

# On the epistemological potential of Worrall's structural realism

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*Abstract:* Structural realism à-la-Worrall is the view that inasmuch as our scientific theories provide us with (partially) adequate descriptions of an objective and independent reality, they do so by shedding light on the way this reality is in itself *structured*, and not on the so-called *nature* of existing objects. This position seems to imply that there is something about reality that lies beyond our grasp. I will reconstruct and shed new light onto Worrall's position and show that, contrary to how it might appear at first sight, its allegedly negative, or pessimist stance has a positive side: by placing a constraint on our (theoretically mediated) *knowledge*, structural realism might tell us something relevant about the nature and functioning of our scientific *understanding* of the world. The paper is divided in three parts. The first part is devoted to a brief reconstruction of Worrall's position. In the second part, I propose a new reading of the position in question by uncovering, highlighting and developing its epistemological consequences. In the last part, I investigate and scrutinize the connection between understanding and structures. The overall aim is to show how Worrall's structural realism, especially in the reading I am proposing here, may provide us with a plausible explanation of the epistemic value of past and actual scientific theories.

*Keywords:* John Worrall; structural realism; scientific understanding.

Structuralism uncovers a unity and a coherence within things which could not be revealed by a simple description of the facts somehow scattered and disorganized before the eyes of knowledge.

Claude Lévi-Strauss

## 1. *Worrall's structural realism*

Structural realism was originally proposed by John Worrall<sup>1</sup> as a form of moderate realist position in philosophy of science, which was able to accommodate two powerful arguments pointing in different directions: [1] the no-miracle argument, pointing towards realism, and [2] the pessimistic

<sup>1</sup> See Worrall 1989.

meta-induction,<sup>2</sup> pointing towards antirealism. The no-miracle argument tells us, roughly, that we have good reasons to believe our best scientific theories to be (at least partially, or approximately) true, in light of the fact that they are stunningly empirically successful. This is because (partial, or approximate) truth seems to be the best explanation we have for a theory's stunning empirical success. The pessimistic meta-induction, on the other side, tells us that the belief that empirically successful theories are true, even just approximately or partially so, is not warranted in light of the history of science. Extremely successful theories of the past have been completely discredited and substituted by new theories associated with ontologies incompatible with the ones previously accepted as true. This discontinuity of scientific progress seems to support the idea that a similar destiny of complete refutation expects the theories we now recognize as valid, and it basically discredits the explanatory connection between truth and empirical success affirmed by the no-miracle argument. So on the one hand, we have a kind of rational obligation to explain the stunning empirical success of science, and (partial, or approximate) truth seems *prima facie* to be the best explanation we have. But on the other hand, truth, standardly conceived, however weakened, cannot be the explanation we look for, as past theories turned out to be false, and sometimes not just marginally, but at their core, in their central claims.

John Worrall takes up the cudgels for the no-miracle argument and formulates a tentative answer to the pessimistic meta-induction: if we switch our attention from objects to structure (I'll briefly come back to the details of this distinction below), we are able to recognize a relevant continuity in theory change, which justifies a new form of realism. If we were to look more carefully at the history of science, so Worrall, we would appreciate that while it is certainly true that ontological commitments to existing objects are rapidly discredited, it is actually common for some formal aspects of theories to survive unaltered the switch from one theory to another. Worrall derives from this observation a general normative thesis concerning the way we should conceive science and its aim: we should renounce to the ambition of finding out what objects inhabit our world, and start to think of theories as codification schemes able to discover real relationships holding between unknown, or *de iure* unknowable, objects. These relationships exhaust, according to Worrall, what we should be realists about.

The idea underlying Worrall's structural realism can actually be put in slightly different terms. Take  $T$  to be a scientific theory. We can think of  $T$  as

<sup>2</sup> Or meta-modus tollens, in Lyons' terms (see Lyons 2002).

having the following three levels, or dimensions:

- [1] *formal* level;
- [2] *descriptive* or *metaphysical* level;
- [3] *empirical* level.

The formal level expresses, or describes, relations and causal links holding in the world. The descriptive or metaphysical level describes the way things are we might say for themselves, i.e., the properties things have independently from any interaction whatsoever. The empirical level is made of everything that follows as empirical consequence of the theory. Given this framework, we can easily appreciate the fact that Worrall is actually making two independent points. First of all, he is telling us that as long as the formal level of a successful scientific theory is concerned, we are justified in believing that there is a correspondence between the theory in question and reality. When it comes to the descriptive or metaphysical level, instead, more caution is needed, and we do not seem to be justified in believing in a correspondence anymore. The second point he is making is that the empirical level of a theory *crucially depends* upon its formal level. To state this point differently: when we are looking for an explanation for the empirical success of a theory, when we want to explain why a theory has the empirical consequences it has, it is the formal level of the theory we need to investigate. It is at the formal level, and not at the descriptive or metaphysical one, that we will find the explanation we need. This is, therefore, the sense in which Worrall's structural realism is meant to be "the best of both worlds": empirical success is explained, appealing to a new semantic notion that we may call (partial) *structural adequacy*; and the pessimistic meta-induction is undermined, by pointing to a relevant continuity in theory change.<sup>3</sup>

The aim of this paper is to shed new light on Worrall's position, to uncover its epistemological consequences and to develop these further. But before doing this, it is useful to make clear what the position in question is *not*, i.e., what Worrall's structural realism is not meant to be.<sup>4</sup>

First of all, Worrall's structural realism is not meant to be a view about *ontology* or *metaphysics*. From an ontological or metaphysical point of view, the landscape remains completely unaltered. Worrall never states that we have reason to believe that there are no objects in the world, or that we need to start

<sup>3</sup> It should be noted that structural realism must be read as an instance of a more general pattern, which is called in the literature "selective scientific realism". The general idea of selective scientific realism is that we should be realists about those parts of theories, which (i) survive, or are more likely to survive theory change; and that (ii) are recognized as responsible for the theories' empirical success.

<sup>4</sup> Worrall, at least in his 1989, is not particularly clear in this respect. In this paper, I choose to follow the reading of his position suggested by Ladyman 1998, Ladyman & Ross 2007, and Morganti 2004.

thinking of objects in structural terms. There is no need to revise our ontological commitments: we may go on thinking about reality in terms of individual objects, that instantiate certain properties and that stay in certain relations to one another. Second, Worrall's structural realism is not to be conceived as a view about *semantics*. What is meant with this is that what Worrall is proposing should not be identified with a specific theory of scientific representation. The more appropriate way to read Worrall's structural realism, instead, is as a view about *epistemology*. The point Worrall is making is, at its core, a point *about us* and about our cognitive relation to the world as mediated by scientific theories. More specifically, Worrall's structural realism has the aim of telling us something about:

- [i] what we are justified in believing to be corresponding to reality, when it comes to our best scientific theories, and
- [ii] the limits and constraints of our theoretically mediated knowledge of the world.<sup>5</sup>

Interestingly enough, by reading Worrall's position as a purely epistemological view, and by embedding this view in an unaltered metaphysical landscape, we get to what I would like to call a *negative*, or *pessimist* stance, that amounts more or less to the following: there is something about reality that lies beyond our grasp. Worrall makes this point quiet clear by claiming, roughly, that scientific theories uncover the structure of reality, while its nature remains (or, at least, has remained so far) unknown.<sup>6</sup>

There are at least two problems related to this negative stance. As they have been widely discussed in the literature, I will just sketch them here. The first problem is that, so formulated, Worrall's view seems to commit us to the existence of something (the nature of reality) we do not have, or worse we *cannot* have, epistemic access to. In Kant's spirit we could ask: if we are dealing with something that is inaccessible to us in principle, *de iure*, how do we even know that there is such a thing? Wouldn't it be more rational for us to opt for a solution all the way down, and to exclude this alleged *thing* completely from

<sup>5</sup> Chakravartty 2004: 877, defends a similar view: "If there is something important to be learned from structural realism [...], it is that relations between things are of paramount importance in connection with scientific *knowledge*. It is only by means of these relations that we learn anything at all – our knowledge is constrained by the relations of which things are capable. As a consequence, *scientific knowledge is primarily about these relations* and [...] the dispositions things have to enter into different kinds of relations under different circumstances". My emphasis. It will become clear in the next section that "knowledge" should probably be substituted here by "understanding", to make the quote acceptable from an epistemological point of view.

<sup>6</sup> See Worrall 1989: 118.

the domain of what we assume as existing? I believe Ladyman and Ross had something similar in mind, when they claimed that Worrall's position would generate a gap between epistemology and metaphysics, which would be unacceptable, and that their development of Worrall's position in an ontic direction was supposed to amend this shortcoming.<sup>7</sup> Besides that, however, there is a further worry. Where exactly are we to draw the line between structure and nature (of an entity, of a real system, etc...)? Psillos, among others, has argued that structure and nature always overlap, to the effect that the claim that "all we know is structure" turns out to be incoherent, or self-refuting. Structure, so Psillos, has to do with the way objects relate to one another; but in order to know how some objects relate, one needs to have at least partial knowledge of their intrinsic properties, i.e., of their natures. Hence, Psillos concludes, we cannot know structure without knowing nature. Knowledge of structure implies, presupposes, knowledge of nature.<sup>8</sup>

One way to answer to Psillos' objection is by identifying the structure of a domain with its formal or mathematical properties. Structure, in this interpretation, concerns just second order properties, i.e., properties of properties and relations (like symmetry, transitivity, and so on), and it is something that can be in principle instantiated in radically different systems of objects.<sup>9</sup> For this move, however, there is a high price to pay: structural realism, if structure is understood in purely formal or mathematical terms, turns out to be exposed to the objection that Newman formulated against Russell's structuralism.<sup>10</sup> Another possibility, which may be more promising, amounts to saying that what Worrall calls nature concerns the properties an object has independently from

<sup>7</sup> See Ladyman&Ross 2007: 154. See also Esfeld 2004 on this.

<sup>8</sup> See Psillos 1999: 155-157.

<sup>9</sup> A structure  $S$  in this restricted sense consists of a non-empty set  $U$  of objects (the domain of the structure) and of a non-empty set  $R$  of relations on  $U$  (where  $R$  can also contain monadic properties, i.e., one-place relations). A structure  $S$  can be conveniently presented as an ordered tuple:  $S = \langle U, R \rangle$ . We say that two structures  $S_1 = \langle U_1, R_1 \rangle$  and  $S_2 = \langle U_2, R_2 \rangle$  are isomorphic iff there is a bijective (one-to-one) mapping  $f: U_1 \rightarrow U_2$  such that  $f$  preserves the system of relations holding on the two domains. So for every  $r_1 \in R_1$  and for every  $r_2 \in R_2$  there are some objects  $a_1, \dots, a_n \in U_1$  which satisfy  $r_1$  iff some corresponding objects  $b_1 = f(a_1), \dots, b_n = f(a_n) \in U_2$  satisfy  $r_2$  (where  $r_1 \in R_1$  and  $r_2 \in R_2$  are corresponding relations). Informally speaking: two structures are isomorphic when for every object and for every relation of the first structure there is a corresponding object and a corresponding relation in the second structure.

<sup>10</sup> The general idea behind Newman's objection is that structuralism, if structure is understood in purely formal or mathematical terms, trivializes scientific knowledge – as any collection of objects  $C$  is able to instantiate a structure  $S$ , given just that  $C$  and  $S$  have the same cardinality. All we would know about the (unobservable) world, having realized that it instantiates a certain structure, would be the number of existing objects. This would be too little for any form of scientific realism, however weakened. See Newman 1928 and 2005. See also Frigg and Votsis 2011 for an enlightening reconstruction.

any interaction whatsoever, and that what Worrall calls structure concerns the properties an object has, i.e., an object actualizes, when it comes to an interaction with other objects (us included).<sup>11</sup> With this distinction in mind, it becomes evident that Psillos is right in stating that we need to have at least partial knowledge of natures in order to know about structures; still, the distinction is clear from a conceptual point of view. Take an object in isolation, consider it independently from any other object – there will be no structure to talk about. Structure needs interaction.

I now turn to the constructive part of the paper, and to the attempt of uncovering the epistemological consequences of Worrall's structural realism. The overall aim is to suggest a new reading of the position, and to show that what I called its negative, or pessimist stance has actually a positive side – that has been neglected, or overlooked, in the literature on the topic.

## 2. *Worrall's structural realism: a new reading*

Worrall's structural realism is usually read as a view telling us about an epistemic failure: our knowledge is limited, or constrained. (The observation of how science works, and of how progress in science is achieved, tells us that) there is something about reality, no matter how we decide to spell this something out, that is beyond our grasp, that cannot be an object of our theoretically mediated knowledge. Take our current best scientific theories: at best, they will tell us something about the structure of reality, and about the way things interact, or have the disposition to interact to one another (and with us), but they will not tell us anything about the way things are independently from any interaction whatsoever. We (at least, we as philosophers of science sympathetic with realism) would like to know more, but we have reason to think that we do not, or, worse, that we cannot.

What the history of transcendental philosophy teaches us, however, is that there usually is a close connection between limits and possibility – in that by defining and setting the boundaries of something (say, a cognitive faculty) we sometimes end up casting light on, and uncovering, the very conditions of possibility of its application. We sometimes end up uncovering its *modus operandi*. Think of the early Wittgenstein: by “drawing a limit to thinking”, he ended up defining the conditions of possibility of significant language. Or think of Kant's methodological exclusion of the *Ding an sich*: this exclusion allowed him to specify the conditions of possibility of intellectual knowledge.

<sup>11</sup> See Chakravartty 2004 on this.

The idea I would like to suggest here is that the very same connection between limits and possibility might hold also for Worrall's structural realism. Worrall's position, as I see it, should not be reduced to a view according to which we are doomed to an epistemic failure. Instead, it could and should be read as a view that also spells out the conditions of possibility of an epistemic achievement of a certain kind. Here is, roughly, what I mean: by placing a constraint on our (theoretically mediated) knowledge, and by pointing to cases where knowledge and truth, as standardly conceived, cannot be had, Worrall's structural realism might tell us something relevant and important about the nature and functioning of our scientific *understanding* of the world. Theories of the past that turned out to be false (i.e., because their theoretical terms turned out to be non-referring) cannot constitute sources of knowledge, for knowledge implies truth. However, structural realism, by making us focus on structure and on the relations holding among individual objects, might explain *why* such theories are still epistemically valuable, and *how* they provide us with (at least partial) understanding.

In order to appreciate this point, a few remarks on knowledge and understanding, on the way they differ, and on how they are related to one another, are necessary.

Both knowledge and understanding may be generally conceived as relations bounding a certain epistemic subject (usually, a human being), who knows or understands, to a certain object, which is known or understood. As long as science is concerned, it is useful to keep in mind the distinction between the so-called *vehicle* and the *object* of understanding.<sup>12</sup> The object of understanding will usually be a real system, a domain, or a set of phenomena. The vehicle of understanding will usually be a certain representational system – a theory, a model – that works as a source of knowledge, or of understanding, or of both, relative to the object under investigation. Although there are epistemologists pursuing a reductionist agenda (who try to show, i.e., that understanding is not to be conceived as a *sui generis* epistemic achievement, and that understanding can be reduced to knowledge after all),<sup>13</sup> the differences between knowledge and understanding seem to run very deep, as Catherine Elgin,<sup>14</sup> among others, has convincingly shown.

Knowledge, first of all, is propositional. What we know are always propositions (single ones, or arbitrary long conjunctions of them). This makes us aware of the fact that there is a kind of metaphysical constraint concerning the

<sup>12</sup> See Greco 2014 on this.

<sup>13</sup> See for example Kelp 2016.

<sup>14</sup> See Elgin 2006; 2007; 2017.

cognitive object that can be involved in an epistemic act of knowing: if there is anything at all that can be known about the world, this must be expressed or be in principle expressible through propositions. Understanding, or so it seems, is not subjected to the same constraint. We seem to gain understanding on the basis of non-propositional means (think, e.g., of a map), and not everything we understand, or we have the feeling to understand, seems to be expressible *via* propositions.

Besides that, knowledge can, and usually is, atomistic in nature. This means, roughly, that knowledge comes, or at least may come, in discrete bits, each of them singularly supported by evidence. Our knowledge grows, or at least may grow, by adding bits to bits – even in the absence of the appreciation of any connection among the single bits we collect. Understanding, on the other hand, is holistic. It is not just a matter of holding true and justified beliefs that have no connection whatsoever with each other. It is about seeing, or appreciating the right connections among single pieces of information; it is about being able to make the right inferences; it is about grasping the relationships holding among certain individuals (objects, facts, phenomena, or propositions, depending on the case).<sup>15</sup> This is the reason why a certain complexity of the cognitive object involved seems to be a necessary condition for understanding: we are not even apt to talk of understanding if the cognitive object we are dealing with is excessively simple. If we have to do with a simple so-and-so fact, like for example the fact that the cat is on the mat, or that the train is leaving in one hour, we just know it – there is basically no relation to grasp about that, so there is also nothing to understand. At best, we can say that we are understanding the language in which the utterances “the cat is on the mat” or “the train is leaving in an hour” are expressed – but in saying so we would locate ourselves at a sort of meta-level of linguistic comprehension and we would shift the cognitive object we are dealing with.

Knowledge, it seems, is an all-or-nothing matter. Either we know something, or we do not. Either we know that  $p$  is the case, or we do not. Either we know that the cat is on the mat, or we do not. There is no apparent way of knowing something more or less, better or worse. Our knowledge grows, of course, but it does not seem to improve from the perspective of internal quality; it is cumulative (we add bits to bits), but it cannot be internally and qualitatively differentiated. Understanding (U), on the other side, clearly admits of degrees, and it can improve (or maybe even get worse) over time. Given two subjects,  $S$  and  $S^*$ , two objects,  $O$  and  $O^*$ , and two moments in time  $t_1$  and  $t_2$ , it makes perfect sense to say that:

<sup>15</sup> See Grimm 2011 and Zagzebski 2011.



- (i)  $U(S, O, t_2)$  better than  $U(S, O, t_1)$ ;
- (ii)  $U(S, O, t_1)$  better than  $U(S, O^*, t_1)$ ;
- (iii)  $U(S, O, t_1)$  better than  $U(S^*, O, t_1)$ .

I.e., it makes perfect sense to say that: (i) given the very same subject and the very same object, the subject understands the object in question better at time  $t_2$  than she did at time  $t_1$ ; (ii) given the very same subject and two different objects, the subject understands the first object better than the second one at the very same moment in time; (iii) given two different subjects, one understands the very same object better than the other at the very same moment in time. This point, however, is trickier than it might seem at first sight. Epistemologists have tried to argue that, contrary to our starting intuition, there seem to be ways how knowledge could be internally differentiated and differently evaluated. We can know something with different degrees of conviction, for example: our knowledge can be more or less stable or safe, then, depending on how easily we are apt to give up the content of our knowledge when confronted with a situation generating doubt. We can know something on the basis of different kinds of reasons, to mention another example: we can know that  $p$  is the case because somebody who we recognize as a reliable epistemic authority told us, but we can also know that  $p$  is the case because we know that  $p$  follows from  $q \wedge z$ , and we know that  $q \wedge z$  is actually the case. Our knowledge, then, can be differently internally justified. But there are at least two further ways of differentiating knowledge.<sup>16</sup> Contextualists hold that “to know” gains a specific meaning in a conversational context that fixes the relevant alternatives that some subject needs to exclude in order to know. A subject may be said to know something better than another, then, if she knows it by exclusion of a larger range of relevant alternatives. Or we could differentiate knowledge by remarking its contrastive aspect: a subject may be said to know something better if she knows it with respect to more contrasting propositions (presenting a *rather than*-structure, like “the subject knows that the object is green rather than red”).<sup>17</sup> However, there is a further element that makes the talk of “knowing better” problematic, which has to do with the relation between knowledge and truth.

Knowledge is factive. This means that knowledge requires truth, that truth is a necessary condition for knowledge. I cannot know  $p$  unless  $p$  is true, I cannot know  $p$  unless there is an actual fact in the world corresponding to  $p$  and making  $p$  true. The relation between understanding and truth, on the

<sup>16</sup> Thanks to Ralf Busse for making me appreciate this point.

<sup>17</sup> See Schaffer 2005.

other side, is trickier. Catherine Elgin and Henk de Regt, among others, defend the view that understanding must be conceived as non-factive, and that by detaching understanding from truth we would do better justice to science.<sup>18</sup> Of course, understanding does not imply truth *simpliciter*, in the sense that we are able to understand theories that have been recognized as false (we are able to imaginatively relate ourselves to the cognitive content of these theories, and to imagine how a world in which they happened to be true would look like), and we are also able to understand a theory or a line of reasoning even if it is inconsistent. The non-factivity thesis defended by these authors, however, amounts to the following: it is possible for an epistemic subject *S* to understand a domain of reality *D* (at least to a certain extent) on the basis of a theory *T*, even if *T* almost *completely* misrepresents *D*. I.e.: even a theory that is not true (not even in a partial sense), even a theory that does not mirror its intended target system correctly, can be epistemically valuable for us. Factivists, on the other side, claim that for a theory *T* to be epistemically valuable for a subject *S* relative to a domain of reality *D*, *T* must be at least partially true of *D* – at least in its central claims, while a few marginal false claims may be admitted and may not compromise the theory’s epistemic value.

Taking a position in the debate surrounding the relation between understanding and truth is not easy. In favor of factivist accounts, there is the strong intuition that a certain grasp of reality is needed in order for understanding to be the case. (Even Elgin admits that understanding must be somehow “tethered”, or bounded to reality, reality-directed, and that epistemologists should work in order to find out what the understanding’s tether might be).<sup>19</sup> We would not say that a subject understands a certain domain of reality if she holds *only* false beliefs about the domain in question. In favor of antifactivist accounts speaks the fact that we seem to gain genuine understanding from theories that turned out to be false – and not just marginally, but also in their central claims. Concerning antifactivists account, however, there is a further worry: how are we exactly to distinguish between false theories that provide us with (at least partial) understanding, and false theories that do not? What is it about a false theory that makes it able to provide us with understanding? How are we to explain the fact that not every false theory is epistemically valuable?

Here, I believe, is exactly where Worrall’s structural realism comes into play. If we learned the lesson of structural realism, we know that, first, not every falsehood is worth the same. A theory can be false, even at its core, even in its central theoretical claims, and still depict reality (partially) correctly from

<sup>18</sup> See Elgin 2009 and 2017, and De Regt 2016 and 2017.

<sup>19</sup> See Elgin 2017: 45.

a structural point of view. What we also know is that our cognitive relation to the world is *constrained* by the relations of which things are capable. This, for me, suggests conceiving understanding as *directed* to the way things do relate, or have the disposition to relate, to one another, and as implying as necessary condition not truth, but a slightly less demanding semantic notion – namely, (partial) structural adequacy.<sup>20</sup>

Here are, briefly, the advantages we would have by adopting this view. First of all, we would do justice to our initial intuition that a certain grasp of reality is needed in order for understanding to be the case. Second, we would not be affected by the fact that a false theory can yield genuine understanding – as we would have appreciated that a theory can be false, even at its core, and still depict reality (partially) correctly from a structural point of view. And third, we would be able to explain what is it exactly about a false theory, that makes it epistemically valuable and makes it able to provide us with understanding. To state this last point differently: we would have a criterion to distinguish between epistemically valuable and epistemically non-valuable falsities. So, it seems to me, by adopting (partial) structural adequacy as the understanding's "tether", we would achieve the best of both worlds in a new, purely epistemological, sense.

### 3. *Understanding (through) structures*

More needs to be said, however, about the notion of understanding involved, and about the relation allegedly holding between understanding and structures. In this last section, I will try to show how by connecting understanding and structures in the appropriate way, we may do justice to three features of understanding widely recognized in the literature: [1] understanding

<sup>20</sup> One might wonder why partial structural adequacy is to be preferred to semantic notions like approximate or partial truth. I think there are at least two reasons for this. The first is that truth, as standardly conceived, however weakened, seems to imply successful reference to existing objects. Partial structural adequacy, instead, is more flexible: even a theory that fails in referring to existing objects may make true claims about the relations and causal links holding in the world. The second is that even a representational system that is not truth-apt, i.e., the cognitive content of which cannot be expressed *via* propositions, can satisfy a criterion of partial structural adequacy (think of a map). Besides that, partial structural adequacy might turn out to be easier to grade than partial or approximate truth. Think of the partial structures approach of Da Costa and French 2003: we define a partial structure as made of a set of objects  $U$ , and a set of partial relations  $R_p$  defined over  $U$ .  $R_p$  is made of three disjoint sets:  $S_1$  is the set of relations we know (or believe with good reasons) to hold on  $U$ ;  $S_2$  is the set of relations we know not to hold on  $U$ ;  $S_3$  is the set of relations *we do not yet know* whether they hold on  $U$  or not. Structural adequacy, in such a picture, may be said to improve in that members of  $S_3$  are assigned either to  $S_1$  or to  $S_2$ .

and *knowing-how*; [2] the grasping-feature of understanding; [3] the modal, or counterfactual aspect of understanding.

Let us start with understanding and *knowing-how*. Linda Zagzebski and Stephen Grimm, among others, suggest an explication of understanding as involving the appreciation of dependence relations holding among a set of individuals (objects, facts, propositions, ...). I suggest conceiving understanding, instead, as a process involving the following three main steps:

- [I] seeing or establishing a *pattern*, or *structure*, on a specific domain of individuals;
- [II] being able to create a kind of *isomorphic* mental model of it;
- [III] being able to apply it or to recognize it as eventually *instantiated*, or as partially instantiated, in contexts different from the original one.

This is a rough and general characterization, of course, but it has some epistemic valuable features. First, it highlights and somehow clarifies the relation that seems to hold between understanding and structures.<sup>21</sup> Second: it makes for us possible to appreciate how understanding may be qualitatively differentiated and differently evaluated. We can understand something better or worse depending on how accurate our mental model is (on how many relationships we are able to grasp and reproduce), on how well we are able to apply the pattern we established to new contexts, on how well we are able to compare it with other similar patterns, and so on. Third: it gives substance to the idea that understanding implies certain skills, or *knowing-how*. Understanding, so conceived, has to do with knowing-how – and knowing about the extent to which it is possible – to apply a certain pattern, or structure, to a certain system under investigation. Think of understanding a map. Understanding a map is a matter of [I] seeing, or comprehending the pattern depicted in the map; [II] becoming familiar with the pattern in question; [III] being able to appreciate the way and the extent to which the pattern is instantiated in the real world, i.e., in the real system the map is supposed to represent. Something similar may be going on when we try to understand a real system by means, e.g., of a model.<sup>22</sup>

Let us now turn to understanding and grasping. The talk of “grasping” has become a commonplace in the literature on understanding. Some authors believe that understanding involves or implies grasping, some other that understanding needs to be explicated in terms of grasping. What is clear is that grasping cannot be reduced to a cognitive act of believing truly, accepting, or

<sup>21</sup> See Zagzebski 2001: 242: “Understanding is the state of comprehension of non-propositional structures of reality”.

<sup>22</sup> See for example Tetens 2013 and Bartels 2005 on this.

even knowing, isolated pieces of information. When it comes to spell out the notion without the help of metaphors, however, things get complicated. Stephen Grimm suggests that understanding involves grasping, where grasping has to do with appreciating, or *seeing* how the various parts of a system depend upon one another.<sup>23</sup> Within the framework of structural realism, I believe, we can make the notion of “grasping” more precise: we can shed light on the *object* of grasping, on the one side, and on the *act* of grasping, on the other. The object of grasping, first of all, can be conceived as a structure – where structure has to do, roughly, with the relational aspects of a certain system of objects. The act of grasping, on the other side, can be conceived as involving the appreciation of structural commonalities or similarities across systems, and involving the appreciation of the way and the extent to which a certain structure is instantiated in a certain system under investigation.<sup>24</sup>

Let us now finally turn to the modal, or counterfactual aspect of understanding. Stephen Grimm, among others, claims that understanding a certain fact or phenomenon is not just a matter of appreciating its causal history, and therefore of being able to answer why-questions concerning its occurrence. It is also, and maybe above all, a matter of appreciating how things would have looked like, if something in the initial conditions had been different.<sup>25</sup> Structural realism, in my reading, brings us to recognize the fact that relations between individuals (objects, phenomena, facts, etc.) and dispositions of interaction and behavior play a crucial role in our cognitive relation to the world mediated by scientific theories. Our scientific understanding of the world is to be conceived as essentially directed to the relations holding among objects, on the one side, and to the relations of which things are capable, on the other. This is only a schematic framework, of course, in need to be spelled out in more detail. But it seems to be promising in order to make sense of the modal aspect of understanding. Suppose understanding, as I suggested, has to do with grasping the structure of a system of objects, and suppose that structure

<sup>23</sup> See Grimm 2006: 531-532, and also Grimm 2014.

<sup>24</sup> Note that, even under the assumption that (i) there is a true structure of the system to be grasped, and that (ii) the fact that a certain system instantiates a certain structure can be expressed by a true proposition, understanding and grasping the structure of a system do not seem to reduce to the knowledge that the system instantiates, or realizes the structure in question. To appreciate this, consider the case of a subject truly believing, or even knowing that the map on her desk happens to instantiate the structure of a town she is not familiar with, say Copenhagen (call this proposition *p*). The subject wouldn't have any insight whatsoever of the structure of the town, merely by truly believing, or even by knowing, *p*. If she happened to go for a walk in Copenhagen, she would probably get lost, despite her true belief or her knowledge about the relation of structural similarity holding between map and town.

<sup>25</sup> See Grimm, *ivi*.

is spelled out in terms of relations – both actual, and possible. By being aware of the structure of a system, it seems, one would be able to tell what relations do hold among objects, and what relations *might* hold, given the dispositions of interaction and behavior that are involved. To state this point differently: grasping a structure would give one a sense of possibility, and would make one aware of how things stand, not just in an actual, but also in a modal, sense.

#### 4. *Conclusion*

To sum up: Worrall’s structural realism is usually read as a view about an epistemic failure, i.e., telling us that our theoretically mediated knowledge is limited, or constrained. In this paper, I suggested a new reading of Worrall’s position, with the aim of showing that it could and should be read as a view about the conditions of possibility of an epistemic achievement of a certain kind. The general idea is that, by placing a constraint to our theoretically mediated *knowledge*, and by pointing to cases where knowledge and truth, as standardly conceived, cannot be had, Worrall’s position is able to tell us something relevant and important about the nature and functioning of our scientific *understanding* of the world. More specifically, by connecting understanding and structures in the appropriate way, and by construing understanding as involving the appreciation of structural commonalities across systems, we are able to do justice to three widely recognized features of understanding: [1] the fact that understanding implies certain skills, or *knowing-how*, [2] the fact that understanding implies, or needs to be explicated in terms of “grasping”, and [3] the fact that understanding has a modal, or counterfactual aspect.

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