# Modeling Cognition: How Fiction Relates to Fact

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## Abstract

The increasing use of computational modeling and simulation methods offers interesting epistemic and theoretical challenges for the philosophy of science. One of the main questions discussed in the philosophical literature relates to the explanatory role of false, unrealistic and sometimes even fictional models. In this paper we argue that (i) some fictional models can offer explanations known as structural model explanations, and (ii) at least some variants of realism, such as the information semantic account of scientific models, can consistently hold that this subset of fictional models are explanatory.

**Keywords:** Models; fictional models; explanation; information semantics

## Introduction

For a philosopher of science interested in the philosophical issues of modeling, cognitive science is a wonderful source of case studies. Cognitive science utilizes modeling in a unique way, both methodologically and theoretically. The increasing use of computational modeling and simulation methods offers interesting methodological challenges for scientists, but also philosophers of science find many things of interest in the theoretical and epistemic status of modeling methods.

One of the main questions discussed in the philosophical literature relates to the explanatory role of models. A growing number of philosophers have proposed that explanation of the behavior and capacities of complex systems (such as those found in the cognitive, biological and neurosciences) does not typically involve natural laws, but specific models of particular mechanisms (Bechtel and Richardson, 1993; Craver, 2006, 2007; Machamer, Darden, and Craver, 2000). It has also been argued that this mechanistic account of explanation could be extended to cover explanations in cognitive science (Kaplan & Craver, 2011, Sun, 2008) and computer sciences, as well as computational neuroscience (for instance, Piccinini, 2007).

According to this account, to explain a phenomenon is to construct a model of how a causal mechanism - a hierarchical system composed of component parts, their properties and their causal relations - gives rise to or produces the phenomenon. Constructing an explanatory mechanistic model involves mapping elements of a mechanistic model to the system of interest, so that the elements of the model correspond to identifiable constituent parts with the appropriate organization and causal powers to sustain that organization.

The mechanistic account of explanation is a typical example of the realist interpretation of scientific models. According to realism, a model explains the behavior of a target system, if and only if it is a correct account of the target's behavior underlying observed phenomena – i.e. the model must correspond to, depict or represent the target system in a sufficiently correct way. In addition, many current realist accounts require that the target systems are actual or real – i.e. have causal power to generate observable phenomena and data.

However, models are always more or less abstract, simplified and idealized descriptions of their real world target systems. Target systems are just too complicated to be studied in a full fidelity, and thus all kinds of assumptions are made to reduce the complexity of a model. Thus most (if not all) models used in science are unrealistic. Often models are nevertheless considered useful, even if they are known to be false, and they are known to contain assumptions that are not even approximately true, but highly idealized. For this reason, it has been argued that this feature of modeling seriously undermines the realist interpretation of models. If all models involve unrealistic elements, how is it possible that they could correspond, depict or describe the real world target system in a correct or truthful way? If they do not, where does their explanatory force come from?

Sometimes models involve assumptions about fictional entities and processes that are known not to exist in the real world. These fictional models describe systems that (i) do not exist in the real world or (ii) have elements that do not exist in the real world. Obvious examples of fictional models in cognitive science are for instance the models of artificial intelligence[1]. These hypothetical (at the time of their conception) systems offer an example of modeling, which starts with explicitly fictitious entities – non-existing, imaginary cognitive systems - and then converts these fictions into the fact-like platforms from which further research can be done.

Although there is a growing consensus among philosophers that fictions have a legitimate role to play in science, traditionally those philosophers who endorse realism have denied that fictional models could explain. For a realist, the main obstacle to admitting that also fictional model can be explanatory is that it is difficult to imagine how a model without an existing target system could be explanatory. Instead, fictional models have been treated as, for example, only tools for generating and calculating predictions.

However, it seems to us that for example the models offered by AI are more than mere "tools for prediction". That these fictional models can be converted into real working systems does require that they get some principles of cognition "right" (a fictional AI model that is completely *unrealistic* has little hope of successful implementation). And they do seem to work more like blueprints or instructions for a design than simply devices for predictions. Not only do they offer structural information about the constitution of a model system, but they also restrict and guide the construction process itself – and not in an arbitrary manner.

For this reason it seems intuitively plausible to think that these models do hold a potential to represent or explain something about cognitive systems. In this paper, we argue that (i) these models explain by showing how the structure of a model limits what sorts of objects, properties, states, or behaviors are admissible within that model, and they offer explanations known as structural model explanations (Bokulich, 2008, 2009). In addition, we argue that (ii) at least some variants of realism, such as the information semantic account of scientific models, can consistently hold that this subset of fictional models are explanatory. However, (iii) whether or not a fictional model can be explanatory, depends also on the relationship of the fictional models and the real world[2].

## Requirements for Realistic Interpretation

Scientific models can be interpreted *realistically* and *instrumentally*. The instrumental interpretation, roughly, holds that scientific models are *instruments for generating predictions about the system´s behavior.* According to the instrumentalist interpretation, the models are only used to produce predictions, and the question whether or not models are realistic or unrealistic, does not arise.

In contrast to instrumentalism, the realist interpretation of explanatory models holds that entities/processes the model posits actually exist and that there is an objective relationship between the model and its target system. In addition, many current realist accounts of explanatory models require that the target system must be actual or real. Following Salmon, many philosophers of science agree that to explain a phenomenon is to describe the actually existing/causal processes that constitute the phenomenon (Salmon, 1984). According to this view, only descriptions of actually existing genuinely causal processes can lead to scientific explanations[3] (Salmon, 1984).

***Aboutness.*** A realist typically thinks that the relationship between a model and its target, the *aboutness* of scientific models, is essential to their explanatory power. A scientific model can *explain* the behavior of a target system if and only if it depicts, describes or represents the target system.

For example, the mechanist account of explanation is a typical variant of realism in this sense. According to it explanation involves constructing a model of such mechanisms that correctly depicts or describes the causal interactions among their parts that enable them to produce the phenomena under various conditions. The relationship between a model and its target is seen, for example, as "one of approximate similarity" (Glennan, 2000) in a way, where "the behavior of the system in nature is described (to varying degrees of approximation) by the model's behavioral description and the internal structure of the system is described (again to varying degrees of approximation) by the model's mechanical description", or as "correspondence" (Craver), because (emphasis added) " in succesfull explanatory models… (a) the variables in the model *correspond to* components, activities, properties and organizational features *of the target mechanism* that produces, maintains, or underlies the phenomenon, and (b) the… dependencies posited among these variables in the model *correspond to* the… causal relations among the components of the target mechanism" (Kaplan & Craver, 2011; see also Craver, 2006).

Following Giere (1988), both Glennan (2000) and Craver & co (2006, Kaplan & Craver, 2011) seem to think that the relationship - "the aboutness"- is some kind of similarity or correspondence relation. But as Quine (1969) pointed out, similarity is a vague notion, and correspondence is actually not much better. In order to specify these concepts, many philosophers of science have appealed various "morphisms" – iso-, partial- or homomorphisms. However, all these various morphisms, similarities and correspondences are usually discussed only intuitively and philosophically problematic[4]. They have been critized on logical and

[1] The aim of AI is not only to help us investigate the existing cognitive systems by simulating them, but also to help us to investigate and understand the structure of cognitive systems by producing or to creating artificially new kind of cognitive systems.

[2] Not all fictional models are explanatory, and some of them are useful as calculational devices, other as prototheories and some are useful in generating predictions etc., but not explanation.

[3] For example, the ontic version of mechanistic explanation requires that the mechanistic organization of the target system causally produces the phenomenon to be explained.

[4] There is a huge debate on this issue in philosophy of modeling. See for instance, Suárez, 2003; Frigg, 2006.

substantial grounds[5]. One particularly difficult problem for these accounts is the problem of relevance: a model typically cannot be perfectly "similar" or "isomorphic" with respect to every entity and every relation in the target system, since almost any target system is too complex. This implies that models should be "sufficiently isomorphic" or "sufficiently similar" to the target "in the relevant respects". However, it is quite tricky to characterize "sufficiency" and "relevance" in a non-circular and precise manner[6].

There are also some other variants of realism in which the relationship between a model and its target is defined in a different way. According to the information semantic account[7], models depict, describe, represent or are about their target systems, if and only if there is an appropriate information-content relationship between a model system and its target. The information connection is implemented in a model building process, in which data about the world is incorporated to the model i.e. the information relationship between a model system and its target is implemented in empirical data, which carries the information about the target system into the model.

***The actual existence of target systems***. As the variants of realism typically do, also the information semantic account requires the target systems must be actual or real. Because in information semantics "carrying information" is understood in terms of statistical dependence (Shannon, 1948; Usher, 2001), and statistical dependence is usually understood in causal terms, target systems must be "actual" or "real": they must have *causal power* to produce the data, which carries the information which is incorporated into the model during the model building process.

To summarize, the realist interpretation of explanatory models requires that an explanatory model (i) represents, depicts or describes the explanatorily relevant features of target systems in a "correct" way, and that (ii) target systems are real and actual. Some variants of realism, such as the information semantic account, require also that (iii) the target systems have appropriate causal properties.

However, most, if not all, models used in science are unrealistic, and sometimes even known to be strictly false because of the abstraction, simplification and idealization and the postulation of fictional entities that goes on in the model building process. This raises the epistemic problem for realism: if models include all these kinds of sources of false assumptions, how can they be explanatory? How, exactly, are these models are used to gain information or knowledge about the real world phenomena?

## The different ways to make a model unrealistic

In practice, when scientists present a model, they offer a model system[8] which is a description of a hypothetical system, and this model system is, or is thought to be, a hypothetical representation of a real world target system. These model systems are always more or less unrealistic descriptions of their real world target systems, because target systems are too complicated to be studied in every detail. This is typically motivated, rhetorically, on pragmatic grounds. If all the parameters were included in models, they would become too complicated to be understandable, tractable or useful. As McClelland (2009) puts it, "the more detail we incorporate, the harder the model is to understand."

There are at least four different ways to make models unrealistic: abstraction, simplification, idealization and fictionalization. In practice, this distinction between these types is not always entirely clear. Moreover, these classes are not exclusive. Models can, and often are, abstracted and idealized at the same time[9]. For example, a Turing Machine can be seen as an abstraction of real computations[10], because it neglects many computationally irrelevant features of computational systems, such as the material basis of the implementing mechanisms. If a Turing Machine is also defined to have properties that are not implemented in any real computational system (unlimited memory, unlimited processing time), it is assumed to never break down and so on, it also involves idealization.

*Abstraction* and *simplification* can be considered to be species of information reduction. Roughly speaking, an abstract model is the result of the process of abstraction, in which information about domain-external factors is disregarded[11] (e.g. a model of a ball rolling on an inclined plane may abstract away the color of the ball, which is not in the domain of Newtonian dynamics). A simplified model is a model, in which some domain-internal factors are given a simplified description (e.g. the ball may be considered a perfect sphere, with the center of gravity in perfectly in the middle). Although abstracted or simplified models do not describe *all* the factors, they describe correctly or approximately certain features of their target systems. Abstracted and simplified models can thus be genuinely explanatory, if they accurately depict the relevant properties of their target systems. These models tell us how phenomena behave in a simpler world than our own[12], or these models can work as surrogate systems[13] for understanding, how fundamental properties of a system

[5] See Suárez, 2003; Frigg,2006; See also Rusanen and Lappi, 2011.

[6] Suárez, 2003; Frigg,2006, see also Rusanen & Lappi, 2011.

[7] Rusanen & Lappi, 2011.

[8] The term "model system" is from Frigg (2006, 2010).

[9] See Thomson-Jones (2005) for the distinction between abstraction and idealization.

[10] See Piccinini, 2007.

[11] An abstract model is sometimes described as a model, in which *only some factors* or only some of potentially many factors of target system are included into a model system. A simplified model is a model, in which *only some factors of the potentially many factors that are relevant* to the behavior of a target system are included into a model or some factors are given a simplified description.

[12] This idea is explicated by Stephan Hartmann, but the authors did not find the article, in which this idea was presented.

[13] The term "surrogate" is borrowed from Uskali Mäki (2009).

generate or produce the certain phenomenon of interest by helping scientists to formulate correct what if- inferences.

However, philosophers of science disagree on the question, whether or not abstracted and simplified models have more explanatory power than non-abstracted models. There are at least two different views about the explanatory power of abstracted models. One of them is the so-called "traditional view"[14], according to which the more exact, more detailed, more complete and more realistic the model is, better it is. The most explanatory model is the model, which offers the complete description of the phenomenon of interest. The non-traditional view maintains that in some cases the abstracted model can explain better the dominant and significant features of the target system, because it isolates and emphasize the crucial elements in a tractable way.

The third way to make a model unrealistic is *idealization*. In idealization one is not only excluding parameters. Instead, idealization involves distorting theories or models, because at least one of the parameters of the target system is represented in a way that makes the model false. For example, if a model in cognitive science is used to analyze the processing of a perceptual system scientists may stipulate that all processing is described in the model as linear and strictly feedforward[15], even if in reality the processing would be non-linear and have backforwarding properties.

The fourth way to make models unrealistic is *fictionalization*. *Wide fictionalism*[16] states that idealization and abstraction are subspecies of fiction (Suárez, 2009). However, there are reasons to argue that models that are only simplified, idealized and abstracted representations of real entities (*about* which they make counterfactual claims) should be distinguished from those which refer to fictional entities which do not actually exist. Logically speaking, there is a difference in kind between a representation of real entity and a representation of an imaginary entity (Russell, 1905, Suárez, 2009)[17].

*Narrow fictionalism* takes it that only those models which involve or describe explicitly fictional or imaginary entities, systems and situations that do not actually exist in real world, are fictional (Suaréz, 2009). Such models do not only involve idealization, simplification or abstraction, but they are, and also known to be false, for a further reason: because they describe fictional or imaginary entities, systems and situations that do not actually exist in real world.

[14] The terms "traditional view" and "non-traditional" are from Batterman, 2009.

[15] See, for example, McLelland (2009) for a detailed analysis of simplification and idealization of this sort.

[16] About the difference between wide and narrow factionalism, see Suarez 2009.

[17] As Suárez (2009) has proposed, one way to describe the distinction is to emphasize the difference between "fictional" and "fictive" representations. A fictional representation is a representation of a non-existing entity, and a fictive representation is an inaccurate representation of a real entity (Suárez, 2009).

***Completely fictional models*** refer to model systems that do not actually exist in the real world *and do not have any real components*. It is difficult to find a genuine example of a completely fictional model in natural or behavioral sciences, because in these sciences most (and probably all) fictional models include at least some real world elements at some level of analysis.

Actually, fictional models are typically only ***partially fictional models***. Often partially fictional scientific models are combinations of real and fictional components. Sometimes these models refer to *real* target systems, but they are fictional, because they include some components or system level descriptions that are taken to represent non-existing entities. For example, the frequency components in the wavelet analysis of EEG components, which are used to explain the synchronization properties of neuron population in neurosciences are typically interpreted as non-existing entities.

Some of partially fictional models consist of realistic constituents, but the combination of constituents is known to be unreal. Some of these model systems may describe systems that are in principle physically possible, or sometimes they are physically impossible, because they violate natural laws etc. Typically these models are used to test the possible behavior of a complex system by creating all kinds of what-if simulations. An example of a model of this sort is the model of xDNA[18]. All of the components of model can be given a real world interpretation, but the combination of these components, xDNA, is unrealistic.

The study of artificial intelligence offers another example of modeling of this sort. For example, if a cognitive scientist wanted to build synthetic brains, she might end up building a model system that does not mimic or simulate any existing brains. Although the design or the computational layout of the artificial brains was novel, the model system might involve elements, which refer to real world entities, such as cells, cell organs, transmitters, or depending on the material implementation, silicon chips, batteries and so on. In addition, if the model system would then be implemented in a concrete way, then a model system of a fictitious entity would have been converted into an actual model organism.

Although the current study of artificial intelligence is not developed to that point, are already existing artificial cognitive systems examples of modeling, which starts explicitly fictitious, non-existing entities – the imaginary cognitive systems - and then convert these fictions into *the fact-like platforms* from which further research can be done. Because these fictional models can be converted into fact-like platforms, fictional models seem to work more like blueprints or instructions for a design than simply devices for predictions. Not only do they offer *structural* information about the constitution of a model system, but they also restrict and guide the construction process itself. For this reason it seems intuitively to think

[18] This example is from Michael Weisberg`s presentation in Helsinki in May 2009. Actually, as also Weisberg mentioned in his talk, there is no such a model in biology.

that these models do explain. They seem to explain by showing how the structure of a model limits what sorts of objects, properties, states, or behaviors are admissible within that model. They also show that whatever the system can do is in fact a consequence of that structure and they also offer information about how the converted system will behave *before* it has been converted

## Do Fictional Models Explain?

Alisa Bokulich (2008, 2009) has recently developed an interesting account of scientific explanation, called "model explanations" to describe the sort of explanation that is being offered by fictional models.

Bokulich (2008;2009) characterizes these model explanations as follows: First, the explanans of explanatory fictions must make a reference to scientific model, which involves some idealization and/or fictionalization. Second, that model is taken to explain the explanandum by showing that the pattern of counter-factual dependence in the model mirrors the relevant respects of counterfactual dependences in the target system. Following Woodward (2003), in Bokulich´s account this pattern of counterfactual dependence can be explicated in terms of "what if things have been different- questions"[19]. That is, the explanation must enable us to see what sort of difference it would have make to *explanandum* if the factors cited in *explanans* had been different in various possible ways. The third feature of model explanations is that they must specify what the domain of applicability of the model is and show that the phenomenon in a real world to be explained falls within that domain. If model explanations are characterized in this way, one subspecies of model explanations are structural model explanations (Bokulich, 2009).

A structural model explanation is one in which the the explanandum is explained by showing how the structure of a model limits what sorts of objects, properties, states, or behaviors are admissible within that model, and then showing that the explanandum is in fact a consequence of that structure. A structural model explanation is thus an explanation, in which the explanandum exhibit a pattern of counterfactual dependence on the elements represented in the model, and this dependence is a consequence of the structural features of the model.

It seems to us that *those partially fictional models that are combinations of realistic parts offer structural model explanations* as Bokulich proposes. For example, a model of artificial cognitive system characterizes why certain cognitive processes are possible for a certain kind of cognitive architecture, or how a possible computational structure of certain type architecture will limit its possible cognitive and computational capacities, before the system is actually implemented.

However, Bokulich´s characterization may be a bit too broad. For this reason, we´d like to add one crucial requirement for model explanations. In order to count as genuinely explanatory a model explanation must also be *credible*. Characterizing the credibility is, of course, a challenging task, and there are different suggestions in the literature. For example, according to Sugden (2000) models are artificial "worlds" i.e. "surrogate systems'", and their epistemic dimension is based on inductive extrapolation from these artificial worlds to the real world. In Sugden´s account the relationship between models and the world can be evaluated in terms of similarity; more similar to the real world a model is judged to be, more credible it is. However, similarity alone is usually not sufficient for establishing credibility[20].

For this reason, credibility considerations must be based on more fundamental claims. According to the information semantic account (Rusanen & Lappi, 2011) the credibility of a model explanation requires that there is, or it is at least possible to imagine, a causally implemented information relationship between a model and its target and a credible data gathering method for that particular model. Information semantic account requires that there is an appropriate information relation between a model and its target. For this reason, if a model is credible, there must exist or it must be possible to imagine a causally implemented information relationship between a model and its target. Because of this, from an information semantic view, completely fictional models, arbitrary models or models, which have only unrealistic constituents, are not explanatory. Instead, only such partially fictional models can offer model explanations, in which the constituents of a model system are realistic. These constituents should (at least to certain extent) refer to/ carry information about real world elements and this information relationship could be, in principle, implemented in data.

So, the final problem is: How is it possible that a fictional model can carry information about the real world? As philosophers of cognitive science know, a structurally similar problem, the problem of uninstantiated properties, plagued the early versions of information semantics in philosophy of mind. In a nutshell, the problem was the following: If A does not carry information about B, it is not a representation of B. So, if B is a non-existing, uninstantiated entity or a property, A cannot carry information about it, and thus A is not, strictly speaking, a representation of B. However, there are still terms, such as unicorns or pegasuses, which clearly have semantic content, even if their referents do not exist. We can attribute properties to these non-existing entities; we can make thought experiments on them and so on. So, if these terms have no existing targets, how do these terms have their semantic properties? What is the basis for the meaning of these terms?

Jerry Fodor proposed (1991) one possible solution for this problem. On his view, these terms, such as "pegasus", could be seen as complex terms, which can be decomposed into its

[19] While in Woodward´s manipulationist construal explanations are restricted purely to causal explanations, Bokulich adds that not all scientific explanations must be causal.

[20] Kuorikoski and Lehtinen (2009) make a similar point.

constituents (a horse and wings), and these constituents refer to/carry information about the real world components. So, these terms can have a meaning, because the constituents of the terms can carry information about the real world.

Partially fictional models can be treated in a same way. They are complex constructions, which can be decomposed into constituents. If these constituents refer to/carry information about the real world elements, they are realistic. For that reason these models are not completely fictional, although the complex composition of constituents would be fictional. Because the constituents of partially fictional models carry information about/refer to real world elements, these models may indeed offer structural model explanations.

## Concluding Remarks

There are at least four different ways – simplification, abstraction, idealization and fictionalization - to make models unrealistic, not all of them make models false in a way that is problematic for the realist. Even if in practice the difference between these types is not always clear, they should be treated separately. They have different implications for the explanatory power of a model. For example, although simplified or abstracted models do not describe all the factors or all the relevant factors of target systems, they describe certain some features of their target systems. Depending on their degree of truthlikeness they can be more or less explanatory. In this paper we argued that also fictional models may explain by showing how the structure of a model limits what sorts of objects, properties, states, or behaviors are admissible within that model, and they offer explanations known as structural model explanations (Bokulich, 2008, 2009). However, whether or not a fictional model is explanatory, depends also on the relationship of the fictional model and the real world. Only such partially fictional models that have constituents, which can carry information/refer to real world elements, can be explanatory. Completely fictional models, arbitrary models, or models with only unrealistic constituents do not explain.

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