and is thus an extremely robust property. Having a voltage gradient is an extremely robust property of the neuron, transmitting action potentials is an extremely robust property of the axon, and so on. However, extending RER to properties has only minimal implications for the truth of theories. Many ways of detecting or measuring the properties of entities such as neurons do not depend on any theory. For example, Golgi’s staining method for observing neurons was developed over 100 years and is still in use, but there is no accepted theory that would explain how it actually works (Guillery 2005, 1290). Furthermore, the requirement of independence guarantees that highly robust evidence for an entity or property does not rely on just one theory, but on many distinct models or theories. Any one of these models or theories may turn out to be false, and the property would still remain robust. For example, even if the Hodgkin-Huxley model for the action potential would turn out to be fundamentally incorrect, plenty of other sources of independent evidence for the action potential would still remain.

Thus, a high degree of robustness and the consequent justification in the reality of a property does not imply belief in the truth of any theory. At best, the robustness realist may be required to believe that there are some true elements among the various theories and models involved, but she can still remain entirely agnostic about the truth of scientific theories in general, and deny the validity of the IBE argument (i.e., deny that we can infer the truth of scientific theories from their explanatory success).[[4]](#footnote-4)

The third problem was that although some entities such as the electron have withstood several scientific revolutions, many of their properties have been eliminated, and thus ER fails to evade the pessimistic induction argument. However, this issue can be reformulated and examined in new light once we understand that we can also have varying degrees of robust evidence for properties. Scientific properties often face elimination, but it is far from clear how often highly robust properties are eliminated. Many properties of neurons for which there was robust evidence in the early 20th century have been retained, such as having a negative transmembrane potential and communicating via synaptic junctions (Guillery 2005). Pessimistic induction reasoning works against RER only if it can be shown that *highly robust* properties have been repeatedly eliminated in the history of science, and it is far from clear whether this is the case.

In sum, none of the objections raised against ER undermine the plausibility of RER. It is a viable and defensible form of scientific realism that deserves to be taken seriously and explored in more detail.

**5. Scientific Realism for the Life Sciences**

An interesting feature of the debate on scientific realism is that the scientific examples and case studies have almost exclusively been drawn from physics. This is understandable, as it is widely assumed that the most mature and explanatorily successful theories and generalizations are found in physics. However, one consequence of this is that accounts of scientific realism often run into problems when applied to the life sciences. For example, Steven French’ (2011) discussion of scientific realism in biology merely gestures towards possible ways in which structural realism could be extended to biology in future work. Ladyman and Ross (2007) are more ambitious, and apply their ontic structural realism to the special sciences, but at the cost of reducing all special science entities to patterns that are defined in highly technical information-theoretic terms. This makes their realism completely detached from scientific practice, providing no tools for assessing our degree of justification for the reality of special science entities and properties, and also forcing us to rethink all special science ontologies in terms of structures and patterns.

In contrast, RER directly supports realism in the life sciences, without imposing any kind of ontological revision, and in a way that is continuous with scientific practice. Above I have illustrated this with the example of the neuron, and this is not an isolated or cherry-picked example; the life sciences are full of similar cases. Consider for example mitochondria, cell membranes, pollen or the *Eschericia coli* bacterium. There is extremely robust evidence for each of these entities and many of their properties, and they have been retained in the ontology of biology in spite of radical changes in biological theories.

One related implication of RER is that we may sometimes be more warranted in believing in the reality of entities and properties in the life sciences than in the reality of fundamental physical entities or properties (see also Eronen 2015). For example, when compared to the neuron, there are relatively few independent ways of measuring, detecting or producing the up quark. Same applies to the recently detected Higgs boson, and for various other elementary particles. In light of the biological examples above, it could turn out that the strongest case studies for scientific realism are not found in physics, as usually has been assumed, but rather in the life sciences. This of course would not mean that these entities and properties of the life sciences are more fundamental than physical entities or properties, but simply that we have more robust evidence for them, and consequently our degree of confidence in their reality is somewhat higher.

As a final remark, it is also possible that ontic structural realism (in the vein of Ladyman and Ross 2007) and RER turn out to be compatible. Ontic structural realism could be seen as a framework for understanding realism in theoretical physics, and for spelling out the metaphysical relationship between special science properties and fundamental physics, while RER could be taken as an account of the science-based ontological commitments in the special sciences. This issue is a topic for future research; in this paper, I hope to have shown that RER is a plausible and defensible form of realism for the life sciences.

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1. Strictly speaking, it would be more accurate to always write “robust evidence for X” instead of “x is robust”, but for the sake of readability, I also use the latter kinds of expressions here. [↑](#footnote-ref-1)
2. Note that the account defended here does not imply that robustness is necessary for being justified in believing something to be real: There may be also other sources of justification for ontological commitments. One important consequence of this is that cases where we are apparently warranted in believing in the reality of something that is not robust are not counterarguments to this account. [↑](#footnote-ref-2)
3. Original ER was also never intended to apply only to the entities themselves. For example, Cartwright explicitly states that we are warranted in believing in the reality of many “theoretical entities and *theoretical properties*” (Cartwright 1983, 8, emphasis added). [↑](#footnote-ref-3)
4. One might object that robustness reasoning also involves a form of IBE: The best explanation for the robust evidence for X is that X is real, so we are justified in believing that X is real (cf. Hudson 2014). However, it is possible to accept a certain kind of IBE as valid, without accepting that IBE generally and universally works (Clarke 2001). A robustness-realist can accept robustness-based IBE that concludes that we are highly justified in believing that X is real, but deny that the IBE from the success of theories to their truth is valid. [↑](#footnote-ref-4)