ENGLISH VERSION

During the last two decades a new approach in philosophy of science has been developed, especially with respect to the nature, structure and function of empirical theories.

The novelty of this approach can best be understood by contrast to the common viewpoint of all other previous conceptions. Three of the most important schools in contemporary philosophy of science, logical empiricism, Popper's school, and the historicists, different as their outlooks are, all share the idea that scientific theories must be analysed through their linguistic formulations. Some philosophers have even identified theories with their linguistic formulations. Thus it is sometimes said they maintain a "statement view" of, or a "syntactic approach" to, theories.

An alternative approach, developed by authors from different schools of thought has attempted to develop a more adequate conception of a theory by means of the notions of a model or an application. This is the core of the *semantic* or *model-theoretic conception of scientific theories.*

The purpose of this paper is to discuss some recent ideas of Bas van Frasseen, who has made important contributions to this semantic conception.

Van Fraassen claims that "to present a theory is to specify a family of structures, its *models;* and secondly, to specify certain parts of those models... as candidates for the direct representation of observable phenomena."[1] This assertion involves a methodological claim as well as an epistemological one. The former proposes a specific way of identifying and reconstructing theories; the latter puts forward a particular conception of the aim of science. Let us examine the methodological proposal first.

Defenders of the semantic conception, and van Fraassen in particular, accept that formal methods are useful for the philosophical analysis of science. The difference between this approach and that of, say, logical positivism, is that the former resort to for more flexible formal tools. It uses resources both from set theory and from model theory. It must be stressed that the difference between the use of certain formal tools instead of others is not just a matter of the degree of precision of theory reconstruction. Rather it reveals

[1] Van Fraassen 1980, p. 64.

distinctive ideas about the nature and structure of theories. I shall try presently to justify this claim.

In what I shall call the classical analysis of science, the laws of a theory had to be expressed in a very precise form, in a formal language. This was necessary in order to apply transformation rules and to control the derivation of consequences. Then a set of correspondence rules was fixed in order to have a (partial) interpretation of the formal language and to relate the theoretical with the observational vocabulary.

Thus this classical conception, of a linguistic orientation, construed theories as sets of statements; moreover, it postulated that the complete formalization of theories (in first order languages) and their axiomatization (in Hilbert's sense) were the ideals to be aimed for. The philosophers who adopted this viewpoint thought that the application of these formal methods, which had been so successful in the reconstruction of geometry and arithmetic, could be easily extended to the analysis of empirical theories. As van Fraassen himself has pointed out,[2] this syntactic approach assumes that the theoretical reasoning of scientists can be completely and adequately represented by means of deductive arguments expressed in a formal language.

A completely different approach results if we take into account the role of models in science, and if theory identity is consequently seen in terms of the kinds of structure that constitute their models. Thus van Fraassen claims that "from this point of view, the essential job of a scientific theory is to provide us with a family of models, to be used for the representation of empirical phenomena." [3]

So purely syntactical methods and problems are displaced since the same kind of structures can be correctly described in several different ways.[4] Van Fraassen comments on the repeated failures of logical positivists in their attempts to account for concepts such as empirical content, equivalence between theories, confirmation, and so on, and he asserts that "the main lesson of twentieth-century philosophy of science may well be this: no concept which is essentially language-dependent has any philosophical importance at all." [5]

I shall now summarize in a non-technical way van Fraassen's main ideas in his proposal for theory reconstruction. Following Suppes,

[2] *Cf.* van Fraassen 1970, p. 337.
[3] Van Fraassen 1972, p. 310.
[4] *Cf.* van Fraassen 1980, p. 44.
[5] Van Fraassen 1980, p. 56.

van Fraassen considers that a theory defines the kind of system it can be applied to; he holds its empirical assertions to have the form "$x \varepsilon M$", where 'x' stands for a given empirical system and 'M' for the class of models.[6]

A physical theory uses a mathematical model in order to represent the behaviour of a certain class of physical systems.[7] A physical system is defined through the specification of the set of states of which it is capable. These states are represented through elements of a mathematical space, the *state-space*. It is usually the case that a physical theory deals with a large class of systems which is in turn divided into subclasses, and it specifies a state-space for each subclass.[8]

The theory also uses a set of physical magnitudes in order to characterize the empirical system. The theory describes the behaviour of this kind of system by means of such magnitudes. In turn, these magnitudes are represented by a function on the state-space.

Van Fraassen includes a linguistic factor: *elementary statements.*[9] It seems to me that these elementary statements are the linguistic formulations of the laws of the theory. Van Fraassen offers the following definition: a sentence U is an elementary statement for a theory T if and only if it formulates a proposition to the effect that a certain physical magnitude has a certain value at a certain time.[10]

The truth of an elementary statement, that is, whether it is satisfied in a physical system, depends on the state of that system. Thus, for each elementary statement there is a set of states satisfying it, and the theory must specify the conditions in which a state satisfies an elementary statement. This relationship between states and elementary statements is a relationship between states and values of physical magnitudes, and it thus constitutes the link between the mathematical model that the theory offers and the results of empirical measurement.[11] The set of elementary statements together with its interpretation in terms of the state-space constitutes a language. Van Fraassen calls it *elementary language.*[12]

[6] *Cf.* van Fraassen 1972, p. 311.
[7] *Cf.* van Fraassen 1970, p. 328.
[8] *Cf.* van Fraassen 1972, p. 311.
[9] *Cf. Ibid.*, p. 312.
[10] *Cf. Ibid.*
[11] *Cf.* van Fraassen 1970, p. 329.
[12] *Cf.* van Fraassen 1972, p. 312.

Van Fraassen points out that these are not languages in terms of which a theory can be formulated. They are just languages the analyses of which enable us to explore what the theory says about the world. It is not at all clear, however, what role those elementary languages play in van Fraassen's reconstruction of theories. He would at least have to explain whether each theory produces just one elementary language or whether it is possible to have different languages for the same theory. It would also be necessary to clarify whether elementary languages are constitutive parts of a theory, *i.e.*, whether they are necessary for the identity of a theory. In such a case, theories would depend on their linguistic formulations to some extent. But this would be at odds with his previous criticism of the syntactic approach.

Van Fraassen's formal analysis seems to imply that physical theories are conceptual structures which determine the configuration of a state-space. This is to say, they are conceptual structures which in turn determine structures or models that represent the behaviour of physical systems. But sometimes the theory seems to be identified with the models themselves.

It seems to me that this ambiguity arises out of van Fraassen's neglect of the problem of the ontological status of theories, *i.e.*, van Fraassen does not tackle the question of what sort of entities scientific theories are. This is perhaps because van Fraassen assumes that the answer to the question "what does the structure of a scientific theory looks like?" already answers the question "what is a scientific theory?".[13] We thus need to ask van Fraassen to clarify his ontological conception of scientific theories.

Let us now turn to some epistemological issues. Against scientific realism, van Fraassen claims that the aim of science is to offer empirically adequate theories but not literally true stories of what the world is like.[14] A theory is empirically adequate if and only if what it says about observable things and events is true, *i.e.*, if it *saves the phenomena*.[15] A more precise definition according to the model-theoretic approach is as follows: a theory T is empirically adequate if and only if it has a model such that all observable phenomena are isomorphic to substructures of that model.[16]

[13] *Cf.* Moulines 1982, p. 330.
[14] *Cf.* van Fraassen 1980, p. 8.
[15] *Cf. Ibid.*, p. 12.
[16] *Cf. Ibid.*, p. 64.

Van Fraassen claims that acceptance of a theory implies belief in its empirical adequacy. There is no committment to the belief that its models offer a true, faithful representation of what the world looks like.

I could not agree more with van Fraassen in this respect. But I cannot accept this claim: "I regard what is observable as a theory-independent question",[17] *i.e.* observable facts are just disclosed by theories, but they are not relative to, nor do they depend upon those theories.

It should be clearly pointed out that this assertion of van Fraassen's is not related to a naive belief in a theory-free language. He explicitely declares that "all our language is thoroughly theory-infected".[18] It seems, however, that van Fraassen admits a theory free level of human perception which is the basis of what is observable. This can be seen when he insists on the distinction between *observing* and *oberving that.* A Stone Age man like one of those recently found in the Phillippines, can surely perceive a tennis ball. We can easily verify that by seeing him handling the ball. But he has not *seen that* it is a tennis ball. He does not even have the relevant concepts.[19] Thus van Fraassen concludes, "To say that he does not see the same things and events as we do, however, is just silly; it is a pun which trades on the ambiguity between seeing and seeing that." [20]

Even if we concede that there is a theory free level of perception, there is no justification for van Fraassen's claim that the aim of scientific theories is an adequate representation of observable phenomena, where 'observable' is taken as theory free. First of all, science does not deal directly with phenomena, but with descriptions of phenomena. Thus, science always involves observation of the kind *observing that* and not just of the kind *observing.* Secondly, the empirical systems that a theory is supposed to explain are *idealizations* of empirical phenomena, since there is always a selection of relevant features, lots of others being excluded. The features selected indicate, precisely, the perspective of the theory.

Thus, even if there were a non-ostensive way by means of which phenomena can be referred to, which in turn did not involve the world image offered by the cultural schemes and the theories pre-

17 *Ibid.*, p. 57.
18 *Ibid.*, p. 14.
19 *Cf. Ibid.*, p. 15.
20 *Idem.*

viously accepted, this way would be of no use for scientists: for they always require a theoretical viewpoint both for theory construction and for theory testing. So if theories always deal with already conceptualized phenomena and not with merely "observable" phenomena (in van Fraassen's sense), it can be suggested, against his idea as to what the aim of a theory is, that the aim of theories is rather that of the construction of models that must be fit by descriptions of phenomena.

Now, van Fraassen mantains that theories themselves designate what is observable; but in order to avoid a possible vicious circularity when theory testing is under consideration, he defends the theory free status of what is observable. Van Fraassen has thus to explain how is it possible for a theory T to delimit the field of observable phenomena, its field of application, while at the same time it is said that phenomena are independent of all conceptual frameworks.

It is not clear how van Fraassen's method of reconstruction preserves the idea that the field of observable phenomena is given by the theory itself. In this respect the distinction between two conceptual levels of a theory, defined as a *theoretical* one and a *non-theoretical* one, as characterized by the structuralist conception of theories, is very useful. This distinction leads to a precise characterization of those empirical systems to which the theory is supposed to be applicable. Those systems are conceptualized by means of *non-theoretical* parameters which are nonetheless parameters *of* the theory. Its *non-theoretical* status just means that the laws of the theory are not necessary for determining their values.[21]

This approach has the advantageous consequence that a non-theoretical concept for a given theory T is not necessarily 'observational', (in whatever way 'observable' is interpreted). The field of applications of a theory is determined by previously accepted theories. At this point I can state another disagreement with van Fraassen, for he considers, for instance, that in classical mechanics all magnitudes that are just space and time functions are "*basic observables*", in his sense of observable, *i.e.* as theory free. But it should be clear that measurement of positions, times, relative distances, accelerations, and so on, presupposes at least a certain geometry as well as certain cronometric procedures.

In order to bring this discussion to an end, I wish to point out

[21] *Cf.* Moulines 1982, p. 83.

another problem related to intended applications. The kinds of phenomena that a theory intends to cover with its models is not a part of the theory, according to van Fraassen.[22] So, he seems to agree with P. Suppes in that he holds that the structure of an empirical theory is not essentially different from the structure of a mathematical theory. For my part I do believe that intended applications should be seen as parts of a theory. But intended applications must be clearly distinguished from phenomena themselves, and from empirical systems. Intended applications should be seen as conceptual structures (descriptions of phenomena) that are constitutive parts of theories and which the theory intends to subsume as models. This provides a criterion for distinguishing empirical from purely mathematical theories, since the latter do not include this type of model.

To conclude, I would like to stress that van Fraassen's approach is very appealing, particularly since it develops an epistemology for scientific theories which is in total harmony with his method of formal reconstruction. Thus he is an example of how a neat (though disputable) epistemological view can be assumed once the field of discussion has been cleared up.

BIBLIOGRAPHY

See the Spanish version of this paper.

[22] *Cf.* van Fraassen 1980, p. 66.