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Bas van Fraassen on Scientific Representation

MICHEL GHINS

Representation is a heavily history-laden philosophical term. If we are to follow Martin Heidegger in *Die Zeit des Weltbilds*, our manner of conceiving natural beings underwent a major ontological shift at the dawn of modern times. Whereas the middle-age construed beings as created by God, the modern era saw them as represented by us. For a modern thinker, to know is to (correctly) represent. For a scientist a being is an object amenable to mathematical representation.[1] This momentous historical turn opened the path to the tremendous success of modern science, but at the unbearable price of losing contact with reality along the way.

A representation is always a purported representation *of* something. Thus, it presupposes a representor and a represented. Two main problems arise here. First, how can the representor represent what is represented? Second, since we are immediately only acquainted with 'observable phenomena' what reasons have we to believe that a representor correctly hits on something real? In his latest book *Scientific representation: Paradoxes of Perspective*, Bas van Fraassen does not rest satisfied with the merit of addressing these daunting – yet central – philosophical problems head-on, but he also offers exciting and carefully argued solutions to them. To tackle the first problem, van Fraassen takes his clue from art and the notion of perspective which he submits to detailed scrutiny. He then contends that the second problem is dissolved by resorting to pragmatics. Although I am by and large sympathetic with van Fraassen's views on representation, I am more reluctant to embrace his proposed pragmatic dissolution which, as far as I understand, depends

1 Some may object that some scientific disciplines do not resort to mathematical representations. True, the representational drawing of a cell for example is not strictly mathematical. But the accuracy in predictions – which is an aim pursued by most scientific disciplines – can hardly be achieved without resorting to mathematics. Cellular models in biology include e.g. quantitative treatment of the cell membrane permeability. At any rate, any entity is certainly mathematically tractable in some respect.

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upon the acceptance of what Michel Foucault appropriately called the *épistèmè de la representation*. As I see it, the major philosophical challenge here is to free ourselves from the view that knowing is representing, a view that opens an unbridgeable chasm between our representations and things.

1. *When is Representation?*

1.1 Resemblance and similarity

After having approvingly quoted Goodman's question 'when is art?' (21), van Fraassen asks 'when is representation?' Just as Goodman's ambition was not to provide necessary and sufficient conditions for what counts as art, van Fraassen doesn't aim at coining a definition or a theory of representation, but to highlight some 'family resemblances' (and differences) in various forms of representation. Certainly, resemblance between A and B is not *sufficient* to qualify A as a representation of B, if only because there is no representation without someone using A to represent B. But is resemblance a *necessary* condition for representation? This issue is important and subtle enough to deserve close examination.

Take van Fraassen's example of Spott's drawing of Bismarck (14) as a peacock, which is used as a representation *of* him *as* vainglorious. In order to function as a representation *of* Bismarck – in a given context – the caricature pictures some of his physical features. Such a resemblance allows us to identify the target (B) of the caricature (A), namely Bismarck (and not Radowitz). So far so good, but the aim of the caricaturist is that we not see A as a faithful portrait of Bismarck but as a caricature, that is as representing (in this case) a person having a specific trait of character, namely vanity, a property which is (in our culture) symbolically associated with peacocks. How is this aim achieved? van Fraassen aptly insists that for the caricature to achieve its purpose some distorting of Bismarck's physical features is necessary (Bismarck's arms are replaced by wings, his chest looks like a long neck…). In other words, the caricature is a *misrepresentation*. But notice that A *mis*represents only with respect to the improbable event that it is taken to be a resembling portrait. On the other hand, the caricature does (ironically for sure) aim at representing a vainglorious Bismarck, just in the same way as a picture of a red apple can successfully represent a red apple, in the appropriate context. To put it shortly, the caricature is a representation *of* Bismarck on the basis of some physical *resemblances* with him but it represents him *as* vainglorious because the drawing of Bismarck includes features that *resemble* a peacock to which vanity is symbolically associated.

From the discussion of several examples, van Fraassen draws what he calls the *Hauptsatz* of his conception of 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' (23). A represents B only for a user X in a proper context C: the representational relation is a four-place relation. A consequence of this is that anything can in principle function as a representation of something. There are no intrinsic characteristics of A and B that *ipso facto* make A the representation of B. This indeed is a healthy lesson to be learned from the consideration of representation in art, a lesson that can fruitfully be exported to the study scientific representation.

Notice that the *Haupsatz* does not entail that resemblance is to be jettisoned altogether from an elucidation of representation. Evidently, many a representation trades for its success on *selected* resemblances that are deemed *relevant* for the *user* in a certain *context*. On this van Fraassen distances himself from Goodman according to whom representing is denoting. Granted, resemblance or likeness is not required for a word to successfully denote a given thing. But again, is *some* resemblance a *necessary* condition for successful representation? I agree that it is not. However, the broader notion of *structural similarity* does provide a *necessary* condition for representation. For A to represent B, they must both be seen (by a user) as systems, that is as sets of elements which stand in some relations among themselves. It is reasonable to suppose that to be a system is an intrinsic characteristic of a thing: to see some targeted thing B as having property P does not imply that we must be agnostic about the possessing of P by B. We have come here to a very general – therefore weak – condition, which only requires that two things possess some relational structure for one to be able to represent the other.

A representation always involves a mapping between A and B that preserves some selected relations. If two elements of B stand in some relevant relation, then some corresponding elements of A stand in a corresponding relation as well. This is what is meant by structural similarity which is accurately captured in mathematics by the notions of isomorphism (when we have a one-one correspondence between the elements of A and B) or homomorphism (in the case of many-one correspondence). The condition of structural (relevant) similarity does not impose any likeness constraints in the sense that elements of A and B must share some properties (e.g. to have a colour) or that some relations in A must be like some relations in B (e.g. be spatial). For example, spatial arrangements of black lines and patches can be used to represent temporal sequences of musical notes. van Fraassen certainly agrees that structural similarity is a *necessary* criterion for *scientific* representation. But I am not quite sure that he would accept structural similarity as a necessary requirement for all forms of representation in domains such as art (admittedly, only when art is meant to be representational), caricature etc. Nevertheless, even in the event of *mis*representation, the discussion of Bismarck's caricature shows that the success of representing him *as* vainglorious trades on some structural similarity between the arrangement of pictorial elements on the one hand, and Bismarck and peacocks, on the other hand. Be it as it may, elucidating the nature of representation in caricature and art is supposed to shed light on scientific representation, which is the main purpose of the book after all, and should not mislead us in attempting to explain *obscurum per obscurius*.

Besides drawing our attention to the importance of relevant similarity, context and user, the examination of caricatures shows that success in representing is distinct from *truth*. Bismarck's caricature succeeds in representing him *as* vainglorious irrespective of whether he really is or is not vainglorious or whether he existed or not. 'Fundamental to the understanding of representation in all contexts is this fact, that images which represent something unreal have their importance, their role, their effect in the context in which they function' (35). Now, the user may ask: is the representation faithful (in some relevant respects) to something real? Then, the user may state a *proposition* exposed to the risk of falsity. *In itself* a representation is never true or false. We might consider adding a green flag or a cross when a representation is meant to be true. By doing this however, we have constructed a *different* representation, which again has to be interpreted by a user in a proper context, and so forth (31).

Thus, it must be stressed that a representation is *not* a proposition, and the converse is not true either. I think that van Fraassen agrees that a representation is not a proposition, but he disagrees with the converse (16). I claim – and I'm aware that this is highly controversial – that language does *not* represent the world, but *describes* it, correctly or incorrectly. In his *Tractatus*, Wittgenstein famously argued in favour of the 'picture theory of meaning' according to which propositions can be analysed into truth-functions of elementary statements that are logical images of atomic facts. When an elementary statement is true, it represents a fact with the same logical form: the arrangement of names in the elementary proposition is the same as the arrangement of the corresponding simple objects in the fact. Whether true or false, the proposition represents a possible situation in logical space. Wittgenstein, the logical positivists and van Fraassen alike are wary to avoid any form of mentalism and psychologism (24). Representations and possible situations in the logical space are not psychological entities, let alone mental images or ideas.

As we all know too well, the picture theory of meaning was later rejected by Wittgenstein himself. True, a propositional sign – a string of strokes drawn on paper, say – is an artefact which can be used as a representation, since anything can be used to represent anything. Thus, we can always construct some homomorphism between a propositional sign and a possible situation. But if a sign is a *propositional* sign, it means that it is employed by a user with some illocutionary force, something that a representation is lacking. A used proposition must have some illocutionary force, e.g. assertion, and may be true or false. Language describes (correctly or wrongly) the world but does not represent it.

1.2 Perspective and invariance

As the subtitle of his book reveals, perspective is key to van Fraassen's understanding of representation. In perspective, things are first seen at the spatial location of a viewer who looks in a certain direction. Second, the picture is constructed in accordance with precise geometrical rules. The first aspect highlights a crucial ingredient of any successful representation, namely its indexicality or self-appropriation by its user. For a picture to represent successfully, its *user* must know where the painter chose to locate and orient the eye of the *viewer* with respect to the things represented 'in perspective' in the picture. The *viewer* is positioned at the point of convergence of certain lines which do not belong to the picture itself and he looks in a definite direction. Provided she knows the rules of projection, the *user* can infer the position of the viewer from intrinsic elements – namely the geometry – of the picture. I think it is important to keep in mind that the user and the viewer are not identical.

The eye of the *viewer* is located at the intersection of some straight lines which start from the thing pictured – a pavement floor, say – and cross the plane of the canvas (63). To successfully use the picture as a representation, the *user* must be able to self-locate herself with respect to the picture and to infer the location and orientation of the eye of the *viewer*. The user can of course move with respect to the picture. But wherever she is located, she must be able to infer the position of the viewer in order to gather information on the objects depicted. The painter could have located the viewer elsewhere and constructed *another* representation. This freedom of the painter shows that things are always seen from a certain perspective, and this fact draws our attention to the self-appropriating – not necessarily self-locating – act which is a precondition of success for any representational activity.

The indexical aspect of representation is best evidenced by van Fraassen's discussion of maps. In order to find *my* way, *I* must first locate myself with respect to the map which otherwise would remain a mere piece of coloured paper completely deprived of any practical use. Of course, as van Fraassen notices, I could indicate my position on the map by means of a cross and write 'location of MG's map-reading at time t'. But then I would have constructed a *new* map whose use would necessitate a fresh act of self-ascription. 'An attempt to replace or eliminate these self-ascriptions leads to an infinite regress, using an infinite series of maps' (79). (Such a regress is similar to the one encountered above with respect to assertion: a representor cannot represent itself as asserting a truth.) The unavoidable indexical ingredient cannot be integrated into the map, and this holds true for every representation.

The second aspect of representation that the analysis of perspective brings to light is the geometrical *information* about things represented that the user can gather from the picture. Such information is conveyed by means of some projective invariants, the most important of which is the *cross ratio*. If the viewer's eye moves, i.e. if perspective changes, the cross ratio between four points on some intersecting lines (of the pictured pavement) remains invariant. This invariance permits the user to gain knowledge of certain definite proportions of the represented pavement (imagined or real) but does not allow her to infer the precise dimensions (in metres, say) of the pavement tiles. For van Fraassen, to construct a perspectival picture is to perform a *measurement*. A picture is a kind of a *data model*, i.e. a set of measurements structured by relations. In a brilliant move, van Fraassen goes as far as saying that every measurement is a representation (although the converse is obviously not true). 'Measurement falls squarely under the heading of representation, and measurement outcomes are *at a certain stage* to be conceived of as trading on selective resemblances in just the way that perspectival picturing does' (91). Measuring is representing and the measurement results are a kind of representor which includes features that can be expressed in mathematical (not necessary numerical) symbols.

Perspective and invariance *albeit* related are by no means interchangeable. Perspective involves a particular case of invariance. A comparison of perspectival pictures with Cartesian frames of reference illustrates this. Perspective capitalizes on the invariants of projective geometry, whereas the Cartesian mode of representation is grounded on Euclidean metrical invariants. One might be tempted to claim that the Cartesian representation captures reality, whereas a perspectival drawing of a cube conveys its appearance only. But it is time to recall that, at the very beginning of his book, van Fraassen introduces an illuminating and novel distinction between appearance and phenomenon. '*Phenomena* will be observable entities (objects, events, processes). Thus 'observable phenomenon' is redundant in my usage. *Appearances* will be the contents of observation or measurement outcomes' (8).

The perspectival and Cartesian representations convey different information about the cube. The perspectival picture shows how the cube is *seen* by a given observer and also conveys some geometrical information on the cube itself; on the other hand the Cartesian picture provides information on its metrical properties. The invariance group of Euclidean geometry is smaller than the group of projective geometry. Therefore, if we identify the objective with the invariant, the projective representation looks more objective – and perhaps captures also more reality – than the Cartesian representation. But let's not move too fast: things are much subtler than that!

In fact, a perspectival picture aims at representing *the object as seen*, whereas a Cartesian picture represents *the object as having specific metrical properties*. They target the same *phenomenon* but are different *appearances*! In the Cartesian representation however, the viewer – and also the user – is purposively removed from the picture. This manoeuvre is quite revealing of the way modern science proceeds in attempting to reach a 'view from everywhere' (which is a more appropriate expression here than 'the view from nowhere') that is, independent of any position of the viewer. Whereas in perspective, clear and distinct reference is made to the viewer, and indirectly to the user, such reference is hidden and thus easily disregarded in the case of Cartesian frames. '(…) the geometrical or physical frame of reference thus conceived is a *depersonalization* [my italics] of visual perspective, relinquishing all but origin and orientation, which can be arbitrarily chosen' (85).

Yet, no Cartesian picture can represent without first-person appropriation by a user. If the Cartesian way of representing is deemed to be more objective, it is first because no explicit reference is made to a viewer. Second, we can construct a perspectival representation of the cube from the Cartesian one by using the resources of projective geometry, but not the other way around. Third, the same Cartesian representation of a cube can be constructed of the basis of visual *and* tactile perceptions, whereas it does not make sense to construct perspectival pictures of things as touched. The Cartesian representation is more invariant with respect to various modes of sensory access to things. Think of Descartes's example of the straight stick merged in water. However, a perspectival picture and a Cartesian representation of a cube are both *appearances* and also measurement results of certain aspects of the cube. This point can be generalized. All measurement contents are representations and appearances which possess some degree of invariance with respect to some set of transformations. Maximal invariance in measurement results is consciously pursued in all scientific disciplines, typically in physics and prominently in the general theory of relativity where space–time coincidences are invariant for the group of continuous transformations of coordinates. These considerations lead us to the second main problem addressed by van Fraassen, namely the connection between our representations and reality.

2. *What is the Relationship between Appearances and Real Phenomena?*

2.1 Phenomenal structures and data models

Scientific models aim at representing (observable) phenomena. This thesis recurs as a well-known *leitmotiv* in van Fraassen's philosophy of science. However, representation can only obtain between things that belong to the same category, i.e. *structures*. Therefore, for a representation of a phenomenal target to be possible at all, we have to perform *ab initio* what I call an *inaugural abstraction* by which a phenomenon is seen as a system. The first problem that arises is to characterize the relation between the result of this abstraction – which I call the *phenomenal structure* – and the phenomenon, which is not abstract. Suppose that we are immediately acquainted with a triangular object. A phenomenal structure (among possible others) could be the structured set of the perceived lengths of the sides of the triangle that we can judge (correctly or incorrectly) to be equal or not on the basis of immediate observation. The second step is to construct a mathematical model of this phenomenal structure. In the case of the triangle, we typically measure the lengths of the sides by means of 'rigid' rods to produce measurement results or data that can be structured by means of the 'x is smaller or equal than y' relation. By proceeding thus, we have constructed a *data model* made of numbers in a measuring unit. The second problem is then: how do we conceive the relationship between the data model and the phenomenal structure?

van Fraassen devotes considerable attention to both problems. He 'honours the first with a special name: *The Loss of Reality Objection*' (258), whereas the second problem is none other than the celebrated 'problem of coordination' already addressed at length by the founding fathers of logical empiricism (Ernst Mach, Moritz Schlick, Hans Reichenbach etc.) and which I shall consider first. The problem here is to construct an homomorphism between two appearances or two measurement results since the construction of the phenomenal structure actually is the product of an – admittedly crude – measuring operation.

Let us follow van Fraassen in his presentation of Mach's historical account of the development of temperature measuring practices. Suppose we are interested in establishing a precise – quantitative – method of evaluating things roughly classified as 'hot' and 'cold'. The perceptual structure is a set of things endowed with a partial ordering defined by the relation 'x is hotter than or as hot as y'. Then, the observed regular correlation between dilation and heating paves the way towards representing the phenomenal structure by means of a geometrical structure whose elements are volumes. Next, a data model of numbers homomorphic to this geometrical structure is constructed.

van Fraassen stresses the importance of the *historical context* in which an interest in developing quantitative methods of measurement as well as some knowledge of Euclidean geometry are already present. A thermometer is an artefact permitting the construction of a data model homomorphic to the phenomenal structure, perhaps suitably corrected since the readings of the thermometer are judged to be more objective: a 'good' thermometer must provide readings that are sufficiently independent of the states of various observers and variations of surrounding conditions (such as changes in atmospheric pressure). This is an invariance requirement.

What does coordination consist in? What does correspond 'in reality' to the theoretical term 'temperature' T? In fact, we have (at least) three homomorphic structures here: the phenomenal structure, the structure of the various states (e.g. volumes) of the thermoscopic substance and the readings in degree (Celsius say). Such a coordination obtains *not* between a theoretical term such as 'temperature' and some element 'in reality', but between appearances. The measurement contents, that is the structure of numbers (the data model) and the structure of volumes, are homomorphic to the structure of hot and cold bodies (or various states of the same body).

Consequently, for van Fraassen, there is no property such as temperature that pre-exists 'in reality' and which is 'revealed' by our measuring instruments. 'How could one decide, before a detailed theory is in place, whether or not the changing height of a column of mercury mirrors the temperature, except by use of a thermometer?' (138). 'In practice a theory eventually emerges which encompasses the measurement procedure itself as well as the items measured, and provides the coordination. Thus, in the case of temperature, the kinetic theory (...) provided the parameter [mean kinetic energy] which then was identified as precisely what was measured by the thermometer' (124). Yet, what the kinetic theory delivers is not a piece of reality on which temperature measurements hit, but a new (theoretical) structure of mean kinetic energies homomorphic to data models: higher degrees correspond to higher mean velocities of molecules. When this final stage is reached, we are in a position to claim that heat phenomena have been embedded in kinetic theory. The mathematical equations and the terms they contain are coordinated to elements of 'reality' in the sense that they are satisfied (made true) by data models homomorphic to phenomenal structures. In this way, in the words of Reichenbach, 'the 'real' is defined by coordination to the equations' (120).

2.2 *Appearance and reality*

We are now in a position to tackle the *Loss of Reality Objection*: '*How can an abstract entity, such as a mathematical structure, represent something that is not abstract*, something in nature?' (240). This question bears on the relationship between data models and phenomena, but it must also be addressed at a more basic level: what is the connection between a phenomenal structure and the phenomenon? A crucial lesson to be drawn from the previous discussion, and on which I could not insist too much is that a representation is always a representation of a *structure*. Thus, strictly speaking, we never represent phenomena but their (partial) structure. Yet, our representations do contain information – and very useful information at that! – about phenomena. How can this happen? Having arrived at this point some remarks on *truth* don't seem superfluous.

Is it *true* that a certain body has some specific value of temperature? van Fraassen grants that statements are literally true or false independently of our psychological states of belief. But what reasons have we to believe that a body has a 37.3°C temperature? Well, because we have constructed – in conformity with well-established procedures – a representation (a data model) of some phenomenal structure abstracted from the phenomena.

That's all. But the reliability of such a construction relies on some basic truths about real observational facts, with respect to which our construction of a representation is, so to speak, parasitic. First of all, we must identify some entities as gas or liquids. We rely on true statements, that we may call observational, such as 'This is a gas'. Then, we have statements such as 'this gas is hotter than this other gas', the truth of which is ascertained on the basis of direct observation. Observational facts, which I identify with phenomena, and true statements that describe them are the soil on which all representative constructions rest.

Predicative statements of this kind (a relation term is a many-place predicate) do not trade on representation. When we attribute a property (denoted by a predicate term) to a thing, we do *not* represent the thing as possessing a property. Whatever a predicative judgement is (and this is not the place to enter into this belaboured issue), it does *not* state a representative relationship between a property on the one hand and a thing on the other hand (and much less a relation between an 'image' in my mind and a thing). It must be emphasized that in a predicative judgement there is no chasm between a representation and a phenomenal thing, simply because there is *no* representation, period. The representational procedure starts from observed things and statements about them that consider some properties and relations *in abstracto* (such as being hot(ter)) in order to construct a phenomenal structure. Then, the representational procedure takes its flight with the construction of homomorphic structures such as data models, empirical substructures, embedding and so on. But this way of proceeding digs out the ditch between the phenomenon and our representations of it.

I agree with van Fraassen that we don't need to posit the existence of a property such as 'whiteness' that exists in the snow in order to account for the truth of the statement 'snow is white'. Yet, if in presence of snow we assert that it is white, our judgement is true or false in virtue of something which is in some sense independent of us. An analysis of the nature of this 'something', of 'independence' and the kind of 'correspondence' that may obtain between our judgement and this 'something' would lead us too far astray. Such an analysis would be the aim of a full-fledged (philosophical) correspondence *theory* of truth. The correct common element to all correspondence theories of truth is that there is something out there – real phenomena at least – that is relevant to the truth and falsity of our judgements which are, as van Fraassen puts it, our reactions to what we are aware of (i.e. phenomena). In this sense, I accept that true statements, in which our correct judgements are expressed, have truthmakers, that is, corresponding real external facts that make them true.

Given that van Fraassen accepts the reality of phenomena, rejects correspondence truth and yet claims that data models represent phenomena, how does he keep in touch with reality? Abiding to empiricist tradition – enriched by some ingenious twists – van Fraassen resorts to pragmatics:

> *For us* the claims
> that the theory is adequate to the phenomenon and the claim
> that it is adequate to the phenomenon as represented, i.e. *as represented by us*,
> are indeed the same! (259)

Indeed – *for us* – it would be inconsistent to doubt the adequacy of a data model (which is a theoretical structure) to the phenomenon when the phenomenal structure is homomorphic to the data model in question. In other words, if a theory saves the appearances, then it also saves the phenomena. Of course, we might be wrong in the sense that other data gathered with, say, more powerful instruments may later be provided. This would result in another representation or appearance which may be more accurate than the previous one. Such a point is epistemological. The 'metaphysical' objection, which consists in asking if the appearance 'really' corresponds to the 'real' phenomenon hangs according to van Fraassen upon the purported possibility of bracketing the indexical aspect of a representation and putting ourselves in a 'godlike point of view' or a 'view from nowhere' and to contemplate the reality as it is *an sich*. Since we are not in a position to do that, van Fraassen confidently claims '*That (A) and (B) are the same is a pragmatic tautology*. (...) this removes the basis for the loss of reality objection' (259).

If we believe that we are prisoners of our representations, then accepting (B) and denying (A) would indeed plunge us into the hot waters of pragmatic incoherence. This would be tantamount to claiming that my data model is accurate but I don't believe it. However, I'm puzzled when I read that some elements of theoretical models (the *empirical substructures*) 'are meant to represent the observable phenomena' (289). This certainly is in line van Fraassen's previous writings: a theory primarily is a class of models some parts of which – its empirical substructures – are possibly homomorphic to data models (or, more accurately *surface* models, i.e. smoothed out data models (167)). But this doesn't seem to square very well with his new distinction between *phenomena* and *appearances*. To repeat, phenomena are *not* structures. Thus, saving the phenomena is not the same as being in agreement with the appearances, because 'the phenomena can be measured and observed in different ways' (289). In other words, appearances are various *perspectives* on the same real phenomenon.

Fair enough, but perspective does capitalize on some similarity in structure between the object and our perspectival representation of it. When discussing Copernicus's model, van Fraassen states that 'Mercury's motion is an observable phenomenon, but *Mercury's retrograde motion* is an appearance' (287). However, Mercury's so-called 'real' motion is the motion that would *appear* to an immobile observer located at the centre of Mercury's orbit (which Copernicus rightly doesn't put at the centre of the sun). Cohen's picture (288) explaining the appearance of retrograde motion seen from the earth shows in a graphic way how an homomorphism can be constructed between two structures (of course!), namely the appearances and the 'real' motion.

3. *Conclusion: Reality Retrieved*

Where does all this leave us? Let us stick to real phenomena and leave aside the debate on scientific realism which hinges on the existence of unobservable structures. What the pragmatic tautology teaches us is that we cannot, on pain of inconsistency, assert that a model represents adequately a phenomenal structure and at the same time deny that the model is adequate to the phenomenon. Simply because asserting that the model is adequate to the phenomenon is to claim that the model – for us – represents the phenomenon *as* having such and such structure. I want to bite the bullet here and submit that phenomena *stricto sensu* are *not* represented by our models. Only phenomenal structures which *we* produce or extract from phenomena can be represented. So, the target or the referent of a representation, the real phenomenon, is not what is represented, only its (partial) structure can be.

Thus, when we speak of the representation *of* some real object, our language misleads us. What is represented is what we decide to abstract from the target, not the target itself. We lose touch with reality only if we remain imprisoned in the world of representations and homomorphic putative relationships among these. (We can't follow good old Descartes who called a (philosophical) god to the rescue to regain access to reality.) We are in close contact with reality in observational acquaintance. We do see Mercury moving in the background of 'fixed' stars. And given some other truths (e.g. grounded on facts such as the trajectories of light rays) we can construct a representational relationship between appearances and 'real' motion (i.e. motion as it would appear to a special observer). Talk of representation keeps us confined to the realm of appearances, unless we forget that it is based on true statements (in which our judgements about external facts are expressed).

In fact only a verbal – not genuine – distinction between appearance and reality is to be found in science. Our theories and models remain confined to structures and representations. This is why antirealist positions, such as idealism and constructivism exert such a strong appeal in philosophy of science. Even if the development of quantum mechanics certainly helped to make this clear (at least to some of us), in classical physics already the distinction between appearance and reality is purely verbal. Empirical adequacy only depends upon the existence of an homomorphism between representations.

To conclude at last, our representations convey information only to the extent that they are buttressed by some facts and true statements that describe them. Truth is more fundamental than representation. It is only because we are in the first place able to make true judgements about hot and cold bodies, the motions of planets and the geometrical forms of objects, as well as about the behaviour of measuring devices, that we can (truly) assert that the temperature of a body is 37.3°C, that Mars revolves around the sun in 687 days and that the rectangular table-top of my desk is 113 cm × 187 cm. The indexicality of our scientific representations is not a threat to the truth of statements that describe the facts on which their success relies. In a predicative statement, we may (indeed, we must) abstract some characteristics of the described phenomenon, but this does not prevent it from really possessing some properties, a fact which can also be ascertained by other observers. At the end of the day, true statements grounded on facts attested by observation provide the inescapable basis for the success of our scientific representations.[2]

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Science without Representation

RICHARD HEALEY

Galileo set the agenda for modern physical science by requiring it to explain how such apparent features of our world as colours, sounds, tastes and smells are produced by a colourless, silent, tasteless and odour-free reality. Van Fraassen calls this the *Appearance from Reality Criterion*. He acknowledges our enormous advances in physics since Galileo's day, but argues that these have in the end come about by abandoning this along with other completeness criteria associated with necessity, determinism and causal explanation. The appearances physics (as practised and preached by the Copenhagen developers of quantum mechanics) has declined to explain are 'the contents of measurement outcomes'.

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