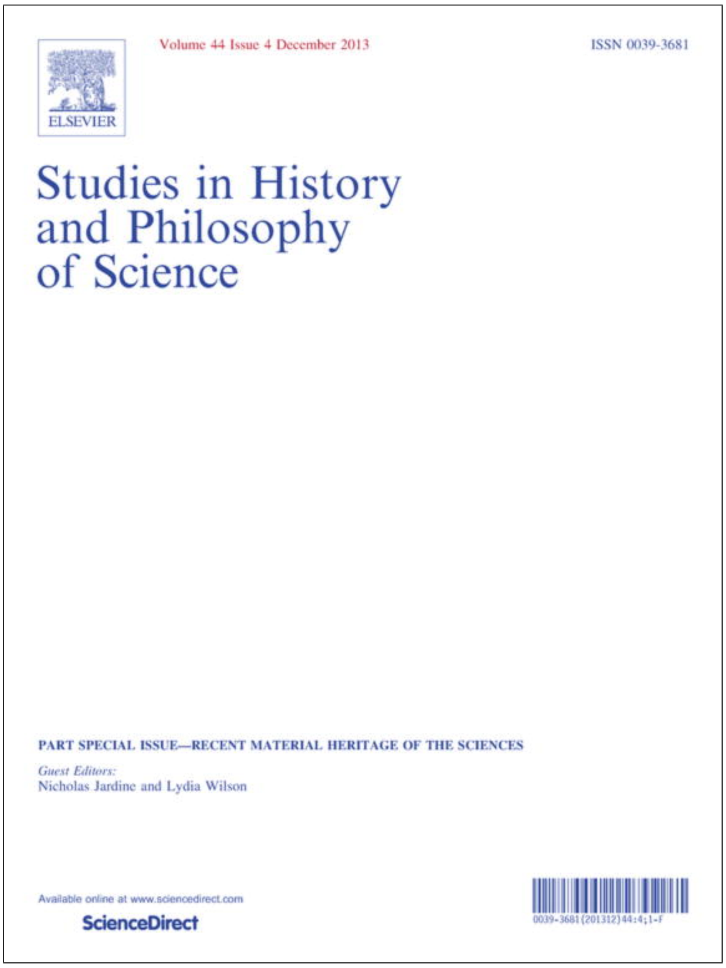
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Discussion

The semantic conception and the structuralist view of theories: A critique of Suppe's criticisms

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ABSTRACT

Different conceptions of scientific theories, such as the state spaces approach of Bas van Fraassen, the phase spaces approach of Frederick Suppe, the set-theoretical approach of Patrick Suppes, and the structuralist view of Joseph Sneed et al. are usually put together into one big family. In addition, the definite article is normally used, and thus we speak of *the* semantic conception (view or approach) of theories and of its different approaches (variants or versions). However, in *The Semantic Conception of Theories and Scientific Realism* (Urban and Chicago: University of Illinois Press, 1989), starting from certain remarks already made in "Theory Structure" (in P. Asquith and H. Kyburg (Eds.), *Current Research in Philosophy of Science*, East Lansing: Philosophy of Science Association, 1979, pp. 317–338), Frederick Suppe excludes the structuralist view as well as other "European" versions from the semantic conception of theories. In this paper I will critically examine the reasons put forward by Suppe for this decision and, later, I will provide a general characterization of the semantic family and of the structuralist view of theories in such a way as to justify the inclusion of the structuralist view (as well as other "European" versions) as a member of this family.

1. Introduction

In some presentations (Lloyd, 2006; Moulines, 2008), different conceptions of scientific theories, such as the state spaces approach of Bas van Fraassen, the phase spaces approach of Frederick Suppe, the set-theoretical approach of Patrick Suppes, and the structuralist view of Joseph Sneed et al. are put together into one big family.[1] In addition, the definite article is normally used, and thus we speak of *the* semantic conception (view or approach) of theories and of its different approaches (variants or versions). However, in *The Semantic Conception of Theories and Scientific Realism* (Suppe, 1989), going beyond some remarks already made in "Theory Structure" (Suppe, 1979, pp. 317–338), Frederick Suppe excludes the structuralist view as well as other "European" versions from his consideration of the semantic conception of theories. In this paper, I first examine critically the arguments put forward by Suppe to defend this decision. Later on, I provide a general characterization of the semantic family and of the structuralist view of theories in a way that justifies the inclusion of the structuralist view (as well as other "European" versions) as a member of this family. Finally, I conclude with some general remarks.

2. Frederick Suppe's criticisms of the structuralist view of theories

In the "Afterword" to the second edition of *The Structure of Scientific Theories*, Suppe claimed that "[t]he semantic conception of theories [. . .] is the only serious contender to emerge as a

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[1] Sneed's book (Sneed, 1971) marks the birth of the metatheoretical approach initially labeled the "emended Ramsey view" or simply "Sneedism," later "non-statement view," and nowadays "structuralist view of theories," "structuralism," or, in order to distinguish it from other structuralisms, "meta-theoretical structuralism," "meta-scientific structuralism," or "Sneedian structuralism" (although in some Anglo-Saxon circles it became also common in the last times to refer to it as "German Structuralism" or "German Structuralist School").

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replacement for the Received View analysis of theories" (Suppe, 1977, p. 709). Twelve years later, he affirmed that "[t]he Semantic Conception of Theories today probably is the philosophical analysis of the nature of theories most widely held among philosophers of science" (Suppe, 1989, p. 3). At the turn of the century, he was still writing that "[t]he Semantic Conception of Theories has been very successful. It is widely accepted with remarkably little published criticism of it—none fundamental or fatal" (Suppe, 2000, p. S105).

Frederick Suppe recognizes the role that Joseph Sneed played in his personal and intellectual development in at least two important points: he introduced him to Kuhn (1962) with such conviction that Suppe became a Kuhnian (Suppe, 1989, pp. 14–15, 36), and he arranged a meeting with Suppes at Stanford during the summer of 1964—which gave Suppe access to a prepublication version of Suppes (1967), which had a profound influence on his dissertation.

Moreover, in his early works Frederick Suppe refers to the structuralist view as a version of the semantic conception (Suppe, 1972, 1974, 1979). However in his 1989 work he dismisses that view, as well as other "European" versions—like those of Dalla Chiara & Toraldo di Francia, Przełecki and Wójcicki—from his consideration of the semantic conception (Suppe, 1989, pp. 19–20, 22).

He dismisses it using reasons he had already presented ten years prior, in his interpretation of the structuralist view in the article "Theory Structure" (Suppe, 1979). However, in 1979, he didn't yet use those arguments to dismiss structuralism as he did later.

According to this interpretation, the character and motivation of the structuralist view are very different from the semantic conception developed by Suppes, van Fraassen, or himself. Their motivation lies in investigating

> "a significant scientific product–theories–[...] to provide explanatory philosophical accounts of theories as they are or can be employed in science. For Sneed and Stegmüller [...] the enterprise is somewhat different; dominating their account are the desires that it provide criteria for delimiting the theoretical from the non-theoretical, and that it provide an account of theory suitable for reworking Kuhn's [...] account of normal vs. revolutionary science." (Suppe, 1979, p. 322; this paragraph is reproduced almost without modification in Suppe, 1989, p. 421).

Besides, and in relation to the character of the structuralist view, Suppe adds that

> "[a]lthough this is not the place to argue it, I would contend that in attempting to meet these demands they build into their analysis various neo-Positivistic ingredients that are as untenable as their thoroughly-discredited Positivistic predecessors; moreover, the extent to which portions of their analysis is constrained by an uncritical acceptance of the (doubtful) historical accuracy of Kuhn's normal vs. revolutionary science views it adds to the unsatisfactoriness of their version of the Semantic Conception of Theories. Thus I find the Sneed-Stegmüller approach far less promising than other versions of the Semantic Conception—largely because they give far more than is warranted to Positivism and to Kuhn." (Suppe, 1979, p. 322).

In the same sense, Suppe asserts ten years later:

> "[...] Stegmüller 1973 is an exposition of Sneed (1971) together with an attempt to exploit Sneed's analysis to provide an improved analysis of Kuhn's notion of incommensurability. (Sneed was involved in the development of Stegmüller's attempt.) This attempt seems to me somewhat bizarre, since a key idea of Kuhn's is the rejection of correspondence rules, and Sneed's analysis of theories retains certain explicit correspondence rules in the form of Ramsey sentences (used in Sneed's analysis of theoretical terms). By retaining some explicit correspondence rules, Sneed seems to concede far too much to positivism–indeed, far more than Kuhn would, or should, be happy with." (Suppe, 1989, pp. 19–20).

Suppe also claims that: "Further, Stegmüller 1973 displays a cavallier disrespect for actual scientific practice—which, I'm afraid, is all too characteristic of this general approach." But since he neither developed this idea further nor specified the sense in which Stegmüller displays his "cavallier disrespect," I won't discuss this claim.

So, Suppe presents three basic and more elaborate criticisms. They are of two different but connected kinds. The first two criticisms are more related to the motivations of the structuralist view, while the third one has more to do with its content. They can be summarized as follows: (1) The structuralist view is dominated by the desire to provide criteria for delimiting the theoretical from the non-theoretical (Suppe, 1979, p. 323; 1989, p. 421); (2) The structuralist view is also dominated by the desire of providing an account of theory suitable for reworking Kuhn's (...) account of normal vs. revolutionary science (Suppe, 1979, p. 323; 1989, p. 421); (3) The structuralist view includes neo-positivistic ingredients, in particular certain explicit correspondence rules in the form of Ramsey sentences (used in the structuralist analysis of theoretical terms), which are unacceptable, and its treatment (of aspects) of Kuhn's thought is somewhat bizarre, because of the use of this particular neo-positivistic ingredient (Suppe, 1979, p. 322; 1989, pp. 19–20). I will examine these criticisms by developing a diagnosis already made by Diederich, according to which "[t]he few remarks on structuralism in Suppe's book (e.g., pp. 19, 22) reveal deep misunderstandings of this approach" (Diederich, 1994, p. 425; see also Diederich, 1996, p. 17).

3. Comments on Suppe's first criticism

It must be said that the structuralist view doesn't intend to provide criteria for delimiting the theoretical and non-theoretical *in general*.

The structuralist view has its origins in the investigations carried out by Sneed (1971), a former disciple of Patrick Suppes, about the way in which *empirical* claims can be made with scientific theories containing *theoretical terms* without the problem of "self-justification." These investigations deepened Suppes' conception along the lines of another of his disciples, E.W. Adams. This problem—together with the decades of discussion of the theory/observational distinction—led him to establish the distinction between theoretical and non-theoretical terms, not in general, but *relative to a theory T*. The structuralist distinction would make it possible to establish, in (almost) any analyzed theory, two kinds of terms or concepts, in the sense delineated in an intuitive formulation by Hempel (1966, 1969, 1970) and Lewis (1970): the terms which are specific or distinctive to the theory in question and which are introduced by the theory, and those which are antecedently available and constitute its relative "empirical basis" of testing. If *T* is the theory in question, the terms of the first kind are called "*T*-theoretical (terms or concepts)," that is theoretical with respect to theory *T*. The terms of the second kind are "*T*-non-theoretical (terms or concepts)," that is non-theoretical with respect to theory *T* (which doesn't mean that they are not theoretical for any other theory; indeed, they are usually theoretical for another presupposed theory *T*′). The structuralist view provides a precise criterion to *T*-theoreticity, which can be informally characterized as follows:

a term or concept used by *T* is *T*-theoretical if and only if it cannot be determined without presupposing the laws of *T*, i.e. if and only if *every* method of determination of that term uses some law of *T*. Otherwise, the term or concept used by *T* is *T*-non-theoretical. Thus, the structuralist concept of theoreticity is not absolute but relative to the very theory in question; it is not empiricist or positivistic, because it is not committed to a notion of observability, but pragmatic, because it is committed to a pragmatic notion of method of determination.

Moreover, the problem of distinguishing the representation of the phenomena that the theory accounts for from the representation of the theory itself was also acknowledged and discussed by van Fraassen and Suppe. In fact, they established a distinction between the two components, but their proposals are more problematic and/or less elaborate than the structuralist one—in the case of van Fraassen the distinction between the observable and the non-observable (van Fraassen, 1976, 1980, 1989), and in the case of Suppe with the distinction "between nonproblematic 'hard' data about physical systems and boundary conditions [...] and the more problematic theoretically obtained assertions about these systems" (Suppe, 1989, p. 71).

4. Comments on Suppe's second criticism

The structuralist view tried from its beginnings (Sneed, 1971; Stegmüller, 1973) to develop a conception that might allow not just a synchronic analysis of individual theories, but the analysis of certain global intertheoretical relations (such as those of equivalence and reduction) and, even more importantly, of some diachronic aspects indicated by Kuhn.

However, as already pointed out and stressed by Stegmüller (1979), the structuralist view doesn't emerge as an attempt to render precise (some of) the Kuhnian notions. Nevertheless, it was very useful for this purpose—as Kuhn himself recognized on several occasions (Kuhn, 1976, pp. 179, 184; 1992, p. 4, 2000, p. 318). He maintains that the structuralists expressed more faithfully what he had in mind when he used the concept of paradigm, in its synchronic and diachronic sense. However, he rejects the idea of characterizing the revolutionary change in terms of the intertheoretical relation of reduction ("I am not confident that *any* pair of historical theories separated by a revolution will satisfy your reduction relation," Kuhn, 1975, p. 22; see also Kuhn, 1976, pp. 190–196; 2000, p. 318). But, in fact, the intertheoretical relation of reduction wasn't intended to apply to every case of revolutionary (or intertheoretical) change (for initial doubts on this, see Sneed, 1971, p. 305; for a later recognition, see Balzer, Moulines, & Sneed, 1987). In addition, different types of diachronic phenomena in the history of science outside "normal science" are distinguished (Balzer et al., 1987, pp. 206–210; see also, more recently, Moulines, 2011). The challenge was, and still is, to develop suitable intertheoretical relations in particular or metascientific concepts in general for treating diachronic phenomena in a satisfactory way—as do the meta-theoretical concepts of theory-evolution for the case of normal science and of reduction for the case in which there is an embedding of one theory into another (without incommensurability).

Besides, the relevance of the structuralist view, or, more importantly for our present concerns, its similarity to other Semantic conceptions, should not be evaluated considering the empirical adequacy of Kuhn's interpretation of history of science. As a matter of fact the structuralist view is independent of it: (some periods of) the history of science cannot be satisfactorily included in the Kuhnian scheme, even though they could be adequately represented by the conceptual tools of the structuralist view. This view makes no empirical claim, either general or particular, about the history of science, but provides conceptual instruments of analysis that allow the representation of different kinds of possible changes. Besides this, Suppe himself recognizes the importance of the treatment of diachronic aspects by the semantic conception as well as the possibility that the structuralist view is pointing in the right direction, through a more adequate identification of theories (Suppe, 1989, p. 427).

5. Comments on Suppe's third criticism

In relation to the third criticism, one might answer that to accept or to make use of certain methods and/or results of the philosophy of science from the 20th century, developed during the "classical" period or phase (Moulines, 2008), such as (an essentially modified version of) "Ramsey sentences," does not commit us to accepting or to making use of "neo-Positivism" or the "received view" as a whole. In particular, the use of the "Ramsey sentence" (or, better said, of the "three times modified Ramsey sentence," also known as the "Ramsey-Sneed sentence") in the first formulations of the structuralist view, or of the notion of "empirical content" in its later formulations in order to characterize the empirical claims of scientific theories and to escape the "self-justification" danger, doesn't mean at all that the structuralist view accepts or includes the "correspondence rules," which were a central aspect of theories according to the "received view."

Although Ramsey's work (Ramsey, 1929) was formulated in terms of the received view of theories, Sneed (1971), Stegmüller (1973, 1979) and other structuralists (Balzer et al., 1987; Díez, 2005) have shown that some of his key contributions do not depend on this particular formulation. And more specifically, it is not true that the structuralist use of the Ramsey sentence implies the implicit incorporation of correspondence rules. The structuralist version of the Ramsey sentence is the theory's empirical claim (to be more precise, the whole set of empirical claims of the theory-elements that constitute the theory-net). The empirical claim says that there are theoretical models such that the structures representing the empirical data or phenomena that the theory intends to account for are "embeddable" into such theoretical models. Equivalently, that given an empirical or data model, which contains only *T*-non-theoretical entities, there exists an extension with theoretical entities that have the empirical model as a substructure. It is this latter reading of the model-theoretic empirical claim that shows the existential features that made Sneed talk of a modified Ramsey-sentence. But there is nothing particularly "classical," or belonging to the received view in this. It is the model-theoretic formulation of the idea that, in explaining phenomena, what the theory does is to postulate additional entities which, if they behave in accordance with the laws, imply the phenomena: that is, the theory makes correct predictions. Nothing thus depends particularly on the received view. As is well known, there are other aspects of the structuralist version of the Ramsey sentence that are not present in the received view version of the Ramsey sentence and that are also treated in set-theoretic (model-theoretic) terms instead of in linguistic ones. Without going into details, they are the following: (1) the relationships between the different models of a theory (innertheoretic relationships between models, represented by the so-called "constraints"); (2) the relationships between the models of a theory with the models of another theories (intertheoretic relationships between models, represented by the so-called "intertheoretical links"); and (3) the distinction between laws that are valid in every application of the theory ("fundamental laws") and those that are valid only in some of them ("special laws") (for details, see Balzer et al., 1987, chaps. II, § II.7, and IV, § IV.3).

To conclude this comment on Suppe's third criticism (in which he also affirms that: "By retaining some explicit correspondence rules, Sneed seems to concede far too much to positivism–indeed, far more than Kuhn would, or should, be happy with," Suppe, 1989, p. 20), I would like to cite Kuhn himself from his discussion with Baltas, Gavroglu and Kindi (1997) and reproduced in Kuhn (2000), against Suppe's assertion and in support of the interpretation presented here:

> "**Kuhn**: [...] I tried to get philosophers more interested in that stuff. And on the whole, for a long time, I couldn't succeed at all—now everybody is talking about the semantic view of theories. But on the whole leaving Sneed and Stegmüller out. And I think now I see the reason; I'd been looking at Fred Suppes' book, and I think I see what that's about. They don't want to get back to anything that looks like...
> **Baltas**: Models?
> **Kuhn**: Well, it's not that. I mean, structures are formal. They see the Ramseyfication, the use of Ramsey sentences as reintroducing—and this is why Sneed does it—something like the theoretical/observation distinction. And they think that's got no place any more. But unless you have something like that—it's not just theoretical/observation, I don't believe in that either. But what it sure is, is antecedent vocabulary, or shared vocabulary between the...if you take a dynamic view, you've got to have something that talks about revision of terminology and introduction of new terminology as part of the introduction of a new theory, of a new structure. And I don't think you can do it without that, and that's why I would still point back to the Sneed–Stegmüller version as the one that best fits with what goes on. It adapts itself to a historical developmental approach." (Kuhn, 2000, pp. 318–319).

6. The semantic family and the structuralist view of theories

In this section I will characterize the semantic family in general terms and the structuralist view of theories in particular in such a way that it justifies the inclusion of the structuralist view (as well as other "European" versions) as a member of this family.

The semantic family has its origins in the work undertaken by J.C.C. McKinsey (McKinsey, Sugar & Suppes, 1953), E. Beth (1948, 1960) and J. von Neumann (Birkhoff & von Neumann, 1932; von Neumann, 1932) in the period between 1930 and 1950. This family extends and obtains general attention in the middle 1970's and 1980's. To it belong the best known approaches, such as the *set-theoretical* approach of P. Suppes (1957, 1967, 1969, 1970, 2002), the *state spaces* approach of B. van Fraassen (1970, 1972, 1980, 1987, 1989, 2008), the *phase spaces* approach of F. Suppe (1967, 1972, 1989), and the *model-based* approach of R. N. Giere (1979, 1983, 1985, 1988, 1994), as well as the *partial structures* approach of N.C.A. Da Costa, S. French, J. Ladyman and O. Bueno (Da Costa & French, 1990, 2003; French & Ladyman, 1999; Bueno, 1997), the approach proposed by R. Torretti (1990), the afore-mentioned *structuralist view of theories* of J. Sneed et al. (Sneed, 1971; Stegmüller, 1973, 1979, 1986; Balzer et al., 1987; Balzer & Moulines, 1996; Balzer, Moulines, & Sneed, 2000), and other "European" versions such as those of M. L. Dalla Chiara and G. Toraldo de Francia (M. L. Dalla Chiara & G. Toraldo de Francia, 1973), M. Przełecki (1969), R. Wójcicki (1976), G. Ludwig (1970, 1978) and E. Scheibe (1997, 1999, 2001).

According to the semantic family, concepts relative to models are more fruitful for the philosophical analysis of scientific theories, their nature and function, than the concepts relative to statements. The nature, function, and structure of theories can be better understood when their meta-theoretical characterization, analysis or reconstruction is centered on the models that they determine, and not on a particular set of axioms or linguistic resources through which they do it.

Since the notion of model is fundamentally a semantic notion (something is a model of a claim or sentence if the claim is *true* for it), and its most frequent analysis is made by model theory, this new approach which emphasizes the importance of models in the analysis of science is called a *semantic* or *model-theoretic conception*. In contrast, the received view of theories is called *syntactic* because it characterizes theories as sets of sentences or statements and it places general emphasis on the linguistic-syntactic aspects.

It is important to understand that the semantic option neither supposes nor intends to disregard statements or, in general, linguistic formulations. It does not mean that linguistic resources are superfluous for the meta-theoretical characterization of theories. Of course, we need a language in order to determine or define a class of models. Insofar as the models are determined in an explicit and precise manner in the meta-theoretical analysis, they are determined by giving a series of axioms, principles or laws, i.e. through statements. Nobody intends to deny this. But even when the determination of the models is made through a series of axioms, the identity of the theory does not depend on these specific linguistic formulations. The linguistic formulations are essential in the (trivial) sense of being the necessary means for the determination of the models (how can it be otherwise?), but they are not essential in a really relevant sense, since nothing in the identity of a theory depends on whether the linguistic formulation is one or another provided that the models are the same.[2]

The different variants, versions, approaches or "members" of the semantic family, in spite of their differences, have some common elements. They are the following:

(1) The most basic component for the theory's identity is a class of structures, more specifically a *class of models*. A theory can be characterized in the first place for determining a class of models: to present/to identify a theory means presenting/identifying the family of its characteristic models. The models are determined through a series of principles or laws, which define a class of models.
(2) A theory not only determines a class of models by means of its laws. As a matter of fact, the systems (models) are defined in order to account for certain parts of the world: to account for certain data, phenomena, or experiences corresponding to certain aspect of the "reality." Part of the theory's identification consists then in the identification of those empirical phenomena that the theory intends to account for.
(3) The theory defines the models with the intention that they should represent the phenomena adequately: in traditional terms, that those concrete phenomena should satisfy the laws of the theory, i.e. that they behave according to the laws. This intention is made explicit by a linguistic or propositional act, by a *claim*. The claim states that between the empirical systems that we want to account for and the models determined by the laws there is a certain relationship, with the intention that our theory should adequately represent "reality".
(4) It is important to emphasize the fact that this claim simply makes explicit an intention already implicitly contained in the pair "⟨defined models, phenomena⟩" It is true that if we identify them in this way, theories are strictly speaking neither true nor false. But nothing philosophically fundamental is derived from this alone. Theories, these pairs, are in a one-to-one correspondence with entities which certainly are susceptible to being true or false, namely, their claims.

[2] For a recent discussion regarding the relationships between the semantic conception (or view) of theories and language, see Halvorson (2012, 2013) and Glymour (2013).

> Therefore, although we cannot primarily ascribe truth values to theories, we can certainly ascribe them *derivatively*: a theory is "derivatively true" if and only if its claim is true. And this derivative sense is important enough from the philosophical point of view. And again, if there is a certain interesting sense in which theories are not falsifiable, it is not because they are not entities to which the predicates true or false cannot be ascribed. They cannot be ascribed primarily, but they certainly can be ascribed derivatively, and this is enough for the important sense of falsifying: if the empirical claim is false, the theory becomes "falsified" in the sense that not everything can remain the same.

On the other hand, within the semantic family we find various characterizations of the notion of a theory, i.e. different variants, versions, approaches or "members of it." They may differ, among other things, in the following four aspects:

(1) the precise nature of these entities which are called models and whose determination identifies a theory (be it models in the sense of formal semantics, model theory, as for Suppes, Da Costa et al. and the structuralist view; or in the sense of state or phase spaces, as in the case of van Fraassen and Suppe; or model in any informal acceptable sense of the term, as for Giere);
(2) the way in which they propose to identify (to represent) the class of models (by definition or introduction of a set-theoretical predicate, for Suppes, Da Costa et al. and the structuralist view; by characterization of state or phase spaces governed by certain laws, for van Fraassen and Suppe; or directly by postulates, laws, and equations that appear on scientific texts, for Giere);
(3) the way of conceiving the phenomena that theories intend to account for, interpret, explain and predict (as "models of data," for Suppes; "empirical substructures that only contain observable entities," for van Fraassen; "physical systems" that function as "nonproblematic 'hard-data'" for the theory, for Suppe; "partial structures," for Da Costa et al.; "intended applications" formally represented as "partial potential models," for the structuralist view; or "real systems," for Giere); and
(4) the relationship established between the models and the phenomena which they intend to account for, interpret, explain and predict (be it of identity, isomorphism, partial isomorphism, approximation, embedding, or similarity).

Besides, the distinct members of the semantic family differ not just technically, but also in fundamental philosophical questions. They don't share a series of substantive philosophical theses (with the exclusion of the general philosophical thesis concerning the fundamental role of models in analyzing the structure, nature, and function of scientific theories), but a way and a framework in which to put and to discuss (other) philosophical problems (about science), such as scientific realism.

However, we consider that the shared aspects justify talking about a family or, using the definite article, to talk about *the semantic conception of theories* and its different approaches (variants or versions), such as the *set-theoretical* approach, the *state spaces* approach, the *phase spaces* approach, the *model-based* approach, the *partial structures* approach, the *structuralist* view, and other "European" versions.

Regarding the structuralist view in particular, there we find not just the fundamental semantic thesis on the centrality of models in the explication of the concept of a scientific theory, but also the totality of the five aforementioned common elements, i.e. in addition to the common element 1, we find also the identification of those empirical phenomena that the theory intends to account for (common element 2), the representation of the "empirical" claim of the theory (common element 3), and the idea that even though we cannot primarily ascribe truth values to theories, we can certainly ascribe them derivatively (common element 4). And if this is so, we must conclude that the structuralist view has to be considered a variant, version, particular approach or member of the semantic family on its own right.

As a member of the semantic family, the structuralist view not only shares some elements with all of the other members of the family, but it also specifies in a distinctive manner the previous four differentiating aspects, like the already mentioned nature of the models (differentiating aspect 1) and the way of identifying them (differentiating aspect 2), shared just with some of the other members of the semantic familiy. Moreover, within the semantic family, the structuralist view is the approach that provides the most detailed analysis of the fine structure of theories through the treatment of more elements as well as by an improvement of elements previously identified. The main features of the structuralist view of theories are the following:

(i) A theory cannot be identified with *a class* (or set or family) *of models*, even though such a class is the most basic component for the identity of a theory, but not the only one.
(ii) A theory is *a complex*, *strongly hierarchical* and *multi-level* entity, which can be identified with *a series of hierarchically organized classes of structures*. Each class of structures is called a "theory-element," and the total series is called a "theory-net."
(iii) A *theory-element* is the simplest kind of set-theoretical structure that can be identified with, or can be used as a rational reconstruction of, or can be regarded as a formal explication of, a theory (in an informal, intuitive sense), and it can be identified, as a first approximation, with an ordered pair consisting of the "(formal) *core*," symbolized by K, and the theory's "domain of intended applications," symbolized by I: $T = \langle K, I \rangle$.
(a) The *core K* constitutes the formal identity of any empirical theory with a certain degree of complexity, which is composed by the ordered classes of *potential models*, of *actual models*, of *partial potential models*, of *constraints* and of *links*.
a.1 The total class of entities that satisfies the "frame conditions" that just settle the formal proper ties of the theory's concepts is called the class of *potential models* of the theory.
a.2 Those structures, which, in addition, satisfy the "substantial laws," are called the *actual models*.
a.3 The T-theoretical/T-non-theoretical distinction is reflected by the distinction between the classes of potential models and of partial potential models. If the T-theoretical concepts are "cut off" of the potential models, then the *partial potential models* are obtained.
a.4 The models of one and the same theory are not isolated from each other, but interconnected, forming a global structure. These innertheoretical relationships between the different models of a theory are represented by the so-called *constraints*.
a.5 In a similar manner, it can be said that different theories are usually interconnected to each other. These intertheoretical relationships are represented by the so-called (intertheoretical) *links*.
(b) Any empirical theory is related to "reality" or "outside world," i.e. to some specific phenomena submitted to some specific conditions, to which it is intended to be applied and for which it has been devised. These phenomena also belong to a theory's identity because otherwise we would

not know what the theory is about, for the class of models contains "all" models, intended as well as non-intended. They constitute what is called the theory's *domain of intended applications*, and is sym bolized by *I*. The domain of intended applications of a theory is conceptually determined through concepts al ready available, i.e. through *T*-non-theoretical concepts (differentiating aspect 3). *I* is a kind of entity strongly depending on pragmatic and historical factors which, by their very nature, are not formalizable.

(iv) Theories are not statements, but are *used* to make statements or claims, which have then to be tested. The (empirical) statements (or claims) made by means of scientific theories are, intuitively speaking, of the following kind: that a given domain of intended applications may actually be (exactly or approximately) *subsumed* (or *embedded*) under the theory's principles (laws, constraints, and links) (differentiating aspect 4). Normally, in any "really existing" theory, the "exact version" of the so-called *central empirical claim* of the theory—that the whole domain of intended applications may actually be (exactly) subsumed (or embedded) under the theory's principles—will be strictly false. What usually happens is that either there is a subclass of intended applications for which the empirical claim is true, or that the central empirical claim is strictly speaking false but *approximately true*.

(v) Some "real-life" examples of scientific theories can actually be re constructed as *one* theory-element, but usually single theories in the intuitive sense have to be conceived as aggregates of several (sometimes a great number of) theory-elements. These aggregates are called *theory-nets*. This reflects the fact that most scientific theories have laws of very different degrees of generality within the same conceptual setting. Usually there is a single fundamental law—which mutually relates all fundamental terms of the theory in one "big" formula, which the respective scientific community accepts as valid in all of the theory's applications, and whose primary role is to provide a frame for the formulation of other laws—"on the top" of the hierarchy and a vast array of more special laws—which apply to a more restricted domain—with different degrees of specialization. Each special law determines a new theory-element. What holds together the whole array of laws in the hierarchy is, first, the common conceptual framework (model-theoretically represented by the class of potential models), second, the common *T*-theoretical and *T*-non-theoretical distinction, and third, the fact that they are all specializations of the same fundamental law. A theory-net—which is the standard structuralist concept of a theory from a static or synchronic point of view—is a finite set of theory-elements (hierarchically) ordered by the (non-deductive) relation of specialization—which is reflexive, antisymmetric and transitive.

(vi) A theory can also be conceived diachronically, i.e. as a kind of genidentical entity. A theory in the diachronic sense is not just a theory-net, which keeps existing in the same form through history, but a theory-net that "evolves." Such an entity is called a *theory-evolution*, which is essentially a sequence of theory-nets fulfilling two conditions, one for the cores and the other for the domains of intended applications: at the level of cores, it is required for every new theory-net in the sequence that all its theory-elements are specializations of some theory-elements of the previous theory-net; at the level of intended applications, it is required that the domains of the new theory-net have at least some partial overlapping with the domains of the previous theory-net.

(vii) Besides the specialization relation, the structuralist view of theories can also take into account other *general intertheoretical relations* such as *theoretization*, *reduction*, (empirical and full) *equivalence*, as well as (intra- and intertheoretical) *approximation*, and discuss problems related to the global structure of science (by using the concept of a *theory-holon*) (see Balzer et al., 1987, chaps. VI–VIII).

(viii) Finally, it can be said that the structuralist view has been proposed to represent not just *intra*theoretical changes that occur in science (by means of the concept of a theory-evolution), but also different types of *intertheoretical changes*, such as *crystallization*, *embedding*, and *replacement with (partial) incommensurability* (see Moulines, 2011).

Metatheoretical structuralism is not just the semantic approach that provides the most detailed analysis of the structure of theories, but also the one that has analyzed and reconstructed the greatest number of particular theories, their structure and their conceptual foundations. The conceptual framework of the structuralist view of theories has been applied to more than forty (not only) empirical (but also formal) theories belonging to the most diverse scientific disciplines, from physics to literary theory, going through chemistry, biology, economics, psychology, and sociology.[3] Emphasizing both advantages, in comparison with other semantic approaches, Nancy Cartwright claims that: "The German structuralists undoubtedly offer the most satisfactory detailed and well illustrated account of the structure of scientific theories on offer" (Cartwright, 2008, p. 65).

7. Final remarks

In this article, I first presented the criticisms of the structuralist view that Suppe gave in order to exclude it from his account of the semantic conception of theories. I then replied to those criticisms, which in my view reveal a deep misunderstanding of the structuralist view on his part. However, Suppe is one of the leading figures in the Semantic Conception in the US, and maybe because of this, his thought exerted a strong influence both in the US and elsewhere. In consequence, Suppe is followed on this point by other supporters of the semantic conception, tending to exclude the structuralist view, in spite of its merits, from the discussion of scientific models and theories, and from the so-called semantic conception (or semantic family). In some cases this is done explicitly for the reasons given by Suppe, with no more argument than the reference to Suppe (1979), e.g. by Lloyd (1988) and Thompson (1983, 1989a, 1989b). In other cases this is done implicitly, without mentioning any reason, just by ignoring the structuralist view and making no reference to it. And what is true for the supporters of the semantic conception is also true for philosophers of science who work either with a different conception of a scientific theory or with other philosophical problems of science. This has hindered the dialogue between the different versions of the semantic conception and ultimately the understanding of scientific theories and of other aspects of science related to it. With this article I hope to have contributed, at least in part, to repairing this situation.

[3] On this point, we can refer to the bibliography mentioned in Diederich, Ibarra & Mormann (1989/1994) and Abreu, Lorenzano, & Moulines (2013). For books or journal special issues containing several applications of the structuralist view, see, among others, Balzer (1982/1997, 1993), Balzer et al. (1987, 2000), Díez & Lorenzano (2002), Díez, Falguera & Lorenzano (2011), García de la Sienra & Lorenzano (2012), Moulines (1982), Peris-Viñé (2012), Stegmüller (1986), Stegmüller, Balzer, & Spohn (1982) and Westmeyer (1989, 1992).

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