Chapter 2
Scientific Activity as an Interpretative Practice. Empiricism, Constructivism and Pragmatism

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Abstract Since the publication of *The Scientific Image* and earlier works Bas C. van Fraassen has defended his constructive empiricism as the most appropriate philosophical interpretation of scientific activity in critical open dialogue with realisms (both old and new) and instrumentalisms. A new impetus was added to the debate by the publication of his most recent book, *Scientific Representation*, in which he qualifies some of his basic suppositions and proposes a new name for his empiricism: *empiricist structuralism*. In this paper I argue in line with his thesis that if philosophy of science aims to offer a specific view and an adequate interpretation of science, the starting point should be a recognition of the complexity of the dialectic process between theoretical construction and data generation, processing and laboratory analysis procedures; also a recognition of the central role of subjects as interpreters in designing and using scientific representations. I also argue that the *family resemblance* which exists between the constructivist/structuralist empiricism and American pragmatism suggests new avenues for analysing the decision-making process and the role played by subjects who interpret, construct or use models in scientific contexts. A connexion with the pragmatists' thesis and perspective that is very much present, not only in van Fraassen's most recent texts on scientific representation, as some other authors maintain, but also from the outset in his earliest publications.

Keywords Scientific representation • Constructive empiricism • Empiricist structuralism • Interpretation of scientific activity • Pragmatism

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W.J. Gonzalez (ed.), *Bas van Fraassen's Approach to Representation and Models in Science*, Synthese Library 368, DOI 10.1007/978-94-007-7838-2_2,

Thirty years after the publication of the celebrated text by Bas C. van Fraassen, *The Scientific Image*, philosophical debates still rage regarding his work, his epistemological position and the nature of his proposal: constructivist empiricism, in critical open dialogue with realisms (both old and new) and instrumentalisms. New impetus was added to the debate by the publication of his most recent book, *Scientific Representation*, in which he qualifies some of his basic suppositions and proposes a new name for his empiricism: *empiricist structuralism*. Our aim will be to explore the principal traits of van Fraassen's philosophy of science, arguing that it is one of the most comprehensive and appropriate views of scientific activity, and that the link between renewed empiricism[1] and pragmatism is very close, not only in the last text, as some other authors maintain,[2] but right from his earliest publications.

2.1 What Is Philosophy of Science?

Philosophy of science plays the part of authorised interpreter of the scientific practices, the epistemological orientations that guide scientific procedure, and of the attitudes towards science. Thus, it compounds a vision of science with the aim of understanding human cognoscitive activity at its most articulate, sophisticated and successful. Philosophy is *interpretation*, it proposes an interpretation of science,[3] with the aim of gaining a better understanding of the whole process, activity or body of knowledge, which can only be achieved through dialogue between those involved in the undertaking. Explanatory success or failure is also linked to the agreement reached between the participants in this dialogue, both in relation to the classification of facts and with regard to the assessment of their relevance and meaning. Participants in philosophical dialogue share a common starting point and have, or may establish, a series of basic agreements and values which stem from the culture and historic moment to which they belong. The empiricist-constructivist interpretation of science offers a view of science, a concept of this activity, which is consistent with this fact: science is a greatly admired intellectual undertaking, the paradigm of rational research, but it is also subject to severe criticism in order to avoid dogmatic establishment in any body of knowledge which, by definition,

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[1] This is how I defined it in the text analysing the work and focus of van Fraassen. Perdomo and Sánchez (2003).

[2] M. Suárez believes that, due to this change of course, van Fraassen ends up "in no man's land. Or in someone else's land. I think we end up in the land of pragmatism." In my opinion, constructivist empiricism and pragmatism have always shared common ground. See Ladyman et al. (2011) (Nov. 2010).

[3] U. Moulines has affirmed that "the philosophy of science constructs interpretative philosophical frameworks which enable us to understand these interpretative frameworks of the reality which we call scientific theory." Beyond the limits imposed by the descriptive/prescriptive dichotomy for defining the task of philosophy of science, what this implies is the possibility of offering a view of things, a way of thinking about certain phenomena in a certain manner. Moulines (1995, 110). This approach is very similar to that offered by van Fraassen.

will always be partial and tentative; thus, we avoid both our tendency to indulge in the realist convenience of belief in an underlying order which our science is just capable of glimpsing, and the dissolution of rules and guidelines in the network of interests and ideologies which plague scientific communities.

In his work, van Fraassen asserts that scientists commit themselves to participating in the search for empirical adequacy. It is an open question as to whether, as individuals, scientists believe that accepted theories are correct, that their work will lead them to discover God's creation plan, that they are on the path to discovering the laws of nature, that their experiments will enable them to discern the structure of certain unobservable entities in whose existence they nevertheless believe. Therefore, the idea that scientists are searching more for empirical adequacy than the truth, or any approach to it, is a question that is compatible with the opinions or beliefs of the individual scientists themselves (van Fraassen 1994c, 181). Scientists participate in a common undertaking, an undertaking in which they establish the empirical adequacy of the theories they produce as the criterion for success, although other criteria may also be defined as relevant. Philosophy of science explains this by analysing the objectives of science, as reflected in the practices and values designed and sustained by the scientific community itself, the beliefs and opinions implied in the acceptance of certain theories, the intentional aspects and the use of scientific models to represent and explain phenomena and the processes of measurement, simulation and technological development, which form the basis of the theoretical construction process.

Style defines the special character or means of expressing concepts that an author bestows on his or her work (van Fraassen & Sigman 1993). Applied mainly to artistic activities,[4] this concept is equally valid for illustrating the character which van Fraassen lends to philosophy of science. The concept of style immediately suggests that of creative imagination and interpretation, and in the case of philosophy, this also translates into conceptual elaboration, the ability to imagine and create new categories or concepts which enable us to illustrate or interpret the specific characteristics of the object in question, in this case scientific activity, and the processes and results of said activity. A philosophical style defines the questions which make up its central focus, as well as the rules or criteria with which the results are assessed or appraised, success and productivity criteria and aesthetics, etc. It also reveals attitudes to topics associated with this activity: a theory regarding how facts are constructed in the laboratory, how data and theory mesh, how theoretical models are used to respond to questions defined as relevant in a specific historical context, referring to certain questions which are pertinent to the philosophy of science but which, above all, offer a vision, an approach, a specific "lens" which enables us to shed light on certain shady areas from other alternative approaches.

[4] It is also applied fruitfully to the analysis of the history of science, as a means of putting into practice different styles of scientific reasoning and creative imagination. The history of science is understood as the result of applying different styles of scientific thinking, and as the product of both processes of mutation and the continuity of said styles of thought. This is the approach adopted by A. C. Crombie (1994).

It may perhaps seem that the inevitable result to which this line of thought leads is an admission of the existence of a multitude of approaches, all at the same level, each one with its own specific set of values, criteria and preferred topics, all equally consistent: indeed, this is what post-modern epistemological thinking would have us admit. And it is true that, having reached this point, it is indeed the only way out; the only possible coherence is the internal coherence of each approach or perspective. However, van Fraassen argues that, before reaching this point, the study of philosophy of science and the discipline itself should adopt as its starting point a sceptical, self-critical and empiricist attitude. Strictly speaking, there is a plethora of approaches, but only two attitudes on which to base analysis and conceptual development: one based on received wisdom, and the other one sceptical, empiricist and critical.[5] It is this second one which enables us to carry out our interpretative task unencumbered and ensure a philosophy of science committed to the task of interpreting the complexity, sophistication and contextual nature of the construction, assessment and use of scientific knowledge.

B. C. van Fraassen assigns philosophy an important role as the interpreter of the interpretations of the world,[6] and this implies a complete renewal of empiricism; from his initial work in 1980, *The Scientific Image*, to his most recent offering in 2008, *Scientific Representation*, he confers on philosophy of science a distinct, key role which is a far cry from its traditional normative and justificatory approach. B. C. van Fraassen's constructivist empiricism defines scientific practice as that which enables the proliferation of interpretations, the suggestion of different models ordering, measuring and interpreting both phenomena and the philosophical task itself, as an interpretation of this interpretative action. This empiricist approach is, in my opinion, also similar to that adopted by H. Longino, who argues that the values which guide the different interpretations are contextual and historical cognitive values, both in science and philosophy, and defines this view of scientific knowledge as contextual empiricism, in the following terms: "It is empiricist in treating experience as the basis of knowledge claims in the sciences. It is contextual in its insistence on the relevance of context — both the context of assumptions that supports reasoning and the social and cultural context that supports scientific inquiry — to the construction of knowledge." (Longino 1990, 219.)

An adequate analysis, both in the world of the basic experience of science and in that of the investigating subject and communities of scientists, and the handling of

[5] There are other models we could use to illustrate this attitude: the attitude of the feminist critique of science, for example, and more specifically, that of critical and contextual empiricism, defended by H. Longino, for whom the possibility of a future non-androcentric science is necessarily based not on the absolute condemnation of science, but rather on the adoption of a critical attitude to both contextual values and internal methodological criteria and the rules that define this practice (H. Longino 2002). This attitude is also expressed by Kant in *Prolegomena*, when he confesses that Hume interrupted his dogmatic slumbering, giving his research a completely different character. This is, according to van Fraassen, a perfect illustration of the empiricist attitude, although Kant did not define it as such.

[6] van Fraassen explores this idea of interpretation, which is similar to that used in the arts context, in "Interpretation in science and in the arts," 1993, 73–99.

adequate notions applied to the description of the processes involved in the construction of knowledge, imply the defence of this empiricism as a global approach, to the extent that it illustrates the type of interactive, interpretative and constructive process which takes place between the epistemic community and reality.

2.2 The Semantic Conception of Theories and Constructivist Empiricism. Scientific Activity as a Constructive and Intervening Process

van Fraassen's empiricist approach was developed within the semantic conception of theories, which offers a basic approach for philosophy of science's new agenda following the foundationalist failures. It conceived scientific theories as sets of models, and opted to formalise them following semantic methods. However, it also analysed the relationships existing between theories and the epistemic community (i.e., subjects, active agents in the process of exploring and intervening in the world), the processes of accepting or rejecting theories and the active role of experimentation in the construction and development of theories; although it is also true that it attached less importance than other similar approaches[7] to the role of prior theories and the processes of scientific change. van Fraassen's approach, within the framework of the semantic conception, enables us to navigate around that which, in my opinion, constitutes the core of debates about science: scientific activity as a constructive and intervening process which generates interpretations of the world. The debate regarding the role of the decisions made by scientists, their commitments to theoretical frameworks which are considered "expert guides" in the development of the scientific image of the world, as well as the foundations of theoretical acceptance and epistemological stances and attitudes to science. Questions which demand that which van Fraassen calls the *self-location* of subjects in relation to the body of knowledge, similar to the process of the *self-location* of the user in relation to a map which tells them where they are, an issue we will deal with later on.

[7] I am referring to Balzer, Sneed and Stegmuller's structuralist view. The structuralist approach defended by both perspectives provides a set of conceptual tools for dealing with the fact that science is, above all, a kind of activity whose aim is to provide an interpretation of its object of study in terms of its structure. They defend this activity as being essentially constructive in nature, i.e., scientists construct models, mathematical objects, which are then used to represent nature. Structuralism continues to defend the ideal of axiomatisation, opting for mathematical methods such as set theory to develop its vision of science. Thus, it offers a series of tools appropriate for reconstructing highly mathematised theories, enabling the adequate establishment of the set of elements and relationships which make up a theory, as well as the relationships between different theoretical elements, whether they be contemporary or part of a historic series. However, at the same time, in our opinion, this approach was unable to offer an image of the processes of theoretical construction based on the idealisation of the world of experience, and therefore, an adequate image of the relationships existing between theories and the world, issues which van Fraassen's approach does tackle.

Scientific activity is not simply a process of discovering truths, no matter how approximate or fallible these truths may be; rather, it consists of a process of constructing appropriate models for explaining phenomena which have conveniently been idealised by the procedures which make up "laboratory life" Theories are conceived as sets of models, extra-linguistic entities which enable scientists to represent, to explain and to intervene in the world; in short, they enable their use, in general terms, for a wide range of different purposes. Scientific theories focus on a type of phenomenon which constitutes their *intended scope*[8] and the aim of every theory is to present a general description of these phenomena which can be used to satisfy the demand for explanation, prediction and detailed description. To this end, the theory abstracts certain parameters from these phenomena, minimising their excessive complexity. These parameters are those deemed by scientists to be relevant, and the supposition is that it is they alone which have any influence, and that therefore, phenomena are isolated systems[9] that can be defined and described solely on the basis of those parameters selected by the theory. Thus, the theory characterises not the phenomena which fall within its scope, but rather ideal copies of said phenomena: *physical systems*.

A physical system is not a system of real phenomena, but rather a highly idealised copy of real phenomena. Thus, although the field of application of a theory is a phenomenon domain, or a specific type of phenomenon, and we can offer explanations based on that theory, the determination of these phenomena is carried out on the basis of a series of parameters abstracted from them, which have been idealised and selected by the theory itself, or to be more precise, by scientists, in accordance with the aims of the research, with only some of the many parameters involved in complex real phenomena being chosen. Thus, the theory constructs an idealised, counter-factual copy of the phenomenon system, which assumes that only those aspects selected actually intervene. This is a constructive element which enables scientists to establish how phenomena would behave under these ideal conditions. The universe of science, in this sense, is not the complex world of events, but rather that of experimental and laboratory research in which said selection takes place.

From his constructivist empiricist approach, van Fraassen believes that this idealisation is not carried out directly by the theory itself, but rather by a theory of experiment which, based on experimental data and measurement reports, etc., constructs data models called *appearances* (van Fraassen 1976, 631), which may be considered descriptions of phenomena relevant for the theory. In this case, as we shall see later on, the idealisation is increased, or even doubled, by this step through a theory of experiment. Physical systems or appearances are also considered to be isolated, and

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[8] This is a concept used by F. Suppe (1974/1977), 257.

[9] This *fiction of isolation* is the reason why the results obtained are, strictly speaking, false. It is, on the other hand, the reason for the explanatory and predictive force of the hypotheses, hypotheses which rather than talking about how phenomena behave, focus instead on how they would behave in the event of said ideal conditions coming to pass. An updated debate based on contemporary references to the Kantian Vaihinger and the philosophy of "as if," or the analyses which explore the use of fictions and simulation in the construction of models and theories.

this itself constitutes another idealisation factor. This *fiction of isolation* is the reason for the theory's lack of precision and the patent falseness of laws when compared to phenomena. The essential function of a law is to describe the behaviour of the type of physical systems which are the focus of a scientific theory; in more specific terms, its function is to describe the conditions of what is physically possible. The difference[10] between *laws of coexistence, laws of succession and laws of interaction* enables scientists to describe the possible states of a system, its trajectories and its behaviour during interaction. Once the laws of the theory have been included, the *state space* is established and the behaviour of a physical system, or the idealisation of a phenomenon, is represented by diverse configurations imposed on the state space in accordance with the laws of the theory, and only those points of the state space whose coordinates satisfy a specific equation will be physically possible.

From this perspective, we could assert that theories are structures, and these structures are state spaces which have a series of specific configurations imposed on them by the theory's laws. In *Laws and Symmetry*, published in 1989, van Fraassen develops this thesis further and asserts that laws are nothing more than the basic principles of a theory, its fundamental equations, model laws. They are those key characteristics by means of which models can be described and classified; and it cannot be claimed that these laws correspond to the laws of nature, as the vast majority of philosophical tradition has established (van Fraassen 1989a). *Theoretical definition* specifies a family of structures which are theoretical models. *Theoretical hypothesis* reflects the affirmations of the theory regarding the real world, i.e., the affirmations that certain real, or at least observable, systems belong to the defined class, since these abstract objects constructed by theoretical definition are related to appropriately mathematised and idealised physical objects. While in that related to theoretical definition there is almost unanimous agreement between all followers of the semantic conception, in that related to theoretical hypothesis and the specific relationship between theory and the world to which it applies, opinions are divided. A number of different stances have been adopted, although the two most commonly debated alternatives are: constructive realism and constructivist empiricism, whose vision is as follows:

> To present a theory is to specify a family of structures, its models; and secondly, to specify certain parts of those models (the empirical substructures) as candidates for the direct representation of observable phenomena. The structures which can be described in experimental and measurement reports we can call appearances: the theory is empirically adequate if it has some model such that all appearances are isomorphic to empirical substructures of that model. (van Fraassen 1980, 64.)

Theories only aim to be empirically adequate. However, the empirical adequacy of a theory is only affirmed after a process of deliberate selection which begins with the routine task of processing the enormous amounts of data generated by measurement and observation instruments. The demand for adequacy is firstly, a structural demand, i.e., it is a relationship between a data model and a theoretical model. It is a

[10] The difference is defined by van Fraassen in "On the extension of Beth's semantics of physical theories," 1970, 325–339.

mathematical relationship. However, it is also an affirmation of adequacy in relation to the structure of the real phenomena described in terms of the theory's relevant parameters. This means that observable phenomena, even if they are only instrument readings, are observable by anyone, but the way in which they are described by scientists (human beings who defend previously accepted theories and who make assumptions and have values and options) may differ widely. The empirical infra-determination of all theories, but particularly the fact that all descriptions of nature are theoretically heavily conditioned, means that the defence of a view of science as an interpretative activity makes perfect sense.

Since the publication of *The Scientific Image* and other previous works, Bas C. van Fraassen has defended his constructivist empiricism as the most appropriate philosophical interpretation of scientific activity. This empiricism is gradually defined also as it dialogically confronts scientific realisms and the new minimal realisms which admit the fallibilism, approximation and tentative postulating of "behind the scenes" observational entities or processes, but which do not renounce to the "metaphysical instinct" of the postulation of entities as real causes of the processes being explained. Reality based on explanatory and predictive success. Concepts such that of "laws of nature," or the natural principles captured by our best theories can be renounced, but not the idea of need which gives meaning to our notions of causality and explanation. This, at least, is what R. Giere argues (Giere 1999). In particular, the core of what van Fraassen defines as metaphysical ingredients of realist philosophical positions consists of giving absolute priority to the demands of explanation and satisfying them through explanations via postulation: In other words, explanations which postulate the reality of certain entities or aspects of the world, which are not empirically evident. For van Fraassen, "science aims to give us theories which are empirically adequate; and acceptance of a theory involves as belief only that it is empirically adequate." [11]

Indeed, in all his works, van Fraassen claims that any other virtue required of a theory, above and beyond its empirical adequacy, is always pragmatic. This does not make the theory more adequate or approximately true, only preferable. These preferences, it could be claimed, may be based on interests, tastes, better efficiency, adequacy to research objectives or technological performance. All this forms part of the series of reasons for which we opt for one theory or another, says van Fraassen; acceptance has a pragmatic dimension. And,

> To accept a theory is to make a commitment, a commitment to the further confrontation of new phenomena within the framework of that theory, a commitment to a research programme, and a wager that all relevant phenomena can be accounted for without giving up that theory. (…) Commitments are not true or false; they are vindicated or not vindicated in the course of human history. (van Fraassen 1980, 88.)

[11] van Fraassen (1980, 12). Although in other later texts van Fraassen tackles the question of belief not as an all or nothing issue, but rather by incorporating the probabilistic model. Belief, according to W. James, as van Fraassen read him, is a question of will and is, above all, a decision to make a commitment.

This empiricism is therefore defended also as an attitude, that which outlines a certain approach to factual questions as being paradigmatically rational. This concept of rationality is written in lower case. In other words, it is a "permissive" concept of rationality. It is a minimal and instrumental rationality which only advises us not to sabotage our chances of defending and justifying our commitment to a specific interpretative framework. However, this commitment includes an element of free choice or voluntarism,[12] which cannot be understood as the mere modification of a previously-held opinion "in the face of new evidence," since this concept has also been clearly reinterpreted in light of current scientific practice. Scientists commit to a specific theoretical framework providing they believe that this is the best way to achieve the objectives established within the community to which they belong. The choice of one specific option from among other possible ones, in order to offer an adequate interpretation of phenomena, leads us in a certain direction; the choice implies commitment, the implicit selection of certain parameters as relevant and the involvement of certain values and assumptions. But the initial position of empirical risk is maintained right up to the end (van Fraassen 1989a, 261), since phenomena can also be modelled on the basis of alternative symmetry arguments.

This prompts van Fraassen to call into serious question the efforts made to formulate an adequate idea of scientific law associated with that of need and universality, a reflection of the principles of order which truly exist or the laws of nature.[13] Particularly, any image of science presented in this way as a mere representative activity overlooks, as Hacking (mainly in 1983/1996) also reminds us, the fact that it is, at heart, an intervening practice. In fact, the dialectic relationship between theory and experiment, as we see it, constitutes the core of theoretical construction, but also of technological innovation.

It is obvious that if philosophy aims to offer a specific view and an adequate interpretation of science, the starting point should be a recognition of the complexity of this dialectic process between theoretical construction and data generation, processing and laboratory analysis procedures. Received topics, arguments which illustrate our faith in a world order which our theories reflect, the emphasis on the explanatory task of science, the central nature of notions of law, causality and evidence are the old dreams of a philosophy of science which is well past its sell-by date, and are revealed as totally anachronistic when we turn our gaze to examine the heart of scientific activity: laboratories or *large scientific facilities* filled with observational and experimental equipment.

The construction of "appearances" to use van Fraassen's term, or "physical systems" as F. Suppe's calls them, or simply, and in general terms, phenomena which have been idealised enough to be treated scientifically, is increasingly restricted to the laboratory field or to large scientific facilities, since even a discipline such as astronomy has stopped being strictly observational and has become a discipline which processes, simulates or *deforms* light so as to obtain images which interpret

[12] The notion is recovered by van Fraassen from American pragmatism, particularly from the works of W. James. It is evident in his text from 1897/2003. Vid. also Perdomo (2003).

[13] The arguments are mainly developed in van Fraassen (1989a), passim.

what is observed in terms of the theoretical framework to which the scientist in question is committed. This relationship is not unidirectional, but rather dialectic, since constant feedback is produced between the experimental and theoretical levels. We can therefore talk about mutual conformation aimed at satisfying pre-established objectives. Data, instruments and ideas are gradually adjusted in a kind of symbiosis resulting from the deliberate process of selection, demand for, and invention of new instruments designed to generate data which will enable the development of a theoretical hypothesis, while at the same time opening up new areas of experimental development (Hacking 1991, 29–64). These studies show the complex interactions between these different elements, between ideas (be they theoretical, systematic or hypotheses) or theories regarding the working of apparatus or things, i.e., all technical instruments, sample preparations, detectors, data generators, etc. and the world of generated, assessed, analysed and, finally, interpreted data. The gradual symbiosis between theories and laboratory equipment is a fact in mature science; they evolve towards mutual adjustment, to the point at which it is possible to stop generating data which are not relevant to theoretical hypotheses. Measurement, van Fraassen also affirms, is designed to answer specific questions, and the information derived from the measurement outcomes is relevant to the responses provided.

However, this symbiosis and internal coherence, which generate a certain degree of stability which is nevertheless contingent, imply that the variation of one element may destroy everything else. Or, to put it another way, alternative data[14] may be produced, data which are generated due to the stagnation and review of practices, to alternative research teams with different values or to the application of more powerful instruments which generate new kinds of data which cannot be accommodated within the previous theoretical framework. The important point here is that, in this case, the incommensurability of both the old theory and the new one which interprets these new data is radical, since we are no longer talking about theoretical or semantic incommensurability, but rather incommensurability which is produced at the level of the instruments used and the data generated, which cannot be interpreted or accommodated by the previous framework. Despite this, however, the old theory may continue to work perfectly in its own data domain, which provokes a curious image of the diversity and locality of science.[15] This diversity is mainly the result of the laboratory production of phenomena using different techniques and instruments.

As defining characteristics of science, constructivism, symbiosis, contingence and diversity provide a new image of scientific activity in which experience,

[14] These data may arise in what have been dubbed the "margins of science" The similarly to Feyerabend is evident, but the resemblance to new studies of science from the gender perspective is also patent. These studies have levelled radical criticism at many aspects and ideas of the more traditional philosophy of science and the resulting images of science, while at the same time outlining new epistemological proposals.

[15] The resulting image may be that of a patchwork of theories, disciplines and laws, with no hierarchical order or systematic relationship. Vid. N. Cartwright (1999).

interpretation and transforming action become key concepts. It is for this reason that the connection between empiricism, constructivism and pragmatism is the one which, in my opinion, offers the best interpretation of that activity.

2.3 Constructivist Empiricism and Pragmatism

A careful analysis of the "family resemblance" which exists between the constructivist empiricism defended by Bas C. van Fraassen and American pragmatism suggests new avenues for analysing the decision-making process and the role played by the subjects who interpret, construct or use models in scientific contexts. Concepts recovered from the pragmatism of W. James, such as voluntarism and the idea of the conflict between epistemic human desires to believe in the truth and to avoid errors are used by van Fraassen to mitigate the rigid proposals of the Bayesian or evidential theories of decision. van Fraassen chooses to view the acceptance of theories as an open, tentative process, in which epistemic agents decide to adopt a theory as their "expert guide," in order to continue moving towards the construction of the model-theory. In his work, van Fraassen has developed other concepts and approaches with pragmatist leanings, such as his pragmatic theory of explanation, or his concept of the ongoing dialectic between theoretical development and experimentation as the key to the process of theoretical construction. These are only some of the aspects which align him with the thesis of pragmatism, or, to put it in a slightly different way, the renovation of empiricism carried out by pragmatism is perfectly illustrated in van Fraassen's work.

Let us not forget that the initial convergence between the pragmatic trend, particularly as developed by Dewey, and logical empiricism at the beginning of the twentieth century was diluted by the academisation of the logical-empiricist trend and the abandonment of committed social discourse by empiricists from the *Aufbau*[16] culture, just as C. Morris recommended to the old members of the Circle, now installed in American universities following their exile. Both the philosophy of logical empiricism in the context of the *Aufbau* and the philosophy of Dewey were motivated by the technological triumph of science and claimed for science also the capacity of transformation. Neurath's rejection of metaphysics also implied a political conviction of the advent of a liberating, modernist and rationalist social movement. The social benefits of *scientific philosophy* were a common cause for

[16] The political, cultural and social context of the inter-war period, in which the Vienna Circle and the Berlin Group arose, has been widely studied by intellectual and political historians. In his work, P. Galison presents what he terms the *Aufbau* culture. The concept has been badly translated as "reconstruction," an interpretation which dilutes all its original revolutionary meaning. The original authors used the term to express a radical sense of newness, a breaking away from the past and a deep-rooted conviction that the inauguration of a "new world" should not be superficial, but should rather mean a complete transformation of culture, education and architecture, expressed in the Bauhaus movement and the new ways of reasoning. Galison (1996).

concern among empiricists and pragmatists like Dewey, for whom the reworking of classical empiricism meant the replacement of past experience with future experience, as the basis of the cognoscitive process.

The formal encapsulation of logical empiricism, a stimulating philosophical project which had much in common with pragmatism,[17] resulted in a specialist academic discipline of philosophy of science, which Putman baptised during the 1960s as the *received view*. In Galison's opinion, the *Aufbau* culture did not cross the Atlantic, and during the 1950s, the majority of philosophers in the American context believed that pragmatism was "wrong" and logical empiricism "right," and often cited the crossfire of declarations between Russell and Dewey: whereas Russell believed that Dewey's pragmatism was nothing more than American commercialism disguised in philosophical garb, Dewey was convinced that Russell's dry, technical philosophy was nothing more than the expression of decadent, aristocratic, English sensibility.

I. Hacking (1983/1996, 62–69) defined van Fraassen as the new defender of positivism, following in the footsteps of Hume during the mid eighteenth century, Comte during the 1830s and the advocates of logical empiricism from the 1920s to the 1940s. Hacking underscored the series of theses which define this position and which are, in his opinion, common to all the aforementioned authors: the verificationist ideal, the negation of causality beyond the mere verification of regularity, or the rejection of the idea of entities whose existence is adduced indirectly, through the postulation of dubious causes or explanations; together, all this constitutes the positivist commitment to "opposition to metaphysics" Despite locating van Fraassen in this trend, his style is characteristic of precisely all that which denies dogmatic establishment in any stance and which defends a constant critical, sceptical attitude — the hallmark of constructivist empiricism. This empiricism is one which maintains some of the assumptions which characterise this trend, not from the eighteenth century onwards, but from as far back as the nominalism of the fourteenth century, as van Fraassen himself points out (van Fraassen 2002, 1994b), but which is considerably far removed from the academic logical empiricism developed in the American universities from 1930 to 1960.

van Fraassen's constructivist empiricism also owes something to pragmatic postulates. Pragmatism, whether it be Peirce's version or in the path followed by James, Dewey, Lewis or Rorty, is antirealist. The concept of truth is radically redefined. It can be conceived as either the end product of the efforts of a community of researchers pursuing a specific goal, or as a set of acceptable general conclusions. Emphasis is placed on the method and on the end result of its application, as Peirce argues, or on

[17] Richardson's analysis moves away from specific philosophical theses in order to focus on the philosophical commitments, goals and aspirations of empiricists and pragmatists, on the motivational and attitudinal elements of *scientific philosophy*, a project shared by both parties in an attempt to overcome an aging philosophy closely allied to traditional conservative discourses. From this perspective, the convergence between empiricism and pragmatism becomes much clearer. Richardson (2002).

the process of constituting knowledge on the basis of our experiences, as James and Dewey claim, thus turning truth into guaranteed acceptability.

Thus, just as James rejected absolute scepticism, asserting that we are capable of establishing truths about ourselves and about what the world is like, so van Fraassen also affirms that in relation to what is observable, in relation to what we have empirical access to, it is possible to assert the truth; however, equally, and contrary to the other extreme represented by absolutism or dogmatisms, both authors argue the fallibilism inherent in all demand for knowledge. We cannot attain objective certainty or absolute guaranty. It is in the rejection of both stances that the virtue of the empiricist perspective lies: experience is the only legitimate source of our opinions about facts. And therefore, all conclusions regarding issues of fact are susceptible to modification in light of future experience. "In this way, theories become instruments rather than answers to enigmas upon which we can rely. We must not lie back and relax on them, but rather move forwards and, on occasions, with their help, rethink their very nature." (James 1907/1997, 41.)

In pragmatic terms, knowing is equivalent to bringing a series of skills to bear on an action aimed at a specific purpose, without forgetting that both are dynamic and moreover, will be subject to different kinds of feedback as a result of the research itself. This implies a radical rethinking of reality itself, of our access to it and of the concept of experience and knowledge, an approach which would be impossible without another basic category: interpretation. Reality is no longer a non-problematic *factum* and accessibility to it inevitably implies a subject with purposes and the capacity to act, whose context is a scenario, a world of experiences, from which said reality is critically elucidated. This critical elucidation of reality therefore implies the acknowledgement of the active role of the subject in the conformation of a cognoscible reality.[18]

The role of the subject is vital to the process of theoretical construction; observation and reasoning are not objective, neutral activities, but are rather mediated by the contexts and criteria of scientificity established by the scientific community itself, interpretation occurs at different levels, the responses provided to demands for explanation are contextually relevant and research objectives are designed in close alignment with applicative objectives. In short, models are used by subjects to attain planned objectives. And all this presupposes a view of scientific activities which further strengthens the connection between constructivist empiricism and pragmatism. The masterly analysis of scientific representation offered by van Fraassen in his text *Scientific Representation* perfectly illustrates the connection with pragmatism, a connection which is even closer here than in his previous works and which links empiricism with the use of models to represent the world of experience, in order to target our actions towards the goals to be achieved.

> A view of science would hardly be empiricist if it ignored the uses of science, as a resource for praxis. How are theories and models drawn on to communicate information about what thing are like, to guide our expectations in practical affairs, to design instruments and technological devices, to find our way around in the world? (van Fraassen 2008, 88.)

[18] These ideas are developed in more detail by Ángel M. Faerna (1996).

2.4 The Scientific Representation of Reality. Constructivism, Interpretation and Uses

Many philosophical texts on scientific representation have been written over recent years. The same question crops up time and time again: despite the levels of idealisation, constructivism and interpretation inherent in scientific practice, how do theories connect to the world? Models should reflect real, significant aspects of the phenomena being studied, even if only in terms of their structure; this has also meant a new revitalisation of structuralism (see Psillos 2006. Also Brading and Landry 2006). Classical or traditional analyses of representation focus on the similarities between aspects of the model and aspects of reality. Precision and completeness are usually presented as the principal values associated with the act of representation, but we must first admit that this is a question of degree. And, in relation to either value, is also required a context in which decisions can be made regarding which aspects to select and which criteria to apply. Thus, representation should be defined as an intentional activity, subject to assessment and the application of criteria, and relative to the context of use and production. However, it is also common to start by establishing a description of representation in the field of the arts, and to analogically transfer the conclusions reached to the field of science.

Thus, questions of similarity or resemblance are posed at the argumentative core of the issue of representation, although the analysis may be rendered even more complex if notions of perspective, distortion or even fiction[19] are introduced into the heart of the debate. In this sense, the profusion of details and examples provided by van Fraassen in his texts on scientific representation are immensely enlightening. van Fraassen coincides with M. Suárez in affirming (Suárez 2004, 771) that representation is not the type of notion that requires a theory to elucidate it, that there are no necessary and sufficient conditions for it, and that the most we can do is describe its more general characteristics. What is a representation? How exactly does it represent? What are the essential elements for talking about an adequate representation? And what are the conditions of possibility for scientific representation, or its variants. These are questions which van Fraassen tackles with skill and dexterity in his text. The responses centre around one key issue: the crucial role played by use and practice, in a new approach to the core of pragmatist thinking. "There is no representation except in the sense that some things are used, made, or taken to represent some things as thus or so." (van Fraassen 2008, 23.) The *Hauptsatz,* term used by van Fraassen, of the text could have been written by pragmatist philosophers, for whom being in possession of a theory or representation of reality means being in possession of a practice, of a connection between actions and ends, symbolically mediated by a system of representation which bestows sense and meaning and which functions in this area of experience.

[19] A comprehensive study of the role of fictions in the construction of models and theories and the epistemological consequences of the use of these strategies has been edited by Suárez (2009).

In *Scientific Representation*, van Fraassen presents a multitude of examples demonstrating that, in many cases, it is not the model of the reflection, but rather that of the diffraction, so to speak, that constitutes the basis of successful representation. As in caricatures, which highlight a face's most characteristic features, distortion also plays a role in representations. Sculptors distort harmonious proportions in order to ensure that they maintain certain forms from a certain distance and angle, and painters calculate perspective in order to draw figures of the size appropriate for representing the relative distances between elements. In the field of advanced science, the adaptive distortable optics of the new great telescopes, such as the GTC, enable light to be distorted in order to "eliminate" the aberrations caused by atmospheric perturbations. The front of the wave is analysed first by a sensor which determines its aberrations. This information is sent to the phase reconstructor, which calculates the corrections to be made and the distortions the distortable mirror must adopt in order to compensate for the original aberrations detected at the front of the wave. The result is a much clearer image which is, according to researchers, more or less equivalent to what we would see from space. Although in fact, what astronomers are actually doing thanks to this technology is generating images of *how the object should appear* if the theory which interprets it is correct.

In the example of the painter, the representation achieved by mathematically calculating the correct perspective is adequate only in relation to the values appreciated from the Renaissance onwards. Paintings from before the *Quattrocento* reflect the size of the figures in relation to their importance in the scene, rather than relative to the logic of spatial relations and perspective. In fact, when we observe these representations, we need to be aware of these codes and values of representation in order to interpret the paintings correctly. Thus, a representation is an adequate representation of whatever only in relation to a representational system which covers such a case and which confers upon it its ultimate meaning. Similarly, the images of the universe constructed by large telescopes enable representations of the universe which can only be interpreted using the techniques and theoretical models used for that purpose.

According to van Fraassen, we really should distinguish between *representation of* and *representation as*, and the latter cannot be conceptually reduced to the former, since although the former is not without interpretative elements, interpretation is central to the latter (van Fraassen 1994a). The simplicity of the idea of mere geometrical projection, argues van Fraassen, is lost. *Representation as* is constructed and this construction is not unique; the same aspect can be represented in various ways, since the behaviour of the phenomena in question allows for different interpretations. Something is represented as this or that, and during this process we gain an understanding of a certain aspect of the phenomena; in other words, appropriate comparisons have the virtue of facilitating understanding.

> There is no such thing as 'representation in nature' or 'representation tout court;' the question whether one given object is a representation of another is an incomplete question. Specifically, in science, models are used to represent nature, used by us, and of the many possible ways to use them, the actual way matters and fixes the relevant relation between model and nature. Relevant, that is, to the evaluation as well as application of that theory. (van Fraassen 1997, 523.)

Relevant relationships between models and the world: This is a vital aspect of scientific practice, and enables us to approach its analysis from a more pragmatic perspective. Both the selection of the aspects of the model chosen to represent reality thanks to their definition as similar, and the decision as to whether or not the similarity expressed is sufficient, may depend on the purposes for which the model is being designed and applied. In other words, it is a function of the context of use, rather than of the mere relationship between the model and reality. Representation fulfils its function only if we accept a certain interpretation based on a series of codes of acknowledgement (visual, symbolic, cultural, etc.), which we accept as valid or adequate, with which we share a way of seeing and perceiving the world and which enable us to act. The level of constructivism of these codes is very high. However, moreover, representation also implies the *intentionality* of the agents as a vital element.

Nelson Goodman (1976, 33) tells a story in which, in response to a complaint by the playwright Gertrude Stein that her, now famous, portrait looks nothing like her, Picasso responds by saying "no matter, it will." It is obvious that, being aware of his artistic authority, Picasso knew that it would end up determining the "represented object" in the conventional manner. If the painter claimed that the figure was Stein, then all "informed" subjects would accept that it was so. The story of the portrait is actually even more interesting, since the different ideas regarding Stein's representation suggest other possible interpretations, such as, for example, that in fact, rather than a portrait of Stein's actual physical features, what Picasso painted was a portrait of her personality traits. In other words, Stein's strong character and vanity was represented by Picasso in the form of a series of physical features and a specific expression, which observers may perceive as an adequate representation of the playwright, since they recognise the physical features conventionally associated with these psychological traits within a shared set of codes. Another possible interpretation is that the figure of Stein actually represents the couple; it is a kind of merging of the features of Gertrude and Alice, recognisable to those who were aware of the relationship. We could even propose a new interpretation, i.e., that just as Stein developed a narrative style far removed from convention, inspired by the teachings of W. James himself, in which the plot was almost entirely eliminated and the prose was free and radically innovative as regards syntax and punctuation, so Picasso did the same in his pictorial representation of the playwright. Basically, he was experimenting with the possibilities of the artistic language, establishing new interpretative codes for reality.

Nevertheless, no matter how interesting this line of argument may be, we should stop here and remember that, despite all the comparative analyses and suggestive analogies that can be established between representation in art and literature and scientific representation, the latter has its own specific traits.[20] Scientific theories, presented through their set of models, are abstract, mathematical structures, and in this sense, the structuralist concept associated with the new label "structuralist empiricism" refers to the theory that all scientific representation is basically mathematical in

[20] This was argued also by Steven French (2003).

nature, and according to van Fraassen, this is a theory not about what reality is like, but rather what science is like.[21] Therefore, the question remains the same: how can an abstract entity, such as a mathematical structure, represent something which is not abstract, like something from nature?

van Fraassen invites us to break down the question by examining the process by which scientific representations are constructed; a perspective which sheds light on their internal elements and dynamics. It is a perspective which is radically different from the usual analyses of representation, which focus on analysing representations as finished products, examining their adequacy or looking for the keys of the representational relationship between theoretical models and the world. From this synchronous analytical perspective, the classification and description of alternative analyses of representation tackle only one aspect of the issue. M. Suárez asserts that van Fraassen defends an intentional concept of representation in which the relationship to be established between representation and that which is represented is one of isomorphism. According to this author, the demand for isomorphism is established between the empirical substructures and the observable part of the world, which implies the defence, in his opinion, of "the view that scientific representation is isomorphism."[22] However, it is important to differentiate between observable phenomena and appearances, and this clarification implies, in his opinion, the introduction of a triadic model: theory-phenomena-appearances, motivated also by van Fraassen's closer attention to the practices of measurement and instrumentation, characteristic of contemporary science, and to the questions of how models are used. These new ideas are, claims the author, presented by van Fraassen in his latest text, and imply the justification of the transformation of constructivist empiricism into structural empiricism. Suárez concludes that, as a result: "The theory is then empirically adequate if it embeds the appearances — and this no longer carries the implication that a substructure of the theory must be shown to be isomorphic to the phenomena." (*Ibid*.)

In my opinion, the differentiation between observable phenomena and appearances is one of the most characteristic traits of van Fraassen's proposal, not just in this text, but right from his early work during the 1970s, which was the result of his research into the Copenhagen interpretation of QM. van Fraassen clearly differentiates, as stated above, between *phenomena*: observable entities (objects, events, processes) which can be measured, including the outputs of measurement instruments, and *appearances*: the contents of the observation or the measurement outcomes (determined, therefore, by the type of measurement process or procedure employed and the instruments, etc. used or developed). Phenomena are observable but their "appearances," i.e., how *they appear to us* as the result of a certain type of measurement or observation process, are something different: "the measurement outcome shows not how the phenomena are but how they look." (van Fraassen 2008, 290.) Appearances are structured according to *data models*: "the selective relevant depiction of the

[21] van Fraassen (2008, 239).

[22] Ladyman et al. (2011), Scientific representation: A long journey from pragmatics to pragmatics. *Metascience.* Book Symposium, published online, November 2010.

phenomena by the user of the theory required for the possibility of representation of the phenomenon." (*Ibid*., 253.) Given that they are means of presenting phenomena, appearances are changeable.

The isomorphism relationship is demanded (as ideal) between appearances and the empirical substructures of models, which may offer an adequate theoretical explanation for them in accordance with the established goals, specific problems to be resolved or questions asked. Data models should be able to be *ideally isomorphically embedded* into theoretical models. However, this relationship which is established between two mathematical structures, between data models or appearances and the empirical substructures of the model, does not yet constitute a representation, although it is a prerequisite if we are talking about scientific representation. What is required also is a subject (an individual or group in a context which confers adequate signs and meanings) who expresses the intentionality of said representation. And it is for this reason that a certain Wittgensteinian movement or a recovery of the Kantian lessons occurs, common also to classical pragmatists and empiricists, in which the subject of knowledge becomes an agent who must organise and interpret the experience before extracting knowledge from it. Moreover, the world is not cognoscible without this interpreting subject. Thus, it is clear that the relationship is not dyadic (model-world), but rather triadic and involves the user, and it does so at different levels or moments of the process, not only during the selection of the relevant aspects during the construction of appearance and data models, but rather in an ongoing manner throughout the whole research and model-theory construction process.

As I interpret him, van Fraassen has not changed his position at all regarding that expressed in his earlier texts; he has merely underscored even more the phrase *by the user*, which, I sustain, is a more explicit option in this text than in others due to the theory of pragmatism, but whose content and orientation had already been presented to the constructivist empiricists. By highlighting the role of the user, have we, van Fraassen asks, succumbed to the post-modern belief that nothing exists beyond the text? The answer is obviously no, but the means of tackling the problem implies a Wittgensteinian movement, as he himself affirms (van Fraassen 2008, 254). The relationship between theory and phenomena is a relationship between mathematical structures, between data models and theoretical models, but the structural relationship between the model in question and the phenomenon, described and mathematised in a relevant way for users, is not enough to turn the model into a representation of the phenomenon.

The importance of the interpreting subject in a process of these characteristics is significant, and implies a continuous decision-making process in which values, purposes and criteria play a key role. The process of theoretical construction is highly sophisticated and contains different levels of idealisation, abstraction and constructivism. Constructivist empiricism explains all this in a manner closely aligned with real scientific practice. The addition of the structural label to empiricism only covers the minimum required in representations: the different kinds of structural relationship established between mathematical models (*mapping*, *embedding, etc.*), at different levels; but while necessary, this condition alone is not enough. What else is there in scientific representation? And what really makes it so?

2.5 Use of Models: "Self-Location"

Accepting a theory means "epistemically submitting to its guidance, letting our expectations being moulded by its probabilities regarding observable phenomena." (van Fraassen 1989b.) This is the epistemic dimension of acceptance: we decide to adopt a theory as our expert, and this attitude towards the theory constitutes the perfect definition of acceptance. The image of the "expert" which guides our opinions is, in my opinion, extremely fruitful in that it highlights subjects' attitudes towards the models or hypotheses of science. The idea can be clearly illustrated if we compare our theoretical models to maps, which guide us and enable us to find our bearings. Like maps, theoretical models are partial, are constructed socially in accordance with a series of specific criteria and interests and reflect the concerns and conventions of the era or context in which they are produced.[23] This analogy has also been explored by realist authors such as P. Kitcher (2001) and R. Giere, for whom however, maps are, despite all their constructive elements, partiality and relativity to contexts of use, etc., maps *about something*.

According to Giere's realist interpretation (Giere 2006), in what is, in my opinion, a new clarification of his minimum realist commitments, what makes it possible for us to use maps and models is the fact that they exploit possible similarities between the model and those aspects of the world which are represented. Strictly speaking, however, and here the author agrees with van Fraassen' view, they are not compared with data regarding reality itself, but rather with data models, which implies a level of idealisation and constructivism. The comparison is therefore established between two types of models. There are various constructive and interpretative levels and different fields of research may have different criteria for assessing this meld. Moreover, no one claims that the model itself represents aspects of the world thanks to this relationship of similarity, since no such simple representational relationship exists in science. R. Giere states that: "It is not the model that is doing the representing; it is the scientist using the model who is doing the representing."[24] In other words, they are designed so that some elements of these models may be identified with some characteristics of the real world. This is what makes it possible for us to use models to represent aspects of the world. This is the key; scientists use models to represent aspects of the world in accordance with various purposes, in the same way as we use maps to get our bearings.

However, van Fraassen proposes that we continue to exploit certain characteristics of the map model, providing we trust that it constitutes a good example of the way in which science represents the world. In specific terms, he proposes that we examine the act of using the map itself. Although it is held that its representational power can be testified to by anyone who has ever used a map to get their bearings in

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[23] In other works I have explored this relationship between models and maps, focusing on the differences between the realists P. Kitcher and R. Ronald Giere and the empiricists H. Longino and van Fraassen. Perdomo (2011).

[24] Giere (2006), 64. The slogan could be, proposes Giere: *No representation without representers.*

unfamiliar territory, it is also true that we need additional information that is not contained in the map itself in order to use it properly. Maps do not include the information "you are here," which we can use to locate ourselves, and even if they do, the act of "self-location" in relation to the arrow which indicates our position is something not included in the map. The act of self-location on or in relation to the map has nothing to do with, or cannot be deduced from, the map's degree of accuracy, nor can it be identified with the contents of the map or with the belief that said map "fits in with" the world, since it does not belong to the semantic field, but rather to the pragmatic one (van Fraassen 1993, 11). The statement that any particular model can be used to represent a specific phenomenon is, according to van Fraassen, an indexical judgement similar to the affirmation that such and such a mark on a map, in relation to which we must locate ourselves, is our actual location. Referring to Kant, van Fraassen states that "the ability to self-attribute a position with respect to the representation is the condition of possibility of use of that representation." (van Fraassen 2008, 257.)

The use of theory to explain, applications to technique, interpretation of data or construction of models are all activities carried out by the scientific community which require a "location" of subjects in relation to the body of knowledge or information in question. To continue with map models, what is characteristic about them, in van Fraassen's opinion, is not their representative function, with all the nuances that can be introduced into said concept, but rather the fact that they constitute useful orientation instruments. From the perspective of empiricism, the model of the map defended by realists, i.e., the model of the map as a constructive representation, albeit, at the end of the day, *representation of*, does not account for the fact that we position ourselves in relation to maps in order to construct them, read them and use them properly. In other words, "self-location" in relation to the map is required for its proper use. van Fraassen again refers to Kant in order to illustrate this point, stating that: "The activity of representation is successful only if the recipients are able to receive that information through their 'viewing' of the representation." (van Fraassen, *Ibid*, 80.) And this is a piece of information not contained in the map or in models; it refers to the relationship established between the model or map, understood as an instrument or artefact, and the interpreting subjects involved in the process of representation, since it is in the act of representation that representations are produced.

We can conceive reality not as a finished structure which must be reproduced from outside, but rather as an open process in which the concept of interpretation gains vital importance. An interpretation which is not retrospective, as in the hermeneutic tradition, but rather prospective, whose aim is precisely to turn reality into intelligible scenarios in which action may be *projected*, in the twofold sense of both planned and pushed forward — a central issue of pragmatism. As a result, we transform reality and interpretative structures should continue adjusting to its movement. We can conceive models as technological artefacts which enable different uses and which can be manipulated and played around with (Morgan and Morrison 1999), we can view them as technologies for research or as fictions which enable us to recreate the feasible or unfeasible possibilities of the behaviour of a phenomenon in a creative and fruitful way. Metaphorical or fictitious licences enable us to explore what would happen to a system of certain characteristics under certain conditions; for this also, computer simulation is, today, a key instrument of model-theoretical research. In this sense, I agree with M. Suárez in recognising the need to develop a more social and pragmatist conception of scientific representation which explores these more dynamic, social and plural aspects, which are characteristic of current scientific and technological practice.

However, at the same time, we can also view the set of "used" and "established" technical, artistic and scientific representations as objects which constitute our world. We can view them as artefacts which become cultural objects to be recreated and interpreted. Let us return to the example of Stein's portrait: some years later, when it *was known* that the picture represented Stein, Picasso is reported to have become angry when he learned that the writer had cut her hair short, although he then thought about it and replied: *"Mais, guand même, tout y est"* (All the same, it is all there). What is all there? We might ask. The system of codes and meanings which make sense of it; the keys to meaning which enable us to locate ourselves in relation to the representation, and which we can reconstruct, understand and interpret; the footprints of our conformations of reality and of our changing interpretations of it throughout history. That's not a realist position, just a way to understand history of science that involves constructivism and contextualism. Science offers us theories which, in addition to being instruments for carrying out tasks in accordance with epistemic or practical objectives, also offer different visions of the world. They are the interpretative coordinates we require to draft the most beautiful cartographies of empirical reality, the ones which will enable us to continue navigating the sea of our intellectual and pragmatic needs. And empiricism offers an adequate vision of this.

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http://www.springer.com/978-94-007-7837-5

Bas van Fraassen's Approach to Representation and
Models in Science
Gonzalez, W.J. (Ed.)
2014, XIII, 233 p. 3 illus., Hardcover
ISBN: 978-94-007-7837-5