Symbols versus Models

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**Abstract**

In this paper I argue against a deflationist view that as representational vehicles symbols and models do their jobs in essentially the same way. I argue that symbols are conventional vehicles whose chief function is denotation while models are epistemic vehicles whose chief function is showing what their targets are like in the relevant aspects. It is further pointed out that models usually do not rely on similarity or some such relations to relate to their targets. For that referential relation they reply instead on symbols (names and labels) given to them and their parts. And a Goodmanian view on pictures of fictional characters reveals the distinction between symbolic and model representations.

Key words: symbol, model, scientific representation, reference, denotation, conventional, epistemic, pragmatic

**1. The Differences Between Symbolic and Model Representation**

We humans, and to a lesser degree our animal brethren, use languages to represent their environment. And, for example, nouns are used for things and events, verbs for actions, and adjectives and adverbs for how things and events appear and happen. The vocabulary in a language essentially comprise symbols, either simple or composite, and the symbols, themselves physical things of a certain sorts – configurations of sound patterns in a medium or markings on a surface – are related to their target objects by their users through the force of convention and/or habit.

In linguistics or in philosophy of language, the issues about representation are dealt with in semantics or theories of meaning. A word can be used to represent a particular object or event when its meaning is fixed and known by the people who use it. Here are a couple of widely acknowledged theories that are relevant to the subject of this paper, controversial though as they are. The traditional “intension-extension” theory of meaning tells us that a word, such as “Plato” or “water”, is accompanied by an intension, which is a sort of abstract object that contains the defining characteristics of the thing it is used to pick out or refer to. Whatever uniquely defines Plato, the person, or water, the substance, is in the intension. And then, the intension determines the extension, which is the set of particular objects the word is used to refer to. Linguistic competence is judged in terms of knowing the intensions and being capable of using them to pick out the particulars in the extensions. The rigid-designator theory of meaning, on the other hand, gives us a different account of the meaning of a word. The reference of a proper name is not determined by the defining characteristics of the object(s); it is determined instead by the “christening” of the object(s) with that name, such as “Samuel Langhorne Clemens” was given to a person by his parents, who later gave himself another name “Mark Twain,” both of which refer to the same person in virtue of the two events. The event of giving the name to the object causally fixes the reference relation, while the intension part, if it still makes sense, is subject to epistemic or social variations. And since the distinction between analytic and synthetic statements can no longer be held strictly (à la Quine’s “Two Dogmas” (1953)), the distinction between what belongs to meaning (i.e. intension) and what belongs to knowledge is thereby non-strict. Reference relations between proper names and natural kind terms and their referents, at least, are determined by causal processes of naming and propagation, while intensions of senses may change alongside with our changing beliefs about the referents. For instance, “water” refers to water, the substance, because it was demonstratively given to it and despite the change of intension of the word over the years, such as from being a odorless, colorless, and so on liquid to being made of H2O molecules.

This brief and rough sketch of how words (or linguistic symbols) represent bits of reality is sufficient, I hope, to provide a backdrop for our discussion on how scientific models represent, if they do (cf. Jackendoff 2002 and Soames 2010). To continue, I shall begin with the assumption that models do represent or are representational vehicles just as words are. Models *prima facie* do not represent in the same way that words do. The equestrian statue of Marcus Aurelius in the Musei Capitolini in Rome is certainly a representation of the Roman Empire of that name, but it doesn’t represent him in any obviously similar way the name “Marcus Aurelius” represents him, which is a typical example of symbol representation.

Linguistic representation, or language, is but one way of using symbols to represent bits of reality for practical purposes, such as communication and record keeping. People as well as animals employ all sorts of objects to stand in for other objects or events that are either inaccessible or difficult to access. What makes a representation job a symbolic one rather than one of modeling is not the lack of substance or physicality or structure but the lack of *epistemic* relevance of (or connection between) the symbol’s substance and/or structure to what is represented. This is in direct contrast to how models represent, for in one way or another, the substance and/or structure of models, especially scientific models, must be epistemically relevant to what they represent in order to properly play their role.

There may be general questions concerning the two modes of representation: *the symbolic representation* vs. *the model representation*, and the pragmatic virtue vs. the epistemic virtue in association with them, respectively. What exactly is the difference between the two? What exactly is the epistemic virtue that distinguishes models from symbols? And why isn’t the epistemic virtue a species of the pragmatic one?

Both symbolic and model representations include a large variety of representational vehicles and may be used to satisfy very different sorts of needs. It is not possible to give a nearly comprehensive discussion of the above general questions. However, we need to start somewhere, and here is a difference that seems to hold in most cases. It is true that the very same object can be used symbolically for one purpose on one occasion and as a model for another purpose on another occasion. And yet, when something is used symbolically, it is primarily used as a label to pick out the thing it represents, while the thing it picks out could be an object, an event, or an aspect of either. It is always the thing rather than its features that the symbol is used to pick out. The opposite is the case when something is used as a model. The object as a model does focus out mind on the thing it represents, but rather than picking out the thing for us to consider, it represents the thing as its surrogate in such a way that we can study or show aspects of the thing that the model represents not from the thing but from the model. In other words, symbols *present* (or *refer*), while models *represent* (or *depict*), their target systems. In being a vehicle for showing what the represented is like, a model fulfills its epistemic function and thus becomes an epistemically relevant vehicle, while a purely symbolic one is not.

This is part of the idea I have developed elsewhere in opposition to a deflationist view on scientific representation (of which models are the main examples). The view, recently articulated by Callender and Cohen (2006) (see also Teller 2001), takes models to be conventional vehicles as well, regarding them as essentially no different from symbolic vehicles.

**2. Representation and Reference**

In the literature on models it is frequently acknowledged that models, unlike theories, are not truth-apt, meaning that they are not the sort of things that make sense to be regarded as true or false. And this non-truth-aptness has even occasioned speculations on the ontology of models (cf. Godfrey-Smith 2006, Frigg 2010, Contessa 2010, Levy 2012). However, words or other sorts of symbols are not truth-apt either, and since models in our general scheme of representation should be compared with words rather than with sentences, the problem cannot be about its non-truth-aptness. Perhaps what is meant is that unlike words, models do not have meaning or at least do not have normal semantic meaning. Let us use some simple examples to explore this point. Take Rutherford’s model of hydrogen atom or Boyle’s model of ideal gas and think about how we use them to communicate our thoughts on hydrogen atoms and diluted gases. The following statements or the like may be found in science textbook.

1. In Boyle’s (ideal) gas model for diluted gas, molecules have negligible sizes.

2. The average kinetic energy in Boyle’s gas with temperature T is …

3. Rutherford’s hydrogen atom structurally resembles a one-planet solar system.

If we don’t reflect on what these statements are really saying, we may find them perfectly sensible; but upon reflection it is not difficult to see that they do not make good literal sense. There are no molecules in Boyle’s *model* of diluted gas nor is Rutherford’s model of hydrogen atom an atom. Only the gas and atom that the models represent have molecules or structures; what their models have are “stand-ins”. The stand-ins may also be physical objects and have their components and structures, but these are not what are stated in the examples.

It is interesting to observe, first of all, that such mistakes, if they are indeed mistakes, would never occur in the use of symbolic vehicles for representation. The following examples should illustrate my point.

4. “Socrates” is Plato’s teacher.

5. Socrates’s name is full of wisdom.

6. The Statue of Liberty is what Americans value the most.

The superficial reason for this difference between the symbolic and model representation is obvious. A symbol does not have to be related to its target by any other relations except the recognition by its users upon agreement or habit that it is such a symbol, while a model usually possesses, or perhaps should possess, some additional relations with its target. The most commonly recognized relation for a model is the resemblance relation (in the broadest sense of it) that it holds to its target.[[1]](#footnote-1) It is not helpful to give a philosophically neat characterization of what such a resemblance relation may be, it suffice to say that it is a relation that allows the users of a model to obtain information about the target without having to examining the target. For instance, even though one cannot say literally that one will find, and can examine, sub-atomic particles inside a hydrogen atom, one can at least find and examine their stand-ins (i.e., those that resemble) in Rutherford’s model, whether they are abstract entities or physical replicas, so that one may learn about the atom’s interior. On the contrary, one can neither find Socrates nor any stand-ins, abstract or concrete, of Socrates in the concatenation of ‘S’ ‘o’ ‘c’ ‘r’ ‘a’ ‘t’ ‘e’ ‘s’.

This difference also illustrates the difference between having an epistemic dimension and virtues therein and having only the pragmatic dimension and its virtues. Models have a pragmatic dimension as well. The users who construct models usually determine pragmatically what information they want to get out of them; and since pragmatic purposes can be of diverse kinds, the resemblance relations tailored to such purposes may also be radically different one from another, which accounts for the diversity of the resemblance relation between models and their targets. But whatever pragmatic concerns one introduces to fix the resemblance relation, the relation must be present to make a model work, and that is the epistemic dimension that symbolic representations emphatically do not have, as the above example shows.

This difference explains why the mistakes in the above examples about models may occur and what they say about the nature of modeling. Statement 1 seems to be most unambiguously mistaken because it appears to be explicitly talking about the molecules in Boyle’s model, while there aren’t any molecules in the model even if the model does represent systems that have molecules in them. Some philosophers think not only that there are no mistakes there but also that it is true. If we think of Boyle’s model of diluted gas refers to an abstract or a possible system of gas, then the molecules refer to the basic components in that system and it is correct to say that in that system, not in actual gas, molecules are of negligible sizes.

There is a venerable tradition that goes back at least to Ron Giere (1988) and Frederick Suppe (1989) that takes models to be physically possible systems. According to this view, within a theoretical framework concerning certain types of physical systems, most statements are about the models, not directly about the actual systems that the models are thought of as representing. In this sense, Newtonian mechanics is about configurations and dynamics of Newtonian models, which includes frictionless planes and ideal pendulums and point-mass planetary systems. There is a problem of whether the idealization, such as neglecting friction or making planets or molecules sizeless, makes the model components physically impossible. But it is not impossible to conceptualize such components not as ontologically frictionless or sizeless (having value 0 for the magnitude) but as having friction or size but with vanishingly small quantity such that it is mathematically equivalent in treating them as frictionless or sizeless. And that may make the problem go away. However, there is another more serious problem. Treating models as abstract entities may be ontologically unproblematic, for we may be said to have been using abstract entities to represent real things in our theories or histories or other genre of writings for as long as we’ve been producing them. Even if one does not like the idea that the reader of Boswell’s *Samuel Johnson* encounters in her reading an abstract entity – the character named Johnson in Boswell’s narrative – that represents the real Samuel Johnson, one has to accept that it is a coherent idea. However, it would be a great stretch to think of this Johnson character as a physically possible person, who exists in an non-actual world. Suppose one is a realist like David Lewis and believe that this possible person actually exist in one of the non-actual possible world. Then Boswell’s tale is about this person, not about actual Johnson; but is that what Boswell was doing in writing Johnson’s biography? Can it be right for us to think about all biographies in this fashion? I think the answer is obviously “no.” And Suppose one is not a realist and think of Boswell’s character as simply what the actual Johnson *could have been*. But that is an even more unreasonable interpretation. The created character in Boswell’s book, though inevitably idealized, is about the actual person, not about another possible real person or the person he could have been but is not.

Hence, it is not a good idea to think of models (as representation vehicles) as physically possible systems; Taking them to be abstract entities is less problematic, and some people even think it a better idea to just regard models as actual physical things that are employed to represent other physical things, e.g., a copy of the Crick-Watson DNA model is a physical thing that is used to represent a whole bunch of other physical things, i.e., all the DNA molecules, via a relation of resemblance (cf. Goodman 1976; Rowbottom 2009). Still, a drawback of the abstract-entity approach is that it makes the representation relations in modeling quite mysterious. How is these abstract objects we call models relate to the particulars that occupy space-time regions? If our theoretical claims are all about models, abstract possible entities, and our experimental claims are all about actual particulars we encounter in real world, what sort of claims can relate these two realms and what sort of theory of truth can bridge this wide gap between the abstract and the concrete/particular? Note, the ordinary notion of truth in semantics doesn’t apply here, for it applies in this tripartite representation relation only to the first pair, between the description and the models, not between the models (which are non-truth-apt) and reality. This is by no means an impossible task and valiant efforts have been made in bridging the gap, some of which might be regarded as quite reasonable and successful (see again Godfrey-Smith 2006, Frigg 2010, Contessa 2010, Levy 2012). The point I want to make here is to register the magnitude of metaphysical cost that such an approach takes on.

Looking at statements 2 and 3 above we couldn’t help but notice that it is ambiguous whether it is the gas or atom or its model that is referred to in the sentences. “Boyle’s gas” and “Rutherford’s hydrogen atom” could certainly mean Boyle’s model and Rutherford’s model; but they could also mean the gas or the atom described or represented by Boyle’s or Rutherford’s model, respectively. In other words, a full rephrasing of the statement 2 may run as follows.

2’. The average kinetic energy of diluted gas with temperature T in accordance with Boyle’s theory of gas which includes his model is...

Here, we do not have to think of Boyle’s model as any sort of abstract object; it is rather part of Boyle’s theory of gas and it is loosely definable by descriptive statements about the configurations and dynamics of actual molecules in a system. Given this option, we can certainly extend the same treatment to the other two statements. Statement 3 can be rephrased to something as follows.

3’. According to Rutherford’s model, the hydrogen atom structurally resembles a one-planet solar system.

Here, neither Rutherford’s model nor a one-planet solar system refers to any real but non-actual system. They are ordinary predicates depicting sets of conditions that may or may not obtain. A Rutherford’s hydrogen atom is just like a one-planet solar system, it is an atom that exists in the way in which Rutherford’s model says it exists, just as a one-planet solar system is a solar system that has only one planet. Similarly, statement 1 can be rephrased as follows.

1’. According to Boyle’s model, molecules in diluted gas have negligible sizes.

True, a fair amount of idealization is involved in this statement because of the idealization evoked by Boyle’s model (which is why it is known as the “ideal gas” model), and yet there is no question that the word “molecules” in the sentence refer to the real things rather than to the stand-ins in the model. And if molecules in diluted gas have sizes that are by no means negligible, statement 1’ as well as statement 1 are still true, but Boyle’s model is seriously flawed. We would not want to say in this situation: no, Boyle’s model is good, and the statement is also true, but “molecules” in both statements refers not to molecules but to the stand-ins in Boyle’s model.

To summarize, whether or not one embraces a realist ontology for models, the following fact does not seem controversial. The construction of models helps to insulate to some extent those who use them from the actual world they aim at studying. And yet claims regarding this world have to be made with the help of the models and tested against experimental findings. Whether we take the claims as mostly about the behavior of model components (as e.g., abstract entities), which would make these claims semi-analytic in nature, or as about the real things that the models as stand-ins represent, which would make the claims fully empirical/synthetic, there has to be a clear notion of representation that specify the main representational relationship between models and reality. In the former, the question is how the abstract systems as models relate to actual systems, and hence how claims about models and their components get to be translated into claims about components of actual systems. In the latter, the question is how the claims about real systems in accordance with idealized models may be legitimately regarded as true or false. In either case, the investigation into the nature of idealization and approximation plays an important role. In the former case, claims are literally true or false, but only true or false with respect to the model systems; and yet such claims tell us in an approximate way what the real systems the models represent are like. In the latter case, claims are almost never literally true (or always literally false), and yet they can be seen as approximately true. A theory of approximate truth as part of philosophy of language should occupy the center stage in this approach.[[2]](#footnote-2)

**3. How Symbols and Models Work Together**

Maps have always been considered a typical sort of models for spatial regions, but unless we are thinking about some special ones that aim at showing geographical details, maps are usually abstract geometrical representations of spatial configurations of, e.g., streets and buildings in cities or towns. For some maps, such as the subway map, any notion that it is similar to the actual subway system it represents is far fetched. How does a map represent and how does such a representation function in the practical scheme of map uses? Another interesting fact about maps in connection with the discussion of scientific models and representation is that it puts serious doubt into the idea that a similarity relation between a model and the modeled is necessary for modelhood. Unlike surface maps of a city (including bus routes), which show some attempt at representing the geography of roads and streets, the subway maps usually do not show any substantial relationship between the geometric patterns and the tunnels, rails, stations in the system other than isomorphism, and such isomorphic relations as we find in subway maps can hardly be regarded as relations of similarity.

Now if maps, especially subway maps, do not bear similarity to the regions they represent, how does one know which region is represented by which map? How can one recognize a map is a map of such-and-such a city or town or subway system? A moment’s reflection on how a map of New York City, for instance, represents the city reveals a simple fact: if we remove all the names of places in the city from the map and give it to someone who frequents NYC but has never used a map of it before, it is unlikely that the person will recognize it as a map of the city. This is so primarily because of the following reasons. (1) Without ever using a map to guide them when they go around in a city like NYC, few people can have in their heads an overall idea of the “geometry” of the city and its internal parts. (2) The highly simplified geometrical relations among lines and dots on the map do not in any sense resemble the impressions and memories a person would form by going around neighborhood to neighborhood. (3) Most overall ideas about the city we have are actually the results of seeing or using a map of the city (or of a similar city). Using a map may just be the easiest way of forming a conception of the geography of the city as a whole. (4) People, who are familiar with the city but have never seen a map of it, may be able, when consulted, to point out local mistakes in a badly made map, but it is very unlikely that they can point out the overall mistakes. Without names on a map to identify places in the city, it is scarcely possible to identify which city it is a map of; and this is even more so with subway maps. And this is certainly not unique to maps as representational vehicles!

To generalize, what identifies the target system that a model represents – *what fixes the referent*, if you will – is not the features the model has, but rather the name of the model and/or names it contains. The names as symbolic vehicles are the determiner of WHAT is represented. The geometrical patterns in a map are HOW it – the WHAT – is represented. And the “how” in principle does not need to serve the purpose of identification or denotation, and that’s why it is a mistake to think that somehow it must be the similarity relation between a map and a region that makes the former a legitimate representation of the latter. Depending on the sort of maps we are dealing with, it is quite possible that it is in fact impossible to identify for what the map is intended unless names and/or labels are attached to it. Whether or not this is also true with other model representations is a question I shall attempt to answer below.

**4. Reference (or Denotation) in Representation**

Depending on the purposes that a model is used to represent its target, which usually includes both epistemic and pragmatic purposes, models in general only represent a very limited number of aspects of its target. Maps as we discussed above are usually only used to represent *selected* geometric features of a region. A simple model for the solar system only represents its astronomical aspects, not the physical ones. Even if a model is constructed to give a vivid representation of something, a reproductive cell for instance, there is always a large number of aspects of the real thing that the model is not and cannot be made to represent.[[3]](#footnote-3) This characteristic of modeling explains why it is not a good idea to use the notion of “similarity” as anything close to a necessary condition for modeling. It is a necessary requirement that a model can be used to identify its target, and yet if I am right in the above analysis, identification or denotation cannot be done by examining the structures the model exhibits. It is through something else, through the names attached to the model and its parts, which bear an entirely different relationship to the target and its parts.

We cognitive agents get to know – having epistemic access to – things and events from different perspectives, different levels, etc., and it is for the purpose of knowing these different aspects that we often construct models to represent things/events. Therefore, models are necessarily “one-sided.” The sides we want to get a grip on through a model, we institute some sort of resemblance relation to approximate those aspects, but we don’t care what the models are like in those aspects that we do not intend for the model to represent. That is why we may use wooden balls for planets in a solar system model, but we wouldn’t want to use a snake-like twisted long stick to represent earth or any other planet in the model. An expert on Mars’s soil wouldn’t necessarily regard the “Mars” in an astronomical model of solar system as resembling the planet and, if she has never seen one, may not necessarily be able to tell, upon seeing a first-rate museum quality model of solar system, what it represents *if there is no names attached to the model*. Does it not often happen that when we walk in a science museum and see various models on display, we often wonder what this or that model represents while bending over to look at their labels, and then say to ourselves or our companions or both, “oh, that’s what so-and-so is like”?

Hence, a conceptual separation between the identification/denotation function and the exhibition function of a model should be clearly made, and under some circumstances, what plays the latter role cannot be thought of as also playing, even if partially, the former. Although this should be a sound conceptual distinction, I do not mean to imply that there are no borderline cases, where certain features of a model serve to name and some features of a name or sign serve to model. But be that as it may, the distinction is especially important with regard to the model representations of essentially unobservable systems[[4]](#footnote-4) in nature. Roughly speaking, all those models that represent the typically unobservable systems or events in reality must depend entirely on the names that are attached to them to fulfill the reference purpose. Their structural features only show us the conceptually relevant structural features of their targets, but since we have no independent access to those features (other than the effects that they supposedly produce and that may be observed in experiments), we often cannot use such features for reference/denotation.

In the first chapter of Goodman 1976 we see an early version of how reality is remade that was later expanded into Goodman 1978 on “ways of worldmaking.” The main problem Goodman dealt with there is this: how could a painting (or any other artistic representation) represent its target without possessing some definite type of relations that is necessary and sufficient for the task? Goodman’s demolition job on similarity[[5]](#footnote-5) being such a relation is so thorough and complete that one wonder why we still find discussions on this issue in the recent literature on scientific models. Also, similarity isn’t relevant even when it makes perfect sense to distinguish realistic representations from unrealistic ones, because it is by no means true that the closer a painting resembles overall its subject, the more realistic it is as a painting (hence the irony of surrealist or superrealist art works). Now a natural questions arises: how does one know whether a painting that looks like a portrait of P is P’s portrait rather than Q’s, while Q is the (identical) twin brother of P? Further, what do we say in the case where the painting in question is a portrait of P but the figure in it resembles Q more, where P and Q do not look alike? Even more troubling are the following cases. A painting of someone is by default more similar to another painting of her (perhaps by the same artist), or a photograph of her, than to herself. Should we then say that it is a painting representing the painting or the photograph rather than the person? Obviously, such objective relations between the representation and the represented are not really pertinent when it comes to the identification or denotation questions. When such questions are asked, the answers often lie somewhere else. Names added to paintings or sculptures often provide definite answers. A painting with the name “Duke of Wellington” on the frame must be, all things being equal, a portrait of the Duke rather than his brother, and so is a painting that bears the name “Marlborough Castle,” the painting of the Castle rather than of another painting of it, even if they resemble somebody else or some other castle more, respectively.

This is of course not Goodman’s answer, nor would it be mine if we are talking about representations in general: everyday, artistic, scientific, etc. Attaching names and labels is not the only way the reference of a representation is determined; however, given what I have argued above, the answer is close to the simple observations, namely, when it comes to the determination of reference or denotation, some *conventional* means must be present to get it done, whether it is a name or a label or some tacitly understood signs or a “christening” of the model itself. Again, as I argued above, in the business of representation (in general), what and who is shown is conceptually distinct from how it is shown or it is shown to be a what; the former is symbolic and fully conventionally, while the latter is not; it is epistemologically.

Habits and histories may have made the denotation questions about artistic or everyday representation complex, but the somewhat unique culture of science and technology makes denotation less subtle and more definite. This is not to say that words are not important for other representation vehicles. On the contrary, if the artist is trying to play a practical joke on the Duke of Wellington by painting a portrait that resembles his brother, the best way to make the joke is to put “Duke of Wellington” at the bottom of the portrait. In fact, none of the referential tricks that pictorial means of representation can be used to play could be made explicit by another pictorial means. They are either made clear by tacitly understood situations or explained in words.

**5. Along Goodman’s Further Insight**

Goodman (1976), in developing his conception of “Reality Remade,” chooses the problem of representation in fiction to illustrate his idea of “representation-as.” To the apparently troubling question of what a portrait of Mr. Pickwick really represents, Goodman answers: nothing! There isn’t anyone, or anything, in reality that the name “Pickwick” is supposed to pick out or refer to, and so the portrait of Mr. Pickwick represents nobody. To resolve this apparent problem, Goodman argues that a portrait of Pickwick is best construed as a “Pickwick-representing” sort of picture, the sort that has the property of being Pickwick as given in Dickens’s novel, *The Pickwick Papers*. A similar and ordinary case of such a picture is one that is for example an “orange” picture, which is a picture of an orange that does not refer to any actual piece of fruit but is a picture of a *kind* of fruit we regard as oranges. Fictional characters are created by pure description, and therefore they exist as pure descriptions, which are analogous to descriptive kind-terms. If Ψ is the complete description of Pickwick (which we can presumably extract from *The Pickwick Papers*), a picture of Pickwick is then a Ψ-picture rather than a picture of Ψ.

Difficulties abound for this solution to the reference problem for fictional objects. Mr. Pickwick, though a fictional character created by Dickens, is not limited to what is actually written in the novel; it is rather an individual that actually exists in the world of pretense, namely, if we suspend our disbelief of the world Dickens created in *The Pickwick Papers*, Mr. Pickwick is a fully fleshed individual in there (cf. Walton 1990) And this is so whether Dickens’s description Pickwick is detailed or sketchy. For instance, even if no mentioning of his nostrils is to be found in the book, Mr. Pickwick is supposed to have them, and to have many other body parts, big or small, which are not mentioned. However, if Ψ is the complete description of Pickwick found in the novel, and nostrils or fingernails are never mentioned there, a portrait of Pickwick as a Ψ-picture is not supposed to have nostrils and fingernails, for otherwise it is not a portrait of Pickwick *qua* “Pickwick-picture” in Goodman’s sense.

This and other difficulties of the view aside,[[6]](#footnote-6) Goodman I think correctly located a key joint of two separate parts of representation, which is particularly well suited for our understanding of scientific models. And it matches well with my earlier argument for the conceptual distinction between symbolic and modelistic representations. If Goodman is right, for fictional characters and events, it turns out that the symbolic refer to nothing while the models represent a type, such that a model with a label (or name), just like a portrait of a fictional character or event, may well be an artifact that shows a certain stable pattern or structure (analogous to a predicate) and does not necessarily represent any particulars. In his language, what works is the separation of the part of representation as “representation-as” from the part of representation as “denotation.”

The denotation part is important because the identity of the target of a painting or a model could be vitally important for many cases of representation in arts and sciences. But the representation-as part is more important because it is important to all cases of representation. Unlike in the case of purely symbolic representation, where the second part does not exist, the point of a painting or a model, if it is taken to be a vehicle of representation of a target, is to show or represent its target *as such-and-such*.

Again, the lesson we learn from Goodman’s articulation of this particular joint of two essential components of modeling is that the task of denotation and that of representation-as are also separate in scientific representations. A model denotes not by its substance or structure but by the labels (or names) it and its parts bear; and once the reference relation is thus established, the model shows us what the system it refers to *is like* (in the broadest sense of this phrase). So, for instance, the hydrogen atoms are “Rutherford’s model like.” The latter is an epistemic virtue because in many cases, cases where we as cognitive agents can never become acquainted with the target systems *as represented* in the models, models are the only things we have that show or display the targets in the aspects our theory (of which the models are a part) focus on.[[7]](#footnote-7)

In his “Models and Representation,” R. I. G. Hughes (1997) gives an attractive account of the subject, which he calls the DDI account (Denotation, Demonstration, and Interpretation) and which has been widely acknowledged. A vivid example is used to illustrate the working of this account, which recounts how Galileo uses a geometric model to solve the problem of the distance of a free falling body in a given time interval. Galileo first transforms the phenomenon of a body’s free fall into a geometric figure, and then geometric demonstration is carried out without referring back to the phenomenon, and lastly the result of the demonstration is “interpreted back” to the phenomenon and thus solving the problem. I have little problem with the second and the third part of this account, but the first, the part about denotation, needs a closer look. It is difficult to miss at the outset that a more natural way of talking about this step, as clearly shown in this example, is of “translation” or “transformation” rather than “denotation.” The path of the free fall is translated into a vertical line in Euclidean geometry. The line may be regarded as “denoting” the path, but the first step or process of model building in this case is more like transforming the latter into an element in geometry than looking for an element in geometry to “label” the path. More generally, the first step of modeling in general is better rendered as translation or transformation rather than looking for symbols or labels. Hughes’s own way of introducing the notion of denotation for this first step is less than convincing. Correctly rejecting an objective relation of similarity as constitutive of denotation, Hughes suggests that we borrow Goodman’s notion of denotation in Goodman 1976 (the chapter I discussed above) and think of models (in general) as symbols of physical systems, as something that refers to them.

Returning to the above analysis of how they refer to or denote the target systems, we can readily see that models as objects, abstract or physical, are not used as labels or names that secure the reference/denotation relations. Denotation is accomplished in general by the names or labels that are attached to the models. In the Galileo’s case, no name for the model is necessary because his geometric model is made solely for the problem of locomotion at hand. If this model had been made for a type of problems of locomotion that includes many different looking scenarios, a name would have been given to it and the geometric element is securely hooked to those problems by the rigid-designating function of the name or label. Galileo’s geometric model does not “denote” the problem; it *reveals* its relevant structure by striping away (or idealizing away) those physical aspects of the phenomenon that are irrelevant to the problem. So, the first step is in essence a step of transformation in terms of idealization, not a step of getting the problem hooked up with an element of geometry by conventional denotation. Name or label searching that results in the fixing of denotation would become necessary if Galileo were thinking of making his model one for a general type of problems in locomotion.

One obviously should not miss the fact that idealization often accompanies the first, while approximation the third, step of the DDI account. When the phenomenon in the Galileo example is transformed into a geometric problem, irrelevant aspects are “idealized away”. At the end of demonstration, the second step, the result does not in fact match the phenomenon: the distances of two actual movements, which are equal in their geometric model, are in fact not equal. Considerations of approximation must be introduced if the result obtained in the model is to be “interpreted back” to the phenomenon. And this, it can be argued, is a general feature of modeling.

If this is true, a separation of denotation/reference function and a function of display or show becomes obvious. No idealization is necessary for the purpose of referring or denoting; A symbol, with a few exceptions, does not have to be a result of idealization of any sort to serve its purpose; and that applies to pictorial vehicles as well if they are use as symbols. The Statue of Liberty cannot be taken as an idealization of liberty nor can it as one for Americans. And that is why looking all we can into the physical properties of the Statue, it will not yield any results that inform us about the nature of liberty, unless heavy metaphorical machinery is applied to the inference. And a similar conclusion holds as well for linguistic items such as words.

To summarize, I am by no mean arguing, in my criticism of Hughes’s notion of “Denotation” in his DDI account, that it is not possible that the users of a representation vehicle can never on account of its physical structure use it as a purely symbolic vehicle, nor do I think that it is impossible to use a “showing-how” vehicle as one for “showing-that” instead. The point is that the two jobs are conceptually distinct in that one is done by purely conventional vehicles and the other by primarily epistemic ones. Which physical thing can be used to do which job is an entirely different issue.

Of course, not all symbolic representations are like the alphabetic systems in some of world’s major languages. Hieroglyphics or pictograms may be seen as representational vehicles whose actual patterns matter in whether they can be the “labels” of things or events; and there are specialized symbolic vehicles in scientific and other communities that explicitly use the surface physical structure of the symbols as representational marks. The thesis I argued above that separates the symbolic from the “modelistic” and claims the necessity of using symbolic vehicles in models to secure the referential or denotational aspect of modeling does not seem to apply to such vehicles of representation.

I have not argued for the *actual* separation of the symbolic and the modelistic, only for their *conceptual* distinction, and also that they in fact exist separately in many languages and models. Scientific models are typically not like the hieroglyphic or pictographic vehicles, if such pure vehicles actually exist and can do their jobs in providing useful representations to actual communities of cognitive agents. There was a time in the distant past when humans used a pure form of pictograms where the “-gram” for an object is also a picture of it. The fact that in order to transform such a system of pictograms into a full-fledged written language, the “picture” function had to be given up and the system of pictograms had to be expanded into a purely symbolic form supports the point about the distinction between the symbolic and the modelistic. And the recently developed evolutionary explanation of the emergence of languages also indicates that the separation is a strategy of labor-division that favors survival (cf. Jackendoff 2002; Nowak 2006).

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Points to be covered:

1. Symbolic representations have structures and physicality, but they are irrelevant to the features of the represented; they are selected for the convenience of use. Model representations are the opposite; the detailed structure is what is epistemically sought after.

2. SR is primarily for labeling, for picking out the represented and getting them to be talked about. What is talked about is the represented, not the representation. MR is more complicated as representation. What is talked about literally are the features of the vehicles, but somehow the such talk is also supposed to be RELATED in a major way to the talk about the represented.

3. The key to understand how MR represents is to see that the reference is fixed by the name of the models or some such understanding of the models, while the features are studied within the models.

4. This is why MR is more like how historical fiction represents reality.

5. When we consider how models represent their targets, we have the problem of thinking whether it’s the name of the model or the model itself that serve in our discourse for saying something about the real system.

6. The reason why the name of a model is for fixing the reference and the model is for showing the features of the referred in some other-worldly manner is analogous to actors playing parts. There may be poor acting that without the name identification would not be recognizable as playing the intended part.

7. Symbols also has some degrees of invariance for its physical realizations: words can be put in different physical shapes and yet they are invariant among those. But the invariance of symbols is different from that of models. The invariance of symbols is for pragmatic purposes, while for models is for epistemic purposes.

1. To avoid confusion and be precise, I shall in this paper use “resemblance” as a technical term that really means “partial resemblance” or the sharing of at least one aspect between the representing and the represented. I shall use “similarity” as a technical term for “overall resemblance,” which means sharing enough aspects such that the users of the representations can recognize what are represented though such resemblances with reasonable ease. Most of the argument against resemblance as constitutive of representation in general is in my term directed again similarity. Nobody denies that when representation is present, partial resemblance of some sort is always recognizable. [↑](#footnote-ref-1)
2. In this discussion we assume that idealization makes sense with regard to model-building for unobservable (or not directly observable) systems, such as Rutherford’s models. If this assumption is challenged, and there certainly are good reasons to challenge it, a different conclusion results. This alternative is discussed in another paper. [↑](#footnote-ref-2)
3. A selected live specimen of some organism may be justifiably regarded as a model for the type of the organism (or perhaps even a larger category of organisms); and in this case, the model is one of the actual things that “represent” the things of its type, much like a senator representing her kind in her district (cf. Goodman 1976; Rowbottom 2009). Whether or not this case constitutes a challenge to what is said in the above statement is a question that cannot be discussed in this paper. There is in fact a plausible defense for the idea that all models are essentially artifacts that represents their targets in selected aspects. When an actual organism is selected as a representation, some of its actual aspects are ignored to make it an artifact. [↑](#footnote-ref-3)
4. One should not get hung up on the notion of unobservable systems used here. I shall not get into the realists vs. anti-realists debate on this notion. It suffices that we go with the scientists to regard some systems as obviously observable and some as typically unobservable, while acknowledging that borderline cases abound. If one really wants clear-cut cases, one can think of the absolute space and time or ether or angels (if there are any) as the unobservables, which could all have models to represent them. [↑](#footnote-ref-4)
5. See footnote 1 for the usage of “similarity” and “resemblance” in this paper. [↑](#footnote-ref-5)
6. See Thamasson 1999 for a realist theory for fictional objects that takes names of fictional characters and events to be real things, and therefore avoids the difficulties we counter with Goodman’s approach. [↑](#footnote-ref-6)
7. Here I am primarily talking about pictorial models, such as paintings, sculptures, mechanical/geometrical models, computer simulations, as well as maps. Some people in the literature on scientific models include mathematical equations or even descriptive narratives as examples of models. With description, the case is very different and a separate treatment of modeling is required. Some authors believe that a pictorial model can also be given by a set of sentences that describe it, which is true enough. However, that is different from a descriptive account of some physical system. For instance, instead of evoking Rutherford’s planetary model of hydrogen atom, one gives a descriptive account of what the hydrogen atom is like. It may contain sentences say that the electron of the atom revolves around the nucleus in a similar manner as a planet in the solar system revolves around the sun. There is an analogy but no imaginary elements in this narrative. The word “electron” refers to the real electron in the atom and so does the word “sun”. The truth-maker of this descriptive “model” would be facts about the hydrogen atom and the solar system and the strength of the analogy, end of story. [↑](#footnote-ref-7)