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Make-Believe and Model-Based Representation in Science: The Epistemology of Frigg's and Toon's Fictionalist Views of Modeling

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RESUMEN

Roman Frigg and Adam Toon defienden una concepción ficcionalista de los modelos científicos. Una de sus tesis fundamentales es que los científicos participan en juegos de fantasía cuando estudian modelos para aprender sobre los propios modelos y sobre los sistemas que estos representan. En este artículo se discute críticamente la epistemología de esos dos puntos de vista ficcionalistas. Argumentaré que ambas concepciones pueden dar una explicación de cómo los científicos aprenden sobre los modelos que están estudiando. Sin embargo, Frigg y Toon no dan cuenta de manera suficiente de cómo el uso de modelos puede fomentar una comprensión de los sistemas representados.

PALABRAS CLAVE: *modelos, ficción, fantasía, representación, imaginación.*

ABSTRACT

Roman Frigg and Adam Toon, both, defend a fictionalist view of scientific modeling. One fundamental thesis of their view is that scientists are participating in games of make-believe when they study models in order to learn about the models themselves and about target systems represented by the models. In this paper, the epistemology of these two fictionalist views is critically discussed. I will argue that both views can give an explanation of how scientists learn about models they are studying. However, how the use of models can foster an understanding of target systems is not sufficiently accounted for by Frigg and Toon.

KEYWORDS: *Models, Fiction, Make-Believe, Representation, Imagination*.

I. INTRODUCTION

The comparison of scientific modeling with the creation or appreciation of fiction has become a popular topic in philosophy of science [see, e.g., Godfrey-Smith (2009); Suárez (2009); Woods (2010); Frigg and Hunter (2010); Levy (2015)]. In this paper, I will critically discuss two particular fictionalist accounts of modeling: Roman Frigg [Frigg (2010a),

(2010b), (2010c)] and Adam Toon [Toon (2010a), (2010b), (2012)] compare models to works of fiction. Frigg's and Toon's fictionalist views build upon Kendall Walton's [Walton (1990)] theory of make-believe and they transfer the insights from Walton's theory about fictional arts such as literature and painting to the sciences. Because of that their views can be called *Waltonian fictionalist* views.[1] In line with Walton's theory of make-believe, both views argue that the practice of modeling can be analyzed as the engagement of scientists in games of make-believe. Yet the two views differ: Frigg defends an *indirect* view of modeling and Toon defends a *direct* view. According to Frigg's indirect view of modeling, model descriptions specify hypothetical model systems and these model systems represent target systems. According to Toon's direct view, model descriptions are imaginative descriptions of target systems and there are no hypothetical model systems.

An important motivation for a fictionalist account of modeling is that many descriptions in the sciences do not seem to be literal descriptions of existing physical or social systems. Examples are descriptions of ideal gases, descriptions of frictionless planes and descriptions of actions of perfect rational agents, among many others. What are these descriptions about if they have no correlate in the physical or social world? One possible answer is that the descriptions are about hypothetical systems that do not exist in our world. This is Frigg's answer. Toon claims that these descriptions are prescriptions to imagine particular propositions and that the propositions are not about hypothetical systems but about existing target systems. Toon (2012) and others call the practice of talking and thinking of such non-existing hypothetical systems as if they existed in our world the *face-value practice*.[2] I will follow these scholars in using this term as a label for the motivation of fictionalism: scientists are participating in the face-value practice when they are speaking and thinking as if there are hypothetical systems. The answer of the two Waltonian fictionalist views to the question of how to interpret the face-value practice is that these descriptions are not genuine statements but prescriptions to *imagine* certain propositions. Frigg and Toon differ in their interpretation of these propositions as such. According to Frigg, the propositions are about hypothetical systems, whereas Toon claims that they are about existing target systems.

The goal of studying models is to pursue an epistemic purpose: modelers want to learn something. At least, they are eager to learn about the models themselves and, at best, they gain insights into target systems that are represented by the models. The main question of this paper is

whether Waltonian fictionalism is able to explain how modelers can learn from using epistemic tools such as scientific models. More in particular I will focus on the question how the two fictionalist views may account for the practice of using models in order to learn about target systems.
The structure of the paper is as follows. First, I will discuss the two Waltonian fictionalist accounts of models in Section II. Part of this section will be an introduction to the notion of a game of make-believe, the discussion of a particular example of such a game and the application of the theory of make-believe to scientific modeling. In Section III, the epistemology of Waltonian fictionalism will be scrutinized in detail and the paper will be concluded in Section IV.

II. WALTONIAN FICTIONALISM

The notion of a game of make-believe is the fundamental concept of the two fictionalist accounts (and of Walton's theory of make-believe, likewise). It is drawn from practices and experiences that almost every human being engages in already as a child. To give a very rough first idea of what games of make-believe are, think of games that children play if they pretend that a broomstick is a horse or if they pretend that they are feeding a baby when they are playing with a doll. The engagement in games of make-believe related to literature and science is claimed to be continuous with these children's games. Nevertheless there are differences: Some games are merely private games and others are practices in a community that are widely shared and stable over time. In the first case a game leads to imaginings that may be merely subjective but in the second case the imaginings have a certain status that grounds objective imaginings. This status of imaginings in so-called "authorized" games of make-believe will be elaborated on, later on, as this "objectivity" may ground the knowledge that models are supposed to deliver.

i) *Games of make-believe*

A game of make-believe is constituted by participants who use objects, so-called "props", in order to imagine particular propositions according to certain rules. These rules are called "principles of generation" [Walton (1990), p. 38]. A principle of generation is a conditional rule that prescribes the imagining of a particular proposition.

Props and principles prescribe the imagining of certain propositions; they "generate" these propositions. A proposition that is in that

way prescribed by a prop and a principle of generation is called a "fictional proposition" [cf. Walton (1990), p. 35]. Frigg defines a fictional proposition with the help of the further notion of a work *w*. In the case of literary fictions, the work *w* may be a novel or a story, which contains or at least supports the propositions that should be imagined; the *w*-prop and the *w*-principles are ingredients of the game of make-believe belonging to the particular work. Frigg's definition of a fictional proposition *p* reads: "*p* is fictional in work *w* iff the *w*-prop together with the *w*-principles of generation prescribes *p* to be imagined" [Frigg (2010c), p. 270]. In the following subsection, a game of make-believe will be discussed that involves the use of tree stumps as props. In general, props can be ordinary objects such as broomsticks or tree stumps that have concrete features such as length or width, but the props also can be linguistic entities that have abstract features such as semantic content.

ii) *Hunting bears*

In order to make the theory of make-believe more comprehensible the following example of a game with concrete props may help. The example is a children's game in which children pretend to hunt bears in a wood. According to the game, the children treat every tree stump that they come across in the wood as a bear. The principle of generation of the children's game is the rule to treat a stump as a bear or, to be more precise, to imagine the proposition that there is a bear if one sees a stump. The essential ingredients of this game are the tree stumps and the rule to imagine the particular proposition when one sees a stump. The convention that every tree stump counts as a bear leads to there being a fact about how many bears there are in the wood according to the game. The proposition that there are say five bears in the wood is fictional in the game if and only if there are five tree stumps in the wood. A fictional proposition is also called a "fictional truth" [Walton (1990), p. 40]. However, theorists of make-believe stress that the notions of fictional truth or truth in a fiction must be distinguished from truth *simpliciter* [cf. Walton (1990), p. 41; Frigg (2010b), p. 117]. Although "truth in fiction is not a species of truth" [Frigg (2010b), p. 117] the fictional truths have a certain status that grounds objective imaginings:

> An oddly shaped stump might prompt a child to imagine a wolf and not a bear, but the proposition that there is a wolf before them is only imagined, not fictional. Fictional truths therefore possess a certain kind of 'objectivity'; participants can be unaware of fictional truths and mistaken about them [Toon (2010a), p. 304].

The acts of imagination according to a particular game are not arbitrary and they are not only subjective imaginings. Because the imagined propositions are prescribed by the principles they have the status of objective imaginings. This status is grounded in a shared practice of people engaging in the same game. On top of that, the status of some fictional truths is related to facts in the world. The fictional truths in the game of hunting bears depend on facts about the tree stumps. If a proposition is fictional then everyone engaged in the game ought to imagine the proposition. There may even be certain fictional truths that are not yet discovered. So, it is common to truths and fictional truths that they both can be discovered. Frigg and Toon give the example of the hidden tree stump that generates the fictional truth that there is a hidden bear in the children's game [cf. Frigg (2010c), p. 271; Toon (2010b), p. 80]. Thus one can even make mistakes in a game of make-believe. Frigg mentions the case of a player taking a mole heap for a stump in the children's game [cf. Frigg (2010c), p. 265f.]. In the case of taking a mole heap for a stump a player would be mistaken if she would claim that there fictionally is a bear. The state of the world together with the principles of generation determines what is fictional in the game. If there is a stump then it is fictional that there is a bear. If there is only a mole heap then it is not fictional that there is a bear.

iii) *Authorized games of make-believe*

Props can be ordinary objects such as the tree stumps in the children's game but they can also be linguistic entities such as literary descriptions in novels[3] or – as we will see shortly – descriptions in science. What is common to all of them is the capacity to make propositions fictional. The principles can be either constituted by ad hoc rules or they can be widely shared rules in a community that are relatively stable. The principle of the children's game of hunting bears is constituted by an ad hoc rule because the principle of that game is not widely shared and it is not stable. In contrast, the principles that govern the use of props in games that are "authorized" are stable. Games that involve well-known works of literature have principles that are widely shared and stable.[4] For example, the rule to imagine certain propositions about Sherlock Holmes, a character in the stories by Arthur Conan Doyle, is a stable rule of an authorized game. An example of a fictional proposition of this authorized game is that a detective lives in Baker Street 212B in Victorian London. So, there are unauthorized games with ad hoc rules such as the children's game and there are authorized games with stable rules that are

publicly agreed upon [cf. Frigg (2010a), p. 259; Walton (1990), p. 60]. Frigg gives the example of Hamlet, the play written by Shakespeare, as a prop in an authorized game of make-believe. A prop of an authorized game is called a "representation" [Walton (1990), p.51; Frigg (2010c), p. 266]. Tree stumps are not representations but works of literature, such as Hamlet, are representations. Representations do not only have the capacity to stimulate the imagination and to generate fictional propositions but it is their function to prescribe certain imaginings and so it is their function to generate fictional truths [cf. Walton (1990), p. 52f.; Toon (2010a), p. 304]. Representations have this function due to their belonging to an authorized game of make-believe.[5]

Fictionalists make a distinction between "primary" fictional truths and "implied" fictional truths. The primary fictional truths follow "immediately" from the props. For example, the proposition that there are five bears might be a primary fictional truth in the children's game. Besides these primary fictional truths there are also implied fictional truths. An example for an implied fictional truth is the proposition that the five bears are dangerous [cf. Frigg (2010b), p. 115]. Corresponding to these two kinds of fictional truths, there are two kinds of principles of generation. "Direct" principles generate primary fictional truths and "indirect" principles together with the primary fictional truths generate implied fictional truths [cf. Frigg (2010b), p. 115]. Let me now discuss the application of the theory of make-believe to the practice of modeling in the sciences. First, an application in the context of Frigg's indirect view will be discussed, and, later on, another example in the context of Toon's direct view.

iv) *The model of Sun and Earth*

Frigg gives examples of descriptions in various disciplines that he interprets as props in games of make-believe. For example, he cites models from physics, biology, and economics as involving props that are used to make-believe particular propositions [cf. Frigg (2010c), p. 261]. One model that he analyzes in detail is the Newtonian model of the Earth orbiting around the Sun. According to that model, the two celestial bodies of Earth and Sun can be compared to an isolated system of two bodies with gravitation as the acting force. Beyond that, the bodies are regarded as perfect spheres with an even distribution of mass and it is assumed that the model sun is at rest.[6] These assumptions are the starting point of the modeling. Frigg calls the assumptions "model descriptions" and he interprets the model descriptions as props of a game

of make-believe [cf. Frigg (2010c), p. 267f.]. Frigg claims that these descriptions are not descriptions of the Sun and the Earth. Rather they are tools to imagine a hypothetical system containing two ideal bodies. This hypothetical system is called the "model system". Participants of the game use the model descriptions in order to imagine propositions about the hypothetical model system.[7] The model system is in certain respects similar to a character in a work of fiction. Frigg compares the model system to a fictional character such as Madame Bovary or Sherlock Holmes and he names three common features of model system and character: 1. Model systems and characters can be subject of thought and debate. 2. One can make claims about them that are judged as correct or incorrect. 3. They are only imaginary and not real things [Frigg (2010c), p. 256f.].[8]

Frigg terms the relation between the model description and the model system "p-representation". As discussed in the previous subsection, a prop in an authorized game of make-believe is called a representation. Thus, p-representation is a relation between the prop and the model system that should be imagined. The model system is conceptualized by Frigg to be equivalent to a set of propositions. The model system is characterized by the "world of the model" and the world of the model is equivalent to the set of propositions that are fictional according to the model descriptions and the respective principles of generation [Frigg (2010b), p. 118].[9]

By using the assumptions in order to imagine a model system it is possible to derive several inferences. One particular inference is that the model earth moves around the model sun in an elliptical orbit. Frigg points out that the determination of the orbit of the model earth around the model sun is an implied fictional truth of the modeling interpreted as a game of make-believe. Props and principles of direct generation generate the primary fictional truths of the modeling. For example, it is generated that the model earth is spherical. The implied fictional truths follow from the primary fictional truths and from principles of indirect generation, in this case the laws of classical mechanics. In this way Frigg reconstructs the activity of modeling as an act of imagination in a game of make-believe. The assumptions of the modeling are the props. Linguistic conventions are the direct principles of the game. The theory of classical mechanics, i.e., the laws and general principles of classical physics, provides the indirect principles of generation of that game. The proposition that the orbit of the perfectly spherical model planet around the model sun is an ellipsis is an implied fictional truth of the game of make-believe [cf. Frigg (2010c), p. 268].

The target of the modeling is the Earth and especially the movement of the Earth around the Sun. The relation between the model system and the target is called "t-representation". Frigg defines t-representation as a relation between two relata, the model system and the target system. Two conditions have to be fulfilled in order for the model system to t-represent the target system: First, the model system has to denote the target system and, second, there has to be a "key" that specifies how facts about the model system are to be translated into claims about the target system.[10] The first condition establishes the aboutness of the model system. The second guarantees that there is cognitive relevance of the model system for the target system [cf. Frigg (2010c), p. 275f.]. The fictional truth that the model earth moves in an elliptical orbit around the model sun can be translated into the claim that the Earth's trajectory around the Sun is *almost* a perfect ellipsis [cf. Frigg (2010b), p. 135].

v) *The model of the bouncing spring*

According to Toon, modelers do not consider hypothetical model systems. Model descriptions prescribe the imagining of propositions about the targets directly. Toon discusses the example of modeling a bouncing spring with the help of the harmonic oscillator:

> When we model the bob bouncing on the end of a spring as a simple harmonic oscillator, we take the bob to be a point mass m subject only to a uniform gravitational field and a linear restoring force exerted by a massless, frictionless spring with spring constant k attached to a rigid surface. [Toon (2012), p. 38]

> [T]hese are not straightforward descriptions of the bouncing spring. Nevertheless, I believe, they do represent the spring, in Walton's sense: they represent the spring by prescribing imaginings about it. [Ibid. p. 39]

These model descriptions prescribe the imagining of propositions about the spring that should be modeled. The descriptions generate – together with principles of generation – fictional propositions about the spring. The world of the model contains primary and implied fictional propositions. There are primary fictional propositions, for example, it is fictional that the spring exerts a linear restoring force. The primary fictional propositions lead to implied fictional propositions such as the proposition that the oscillation of the bob is sinus-shaped.

Because of this direct approach, Toon does not need to postulate further notions such as t-representation or key like Frigg does. However, this parsimonious approach has problems with accounting for the knowledge about targets a model can deliver, which will elaborated on in the next section.

III. The Epistemology of Waltonian Fictionalism

The two fictionalist views give an elaborate account of how games of make-believe are involved in the practice of modeling. The question is whether they are able to explain how modelers may learn from using epistemic tools such as scientific models. In the following two subsections, I will discuss this question in detail.

According to a particular game of make-believe, model descriptions generate fictional propositions. Model descriptions are comparable to works of fiction because both can generate fictional propositions. The fictional propositions of a particular model constitute the world of that model. One aspect of learning from models is to learn about the models themselves. Frigg and Toon agree on this point. Modelers can learn about models by finding out which propositions are indeed fictional propositions that belong to the world of the model (see III.1). The more important aspect of learning from models is to find out about target systems. On this second aspect Frigg's and Toon's answers diverge. According to Toon, some fictional propositions are not only to be imagined but also to be asserted about target systems. The fictional propositions that are true of target systems can foster the knowledge about the targets (see the first part of III.2). According to Frigg, fictional propositions have to be translated into claims about target systems. This translation is achieved with the help of a so-called key, a notion that is not based on Walton's theory (see the second part of III.2). Let's first address the issue of learning about models.

III.1 *Learning about Models*

Both views stress that the world of a model is an important aspect of the object of study of modelers. The world of the model consists of all propositions that are fictional in the particular game of make-believe. Primary fictional propositions and implied fictional propositions belong to the world of a particular model. The practice of learning about a particular model is mainly about examining which propositions follow from

the primary fictional propositions. These implied fictional propositions constitute the important knowledge about the models that modelers strive for. The implied fictional propositions are generated with the help of the indirect principles of generation of the particular modeling task and in case that these principles are explicit principles the modelers have indeed a justification for knowing these propositions. The primary fictional propositions and the principles together imply these propositions. And modelers can point to the principles as reasons of how they know that a certain implied proposition is indeed fictional.

Hence one can say that both fictionalist views account for knowledge about the models themselves given the appropriate principles of generation. Nevertheless, the notion of a principle of generation remains somewhat opaque. Both views don't define the notion. They distinguish between, on the one hand, principles of direct generation and, on the other hand, principles of indirect generation or principles of implication:

> Thus, we may divide the principles by which fictional truths are generated into two kinds: principles of direct generation and principles of implication. The former are conditional upon the features of the representation. They say for example, that if a novel contains certain words then certain fictional truths are generated. Principles of implication tell us what further fictional truths are implied by primary fictional truths [Toon (2012), p. 46].

Frigg gives some examples of principles of generation. He mentions, e.g., linguistic conventions as an example of direct principles and the laws of classical mechanics as an example of the indirect ones [cf. Frigg (2010c), p. 268]. Toon admits that it is difficult to state the principles of implication:

> I believe that principles of implication are more difficult to specify explicitly and will vary from case to case. […] Even without an explicit statement of the various principles of generation, however, this account provides us with a way of understanding learning about a theoretical model. This is not a matter of learning facts about any object. Instead, it is a matter of discovering what is fictional in the world of the model. [Toon (2012), p. 47]

Granted that the practice of science can deliver evidence for the existence of principles of implication on a case-by-case basis both accounts do give an account of how modelers learn about the world of a model. But what about learning about the targets of models?

III.2 *Learning about Targets*

First, I will scrutinize Toon's answer to how a fictionalist view can account for learning about targets (i) and thereafter Frigg's answer (*ii*).

i) *Toon's account*

The point of discussion will be how modelers learn about a bouncing spring from using the model of the bouncing spring. There are several propositions in the world of the model of the bouncing spring. Some of the fictional propositions are false about the actual bob and spring. For example, the proposition that the bob is a point mass is false as is the proposition that the spring in fact exerts a linear force [cf. Toon (2012), p. 42]. Nevertheless these propositions belong to the world of the model and they are fictional propositions. In contrast, other fictional propositions about the bob are true or at least approximately true.[11] For example, the fictional proposition that the bob's period of oscillation is roughly equal to 2π times the square root of the quotient of the mass and the spring constant is true [cf. Toon (2012), p. 67]. Toon's view needs to distinguish fictional propositions that are true about targets from propositions that are not true about targets if it is to explain how modelers may learn about targets. It seems that Toon cannot appeal to the principles of generation and the model descriptions; they simply generate a set of fictional propositions and they are not able to distinguish between those propositions that are true of the target and those that are not. Toon can only defer the problem of detecting the true propositions among the fictional propositions to other principles. However at some point, where he speaks about the principles of generation, he seems to load the principles of generation with that further task too:

> Principles of generation often link properties of models to properties of the systems they represent in a rather direct way. If the model has a certain property then we are to imagine that the system does too. If the model is accurate, then the model and system will be similar in this respect [Toon (2012), p. 68f.].

Here, the principles of generation seem to ensure that model and target share certain features. This is however conditionalized on the model being *accurate* which is a condition that itself is not further spelled out.

In my opinion, Toon's view cannot distinguish between fictional propositions that are true and fictional propositions that are not true.

One needs to discern fictional propositions that are true from fictional propositions that are not true in order to learn something from a model about a target. Since Toon's view is not able to deliver a criterion for which propositions from the set of fictional propositions are also true propositions about the targets, I conclude that Toon's view does not give a satisfactory epistemology of modeling.[12]

A possible reply that Toon might give is that only the implied fictional propositions are the propositions that are to be asserted about the targets, whereas the primary fictional propositions are the ones that are not true about the targets. There are two problems with this reply. First, it is not clear why the combination of *untrue* primary fictional propositions with the principles of implication would generate implied fictional propositions that are *true* about the targets. Second, there is the problem of distinguishing primary from implied fictional propositions. The distinction between primary and implied fictional propositions hinges on the distinction between principles of direct generation and principles of implication. This distinction itself is not clearly explicated. If Toon's answer to the question of the missing criterion is indeed based on this distinction then he faces a similar problem as Frigg, which brings me to the next subsection.

ii) *Frigg's account*

According to Frigg's view, modelers first learn about hypothetical model systems. There are facts about models that can be inquired about by studying the worlds of the models. In a second step, facts about models can be translated into claims about targets. A so-called key allows for the translation of a fictional proposition into a claim about a target. Unlike Toon, Frigg does not have the problem of distinguishing fictional propositions that are true from fictional propositions that are not true because fictional propositions are not about targets according to his account. However, a question is whether all fictional propositions are candidates for a translation into true claims about targets. Frigg does not say much about this but a reasonable assumption is that only some propositions are candidates. One might guess that only the implied fictional propositions are candidates for a translation into claims about the targets. In this case the already mentioned problem of distinguishing primary from implied fictional propositions and distinguishing the two sorts of principles of generation is as relevant for Frigg as it is for Toon.[13]

Granted that there is a definite set of propositions that are candidates for a translation, a second problem is how to account for this

translation. Frigg's view postulates a key that allows translating a fictional proposition into a claim about a target. Frigg gives no explication of the notion of a key, but he gives the analogue of a map of London, which has a "key of translation" that helps to infer "facts about the city […] from facts about the map" [(2010b), p. 126]. The keys of models differ from keys of maps, though.

> However, unlike for maps where we know the key by construction (we have used a certain projection method, certain symbols, etc. when drawing the map), in the case of models the key has the character of a hypothesis [Frigg (2010b), p. 129].

The key of a map is a legend but the key of a model is only a hypothesis. Therefore the key of the model does not translate facts about the model system, i.e., fictional propositions, into facts about the target system like the key of the map. The key of the model translates fictional propositions into claims about targets. Frigg is explicit about this difference and he writes, "keys [of models] are often implicit and determined by context" [Frigg (2010b), p. 128]. Therefore a philosophical analysis is required "to make hidden assumptions explicit, and present a clear statement of them" [ibid.]. However, Frigg's account does not deliver an explication of the notion of key. The only thing that he delivers is that he discusses the ideal limit as an example for a key of models.[14]

One may argue that the absence of a clear explication is a problem only if essential questions are left unanswered, and if the account contains fundamental ambiguities.[15] This is fair enough but usually this kind of answer is given when concepts are used that are well established in philosophy. The concept of a key is not an established one in philosophy and the few remarks that Frigg gives to characterize it are not supporting an explanation of how the key can foster knowledge about a target.

Given that a key only has the character of a hypothesis it is not clear how the study of model systems really can deliver knowledge about the target systems. The key functions as the important tool in order to translate a fictional proposition into a claim about the target. Hence, the translation inherits the character of a hypothesis and it is questionable whether any claim about the target generated by a hypothetical key is true and so could instantiate knowledge about the target.

One may further object that a model cannot establish by itself that a claim is also true and that only experimental test can establish that a claim is true. This objection may be answered with the help of a distinc-

tion that is not spelled out in Frigg's account, namely the distinction between models that are used in an early phase of research and models that are developed in the context of an established body of knowledge. The context of the discussed model by Frigg is classical mechanics and this part of physics is not in an early phase anymore. For example, one may want to use an expanded model of the celestial bodies that also incorporates the moon to predict the next solar eclipse. If the model allows for the translation of a fictional truth into a claim that the next eclipse will be in September 2016 then this is more than just a hypothesis. This claim can be regarded as a reliable prediction. One might regard this claim as a justified claim that constitutes knowledge and one might even regard this claim as a true claim.[16]

IV. Conclusion

Both, Toon and Frigg as Waltonian fictionalists give an account of how modelers learn *about models*. According to them, the modelers use principles of generation in order to learn about the models: model descriptions and principles generate the fictional propositions of the particular games of make-believe. The worlds of the models are characterized by the set of fictional propositions of the games. To know the fictional propositions is to know facts about the models.

In *Toon's* case the fictional propositions are propositions about the targets. Some of these propositions may be true about the targets and therefore they may ground knowledge about the targets. However, Toon's account cannot distinguish between fictional propositions that are true and fictional propositions that are not true about the targets and therefore the account cannot give a criterion for knowledge about targets. One solution to this problem of distinguishing fictional propositions that are true about the targets from propositions that are not true could be that the principles of implication may generate the true propositions about the targets. That solution, however, presupposes a clear distinction between direct principles and principles of implication, a distinction which Toon's account does not sufficiently spell out.

In *Frigg's* case, the knowledge about the targets is dependent on fictional propositions and on the keys that support translating the fictional propositions into claims about the targets. So, for Frigg there are three different kinds of tools that are needed in order to reach claims that may constitute knowledge about targets: props, principles and keys. On top

of that, the principles are separated into direct and indirect principles of generation. However, this distinction is – just as in Toon's account – also missing a proper explication in Frigg's account. That is why to interpret the indirect principles as functioning to detect the fictional propositions that are candidates for a translation into claims about the targets is problematic. The third tools, the keys, are not given an explicit definition but they are characterized as hypotheses. It is not clear how hypothetical keys could translate fictional propositions into true claims about targets. Because of that it is questionable whether Frigg can explain how a justification for true claims about the targets can be given. Therefore the epistemology of Frigg's fictionalism stands on a rather weak footing.

Let me finally add a brief constructive remark to this rather negative result of the paper. Although I criticize both views for not giving a sufficient epistemology of modeling, it might be feasible to combine Frigg's view with a structuralist account of representation. In the case of the model of Sun and Earth, it seems that the model system and the target system share a common structure. Because of this shared structure, claims about the target that are inferences of the modeling can be justified. There are many structuralist accounts in the literature and these accounts may help to formulate a solution to the problem of how one may learn from models about targets in the context of an indirect fictionalist view.

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NOTES

[1] The term 'Waltonian fictionalism' is borrowed from Weisberg (2013) who uses it to label Frigg's account.

[2] This name of the practice originates in Thomson-Jones (2010) and the practice is discussed also by Godfrey-Smith (2009) and Weisberg (2013). On top

of that, Thomson-Jones calls the hypothetical systems "missing systems". This notion of a missing system can be used to identify fictional model systems, as well as, fictional elements in modeling practices.

[3] Walton and the fictionalists regard the whole work of fiction as a prop in a game of make-believe.

[4] It is often the case that people in a community agree on certain issues about a fictional character, which are not told explicitly in the work itself. Readers or friends of theater agree for example that according to Shakespeare's play it is very likely that Hamlet's uncle killed Hamlet's father. However, the same persons do likely not agree on the question of whether Hamlet's refusal to kill his uncle is due to an unresolved Oedipus complex. It seems to be a fictional truth in Shakespeare's play that Hamlet's uncle killed Hamlet's father. It is at least debatable whether certain statements supported by a psychoanalytic interpretation of the play also express fictional truths [cf. Walton (1990), p. 138].

[5] With regard to representation, a crucial difference between Frigg's and Toon's fictionalist accounts of models in science shows up. For Toon, Walton's notion of representation is to be equated with the notion of model-based representation in science whereas Frigg distinguishes between *p-representa*tion, representation of a model system with the help of a prop, and *t-representation*, representation of a target system with the help of a model system. I will elaborate on these two notions of p-representation and t-representation in the next subsection.

[6] Note that when I refer to the Earth and Sun of our solar system I use capitals to indicate that we are using proper names. When I refer to model sun and model earth I use lowercases.

[7] In this respect there is striking difference between Frigg's account and Toon's account. Toon claims that the postulation of hypothetical model systems is not necessary. According to his view, the model descriptions prescribe imaginings about the targets themselves and not about model systems. See also note 5.

[8] The third claim about characters in fictions hinges on a particular position concerning fictional entities that is not shared among all scholars. If you are a fictional realist then you believe that characters are part of our world and that they do exist. For example, characters may be regarded as cultural artifacts [cf. Thomasson (1999)].

[9] Although Toon does not use the notion of a model system he nevertheless uses the notion of the world of a model. Toon also takes the world of a model to be constituted by the fictional propositions of the particular game of make-believe [cf. Toon (2012), p. 45].

[10] The notion of a key is not sufficiently accounted for by Frigg and this will be the topic of my criticism in Section III.

[11] In the following I will omit the disclaimer but I will mean *true or approximately true* proposition when I write that a proposition is true.

[12] In a recent publication, Arnon Levy (2015) elaborates on a direct view of modeling. He explicitly claims that his position is in agreement with Toon's

one. Levy mentions that Toon largely is concerned with the content of models and not with how knowledge about targets is possible. He gives an account of modeling that utilizes the notion of partial truth to explain how modelers learn about targets. It may be that this strategy can solve the problems of Toon's view that I discussed. Levy, however, very briefly touches on his view of make-believe, only, and from these few remarks it is not clear whether he really is perfectly in line with Toon's approach. For example, Levy seems to regard the real-world phenomena as the props and not the model descriptions like Toon and Frigg have it [cf. Levy (2015), p. 791].

[13] An anonymous reviewer pointed out that Frigg is not committed to the claim that only implied fictional truths are candidates for a translation. The primary fictional truth that the model sun and the model earth have mass and attract each other gravitationally can be translated into a claim about the target. If this is the case then the problem still is how to distinguish the fictional truths that *can* be translated from the fictional truths that *cannot*.

[14] The discussed model of Sun and Earth appears to largely use the key of ideal limit. For this special case of a mathematical model in classical physics Frigg gives at least examples for the basic notions of his theory but there are no explications of the notions. Nevertheless, Frigg can point out that there is at least one instance for each of the mentioned tools of *direct principle*, *indirect principle* and *key*.

[15] Thanks to an anonymous reviewer for raising this objection and the following one.

[16] This issue touches upon deep and longstanding philosophical problems, namely the question of statements about the future and the nature of truth. Are claims about future events true or false? Is truth an epistemic concept or not? A discussion of these problems falls outside the scope of this article.

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