Entity Realism and Natural Kinds

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1. Scientific Realism vs. Scientific Anti-Realism; Is There a Middle Ground?

One of the most controversial debates in the literature of philosophy of science is the dispute between scientific realism and scientific anti-realism. The main topic in question is to what extent we can be optimistic that scientific inquiries tell us what the world really looks like. More precisely, this philosophical issue is structured around the question of what is the best way of interpreting scientific theories with respect to unobservable entities, processes, and properties.

Scientific realists, on the one hand, insist that one of the legitimate aims of scientific inquiries is to discover the true claims about the natural world, and scientific theories have approximately succeeded in attaining this aim. These philosophers have an epistemically positive attitude toward the outputs of scientific investigation, regarding both observable and unobservable aspects of the world. Scientific realists believe that well-confirmed and mature scientific theories are approximately true, and the entities postulated by these theories (such as electrons, genes, quasars) are among the real furniture of the world, too.

One of the well-known arguments that scientific realists have put forward in defense of their position is known as ‘No Miracle Argument’ (NMA). Considering the impressive predictive and engineering successes of best scientific theories, some scientific realists argue, roughly speaking, that these successes can coherently and plausibly be explained based on an assumption that these theories are true (or approximately true) and their truth is grounded in reality; otherwise, the success of scientific theories must be seen as a miracle. Thus, on the bases of NMA, claims of well-established theories track the truth and often get close to reach it.

Nevertheless, scientific realism is not an uncontroversial view. The opponents of this philosophical position, i.e., scientific anti-realists, argue that the best explanation of the success of science does not imply that scientific theories are true or approximately true. Consequently, we are not ontologically obliged to commit ourselves to unobservable entities postulated by these theories. Several anti-realist philosophers, for instance, have raised serious objections regarding the aforementioned realist abductive argument, i.e., NMA.

One of the major arguments against scientific realism, in general, and NMA, in particular, is the pessimistic induction (PI) which challenges the relations between success and truth of a scientific theory. PI has been presented in various ways in the literature. One of the latest versions of this argument, presented by Larry Laudan (1981), gives a long list of theories from the history of science which were empirically successful but known as false from a scientific realist point of view. History of science reveals an undeniable issue that most of the empirically successful and well-established theories were later rejected. Moreover, Laudan's historical cases display that the past successful scientific theories introduced theoretical terms which were expected to refer to unobservable entities, but further investigations showed that these postulated theoretical terms are non-referential.[1] Since all the past empirically successful scientific theories are false, it is likely that present empirically successful theories are also false. Hence, it is plausible to say that the current successful and mature scientific theories cannot be regarded as true or even approximately true either. Therefore, based on this historical insight,

[1] To see the discussion on theoretical term, see: Hashemi (2021)

Laudan argues that scientific realism is not a tenable position to explain the success of science (Laudan, 1981, pp. 32-47).

Philosophers who have a realist inclination with respect to scientific inquiries (or at least some aspect of them) have put forward several responses to PI. The underlying common approach in most of these responses is the view called ‘selective skepticism’. Selective skepticism, roughly speaking, is a middle ground between two extreme positions, i.e., full-blown scientific realism and full-blown scientific anti-realism. Proponents of selective skepticism say “as in life generally, so too in science: do not believe everything you are told. Not all aspects of scientific theories are to be believed. Theories can be interpreted as making many claims about the nature of reality, but at best one has good grounds, or epistemic warrant, for believing some of these claims. Only some aspects of theories are likely to be retained as the sciences march on” (Chakravartty, 2007, p. 29).

Accordingly, proponents of selective skeptical approach argue that it is a hasty conclusion to hold that the entire aspects of an old falsified but successful scientific theory are not tracking the truth. These philosophers of science believe that a deep comparison between the new and the old theories shows that some elements of successful theory tend to be preserved from old theories to new ones. Hence, these philosophers try to draw a line between the true and belief-worthy elements of empirically successful theories, and the false, belief-unworthy elements, which tend to be discarded in the future. “The primary motivation for this modification to realism simpliciter is to pick out, from among the numerous claims embedded in theories, the ones that are most epistemically secure and thus likely to survive over time” (Chakravartty, p. 29).

Selective skepticism can mitigate some of the realist concerns with respect to PI; however, this view raises a new and serious question: what aspects of scientific theories can remain true when these theories undergo radical changes?

There are several responses to this question and each response formulates its own solution to remove the worry that PI raised against scientific realism. Broadly speaking, selective skepticism, as Chakravartty classifies, can be categorized into two groups: entity realism and structural realism. While the latter holds that we should epistemically commit ourselves only to the mathematical or structural content of our mature scientific theories, the former maintains that some of the entities introduced by scientific theories exist in reality. According to entity realism, we can be generally skeptical about scientific theories, but we can coherently endorse existential claims about some unobservable entities. Since this view accepts that some unobservable entities postulated by well-confirmed scientific theories really exist in the mind-independent word, entity realism can be categorized as a thesis in defense of scientific realism; however, entity realists tend to remain antirealist or skeptical regarding theoretical claims. In general, a proponent of entity realism tries to prove that the content of scientific theories can undergo change, while we can know that some of the postulated entities within these theories really exist in the mind-independent reality.

In this paper, I focus on a version of entity realism developed by Ian Hacking (1982/1983) who argues that scientific experimentations can plausibly imply ontological commitments about some certain unobservable theoretical entities. Drawing a sharp line between entities and theories in which entities are postulated, Hacking restricts his favorite account of realism only to some theoretical entities rather than the truth of the theories. Hacking distinguishes between two types of unobservable entities: experimental entities and theoretical ones. As opposed to a full-blown realist assumption that maintains that all theoretical entities postulated by a well-confirmed and mature theory exist in the world, Hacking narrows his realism only to experimental entities. Experimental entities are entities that experimenters use in their labs in order to study other phenomena. These entities are real and the vast majority of experimental physicists, Hacking believes, are rationally justified to believe in the existence of entities that they use. Electrons, according to Hacking, can be seen as a good example of these types of experimental entities, because experimenters spray them to study weak neutral currents, which are theorized to be carried by bosons. In the words of Hacking, "if you can spray them then they are real" (Hacking, 1983, p. 23).

> Experimenters are often realists about the entities that they investigate, but they do not have to be so. Millikan probably had few qualms about the reality of electrons when he set out to measure their charge. But he could have been sceptical about what he would find until he found it. He could even have remained sceptical. Perhaps there is a least unit of electric charge, but there is no particle or object with exactly that unit of charge. Experimenting on an entity does not commit you to believing that it exists. Only manipulating an entity, in order to experiment on something else, need do that (Ibid, p. 262). [Original emphasis]

When an experimenter can manipulate some unobservable entities so as to intervene in other things, she is using them as tools for scientific investigation. Experimenters manipulate theoretical entities to learn about some real phenomena. These theoretical entities enable them to causally interact with some real aspects of the world. Consequently, experimenters are in a causal interaction with experimental entities. By exploiting their causal powers, one cannot doubt their existence. When we intervene in the world by building bridges, chopping down trees, driving cars, and so forth, we are plausibly realist about the items that we interact with. In the same vein, when an experimenter manipulates an entity in her lab, the causal interaction with the manipulated entity, not the theory, provides evidence that the entity exists. Experimentation, Hacking argues, gives us an opportunity to causally interact with far-fetched aspects of the world to produce, control, and observe phenomena. If we use one part of the world to intervene in the world, then we are entitled to believe that our tool for intervention is real.

> Theoretical entities are often supposed to have causal powers: electrons neutralize positive charges on niobium balls. The original nineteenth-century positivists wanted to do science without ever speaking of causes', so they tended to reject theoretical entities too. This kind of anti-realism is in full spate today (Ibid, p. 24).

So, Hacking holds that experimental entities (or properties, processes, and events) are real; that is, they are part of the causal structure of the world. When we are able to manipulate these entities, then an entity realist claims that we are able to know that these manipulated entities, even if they are unobservable, exist.

> 'Real' is a concept we get from what we, as infants, could put in our mouths….Reality has to do with causation and our notions of reality are formed from our abilities to change the world. Maybe there are two quite distinct mythical origins of the idea of 'reality'. … We shall count as real what we can use to intervene in the world to affect something else, or what the world can use to affect us (Ibid, p. 146).

According to Hacking, experimenters need only be a realist about the entities they use as tools. They need not to assume the truth of the theories in which these entities are introduced. "The best kinds of evidence for the reality of a postulated or inferred entity is that we can begin to measure or otherwise understand its causal powers. The best evidence that we can have this kind of understanding is that we can set out, from scratch, to build machines that will work fairly reliably, taking advantage of this causal nexus. Hence, engineering, not theorizing, is the best proof of scientific realism about entities" (Hacking, 1982, p. 170). In general, the casual interaction with experimental entities, Hacking argues, shows that these entities are real.

2. Is a theory-free form of Realism a defensible idea?

Hacking defends a moderate and minimal version of scientific realism; however, the success of his project has been put in doubt by some considerable objections. These objections, in general, try to show that Hacking cannot safely hold a middle-ground position in the dispute between scientific realism and scientific anti-realism. In this way, a prominent objection, which has been frequently asserted in the literature of scientific realism, argues against the defensibility of the main assumption embedded in Hacking's idea, i.e., a theory-free form of realism. Entity realism, as mentioned above, is expected to be a theory-free form of realism, i.e., we can legitimately remain skeptical about theoretical claims in which experimental entities are introduced. However, this view is not a tenable assumption in the eyes of some philosophers of science. [2] According to these people, roughly speaking, the distinction between realism about entities and realism about theories is misconceived. Entities are not introduced in a vacuum; hence, we cannot have knowledge of the existence of entities in isolation. One must know the details of at least some of properties and relations of theoretical entities to know that they exist.

> It may well be the case that electrons exist, even though some (or most) of our descriptions associated with the term 'electron' are false. But the issue at stake is different. It is this: can we assert that electrons are real, i.e. that such entities exist as part and parcel of the furniture of the world, without also asserting that they have some of the properties attributed to them by our best scientific theories? I take it that the two assertions stand or fall together (Psillos 1999, p. 256).

In addition, these critics believe that although experimenters can know that they are manipulating something, they do not know what exactly it is that they manipulate unless they adopt some theoretical descriptions of the manipulated entity. What makes electrons, for example, different from neutrons is that they have different properties, and obey different laws. One should rely on these theoretical descriptions in order to manipulate these entities effectively

[2] The objection has been formulated in various ways in the literature. For instance, see: Mugrave (1996), Morrison (1990), Resnik (1994), Massimi (2004) Psillos (1999) *et. all*.

and exploit their causal powers. “The experimental realist can only have knowledge about theoretical entities if she assumes that the theories which describe those entities are at least approximately true; and …that experimentation is not nearly as theory-free as Hacking maintains” (Resnik 1994, p. 395). Thus, on the basis of such an argument, the opponents of Hacking argue that his account of realism cannot justifiably remain skeptical about theoretical claims. Obviously, this issue poses a serious threat to Hacking’s theory and severely undermines the plausibility of entity realism. So, it is worth investigating Hacking’s theory more carefully to see whether his theory-free form of realism is epistemologically defensible.

It is true that entity realism remains skeptical about theoretical claims; however, it is wrong to assume that Hacking’s theory underestimates the role of scientific theories in experimentation. Hacking does not hold that a belief in an unobservable experimental entity does not require any kind of theoretical background at all; rather he acknowledges that experimenters “need to rely on some low-level generalizations about their instruments, as well as some theories about phenomena they are not studying, but they do not need to subscribe to full-blown scientific theories about the phenomena they are investigating in order to achieve their results” (Hacking, 1983, 176). In addition, they can know a modest number of “home truths” about experimental entities, which consist of thinly theory-laden low-level generalizations about their well understood causal properties; for example, their mass, spin, and charge. What Hacking denies is that an experimenter does not need to assume the truth of specific theoretical claims about the experimental entity which is manipulated by her. The experimenter can benefit from theoretical claims; in some cases, she needs to be fully familiar with the theoretical aspects in details. However, she does not need to assume that these theoretical claims as true in order to justifiably remain realist about the manipulated entity.

Opponents of Hacking, nevertheless, argue that this minimal amount of theoretical knowledge is not enough to settle the mentioned worry. Considering the essential role of justification in forming knowledge, David Resnik (1994) argues that experimenters have to be justified in their belief in order to know that manipulated experimental entities exist; but, Hacking's entity realism, Resnik Holds, cannot solely provide such a justification (Resnik, 1994, p. 407).

In Hacking's view, such a justification is provided by appealing to Patnam's semantic theory. Given Putnam's causal semantic, Hacking holds that we are justified in believing in a theoretical entity without believing in the theory in which the entity is embedded because Putnam's semantic theory enables us to successfully refer to that entity even when our theory about that entity undergoes a radical change.

> It was once the accepted wisdom that a word such as 'electron' gets its meaning from its place in a network of sentences that state theoretical laws. Hence arose the infamous problems of incommensurability and theory change … Putnam saved us from such questions by inventing a referential model of meaning…..J.J. Thomson, H.A. Lorentz, Bohr and Milikan were, with their different theories and observations, speculating about the same kind of thing, the electron … The stereotype of the elector has regularly changed, and we have at least two largely incompatible stereotypes, the electron as cloud and the electron as particle…Stoney, Lorentz, Bohr, Thomson and Goudsmit were all finding out more about the same kind of thing, the electron (Hacking, 1984, pp. 157-8).

Resnik acknowledges that Putnam's semantic theory can increase the epistemic cogency of Hacking's entity realism; however, Resnik argues that we cannot successfully refer to a theoretical entity unless we are justified in claiming that the entity in question is a natural kind; and in order to understand whether an entity is a natural kind, it should be understood within a theory.

> Theory-free entity realism is on epistemologically solid ground - it can give us knowledge - only if we know that the entities to which we refer are natural kinds; that is, we know that they are fundamental parts of the world's causal structure. However, if we do not know that a theoretical entity is a natural kind, then we cannot claim to continue to successfully refer to that entity when our theories about it change. If a theoretical entity is not a natural kind, then it is an artifact of our theories and classificatory systems. If an entity is a mere artifact, then we cannot have knowledge about that entity (Resnik, 1984, p. 407).

Resnik properly shows that in the history of science many theoretical entities were recognized later as mere artifacts. Phlogiston, for instance, was one of these theoretical entities. Theoretical investigations eventually showed that phlogiston was not a natural kind; it was merely an artifact of specific chemical theories. Resnik argues that if we want to successfully use Patnam’s semantic theory, we need to show that the referred entity belongs to a natural kind. Hence, the question we need to put before Hacking is this: how do we know that experimental entities like electrons will not one day be shown to be artifacts of current physical theories? How do we know that the effect of electrons is not really produced by some other unknown entities?

In this way, Resnik argues that the main challenge for entity realism is to answer, then, to question of how we can know that a theoretical entity is a natural kind. Resnik believes that a plausible response to this question makes Hacking’s view far from its assumption about being a theory-free form of realism. In order to address this problem, Resnik believes that Hacking has two options at his disposal. Either he can keep his skeptical approach about theoretical claims and hold that we are not able to find answer to this question; such an answer converts Hacking’s entity realism into a form of scientific anti-realist view. Or he can welcome a theoretical version of scientific realism and maintain that we know that an entity is a natural kind provided that it is postulated by a well-confirmed, explanatorily successful, approximately true theory. Resnik does not see a middle-ground solution to the problem.

I agree with Resnik that Hacking's entity realism should be combined with natural kind realism in order to provide enough justification that an experimental entity is real and undergoes radical theoretical change; nonetheless, I disagree with Resnik that this issue implies that we should embrace a full-blown version of scientific realism to identify an entity as a natural kind.

In the following paragraphs, I try to show that Hacking's entity realism, as opposed to a full-blown form of scientific realism, puts us in a better epistemic position with respect to identifying what natural kinds are. Then, I argue that theoretical claims, despite what Resnik says, might not help us to identify what entities are natural kinds. Thus, there is no need to leave entity realism to justify that experimental entities are natural kinds. In order to clarify my argument, I need to briefly review some relevant philosophical discussions about natural kinds realism, what natural kinds are, and what kinds of features they have.

3. **How to identify Natural Kinds? Theories or Experimentation**

There are various ways to classify objects into different kinds or categories. These classification of objects into kinds can be arbitrary, heterogeneous, or gerry-mandered. Nonetheless, if we assume that there are real mind-independents things in the external world, it is plausible to hold that among the countless possible types of classifications, there are genuinely natural ways of classifying things. There are types of classifications which, using Plato's famous metaphor, carve nature at its joints. A natural kind is a group of similar entities which are classified on the basis of some natural similarity relation to one another, and this classification reflects the structure of the natural world rather than the interests and actions of human beings (Koslicki, 2008, 789-90).

Given that there are natural kinds, one important question which is highly relevant to our discussion is how to identify them; how natural kinds can be distinguished from non-natural kinds or artifacts. Indeed, this question can be answered in various ways because different accounts of natural kinds ascribe different features to them. However, there are minimum features of natural kinds which are less controversial and are commonly accepted. In general, it is commonly believed that natural kinds are identified based on the role they play in inductive generalizations, scientific laws and causal explanations.[3] The first element indicates that natural kinds "are often said to be particularly well-suited, in comparison to other sorts of taxonomic classifications, to the task of grounding legitimate inductive inferences concerning the members of the kind in question." The second element suggests that natural kinds distinguish themselves by figuring in laws of nature. And the third element, which is the most important feature of being a natural kind, holds that natural kinds are grounded in the causal structure of the world. Indeed, the third feature, i.e., being rooted in the causal structure of the world, enables natural kind classifications to play the role that they do in inductive inferences and laws of nature (Ibid, pp. 790-792).

These three fundamental features of natural kinds explicitly show how scientific theories and consequently philosophy of science are related to the discussion about natural kinds. If we assume the metaphysical realism about natural kinds, the dispute between scientific realists and scientific anti-realists can be re-structured around the question of whether theoretical entities postulated by mature and well-confirmed scientific theories represent natural kinds or not. A scientific anti-realist would definitely respond that we cannot know the answer of this question,

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[3] The explanatory role of natural kinds can be understood in other ways; but here for the sake of the purpose of my argument I assume that causal explanation is preferable to other types of explanations.

so it’s better to remain skeptical about the relations between these types of unobservable entities and natural kinds. A full-blown scientific realist takes the opposite view and confirms that all entities postulated by a mature and well-confirmed theory can be categorized as natural kinds. What would be the answer of an entity realist who is skeptical about scientific theories, but realist about entities which are manipulated by experimenters? As I mentioned above, Resnik believes that an entity realist like Hacking cannot provide a distinctive answer to this question. Any plausible realist response to this question, according to Resnik, converts entity realism into a form of a full-blown scientific realism. The main assumption embedded in Resnik’s argument is that natural kinds, if they are introduced by science, can be determined by mature and well-confirmed scientific theories. I disagree with this claim, and in the rest of the paper, I try to show why Resnik’s claim is not defensible. Despite what Resnik holds, I argue that entity realism can provide a more reliable epistemic ground for us to see what kinds of theoretical entities can be regarded as natural kinds, not mere artifacts.

As explained above, the main feature of being a natural kind is that a natural kind is embedded in the causal structure of the world. In order to identify an entity as a natural kind, the first and foremost necessary condition is that the entity is causally engaged in the causal structure of the world. Put differently, this issue is a necessary and primary condition of identifying an entity as natural kind. As mentioned at the outset of this paper, entity realism is only ontologically committed to experimental entities. These entities, according to Hacking, are real because of the role that they play in the causal structure of the world. For Hacking, as quoted above, “[r]eality has to do with causation and our notions of reality are formed from our abilities to change the world” (Hacking, 1983, p. 146). Thus, only the theoretical entities which have causal interactions with the world are real. In contrast, a full-blown realist holds that theoretical entities postulated by mature and well-confirmed theory are real. Assuming the truth of theoretical claims does not in itself guarantee that these theoretical entities are involved in the causal structure of the world. In other words, we cannot know that theoretical entities postulated by theories are causally engaged in the causal structure of the world, while experimental entities are easily identified based on their causal interactions with the existing phenomena. When experimental entities are used or manipulated by experimenters in order to change something real in the world; these entities are involved in the causal structure of the world. Put differently, experimental entities already satisfy the necessary condition of being a natural kind. As opposed to mere theoretical entities which do not presumably show any causal interaction, experimental entities are engaged in the causal structure of the world.

Given that being involved in the causal structure of the world is the necessary and fundamental feature of being a natural kind, Hacking's emphasis on the causal role of experimental entities put such entities in a better position to be regarded as natural kinds. In contrast, a full-blown scientific realism which only focuses on the role of theories is not able to show that theoretical entities postulated by a well-confirmed and mature theory are in a causal interaction with the world.[4] Thus, it is not extravagant to hold that experimental entities are more likely than mere theoretical entities to be identified as natural kinds.

In addition, despite what Resnik says, theoretical claims do not put us in a better epistemic position with respect to identifying what real natural kinds are. Epistemically speaking, there are good reasons which motivate us to remain skeptical about the truth of theoretical aspects of

[4] Reviewing the story of phlogiston and many other similar theoretical entities is useful here to remind us we cannot rely on scientific theories to identify natural kinds. Phlogiston, as a mere theoretical entity, was introduced by a mature chemical theory to explain chemical phenomena such as combustion, rusting, metabolism, etc. However, it was not a kind of experimental entity to be manipulated by an experimenter. Now, phlogiston is firmly believed as an artifact of a specific chemical theory.

scientific inquiries. In general, as some philosophers have pointed out, philosophy and history of science show how the distinction between experimentation and theoretical assumptions is epistemically fruitful.[5] There is always an important epistemic gap between experimentation and theoretical assumptions. This gap, which shows why theoretical claims are not always epistemically trustworthy, is created due to some errors which inevitably appear when theoretical claims are drawn from experimental data. These errors can have various known or unknown sources, but, as Kent Staley (2014) properly argues, they are inevitable because of two problems: the problem of scope and the problem of stability. The former indicates that theoretical assumption because of their great generality "are difficult to test exhaustively and sometimes must be applied in domains far from those in which they have previously been tested." The problem of stability shows that "the rare-but-recurring historical phenomenon of unforeseen dramatic change in general explanatory theories arguably constitutes some reason to worry about similar upheavals overturning theoretical assumptions that presently seem sound; moreover, conceptual innovation sometimes enables erroneous implicit assumptions to be brought to light" (Staley, 2014, pp. 39-41).[6] Staley shows both of these problems are avoidable at the level of experimental investigations. "Experimenters can avail themselves of methods that allow them to secure their experimental conclusions against possibilities of erroneous theoretical assumptions, provided that they confine themselves to certain kinds of conclusions i.e. those which rest upon secure premises" (Ibid, p. 40).[7]

[5] See: Hacking (1983, pp. 29-64) and Staley (2014)
[6] This philosophical issue can also be supported by many cases in the history of science. See: Staley (2014)
[7] In his paper, Staley provides philosophical and historical reasons for this claim, but for the sake of brevity, I skip explaining them here.

This philosophical insight, which is properly illustrated in Staley's paper, shows why the limited results of experimentations are epistemically more reliable than general theoretical inferences drawn from experimental activities. Thus, it is epistemically defensible to remain skeptical about the truth of theoretical claims and confine the epistemic judgments about scientific inquiries at the level of experimentations. Underlining this important epistemological issue, I would like to conclude that, despite what Resnik says, it is unlikely that theoretical assumptions put us in a better epistemic position with respect to identifying what kinds of theoretical entities are natural kinds. Instead, Hacking's emphasis on the role of experimentation makes his entity realism more epistemically trustworthy.

Based on the aforementioned reasons, I think that entity realist sounds to be more successful than a full-blown realist to show what kinds of theoretical entities can be regarded as natural kinds. Now, I like to focus on the epistemological and semantic components of natural kinds realism to show that realism about natural kinds does not necessarily assume that theoretical claims about them have to be true. We can have epistemic ignorance or/and epistemic error about real natural kind entities, while we still remain realist about them. Considering the epistemic and semantic elements of natural kinds realism, the realist picture depicted by entity realism is more congenial than the picture of a full-blown scientific realist to natural kind realism.

As Amie Thomasson (2003) properly explains, we should separate ontological, epistemological, and semantic aspects of being realist about natural kinds. The ontological dimension is defined based on these two principles: the independence principle which asserts that the extensions of the kind K exist independently of our mental states; and the natural boundary principle which holds that the kind K has natural boundaries which are not at all artificial, conventional or imposed by human concepts (Thomasson, 2003, p. 582).

The epistemological component holds that descriptions about the nature of the kind are not determinable by conceptual analysis. There are unknown substantial and non-trivial facts about natural kinds which are only discoverable through *a posteriori* investigations; this view is compatible with the idea that these facts might remain unknown forever. The epistemological dimension of realism about natural kinds can be summarized into two principles: the principle of ignorance and the principle of error. The former allows the possibility of this issue that there are unknown features of a kind K and these features may remain unknown forever, and the latter asserts that we might have wrong information and false beliefs about the unique features of a kind K that determines its boundary (Ibid, p. 583).

Finally, the semantic component of natural kind realism presupposes the idea that “there is a kind with pre-existing boundaries that can determine the extension of the terms regardless of speakers’ beliefs and concepts about the kind” (Ibid, p. 583). The best semantic theory which is able to manifest this view is the causal theory of reference according to which when the reference of a term is determined, by using the term we are able to refer to the extension of the kind through a causal chain regardless of the truth or falsity of the beliefs associated with the term.

Given that there are kinds with their real boundaries irrespective of our thoughts and theoretical claims about those kinds, even if we have wrong beliefs about them, we are still able to refer to the extensions of those kinds. So the semantic component of natural kind realism makes it possible to refer an entity, which belongs to a natural kind, without having any unique description of it. Consider Putnam’s well-known example about beeches and elms. We might not know anything about the difference between these two different trees, but whenever we use the term ‘beech’ we successfully refer to beeches, and whenever we use the term ‘elm’ we successfully refer to elms. The example clearly shows why being ignorant about something does not make a serious obstacle in the mechanism of referring to it. In addition, we can have some wrong belief about something, but we still can refer to it successfully. A competent user of a term can wrongly associate erroneous and incorrect descriptions with it, but she is still able to successfully refer to the object by the term as far as the reference is determined by a causal connection. Having false beliefs about objects does not rule out our ability to pick out objects (Kripke, 1980, pp. 118-119).

Considering ontological, epistemological, and semantic components of natural kind realism, I believe that Hacking's entity realism can coherently hold that experimental entities, not all theoretical entities postulated by a mature and well-confirmed scientific theory, are potential candidates to be considered as natural kinds. Moreover, Hacking can still remain skeptical about theoretical claims which describe these entities. As mentioned above, his skeptical attitude about theories is compatible with being realist about natural kinds. The principle of error and the principle of ignorance enable Hacking to coherently maintain his skeptical attitude towards theoretical claims. Having said that, theoretical claims are still very important for other purposes of scientific inquiries, they can also play a significant role to fix up the reference of experimental terms; nevertheless, at the end, it is the physical experiment which *can* make an ontological commitment. Thus, I believe that entity realism can coherently and plausibly hold that only experimental entities are potential candidates to be regarded as natural kinds. Despite what Resnik says, theoretical claims, no matter how strong and successful they are, cannot make us sure that a theoretical entity can convert into a natural kind, while the experimental manipulation of a theoretical entity in a lab makes us connected to a physical thing through a causal chain.

Theoretical claims by themselves, no matter how strong they are, cannot demonstrate that a theoretical entity is real, while Hacking gives us a more defensible test to understand what kinds of theoretical entities potentially can convert into natural kinds. I do not say that all the experimental entities immediately turn into a natural kind, but it is not far from reality to say that those experimental entities which undergo several radical theoretical changes are likely to be counted as natural kinds. As opposed to what Resnik says, Hacking's entity realism provides a criterion for us to understand what kinds of theoretical entities have potentiality to be considered as natural kinds.

For those realists who invest on theories and hold that entities postulated by theories which exhibit explanatory and predictive success are natural kinds, the skeptical problem still remains because we cannot distinguish between theoretical entities which might turn out to be artifacts and theoretical entities which are real. Indeed, theoretical entities which have not been experimented or have not been used by experimenters are not still able to be regarded as a candidate of being a natural kind. Even if a theoretical entity boosts the explanatory power of a theory, we are not able to consider it as a natural kind. Theories can play a role, they introduce entities, but we do not rely on the success of theories to see whether an introduced entity is real or not; it is the experiment which finally reveals whether an entity can be regarded as a natural kind or not.

Conclusion

In this paper, I tried to argue that entity realism sounds to be more successful than a full-blown scientific realism to show what kinds of theoretical entities can be regarded as natural kinds. Considering ontological, epistemological, and semantic components of natural kind realism, I believe that Hacking's entity realism can coherently and plausibly hold that experimental entities, not all theoretical entities postulated by a mature and well-confirmed scientific theory, are potential candidates to be considered as natural kinds.

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