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History is replete with views and movements sharing the same name, though exhibiting considerable divergence in detail. The term *structuralism* is no exception. Structuralisms have emerged in fields as diverse as anthropology, architecture, economics, linguistics, literary criticism, mathematics, philosophy, psychology, and sociology. What they all have in common is an emphasis on structural analysis—that is, on understanding a given system by paying close (and sometimes exclusive) attention to the relations that organize its elements. Even within philosophy, structuralist views have popped up in a number of subfields including aesthetics, the philosophy of language, the philosophy of mathematics, and the philosophy of science. This entry focuses on two prominent and interrelated structuralisms in the philosophy of science, namely structuralism in the scientific realism debate and structuralism in the scientific theory and representation debates.

Structuralism in the Scientific Realism Debate

The scientific realism debate is primarily a discussion over what epistemological (sometimes also over what metaphysical and axiological) commitments one should endorse vis-à-vis scientific theories and models. Roughly speaking, scientific realists—henceforth just *realists*—hold a generally positive epistemic attitude toward theories and models. In more detail, they claim that our best—our most explanatorily and empirically successful—theories and models are likely to be approximately true or to at least contain some nonnegligible truth content in relation to both observable and unobservable features of the world. By contrast (and equally roughly), scientific anti-realists—henceforth just *anti-realists*—hold a generally negative epistemic attitude toward theories and models. That is, they claim that theories and models, even the best ones, are unlikely to contain nonnegligible truth content (and hence are unlikely to be approximately true) in relation to both observable and unobservable features of the world or that we are never in an epistemically secure enough position to assert that they do.

It is worth dwelling a bit on the distinction between observable and unobservable features of the world. Crudely put, observable features are those that are directly detectable through our unaided sensory organs. Unobservable ones are those that resist such detection. Thus, animals, volcanoes, and dwarf planets are observable but viruses, atoms, and subatomic particles are not. In effect, anti-realists are skeptics about many of the posits of modern science because drawing ontological conclusions from instruments typically involves long chains of inferences, each of whose links can be questioned. For example, the detection of subatomic particles relies on circuitous inferences that begin with the observable tracks they presumably leave behind in particle accelerator chambers. The significance of the observable–unobservable distinction has been questioned by some realists. Generally speaking, the realists are happy to concede the distinction but argue that instruments nonetheless provide some epistemic access to some posits.

Structuralism in the scientific realism debate is a view that has developed against the backdrop of several renditions of the debate. It is more commonly known as *structural realism*, although, as we shall soon see, not all views under its banner are realist. Structural realists argue that our best scientific theories and models have no trouble providing accurate descriptions of various features of the observable world but are limited in their ability to accurately describe the unobservable world. More formally, such theories and models describe the unobservable world up to isomorphism (a technical notion which means, roughly, having the same form or structure). On this view, we can only hope to describe the structure of the unobservable world. One of the earliest motivations for the view appears in the work of Henri Poincaré (1854–1912) and is historical in nature. Crudely put, we can only know the structure of the unobservable world because when we examine the history of science, we discover that any description seeking to go beyond structure comes undone at the next scientific revolution. Structure, contrariwise, seems to survive in at least some approximate form. To give some examples, although the ontological posits in classical descriptions of thermal, optical, electrical, and magnetic phenomena have been supplanted by distinct ontological posits in nonclassical ones, parts of the structure of those descriptions have remained invariant. Let's take the case of optical phenomena. We no longer believe in light as a vibration in an all-pervading elastic medium—what was once known as the *luminiferous ether.* Even so, we use some of the same mathematical structures, such as Henri Fresnel's equations, to predict and explain the corresponding phenomena. To sum up, despite having to discard ontological posits such as the ether, some of the same mathematical structures remain with us. This gives some prima facie reason to believe in structural realism. More broadly, if the history of science does indeed follow this pattern, we have good grounds for endorsing structural realism over any other form of realism or anti-realism. (Other cases of structural continuity have also been proposed—see, e.g., Votsis & Schurz, 2012.)

There are more than a few structural realist views out there. As we cannot explore all of them here, we will restrict our attention to the general divide between the epistemic and ontic families. What we have said so far chimes well with both families. The main difference between them is that the ontic structural realists employ revisionary ontological considerations to reach the same epistemic conclusions (see French, 2014, for details). To be more precise, they argue that the reason why we cannot know anything beyond the structure of the unobservable world is effectively because only structure matters. This claim has been interpreted in distinct ways. In the extreme, it is taken to mean that only structure exists. Objects are just placeholders for the intersections of relations and thus do not strictly speaking exist but are at best useful fictions. A more moderate reading allows for the existence of objects but denies that such entities are individuals and hence demotes their overall role in understanding the unobservable world. Motivations for ontic structural realist views vary, but they are typically drawn from quantum physical considerations. Those who advocate the moderate reading, for example, point out that fundamental objects in quantum physics lack individuality because they fail Leibniz's principle of the identity of indiscernibles, which holds that two objects sharing all their properties are in fact identical.

As alluded to earlier, not all structuralists in the scientific realism debate are realists. There are also structural anti-realists, though they often go by more affirming names like *structural empiricists* or *empiricist structuralists.* The essence of such views is that even though we must remain agnostic with respect to the exact nature or denizens of the unobservable world, our best theories still give us a pretty good description of the observable world. In particular, the claim is made that, if we understand theories as collections of structures, then theories can be used to adequately represent only structures in the observable world. Of note here is that this conception of theories as collections of structures is shared by some of the structural realists, such as Steven French. It is also a good segue into other types of structuralism, which we will explore in the ensuing section.

Objections to structuralist views abound (for an in-depth discussion of arguments for and against structural realism, see Frigg & Votsis, 2011). Some are more serious than others. Structural realism has been accused of being either too weak to be realist (and hence collapsing into empiricism) or too undistinctive (and hence collapsing into traditional versions of realism). The latter accusation affects also structural anti-realists, their view presumably collapsing into traditional versions of anti-realism. Ontic structural realists have been accused of being incoherent—this is predominantly an objection to the extreme version of the view outlined earlier, since it seems to assert that there can be relations without relata. More generally, all structuralist views in the scientific realism debate seem to be affected by the following questions: (1) What formal frameworks need to be in place to do justice to the requisite notion of structure? and (2) What ontological category plays the role of the non-structural features of the world? As to the first question, the proposals range from second-order logic (and particularly the device known as the *Ramsey sentence*) to set theory, quasi-set theory, and category theory. As to the second question, the proposals range from qualities to intrinsic properties, monadic properties, and haecceities. It is worth noting that this objection runs deeper than the others and has been justifiably underscored by critics.

Structuralism in the Scientific Theory and Representation Debates

The scientific representation debate is primarily concerned with the question of how scientific theories represent their target systems. Taking a stance in this debate often means taking a stance in the debate over the nature of scientific theories. The two main stances in the latter debate are the syntactic view and the semantic view. (A third view, known as the *pragmatic view*, seems to be emerging in popularity, though it is not currently systematic enough or sufficiently distinct from pragmatic-oriented versions of the other two views to deserve attention here.) The *syntactic view* is taken to construe theories as sets of sentences axiomatized in some meta-mathematical framework, for instance, first-order predicate logic with set theory. By contrast, the *se-*

mantic view is taken to construe theories as sets of models, where a model is a set-theoretic structure. Thus, depending on which view of theories one advocates, the representation relation seems to manifest itself in distinct ways: Target systems are represented by linguistic entities—that is, by sentences—if one follows the syntactic view, or by extralinguistic entities (in other words, abstract set-theoretical structures) if one follows the semantic view.

It is tempting to assume that the semantic view alone deserves the appellation *structuralism* in the scientific theory and representation debates and, additionally, that it alone aligns with structuralism in the scientific realism debate. After all, the semantic view typically construes the representation relation as a mathematical morphism, for example an isomorphism, between theories and the world. Moreover, it explicitly conceives of theories in terms of set-theoretic structures, and such structures, as we have seen, offer one of the ways through which structuralists in the scientific realism debate express the commitments of their views. Such an assumption seems ill-advised. One reason to resist it stems from the fact that some versions of structural realism, namely Ramsey-style structural realism (see Worrall, 1989), are married to the syntactic view of theories. Named after its inventor, the philosopher-mathematician Frank Ramsey, Ramseyfication is achieved by first expressing theories in predicate logic and then logically weakening them by stripping away the interpretations of all non-logical terms meant to denote unobservables. (It is worth noting that the process leaves intact the interpretations of nonlogical terms intended to denote the observables. Ramseyfied theories thus restrict what features of the unobservable world can be adequately represented to their logical structure.

Another reason why we should not be tempted by the foregoing assumption stems from the fact that the two views have been variably interpreted. Once we put aside naive readings of each view, the differences between them appear to be few and superficial, if not altogether absent. For example, the syntactic view need not take the sentences which make up theories to be uninterpreted. Indeed, for each such set of sentences, there is in fact a corresponding set of models which makes those sentences true. Conversely, the semantic view need not take the models which make up theories to be detached from sentences. After all, the function of models, construed as set-theoretical structures, is to make sentences true. (In fact, that's what we mean when we say that models satisfy a theory. The notion of *satisfaction* is central to any discussion of models in the model-theoretic sense.) Other objections that seek to drive a wedge between the two views can be, and have been, questioned on the basis of different interpretations. These include the reputed requirements (attributed to the syntactic view) that theories should be axiomatized and the metamathematical framework should be first-order predicate logic—see Lutz (2012) for a counter—and the reputed requirement (attributed to the syntactic view) that only mathematical (vs. metamathematical) frameworks must be used in analyzing theories and in representing target systems. To summarize, when offered more sophisticated construals, the semantic and the syntactic views seem equally qualified to earn the appellation *structuralist* in their conception of theories and of the representation relation. Both also appear to be a good fit with structuralism in the scientific realism debate.

Thus far, we have presupposed that the representation relation is a kind of mapping between the structures of theories and the structures of the world. There are, however, other accounts of representation which may not be as amiable to the structuralist ideology. Indeed, such accounts purposely try to dissociate themselves from that ideology. On the similarity account, a theory or model represents a target system just in case it is similar to that target system in some relevant respects. Which respects are relevant is sometimes deliberately left unspecified to deal with the kinds of cases that the structuralists are accused of being incapable of handling, namely cases where no direct mapping can be established between theories and the world. The trouble with this approach is that, unless its advocates provide some sort of principled way to circumscribe the similarity relation, they risk trivializing the view. After all, and as countless philosophers have pointed out, everything is similar to everything in some respect or other. A more promising approach to the similarity account is to insist that the relevant respects are context dependent. Another notable account of the representation relation is *inferentialism.* On this account, a necessary condition for a *surrogate* (the entity that does the representing) to represent a target system is that we can draw inferences from the former to the latter. Inferentialism prides itself in being neutral with respect to the kinds of entities that can be used as surrogates. They can be theories; models; physical, abstract, or fictional objects; and so on. Just like in the case of the similarity account, this strength of the inferentialist account also proves to be a potential weakness. It is always possible to draw some inferences from one object or system to another. Unless the permissible inferences are restricted, the inferentialists risk trivializing their view.

The success or failure of the similarity and inferentialist accounts depends on what kind of information is vital for a representation to genuinely tell us something about target systems. If the requisite kind of information must always be structural in nature, then the two views are faced with an unpalatable dilemma. Either construe the representation relation in a nonstructural way and therefore end up missing the mark or construe it in a structural way and end up collapsing into structuralism.

Conclusion

Whether it is a view within the scientific realism, the scientific theory or the scientific representation debates, structuralism has proved to be highly influential and resilient. Those who wish to study the epistemological, metaphysical, and methodological aspects of these debates are unlikely to make any headway unless they pay such views the attention they deserve.

See also Metaphysics; Modeling; Scientific Realism; Philosophy of Science

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- structuralism
- theories
- scientific realism
- realism
- philosophy of science

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