Bas van Fraassen on Success and Adequacy in Representing and Modelling

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Abstract In his *Scientific Representation. Paradoxes of Perspective* (2008), Bas van Fraassen offers a pragmatic account of scientific representation and representation *tout court*. In this paper I examine the three conditions for a user to succeed in representing a target in some context: identification of the target of the representational action, representing the target as such and correctly representing it in some respects. I argue that success on these three counts relies on the supposed truth of some predicative assertions, and thus that truth is more fundamental than representation. I do this in the framework of a version of the so-called "structural" account of representation according to which the establishment of a homomorphism by the user between a structure abstracted from the intended target and some relevant structure of the representing artefact is a *necessary* (although certainly not sufficient) condition of success for representing the target in some respects. Finally, on the basis of a correspondence *view* (not *theory*) of truth, I show that it is possible to address what van Fraassen calls "the loss of reality objection".

In his book *Scientific Representation. Paradoxes of Perspective* (2008) Bas van Fraassen offers a philosophical analysis of representation which is both empiricist and pragmatic. To represent is to perform some kind of action, and actions are evaluated with respect to their success or failure in attaining specific goals. Moreover, in science success or failure in representing a target must be assessed on the basis of observable phenomena.

As is well known, according to van Fraassen, science aims at empirical adequacy, that is, at saving the phenomena. Thus, a scientific theory is successful if we

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have good reasons to believe that it saves the phenomena within its domain. Since for van Fraassen scientific theories are models in the first place, a theory is successful if its empirical parts, called "empirical substructures", adequately represent the phenomena within its domain.

A satisfactory account of representation is thus central to van Fraassen's philosophy of science. The success of a representational action can be evaluated on three counts. First, the user of a representing artefact must succeed in identifying its target or referent. Second, the target is always represented from a certain perspective *as* having such and such properties. Third, we may ask if our representing activity conveys some reliable information about its target or, in other words, if our representing artefact (a scientific model for example) is adequate or accurate to its target in some respects.

I will argue that the three criteria of success in representing always rely on the truth of some predicative assertions or statements and thus that truth is more fundamental than success. I will also defend that successful representation necessarily involves the institution by the user of a homomorphism between what is represented and its representing artefact. Given this, it is possible to show that, contrary to what van Fraassen defends, what he calls the "loss of reality objection" is not dissolved but solved.

1 Success in Representing a Target

van Fraassen's ambition is not to delineate a set of necessary and sufficient conditions which would allow a user to declare that his *representational action* (called "representation" in what follows) is successful or not. His main objective is *not* to provide a definition of representation but to identify the circumstances in which a representation succeeds. Thus, his main query is not "*What* is a representation?" but "*When* is a representation successful?" (van Fraassen 2008, p. 21).

Since representation is an action, it presupposes someone who acts, the "user" who employs a representing artefact, which I will call the "representor", in order to represent a specific target, at least partially. When the target is observable and perceptually present, the user can identify the target by means of some observable properties presumably belonging to it. Such referring action would be *external* to the representor. Generally, the user intends to represent some target. Intentionality is essential to any kind of representation.[1] Indeed, it is crucial to distinguish denotation (or reference) from representation. Denotation of the target is a preliminary, necessary condition for representation, but it is far for being sufficient. In

[1]See Chakravartty (2010, p. 206). Intentionality is essential to the success of all kinds of representation, not only scientific representation.

order to have a relation of representation by a user U in some context C between a representor R and a represented target T, some additional conditions must obtain. One of my main contentions is that some kind of mapping—specifically a homomorphism (see below)—between structures abstracted from the target and the representor is a *necessary* condition—but certainly *not sufficient*—for representation to occur. On this point at least, I agree with the so-called "structural" or "informational" accounts of representation defended by Suppes (1967, 2002), Da Costa and French (2003), Bartels (2005, 2006) and Chakravartty (2010), among others.

Now, one of the most important claims made by van Fraassen is that there are no properties of a thing which make it ipso facto a representor of a specific target. On this, he approvingly quotes Nelson Goodman:

> The most naïve view of representation might perhaps be put something like this: "A represents B if and only if A appreciably resembles B". Vestiges of this view, with assorted refinements, persist in most writing on representation. Yet more error could hardly be compressed into so short a formula. (Goodman 1976: 3–4) (van Fraassen 2008, p. 11)

Certainly, both Goodman and van Fraassen are right on this. We could use a photograph of the Atomium in Brussels to represent the Eiffel tower in Paris provided we make explicit some conventions which would obviously depart from the conventions implicitly agreed upon in our culture when we look at a postcard. Success in representing a target depends on specifying a *code*, be it implicit or explicit. But what is a code? A code is a *mapping* which institutes a correspondence between some characteristics of a representor and some characteristics of its target. So, "czmfdq" written on a piece of paper can represent the word "danger" given a certain code (which I leave for the reader to find as an exercise…). True, a different code could have been used so that "czmfdq" represents "change" (another exercise…).

Thus, van Fraassen states what he calls the *Hauptsatz* of his approach to representation:

> 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, p. 23)

Success in representing a target then presupposes a mapping between *selected relevant* ingredients of whatever thing you like to use as a representing artefact and selected ingredients of an intended targeted thing. Once the code has been instituted, some things acquire the status of representors and other things the status of represented targets. Of course, some artefacts and codes are more manageable and practical than others for representing some targets. But this is not the point. The point is that the code is *external* to an artefact: it is brought from outside to bestow on a thing the role of a representing artefact. And this is why the representor deserves to be called an "artefact" even if it is a natural object such as a shell or a pebble collected on a beach.

Since the code is *external* to the thing used as a representor, the success of a representation does not have to trade on some resemblance between the representor R and its target T. Resemblance or likeness can certainly play a representational

role in some cases such as pictures and portraits, but this happens because it has been freely decided and agreed upon that some colour or shape in the representor is relevant for representing a given target. More generally there are no inner properties of a thing or relations between its parts that make it ipso facto the representor of a specific target. Consequently, *anything can be used to represent anything* (van Fraassen 2008, p. 23).

Technically the code is stipulated by a specific mapping between structures extracted by abstraction from the target and the representing artefact. Thus, except in pure mathematics, the target and its representor are not structures; they are *concrete* things (whether imagined or real). For representation to occur, the user must select some elements and relations among them in order to construct relational structures.

Now, following Dunn and Hardegree (2001) (thereafter D&H) let us give some definitions. A relational structure[2] **A** is a couple of two ingredients: a domain A of individual elements and a family $\langle R_i \rangle$ of relations on A. For some natural number n, a n-place relation R_i or a relation R_i of degree n is a set of n-tuples of elements of A (D&H, p. 10).[3]

Take two (relational) structures $\mathbf{A} = \langle A, R_i \rangle$ and $\mathbf{B} = \langle B, S_i \rangle$. A *homomorphism* from **A** to **B** is any function h from A into B satisfying the following condition for each.

$$\text{(ST) If } \langle a_1, \ldots, a_n \rangle \in R_i, \text{ then } \langle h(a_1) \ldots, h(a_n) \rangle \in S_i$$

In this case, the homomorphic function h achieves a *structural transfer* (ST) from **A** to **B**.

(ST) does not require that h is surjective. We say that **B** is a *homomorphic image* of **A** if there exists a *homomorphism* from **A** to **B** that is *onto B* [in symbols $\mathbf{B} = h^*(\mathbf{A})$].[4] A function h maps **A** *onto* **B** if for every $b \in B$ there exists an a in A such that $h(a) = b$. (Ibidem, p. 15) In other words, h is *surjective*. If h is also injective and thus bijective, then we have an *isomorphism*.

Suppes (2002, p. 56) uses a stronger definition of homomorphism since he replaces (ST) above by:

$$\text{(PS)} \langle a_1, \ldots, a_n \rangle \in R_i \text{ if and only if } \langle h(a_1) \ldots, h(a_n) \rangle \in S_i$$

[2]We use bold font to refer to structures, e.g. **A,** and italic to denote the domains, e.g. *A*.

[3]If some of the elements belonging to the domains do not stand in any relation, we have what Da Costa and French call a "partial structure" (2003, p. 19).

[4]Dunn and Hardegree give the definition for *similar* structures, namely structures of the same *type*, that is, whose families of degrees of their respective relations are the same (p. 10). Our philosophical discussion will implicitly be restricted to representations which involve structures of the same type. For example, two structures which contain only one-place relations (properties) and two-place relations are similar.

Suppes remarks that a weaker notion of homomorphism is generally used in algebra (this weaker definition is the one provided with (ST) by Dunn and Hardegree). "However (…) in the philosophy of science, the definition here used is more satisfactory" (Suppes 2002, p. 58, Footnote 5).

The further condition adduced by Suppes is what D&H call *absolute faithfulness*.[5]

A homomorphism h from **A** to **B** is *absolutely faithful* if for each i

$$\text{(AF) If } \langle h(a_1)\ldots,h(a_n)\rangle \in S_i, \quad \text{then} \langle a_1,\ldots,a_n\rangle \in R_i$$

Take the simple example of two structures **A** and **B** with their respective domains

$A = \{a_1, a_2\}$ and $B = \{b_1, b_2\}$ and two 2-place relations R and S on A and B respectively.

$\mathbf{A} = \langle A, R\rangle$ and $\mathbf{B} = \langle B, S\rangle$ are *homomorphic* according to (PS) if and only if there is a function h such that:

1. The domain of h is A and the range of h is B. h: $A \rightarrow B$
2. h is surjective
3. If x_1 and x_2 are in A then x_1Rx_2 if and only if $h(x_1)Sh(x_2)$ (Suppes 2002, p. 56).

In a discussion of representation it is useful to introduce a weaker notion of fidelity, which D&H call *minimal fidelity*.

A homomorphism h from **A** to **B** is *minimally faithful* if for each i

(MF) If $b_1,\ldots,b_n$ are in the range of h, then if $\langle b_1,\ldots,b_n\rangle \in S_i$, then there are elements $a_1, \ldots,a_n \in A$ such that $h(a_1) = b_1 \ldots$, $h(a_n) = b_n$, and $< a_1, \ldots,a_n > \in R_i$. (Dunn and Hardegree 2001, p. 16).

Thus, minimal fidelity requires that the image has no "gratuitous" structure but contains only the amount of structure necessary for the structure of the source to be transferred to the image. "Beyond the structure required by the structural transfer condition, the image has no further structure." (Dunn and Hardegree 2001, p. 16).

In mathematics all is well and clear. But in representational acts, we use concrete representors to represent concrete targets. It is thus important to distinguish, as we said above, concrete things on the one hand, and the structures we abstract from them to perform representations on the other hand. In accordance with what is called the "structural account of representation" I will defend that in order to use a thing, a representor, to represent another thing, its target, we must establish a *minimally faithful homomorphism* between structures which we selectively abstract from the target and its representor. Before I do that, some further formal observations are in order.

The notion of isomorphism is very weak. It only requires that the two domains A and B have the same number of elements (cf. Newman's theorem). The relations

[5]A structure can be a *faithful* homomorphic image of another structure, without being *accurate* or *exact*. We come back to this important point below.

on the two domains can be very different. A relation such as "*x* is higher than *y*" can correspond to the relation "*x* is brighter than *y*" or '*x* is stronger than *y*' and so on. Remember that anything can be used to represent anything… Yet, the relation of isomorphism between two structures has some formal properties, namely symmetry, transitivity and reflexivity, which are independent of the specific relations in the respective structures. Certainly, as it has often been observed, representation cannot be *reduced* to isomorphism, since representation is not symmetric, not reflexive and not transitive. Asymmetry for example, must come from outside by means of a *referential action*: the agent uses the representor with the intention of representing a given target and not the other way around.[6]

The definition of homomorphism is a weakening of the definition of isomorphism. Whereas isomorphism has to be bijective (one-one), a homomorphism is a surjective (many-one) and not an injective mapping. The standard example is a two-dimensional photograph which represents a three-dimensional subject. A set of elements of the three-dimensional object is sent by the function *h* to only one element of the two-dimensional picture. Moreover, not all characteristics of the target are sent to elements of the picture. For example, colour is not taken into account in the representor in the case of a black and white picture. "Going to the subject to its image involves (so to speak) compressing the three-dimensional subject into two dimensions" (Dunn and Hardegree 2001, p. 15). Homomorphism is not symmetric and not reflexive. However, representation cannot be reduced to the establishment of a homomorphic function between a targeted structure and its representor, if only because representational success necessitates a prior referential intentional act.

Given this, I maintain that what is called "mistargeting" (Suárez 2003; Pero and Suárez 2015) amounts to *incorrect representation* of an intended target. Intuitively, mistargeting is to take the representor to represent target T when in fact the representor represents target U, which is distinct of T. How can this happen? First of all, we must never lose sight of the fact that representing is an action performed by a user or agent. The user must identify what she intends to represent. And what she intends to represent is in the first place a thing, a concrete object which can be *identified in a referential act*. Typically, the user identifies some specific properties allegedly belonging to the intended target, thereby presupposing the truth of some predicative statements attributing these properties to it. Ostension is not enough in most contexts to convey to others what the user is referring to. At this stage, we do *not* have representation yet but denotation only. This is not the place to discuss the various philosophical theories of reference, and I will assume that reference is by and large unproblematic for common observable things.

Thus suppose I intend to represent my desk, that is, an object which is used to write, say. Certainly, in order to construct a representation of my desk under some

[6]On this I disagree with Bartels (2006, p. 12) who claims that "causal relations" between two things, such as between an object and a photograph of it, can play a role in determining the direction, and thus the asymmetry, of a representation. The asymmetry is determined by the intention of the user only.

perspective or point of view, I must point out some of its properties which, for some reason, I consider to be of interest or relevant. I have several options. Suppose I wish to construct a geometrical representation. Then, I assume that the desktop has, say, a circular shape. In other words, I suppose that the proposition "The top surface of the desk has a circular shape" is true. I might be wrong about that. Perhaps, my desktop doesn't have a circular shape. And I assume the truth of other propositions of this kind. Then I draw a geometrical picture (with a circle in it) of my desk and claim: this picture represents my desk. Then I show the picture to my friend Lucy who, without having seen my desk, says: this is not a picture of a desk, but the picture of a table. Desks are not circular, but tables can be, so she argues.

Does this remark show that I have misrepresented my desk in the sense of mistargeting it? No, not in my regimented use of the word "representation". Identification of a target rests on an intentional referring action, which is not a representational action. Such referring act is *independent* of the kind of homomorphism I will establish to construct a representation of the target I referred to, and on this I agree with Suárez. However, in order to be able to speak of a *representation of* a specific target I necessarily must attribute (rightly or wrongly) properties to the target, which will be put in correspondence with properties of the representor by some homomorphism. If not, we have denotation only and not representation yet. If Lucy claims that the picture represents a table and not a desk, she says so because she relies on conventions which are a matter of course in some cultural milieu (ours…). Equivalently, she presupposes the truth of some other propositions than the ones I have been using in constructing my representation of the desk. If she is right, then I have *misrepresented* the desk in the sense that I have *incorrectly* represented it, but it is still a (wrong) representation *of* my desk and not of something else.

Goodman (1976) and van Fraassen (2008) mention the example of "the painting *of* the Duke of Wellington which everybody agreed resembled the Duke's brother much better" (van Fraassen 2008, p. 19). If a user bestows to the painting the role of representing the Duke of Wellington by a referential intentional action, the painting does indeed represent the Duke of Wellington (and not his brother). Further, success in representing relies on an established a minimally faithful homomorphism between some structure abstracted from the target and some structure abstracted from the painting. It might be true that the painting *misrepresents* the Duke of Wellington. But such a judgement relies on the supposed truth of some predicative statements or assertions. For example, the Duke's brother has some specific facial features and these features correspond to shapes and colours in the portrait which resemble the Duke's brother features according to our implicitly accepted codes better than the Duke's himself.

Thus, mistargetting cannot be, as Pero & Suárez claims, using a model "as a representation of a system or object that is not intended for" (2015), since the target is determined by an intentional referring action. What can happen, of course, is that the user employs a model which incorrectly represents its intended target. But in order to make such a claim representation must occur in the first place and this

necessarily involves the establishment of some homomorphism by the user as will be further explained below.

So far, we have reached three important conclusions. The successful identification of a target of a representation is achieved firstly by a referential action which isolates what the user intends to represent by picking out some properties allegedly belonging to the concrete target. At this stage, we do not have representation yet, but only reference. Next, the user must establish some homomorphism between a selected structure abstracted from the concrete target and a structure abstracted from the representor, thereby specifying a code. Only then can we speak of *representation*, and not mere denotation. However, and this is the third conclusion, although there are no intrinsic properties of a thing which impose its use as a representor of a specific target, representors and their targets do possess characteristics independently of their possible selection to play a representational role in some context. Some predicative statements assert that representors and their targets (whether the latter are real or imagined) possess specific characteristics, truly or wrongly.

2 Success in Representing a Target as Such and Such

Users aim at representing a target *as* having some properties. In science, when a model (representor) is proposed by a scientist, it is put forward as adequate, at least possibly so. Even if scientific models are structures (specifically, they are relational structures of *properties*: see below) they implicitly convey some claims about the properties possessed by their targets. However, and I wish to insist on this, models and statements belong to different categories. It would be a category mistake to say that a model is true or false; only statements can be true or false. Thus, only statements permit to ground inference, that is, a reasoning which goes step by step from one statement to another according to a rule. If models can perform an inferential function (as contended by Suárez 2004) it is because the user realizes that the success of the model relies on the supposed truth of some statements.

Let us look more closely at this through one of van Fraassen's examples, namely the caricature of Margaret Thatcher *as* draconian (van Fraassen 2008, pp. 13–15). For the caricature to function as a representor *of* Margaret Thatcher its target must first be identified. In this case, the identification of the target is not achieved by means of an ostensive act, but the referential intention is sustained by statements, which are supposed to be true by the user and which assert that Mrs.T. has specific physical traits.[7] Some of her facial features are mapped by means of a homomorphism into some corresponding parts of the caricature (representor) which preserve some spatial relations, for example the relation that her mouth is below her nose. The spatial arrangement of selected elements of Mrs. Thatcher's visage resembles

[7]Again, a user could use the so-called caricature of Mrs. Thatcher to represent Bismarck say, by means of another referential action.

the spatial relations of the corresponding selected elements in a structure extracted by the agent from the caricature. In a certain context C, the user U of the caricature takes it as a representator R of the target T, namely Mrs. T. So, a representation is a four place relation. It is not a two place relation between a representor and a target. There is no inner structure of the caricature that necessarily makes it a caricature of Mrs. T. The thing which we take as a caricature by relying on implicit conventions and codes could have been used to represent anything else.

Yet, it certainly is true that the caricature-thing does possess some properties. These facts can be expressed by predicative statements such as "This part of the picture resembles a nose". On the other hand, it is also true that Mrs. Thatcher does have a nose of a certain form and facts like these can also be described by true predicative statements. To achieve the identification of a *represented*—and not only denoted—target, the user must institute some kind of mapping between a referent or target and its purported representor. Such mapping is called the "representational function" and is a homomorphism (many-one correspondence) because it preserves the structure or the form which we—the users—consider relevant. Of course, an infinite number of mappings between a given thing and another thing could be generated but each mapping must be based on a selection of properties and structures which do belong to the things involved in a representational correspondence.

A representation is an action which is performed with a certain *aim* in sight. In the example of the caricature of Mrs. Thatcher, the aim of the caricaturist is this: whoever appropriates the representor and knows the code will understand that the target is Mrs. T. and will use it as representing her as draconian. Moreover, the user is supposed to laugh. The caricaturist certainly surmises that Mrs. T. *is* draconian, otherwise this other intended aim would not be reached. But success in representing Mrs. T. *as* draconian does not depend on whether she was in fact draconian or not.

Suppose now that I have never heard of Mrs. Thatcher and that I happen to have a neighbour whose name is Grace and resembles her very much. Then, when looking at the drawing, and given the context and the codes implicitly in place, I will appropriate the drawing and make it a representor of Grace *as* draconian, even if she is a very gentle and amiable person. My referential act will attribute a referent distinct from Mrs. T., but I will represent my target in the same way, namely as draconian, given the mapping and the code implicitly in operation.

van Fraassen insists that representational success of Mrs. T. as draconian is achieved because of the *distortion* of some of Mrs. Thatcher's features into some properties of a mythical animal—a dragon—which western legends portray as mean and mischievous. In a caricature some exaggeration must be present… The distortion, which is necessary to represent the target *as* having some property, entails that representation here is a *misrepresentation*, as van Fraassen contends. Obviously, we all know that Mrs. T. did not physically resemble a dragon. Thus, the qualification of the caricature as a misrepresentation rests on the improbable situation in which a user would believe in the truth of some statements attributing to Mrs. T. facial properties resembling the ones attributed to dragons. Yet, the caricaturist manages to represent Mrs. T. *as* draconian by means of a mapping between some features of imaginary dragons and some parts of the caricature. Again,

establishing a homomorphism is necessary in order to attain the caricaturist's goal. The distortion of some of Mrs. T.'s physical traits into a dragon's features allows an user who knows the code to understand that the caricature is meant to attribute (rightly or wrongly) to Mrs. Thatcher's specific psychological characteristics which in our culture are associated with dragons.

Also in this example, the success of the representation rests on the supposed truth of statements attributing properties to Mrs. T. and dragons, and a homomorphic mapping between properties which bestows to the artefact its representational function. Specifically, the spatial relations between some colours and shapes of an imagined dragon are put into correspondence with some colours and shapes in the caricature. On the basis of statements supposed to be true in some context, a user might take as true a statement attributing to the caricaturist a specific intention. The user may also attribute a psychological property to the target, which is the relation of possession between a property and its bearer, specifically between the property D (draconian) and the target T (Mrs. T.). More generally, I submit that the institution of some homomorphism between the purported target and the representor is a necessary condition for the success of a representation, even if resemblance is not. *I call this necessary, but not sufficient, condition of success* "*structural similarity*". (Structural similarity is not to be confused with resemblance or likeness.)

This is not to say that a representation is a form of predicative act (Ghins 2010). The caricature of Mrs. Thatcher is not a statement which could be true or false. True, as Goodman and van Fraassen contend, we could interpret the caricature as predicating a psychological trait to the target. But this would be an *external* ingredient added to the representation. Since representing is an action, the categories of true or false are *not* applicable; only success and failure are. To succeed in representing a target *as* such and such is independent of the physical existence of the target or its actually having such and such properties. If we add a cross or a green flag in a representor to indicate that it is meant to convey correct information about the target, this move is tantamount to constructing *another* artefact which would require a new act of appropriation by a user.

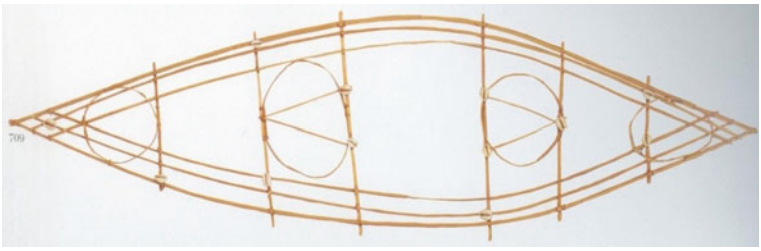
On the other hand, success in representing a target as such and such presupposes the assumed truth of some predicative statements about the target and other entities, as we saw. But predicating is not representing. Granted, predicating is also an action. It consists in attributing a property to an identified subject, which can be called the "target" of the predicating action if you wish. The result of such an action is the production of a statement of the form "S is P". But a statement is *not* a representation (Ghins 2010, 2011). First, because it states that some situation or state of affairs obtains. It is an assertion. It then possesses an illocutionary force, namely an assertive force, which is a characteristic representations lack. If I intend to assert that a portrait is beautiful by drawing a cross on it, I only have manufactured another artefact which is deprived of any illocutionary force. The second reason why to predicate is not to represent is that a statement needn't exhibit some structural similarity with a possible state of affairs which would make it true to perform its function, which is to assert that some state of affairs obtains.

Granted, it is always possible to use a sentence sign, written or spoken, as a representation, since anything could be used as a representor by attributing a representative role to it. In doing so, we represent but do not assert. Famously, Wittgenstein's picture theory of meaning developed in his *Tractatus* mainly foundered on its inability to account for any kind of illocutionary force because it attempted to reduce meaning to structural similarity (see Ghins 2011). In the *Tractatus* a proposition is meaningful if and only if there is a isomorphism between its components (called "names") and the components (called "objects") of a possible state of affairs the existence of which makes the proposition true. Such isomorphism was supposed to preserve the logical form common to the proposition and the possible state of affairs it represents.

If some instituted structural similarity between a representing artefact and its target is taken to be a necessary condition for the success of a representation, then statements do not represent. Thus, language does not represent the world, according to this restricted, regimented sense of representation. Although I maintain that there is some kind of correspondence between statements and facts when they are true (see below) such correspondence cannot be construed as structural similarity and, as a consequence, is not representational.

3 Success in Adequately Representing the Identified Target

Scientists aim at constructing models which adequately represent at least observable phenomena. But scientists are not the only ones who strive to construct correct representations. A map user relies on the information that he manages to extract from a particular artefact in order to find his way. This is what Micronesian navigators did when they used artefacts such as this one[8]:



[8]Meyer (1995, p. 616, Fig. 709). The map is part of the collection of the Linden-Museum in Stuttgart. I wish to thank Anthony Meyer and Dr. Ingrid Heermann, curator of the Oceanic art section of the Linden-Museum for their kind authorization to reproduce this photograph. [I here revisit an example discussed in Ghins (2011)].

To gather correct, and therefore useful, information from this artefact I must know the code, which is external to it. But this Micronesian object has internal properties: it is made of wooden sticks bound together by knots and shells. The environment specifies which properties are pertinent to navigation, such as dominant winds, sea currents, stars, locations of the islands etc. But to make good purpose of this object as a map, I must know the code, i.e. the kind of homomorphism between the properties of the target which the map manufacturer intended to convey to a potential sailor and the properties of the artefact. Equivalently, I must know which relevant statements the craftsman took to be true, such as: With respect to island I current C flows in the direction of the polar star.

In order to make efficient use of this navigational map, a sailor must also locate himself with respect to the map. A map in itself is "impersonal" in the sense that it can be read by different people at several locations. Localization involves both position and orientation. If I locate myself erroneously on the map, I will be unable to utter correct statements such as: sailing in direction D will get me to island I. Adequate use of the map presupposes the truth of an indexical statement which says: I am here on the map.

As far as correctness is concerned, we reach the same conclusions as above when we discussed success in identifying a target and in representing the target as such and such. Correct information about the target can be gathered by the user only when he brings in information which does not belong to the artefact itself and which typically is expressed by assertions about—monadic or structural—properties of its target and characteristics of the context. It is not sufficient for the map to be a "faithful homomorphic image" of the target, since the Micronesian artefact does not have an inner structure that makes it ipso facto a maritime map, let alone a correct one. It could be used to represent the lamp on my desk, and still be, given some instituted homomorphism, a faithful image of it, and even an incorrect or inexact one. If I take the spatial relation of the bulb and the plug of my lamp to correspond to the spatial coincidence of a specific shell with the intersection of wooden sticks, then my representation is incorrect, *albeit* faithful in the technical sense defined above.

Successful utilization of a map necessitates that the traveller manages to handle it as a tool for collecting correct information about what is pertinent in its environment relatively to the aim pursued, namely reaching a specific destination. This presupposes that the traveller is able to use the map in order to formulate some true statements about the location of selected elements of his environment as well as the spatial relations among them. Given this, and also by correctly positioning himself on the map, he will be able to infer the truth of some other statements on the right way to safely arrive at his chosen destination.

At each of the three stages of the representational activity (identification of the target, representing it as such and such and representing it correctly in some respects), the user adopts some standpoint or perspective on what she aims at representing. Selection of a concrete target and its relevant properties is crucial at

each stage. Selecting implies neglecting. Traditionally, such a way of proceeding has been called "abstraction". In what follows, I will briefly examine the way in which abstraction operates in scientific representation.

4 Scientific Representation

Examining representing practices in various domains such as caricature and travel, as van Fraassen does, is supposed to shed light on the way representation works in science. Scientific activity starts with what I call an "original", "inaugural" or "primary" abstraction (Ghins 2010, p. 530), which consists in looking at phenomena as *systems*, that is, sets of properties standing in some relations. The poet looks at the night sky as a magnificent whole and expresses the awe it inspires in beautifully sounding words. The religious person sees the celestial vault as the work of God. Both attitudes are *holistic*. By embracing them, the poet and the religious see the sky as a unified totality with which they attempt to personally and closely connect in a particular way. The scientist, on the contrary, adopts an *objective* attitude and sets himself at a distance from the phenomena by seeing them as systems. Such systems are not only posited as external to the scientist but are estranged from his human nature as a person.[9]

In performing an original abstraction, an astronomer intentionally isolates in the sky luminous spots which move relatively to other apparently stable bright points. He calls the former "planets" and the latter "stars". Planets are identified by their properties of brightness and motion. Then, in a next abstracting move, the astronomer decides to take orbital periods (the durations of the complete revolutions of planets) and apparent distances to the Sun as the relevant properties of interest. This second abstracting move, which actually occurs simultaneously with the first, I call the "secondary abstraction". The observed properties of orbital periods and distances to the Sun can be organized in a system by means of an ordering relation. The orbital period of a planet is proportional to its distance to the Sun. The astronomer has then constructed a system of properties organized by relations which I call a "phenomenal structure".

In science, the properties of interest usually are susceptible of being quantified. This is the case of course for orbital periods and distances to the Sun. Whereas the phenomenal structure is constructed on the basis of crude observations, a data model is a structure of carefully measured properties. Since the data model and the phenomenal structure are both systems of properties organized by relations, a homomorphism can be instituted between them. Such a homomorphism is a representational function which captures the intended structural similarity between the target—the phenomenal structure and its representor—the data model.

[9]For a presentation of the distinction between the holistic and the objective attitudes, see Ghins (2009). The scientific objective attitude is extensively discussed by van Fraassen (2002).

"Target" is thus an ambiguous word. On the one hand, it refers to concrete objects, e.g. the planets and their successive positions, which are observable phenomena. On the other hand, it denotes the phenomenal structure which has been abstracted from phenomena. Thus, it would be useful to use different words, namely "concrete target" and "targeted structure" to refer to the former and the latter, respectively. As van Fraassen rightly stresses, observable phenomena are not abstract. Instead, they are concrete entities. He is very clear about this:

"*Phenomena* will be observable entities (objects, events, processes). Thus 'observable phenomenon' is redundant (…) *Appearances* will be the contents of observation or measurement outcomes." (van Fraassen 2008, p. 20).

Thus, the concrete phenomenal targets are the planets but these are represented *as* having some abstracted properties organized into a structure of appearances, namely the phenomenal structure, of which the data model is a homomorphic image. A data model also is a structure of appearances according to van Fraassen's terminology. In my regimented use of the word "representation", success is achieved only when some homomorphism has been established by a user between what is represented and the representor. Therefore, only systems or structures can be represented by other structures or systems. The concrete system is represented in a *derivative* sense only. Strictly speaking the concrete target is *not* represented but denoted or referred to by the representor, i.e. the data model. What is represented by the data model, namely the phenomenal targeted structure, also denotes or designates the concrete target.

Notice that the scientist can succeed in representing a planetary system as having specific properties even it does not actually possess these properties, such as being inhabited by intelligent beings like Martians. Of course, scientists aim at constructing models of properties which are actually possessed by concrete phenomena. Individual planets are observationally identified by means of visual properties. Having done this, an astronomer attempts to represent their arrangement with respect to some relevant properties which are abstracted from them, such as an orbital period and a distance to the Sun. Of course, a scientist might err in attributing to planets characteristics they do not possess, such as producing musical notes as the Pythagoreans believed.

Constructing a data model the domain of which only contains properties which belong to concrete phenomena is not sufficient for the data model to be accurate. The institution of a representational function between the data model and the phenomenal structure is not sufficient either. Just imagine that a systematic error has occurred when measuring some property. Then, the representational function will be in place, but the data model wouldn't be adequate. Faithfulness does not imply correctness. We fall back to the same point: the correctness or adequacy of a model rests on the truth of predicative statements. If the properties organized in the representor, the data model, do not belong to the concrete target, the representation is inaccurate.

Scientists do not stop at the level of data models in their representational activity. As van Fraassen says, they manage to embed the data in theoretical structures which provide a unifying view of the domain, deliver explanations and satisfy some

useful aims, such as permitting the calculation of future data in a deterministic way (van Fraassen 2008, pp. 36–37). Embedding phenomena means constructing theoretical models which contain, in a minimal set-theoretical sense, empirical substructures homomorphic to data models, or surface models [which are smoothed out data models (van Fraassen 2008, p. 143)]. Since empirical substructures are substructures of theoretical models, they are theoretical as well. Phenomena can be said to be embedded in a theory to the extent that an accurate data model is homomorphic to an empirical substructure of the theory. The overall situation can be summarized in the following table:

Real phenomena
@ *Inaugural abstraction*: system of properties
Secondary abstraction: selection of properties
Phenomenal structure: appearances (crude naked eye observations)
↓ *Homomorphism*: representational function
Data model—Surface model: appearances (measurement results)
↓ *Homomorphism*
Empirical substructure
∩ *Set theoretical inclusion*
Theoretical models: embedding the phenomena.

5 The "Loss of Reality" Objection

Since phenomenal structures and data models are abstract structures, how can we use them to represent concrete targets? *Stricto sensu*, as we saw above, representation is successful only if a homomorphism has been established between a targeted structure and a representor, which is also seen as a relational structure. Structural similarity is an essential condition for the success of a representation. If this is so, a wide gap opens between the representing artefacts and the concrete targets we aim to represent.

> How can an abstract entity, such as a mathematical structure, represent something that is not abstract, something in nature? (van Fraassen 2008, p. 240)

Such question echoes the problem faced by the founding fathers of modern science, such as Descartes, who were at pains to prove that our mental geometrical representations or ideas adequately represent external realities. Surely, some distancing from the things immediately given in perception was the price to pay to achieve the mathematizing of the world. The objective attitude essentially consists in seeing a thing as a system, i.e. as a domain of properties standing in mathematical relations. Then, a mathematical representation becomes possible because targets are systems which are structures just as mathematical representations are. Initially, at the birth of modern science, things were not only seen as mechanisms but identified

with mechanisms, namely systems of geometrical parts in relative spatial motions which could accurately be represented by geometrical ideas.

For the philosophers of modern times, to know is to represent. Once this epistemological posture had been embraced, a wedge was driven between our ideas and the real things in the world. While mathematical ideas are structures, concrete things—phenomena—are not. The latter certainly cannot be reduced to mechanisms as the initiators of modern science believed. Moreover, they cannot even be identified with any kind of single system because the same thing can be seen as a *different* system, depending on the perspective adopted. If a thing could be reduced to a unique system, there wouldn't be any difficulty to represent it, because both the target and its representor would belong to the same category: the category of systems.

What I call the "idealistic predicament" consists precisely in the quandary of bridging the gap between our abstract mathematical structures and concrete things. This is not the place to look at the diverse sophisticated ways scientists and philosophers since Galileo and Descartes grappled with this issue, yet without reaching any satisfactory solution. I just want to submit that the loss of reality objection is a revival of the idealistic predicament clad in a new garment. This objection brings back an ancient difficulty which takes its roots in what Michel Foucault appropriately named the *épistèmè de la représentation*.

Surely, van Fraassen is right to insist that scientific models are not mental ideas.

> I will have no truck with mental representation, in any sense. [This] view (…) has nothing to contribute to our understanding of scientific representation—not to mention that it threw some of the discussion then back into the Cartesian problem of the external world, to no good purpose. (2008, pp. 16–17)

However, the model-theoretic approach to theories emphasizes that theories are foremost classes of models. If this is so, the cognitive role is mainly carried out by models and their representational function. If models "take centre stage" as van Fraassen puts it (1980, p. 44) statements are relegated behind the scene and carry less cognitive weight.

So, how does van Fraassen address the "loss of reality objection"? As a genuine empiricist, it is natural for him to resort to pragmatics. His answer is simple but quite ingenious.

> *For us* the claims:
> (A) that the theory is adequate to the phenomenon
> (B) that it is adequate to the phenomenon as represented, i.e. *as represented by us* are the same! (2008, p. 259)

The claims (A) and (B) are both assertions made by the user who aims at representing a targeted concrete phenomenon by means of a representing artefact, a theory in this case. Certainly, I cannot assert (A) without also asserting (B) since claiming that a theory—a model—is adequate to a given phenomenon, is tantamount to saying that it contains an empirical substructure that is homomorphic to a data model containing measurement results, i.e. numerical properties supposedly carefully gathered from the phenomenon. Representation always is indexical. It is

impossible for me to climb on some kind of overarching platform from which I could contemplate phenomena on the one hand and my model on the other hand in order to compare them and check whether they correctly match. A godlike point of view or a view from anywhere, which would bracket my own perspective, lies beyond our reach.

van Fraassen's contention can be reformulated at a more basic level in the following way:

> *For us* the claims:
> (A′) that the *phenomenal structure* is adequate to the phenomenon
> (B′) that it is adequate to the phenomenon as represented, i.e. *as represented by us*, are the same!

Quite remarkably, van Fraassen offers his pragmatic move not as a *solution* but as a *dissolution* of the loss of reality objection. Given the unavoidability of the indexical ingredient in any representational activity, it makes no sense for him to ask if a proposed model hits on something external. Such external reality would be a metaphysical posit, devoid of empirical meaning. If this kind of *ding an sich* exists, a possibility which is not excluded after all, it is definitely beyond our ken.

6 The Loss of Reality Objection Solved

I agree with van Fraassen that denying (B′) while asserting (A′) would be a pragmatic inconsistency. It would be tantamount for me to assert "p is true" and at the same time say "I don't believe p" (van Fraassen 2008, p. 212). But the main question is the following: what reasons do I have to believe that a model correctly represents a concrete target? Pragmatically, if I subscribe to the representational way of knowing, there is no way to deny that I represent the concrete target when I claim that my representation is adequate to it.

At this point, two questions can be raised. First, what does it *mean* for a model to represent a concrete entity? Second, what *reasons* do we have to believe that the concrete target is adequately represented?

First, as I emphasized, adequacy relies on the truth of some predicative statements which assert that planets, for example, possess some specific quantitative properties such as an orbital period of a certain value. Although van Fraassen doesn't give pre-eminence to statements, he acknowledges that adequacy rests on the truth of some claims.

> To offer something X as a representation of Y as F involves making claims about Y, and the adequacy of the representation hinges on the truth of those claims, but that point does not put us in the clutches of a metaphysics of 'truth makers'. (2010a, b, pp. 513–514)

Unlike van Fraassen, I maintain that true statements do have truth-makers, namely facts which make them true, and that there is some sort of correspondence between facts and true statements. For example, it is a fact that planets are in motion

and this fact can be ascertained by simple observation. The strongest argument in favour of a correspondence *view* (not a *theory*) of truth, is our experience of error, when we are forced to change some of our beliefs when confronted to new evidence. In such occasions, we realize that there are facts external to us, which we don't control and exist independently of our wishes, language and models. There is no need to resort to a metaphysics of things in themselves to account for this quite common experience. The occurrence of some facts can be ascertained on the basis of immediate perceptual experience, while not eliminating any risk of error.

Admittedly, I am unable to explicate in what consists the correspondence between statements and their truth-makers. Such an explication could perhaps be provided by a full-fledged correspondence *theory* of truth which would detail the characteristics of such correspondence. As we saw above, a famous example of a (failed) correspondence *theory* of truth is given in Wittgenstein's *Tractatus*. To my knowledge, no satisfactory correspondence *theory* of truth has been devised so far. But this situation, doesn't prevent us to defend a minimal correspondence *view* of truth, which makes the quite limited claim that some kind of correspondence obtains between the facts and the statements they make true, while remaining silent on the exact nature of such correspondence.

Since van Fraassen subscribes to a deflationary theory of truth, he cannot rely on the truth of statements to warrant that our adequate representations do represent our intended targets. For a deflationist to say that "snow is white" is true is simply to assert that snow is white. That is all there is to it, and there is no need to gloss on what truth is and the specific relation, should there be one, between an assertion and a fact. Searching the nature of truth is a will-o'-the-wisp. But if we do gloss (just a little bit) on the relation between statements and facts, simply by claiming that there is a truth-maker, a fact, which is external and independent of what we may assert about it, then we are in a position to identify the concrete target of our representations. The concrete target is just what we talk about, namely the things to which we attribute some properties in an act of predication resulting in a statement. Again, to admit the existence of truth-makers doesn't commit us to a lofty metaphysics remote from perceptual experience, but to facts to which we have epistemic access in perception, independently of our wishes, language and modelling activity.

A correspondence view of truth is part and parcel of a realist position in epistemology, *already at the empirical level*. (In this paper, I leave aside the issue of the existence of unobservable entities posited by some scientific theories.) On the contrary, a deflationary theory of truth implies the following:

Asserting Snow is white means the same thing as asserting that "Snow is white" is true.

Certainly, pragmatically if we assert that snow is white, we must also assert that "snow is white" is true, as Tarski instructed us a while ago. But the two statements do not have the same *meaning*, contrary to what the deflationary theory of truth claims. If we accept this, we are invited to tell what the word 'true' means. According to the correspondence view it means that there is some relation between a statement and something distinct from it, namely its truthmaker. If this is correct, a true predicative statement identifies what it talks about—its target—without

ambiguity by mentioning some of its properties. Then, some of its other properties can be employed to construct representors and models as I explained above in the example of the planetary system.

The loss of reality objection is solved because true predicative statements provide firm ground of contact with the concrete targets from which our representations are constructed. Predication is not representation however. When I attribute a property to a thing, I do not represent the thing as having a property. I simply attribute a property (rightly or wrongly) to the concrete targeted thing. Representation proceeds next in organizing properties in systems, structures and models. If a representation succeeds in representing a concrete entity it is only derivatively so, since its success is parasitic on the truth of predicative statements which hit on targets in their concreteness. Abstract representors are organized sets of properties supposedly pertaining to concrete targets (whether fictional or real).

Now, to briefly address the second question raised above, let us simply point out that the adequacy of a representation depends on the possession by the target of the properties involved in the representational activity. In the example of the planetary motions, an astronomical model is adequate if we have reasons to believe that planets have the properties used to construct the model and that these properties are arranged in the planetary system in a way which is correctly and structurally similar to the way the corresponding elements in the model are. This is all.

Is such a solution of the loss of reality objection committed to the view that there is some unique fundamental structure in the world which somehow "carves nature at its joints" just as the mechanistic conception of nature of modern times assumed? No, not at all.

Although the scientist certainly carves a targeted phenomenon into properties that belong to it (at least he so believes), he always operates from a certain point of view and accepts that there are other ways to look at the phenomenon. If he is correct in doing so, predicative statements attributing properties and relations among them are true. In this limited sense, there is some structure intrinsic to the phenomenon that is capable of being represented by a user. However, there is no inner structure in a phenomenon that makes it ipso facto representable by a specific representor, such as a photograph, as we saw. The fact that a phenomenon possesses a certain structure (among other ones) does not determine the nature of the representing artefact which could be employed to represent it. Conversely, there is no intrinsic structure of a thing that makes it a potential representor of a specific target or class of targets,[10] since anything can represent anything. Any entity could be used to represent some characteristics of planetary motions, provided some homomorphism is conventionally established between the representing artefact and its targeted system. Some properties and relations in the representing thing are chosen by the user as relevant, but this doesn't prevent the representor from intrinsically having those properties and relations. On the contrary, it is because the representor really possesses some identifiable properties that a representational

[10]On this I disagree with Bartels (2006, p. 14).

function can be bestowed on it by the user. Of course, the same thing can be endowed with a large variety of representational roles when used as a representor.

Given that a concrete thing can be looked at as having some structure S from a certain point of view, and as having another structure S' from some other perspective, a realist must demand that the properties and relations that are believed to actually belong to the target be logically compatible. A concrete thing cannot have contradictory properties at the same time. However, in science, some representations of the same target appear at first sight to be incompatible. This situation especially occurs when various models are offered to represent unobservable things, such as atoms. According to some models, molecules and atoms contain no parts, and according to other models they are composed of protons, neutrons and electrons. For quantum mechanics, particles can be entangled, whereas in classical contexts they don't.

Such a situation surely raises a problem for the realist. But here we can't examine this issue in depth. Let me just make three brief observations. First, a model always neglects some properties of the target. In these cases, the realist should refrain to attribute to them properties which they would always possess, beyond a specific context of investigation, such as indivisibility in the case of atoms. Instead, the realist should only claim that molecules and atoms do not break, and behave as if they were indivisible, in some particular context such as the emulsions studied by Perrin. Second, some relevant properties may be approximately exemplified by the target as in the liquid drop model of the atomic nucleus (Da Costa and French 2003, pp. 50–51). Third, some properties of the representor may play a representative role without being put in correspondence with actual properties of the target. Mrs. Thatcher doesn't have dragon's wings, but the caricature aims at representing her *as* having a specific trait of character. Such a procedure is typical of graphs widely used in many scientific disciplines in which the abscissa and ordinate axis do not have correlates in the target.

7 Conclusion

Success in representing crucially rests on predicative statements which are true in accordance with a correspondence *view* of truth. These statements play a decisive role in the three aspects involved in the success of a representation. The user of a representing artefact intentionally identifies her target by relying on supposed properties of the target, be it real or only fictional, e.g. being a bright spot moving to apparently immobile bright spots in the sky. She successfully represents the target *as* such and such by instituting a homomorphism between some relevant supposed properties of the target and properties of the representor, in some context. Finally, her representation is correct or adequate if the target actually possesses the relevant properties attributed to it. Truth, or at least supposed truth in the two first stages, is therefore more fundamental than success, since the latter is achieved on the basis of the former.

Such a conception of representation does *not* involve the heavy metaphysical commitments to "things in themselves" or a unique "carving of nature at its joints". Phenomenal things at least are directly accessible to human sensory perception. We are then in a position to ascertain (or not) the occurrence of facts which are the truth makers of (true) predicative statements. Moreover, several perspectives can be adopted when attempting to represent things. In doing so, the user selects in the phenomenon some properties which are organized in a certain manner. The targeted phenomenon is then seen as a system which can be represented by another thing, an artefact, which is also seen as a system. Despite the various possible perspectives and the leeway allowed in choosing the relevant conventions, both the target and the representor can be said to actually possess some intrinsic properties. When various perspectives are taken on the same target, the realist must certainly avoid to attribute contradictory properties to it.

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