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The unfeasibility of onto-representationalism

(La inviabilidad del onto-representacionalismo)

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ABSTRACT: Much effort has been devoted to explaining in what sense models represent their corresponding target systems. This has been considered a pivotal philosophical problem since representational models have been widely assumed to canalize our knowledge and understanding of reality. The aim of the paper is to analytically structure the framework commonly adopted to address the Scientific Representation Problem (SR-P), i.e., onto-representationalism, and to examine its main problems. Due to its very theoretical conditions, I conclude that onto-representationalism constitutes an inadequate meta-scientific platform to approach SR-P. I locate the problem in the semantic assumption. To materialize these analyses, I examine the main arguments proposed by the main variants of onto-representationalism: classical onto-representationalism and sophisticated onto-representationalism.

KEYWORDS: Veritism, Representationalism, Realism, Models, Idealization.

RESUMEN: Se ha dedicado un esfuerzo notable a intentar explicar cómo los sistemas modelos representan a sus correspondientes sistemas objetivo. Dado que los modelos representacionales son centrales a la hora de canalizar nuestro conocimiento y comprensión de la realidad, se ha considerado que el Problema de la Representación Científica (P-RC) constituye una cuestión filosófica central. El objetivo del presente artículo es estructurar analíticamente el marco comúnmente adoptado a la hora de abordar el P-RC, i.e., el onto-representacionalismo, y examinar sus principales problemas. Argumento que el onto-representacionalismo constituye una plataforma meta-científica inadecuada a la hora de ofrecer una solución satisfactoria al P-RC. Localizo las dificultades en el presupuesto semántico. Para materializar estos análisis, examino los principales argumentos propuestos por las principales variantes del onto-representacionalismo: el onto-representacionalismo clásico y el onto-representacionalismo sofisticado.

PALABRAS CLAVE: Veritismo, Representacionalismo, Realismo, Modelos, Idealización.

SHORT SUMMARY: The aim of the paper is to analytically structure the framework commonly adopted to address the Scientific Representation Problem (SR-P), i.e., onto-representationalism, and to examine its main problems. Due to its very theoretical conditions, I conclude that onto-representationalism constitutes an inadequate meta-scientific platform to approach SR-P. I locate the problem in the semantic assumption.

1. *Introduction*

Currently, philosophers of science widely accept that non-epistemic factors such as ethical values, economic, or political incentives play a pivotal role in the institution and development of scientific practices. However, much less attention has been paid to analyzing the important theoretical role and implications of meta-scientific assumptions on scientific practice. One author who appreciated their significance was J. H. Woodger (1929). In his doctoral thesis, published as *Biological Principles*, he demonstrated how scientific practice relies on elements that are not strictly scientific. What is more, he consistently argued that they were the origin of many of the everlasting debates that pervade the biology of his time—e.g., Mechanism vs. Vitalism, Organism vs. Environment, or Structure vs. Function. Hereafter, by meta-scientific assumptions I mean the set of theoretical assumptions—ontological, epistemological, and semantic—used to define how scientific work has proceeded and/or how it should proceed.

In this paper, I intend to revive Woodger's fundamental intuition in light of a current debate within the general philosophy of science: the problem of scientific representation. Certainly, this debate has taken place primarily in the philosophical sphere. In the mid-1960s, philosophers of science realized that scientists, instead of studying phenomena directly, usually rely on simpler hypothetical systems to reason about the phenomenon of interest. Far from being a mere heuristic complement to theories, scientific models seemed to play an essential role in the scientific process of understanding the world. This shift towards "a model-based science" (Godfrey-Smith, 2006) significantly altered the contours of the philosophy of science, giving rise to a series of ongoing debates that resonate to this day: How should we understand the relationships between models and those entities, phenomena, or portions of the world that the models represent?; In order to understand a phenomenon, is it necessary that our models accurately reflect all aspects of interest or only the causally central ones?; What is the role of idealizations and abstractions? I suggest locating this apparently heterogeneous set of questions in a more global and central problem, namely "the Scientific Representation Problem" (SR-P):

> *SR-P*: In what sense do our model systems represent their corresponding target systems and allow scientists to gain knowledge and understanding of reality?

Echoing Woodger, this debate, although philosophical in nature, can eventually shape and impact real scientific practice. If we think of science as just another human activity, it seems hard to deny that scientists do make use of certain meta-scientific assumptions in their daily scientific practice: when interpreting the construction, manipulation and cognitive salience of models and representations. They are not ideal agents isolated from all those beliefs deemed "non-scientific". Consequently, nothing prevents scientists from being influenced by the generally accepted and widely shared theoretical view on scientific representation. Although SR-P is a fundamentally conceptual puzzle, we cannot overlook its potential impact on real scientific practice, both from a descriptive and a normative point of view. Considering the descriptive dimension, meta-scientific assumptions may influence how scientists assess certain modeling scenarios. For example, they can constrain how to evaluate the epistemic validity of models that do not maintain any connection with reality (i.e., holistically distorted models) or address the existence of a plurality of conflicting models. A researcher with strong realist commitments will assess the latter situation—e.g., cancer (Soto & Sonnenschein, 2021; Weinberg, 2007)—quite differently from someone with anti-realist, or pragmatist commitments. Here, the realism-driven researcher might be prompted to promote a unified investigation aimed at finding the alleged missing common cause. Considering the normative dimension, they may influence the formulation of criteria through which to assess the validity of the representations. A researcher with realist and veritistic

commitments will require a connection with the world; another who refuses to embrace substantial metaphysical and epistemological commitments—i.e., a pragmatic standpoint—will simply resort to community and research needs. In short, the meta-scientific commitments adopted in answering SR-P, while theoretical in nature, may eventually impact how scientists conduct their research.

The theoretical and practical importance of meta-scientific assumptions calls for an assessment of their role within the debate on scientific representation.[1] I will contend that a specific meta-scientific platform has dominated the philosophical debate. Namely, onto-representationalism. This framework has been structured around three principles: representationalism, realism, and veritism. I will illustrate how a substantial number of accounts have implicitly adopted it in answering SR-P. Representationalism constitutes one of the ideas usually adopted by default. Roughly speaking, it holds that the epistemic status of models derives from their ability to faithfully represent, directly through shared features or indirectly through robust counterfactual patterns, certain aspects of the causal/mechanistic structure of phenomena (Knuuttila, 2011, p. 263). It is the representational relationship that allows us to explain the virtues and epistemic value of our best models. In turn, representationalism is based on two additional meta-scientific ideas: one ontological, realism, and the other epistemological, veritism. Our scientific models are representations of the target systems because they provide true information—veritism—and do so by accurately reflecting certain parts of the ontic structure of the phenomena in certain degrees and respects—realism. The combination of these three ideas has shaped the main meta-scientific platform adopted to offer a solution to SR-P.

My hypothesis is that onto-representationalism leads to an inadequate conceptualization of SR-P that negatively impacts scientific practice. More specifically, I will argue that the problem lies in the *semantic assumption,* which is usually overlooked. The latter is the one that allows us to determine which models are genuinely representative by providing a way to discriminate whether the linguistic items that structure the model system represent the non-linguistic items of the corresponding target system. I will show that this is an unavoidable problem consubstantial to this framework since it is impossible to renounce the semantic commitment, adopting only the representational, ontological, and epistemological ones. In other words, it is impossible to dissociate the assumptions that integrate onto-representationalism: the viability of one rests on the validity of the others. Therefore, if one wants to retain the representationalist, realist or veritist commitments, one must face the challenges raised by the semantic assumption: the articulation of a criterion that allows one to answer the question of what makes a representation accurate and, hence, true. This forces onto-representationalist to face the challenges inherent to the interpretation of language, a problem that the history of philosophical thought has shown to be extremely elusive.

To substantiate these analyses, I will discuss the different variants framed within onto-representationalism: classical and sophisticated. I will show that both suffer from deficiencies. The former, which grounds the representational relation on certain shared characteristics, faces the problem of accounting for the epistemic role and the representational character of models based on holistic distortions. The latter, who argues that our models can represent their corresponding target systems without literally representing the causal/mechanistic structure of the phenomenon, leaves the semantic problem unanalyzed, thus calling into question the validity of SR-P analysis.

In a nutshell, the aim of the paper is to analytically structure the theoretical assumptions underlying one of the meta-scientific frameworks commonly used to account for SR-P—i.e.,

[1] Hereafter I will discuss only the proposals of the advocates of the indirect view of representation (Levy, 2015; Toon, 2012). Notice that SR-P refers to the attempt to clarify the relationship between a model and a target system. By stating that models function as a prop in the game of make-believe which prescribes imaginings about T, advocates of direct representation simply do not address SR-P.

onto-representationalism—, as well as to elucidate its main shortcomings, which I will locate in the semantic assumption. The paper will be structured as follows. In the second and third sections, I will articulate the fundamental theses that structure the onto-representational approach. In the fourth section, I will discuss the main arguments presented by the advocates of classical onto-representationalism. In the fifth section, I will introduce the attempts made by sophisticated onto-representationalism to overcome the limitations of the classical approach.

2. The Onto-representational Approach

There is great controversy about the nature of the representational relationship connecting model systems and their corresponding target systems. Anjan Chakravartty (2010) has made an analytical distinction between those authors who advocate an informational account and those who defend a functional account. The former (Bueno & French, 2011; Craver, 2014; Craver & Kaplan, 2020; da Costa & French, 2003; Giere, 1988; Strevens, 2008; van Fraassen, 1980), exponents of the so-called dyadic view, state that the representational relation is based on an objective parameter that is independent of any pragmatic consideration of the agents. This objective correspondence—usually articulated in terms of similarity or some kind of -morphism—allows scientists to obtain true information about the phenomenon under study. The latter (Frigg & Nguyen, 2020; Giere, 2006; Suárez, 2004; van Fraassen, 2008), advocates of the triadic view, deny that the representational relation can be conceptualized independently of the pragmatic interests and needs of the cognitive agents. No representational relation exists until an agent takes certain correspondences to satisfy specific cognitive needs. To my mind, the situation is somewhat more complicated than that proposed by Chakravartty. I suggest the following analytical classification.

(1) A first group would include those authors who adopt an onto-representational approach to account for the epistemic value of models. Two variants can be distinguished: "classical onto-representationalism" (e.g., Giere, 1988, 2006; van Fraassen, 2008; Weisberg, 2007) and "sophisticated onto-representationalism" (e.g., Bokulich, 2018; Kuorikoski & Ylikoski, 2015; Rice, 2021; Verreault-Julien, 2021). The difference lies in the parameter proposed for establishing the representational relationship between the model and the target system. The former have argued that there must be certain shared characteristics, whether material or formal. For this reason, they have resorted to the idea of -morphism or similarity. The latter have contended that the existence of certain kinds of models—i.e., holistically distorted models—prevents the establishment of a direct representational relationship. Consequently, they have suggested an alternative representational parameter: universal patterns of behavior based on stable relations of counterfactual (in)dependence that take place between certain variables in the system. What is important is that both approaches are based on a common meta-scientific platform: onto-representationalism. Note that there is no incompatibility in introducing pragmatic aspects and defending an onto-representational perspective: the agent decides what to represent and how; the world determines the epistemic virtues of representations.

(2) The second group would be integrated by those authors who refuse to adopt onto-representationalism to account for SR-P (e.g., Elgin, 2017; Knuuttila, 2021). These authors have challenged some assumption, whether realism, representationalism, or veritism. This is the reason why they conceptualize the representational relation differently. For example, Elgin speaks of exemplification. Knuutila frames the problem in artifactual terms; depending on the media and modes of presentation, the representational relation will be one or another.

To evaluate the adequacy of the models, these authors offer an epistemic standard related to the social practices of justification.

(3) A third group would be composed of those authors who avoid making substantive commitments of a meta-scientific nature, just emphasizing the pragmatic component of representation (e.g., Frigg & Nguyen, 2020; Suárez, 2004). Obviously, this is not a unitary stance. For example, Suárez has argued that no basic parameter connects the model systems with their corresponding target systems in a general way (Suárez, 2003). Inference, he says, constitutes the superficial characteristic of scientific representation. Thus, a model represents its target if users are able to draw inferences from the phenomenon through the model. On the other hand, Contessa has deemed it necessary to explain why a user can employ a model to make valid inferences about a target system (Contessa, 2007, p. 57; see also Contessa, 2011, pp. 126-27). Thus, he has offered a substantive proposal of representation that places the notion of interpretation as the necessary and sufficient condition of epistemic representation. What binds these different accounts is their belief that an adequate response to SR-P does not involve any substantive commitment to principles of a philosophical nature—e.g., realism or veritism.

(4) A fourth group would gather those authors who argue that it is not necessary to talk about representation in order to render our modeling practices meaningful (e.g., de Oliveira, 2022). Models are not meaningful because they represent reality, but because their use allows us to learn about the world. Through a material engagement with them, cognitive agents are able to scaffold certain types of activities to solve research problems, making sense of reality. The problem of scientific representation consists in analyzing the interactions that exist between modelers and models, not the representational relationship.

Here, I will focus on onto-representational proposals (1) since they have dominated and shaped much of the debate. Advocates of onto-representationalism *sensu lato* believe that one of the most valuable goals of scientific practice is to produce faithful representations of reality that allow us to advance our understanding of the world. To achieve them, it is necessary to obtain true information about the aspect of interest of the phenomenon we are modeling. Let's say, for example, to understand the role of a particular cyclin-dependent protein kinase in the cell cycle, the dynamics of a population, the behavior of a gas, or the evolution of an economic system. This usually requires the construction of model systems: more manageable devices—whether abstract or material—that help researchers reason about the target system by reducing its complexity. The manipulation and study of these systems allow scientists to obtain true information about certain aspects considered critical to the behavior of the target system.

Representationalists consider that merely possessing bits of true information about the aspect or behavior of interest is insufficient. Modelers must assemble the pieces of information into explanatory narratives that successfully answer specific why questions—usually codified as research goals. This calls for providing explanations that detail the causes, mechanisms, or patterns of behavior that make sense of the emergence of the (aspect/behavior of the) phenomenon considered relevant within the research domain (Craver, 2014; Glennan, 2017; Machamer et al., 2000; Strevens, 2008). The representational function is linked to the explanatory function. A model is representational iff it includes an explanation that accounts for a certain aspect of the world. Note that the representation of that aspect of the world can be done either directly or indirectly. The former strategy will consist in providing an explanation describing the causes or mechanisms involved in the production of the phenomenon—classical onto-representationalism. The latter will aim to provide an explanation that uncovers universal patterns of behavior. That is, invariance

relationships that hold between variables—sophisticated onto-representationalism. Consider the following example. Cancer cell invasion is typically assumed to be a protease-dependent process: cancer cells secrete proteases that degrade the basement membrane (BM) and invade the extracellular matrix. In recent years, 3D cell culture models have suggested the possibility of protease-independent invasion (Glentis et al., 2017). This statement derived from the model will be true iff, indeed, it is effectively confirmed in real systems, and not only in model systems or the results prove to be replicable in different kinds of cell cultures. Note that the appeal to truth is essential: only models that provide true information/explanations are epistemically adequate. For the onto-representationalist, truth constitutes the *standard of epistemic acceptability*. It provides the criteria to judge whether the descriptions comprising the model system, or the inferences drawn from it, are adequate and valuable. As can be appreciated, advocates of onto-representationalism suggest an extremely tight connection between representation, explanation, and truth.

I think it is possible to trace the origins of this explanationism, and its close link with onto-representationalism, to the Ontic Conception of explanation, originally put forward by José Alberto Coffa in the late 1970s and extensively developed by Wesley Salmon (Bokulich, 2018; Salmon, 1984; Wright, 2015, 2018). It contends that the world possesses a causal structure independent of the mind. Explanations, rather than constituting arguments, or representations, are objective entities that subsist *de re*, being independent of any pragmatic consideration (Craver, 2014, p. 40; Strevens, 2017). This view has been opposed by proponents of the so-called epistemic conception, who argue that explanations should be thought of in essentially representational terms (e.g., Bechtel & Abrahamsen, 2005). Recent work on scientific modeling has forced advocates of the ontic conception to make certain concessions to the epistemic view. Two reasons can be advanced. First, it seems clear that explanations, rather than being objective elements directly perceived or grasped, are the epistemic result of the manipulation of models constructed by cognitive agents. Second, it is necessary to have clear criteria to distinguish good explanations from bad ones (Craver & Kaplan, 2020; Kaplan & Craver, 2011). Alisa Bokulich has argued that these considerations led proponents of the ontic conception to focus on *how explanations work* rather than what they are, thus emphasizing their agential and representational character (2016, p. 263). Once this semantic turn takes place, the "ontic"—the objective portions of the structure of the world—is no longer perceived as elements that can be accessed directly. They are now grasped indirectly through *veridical representations*. What Bokulich has not noted is that this has blurred the boundaries that initially separated the ontic conception from the epistemic one, giving rise to an approach that fuses intuitions belonging to both approaches: onto-representationalism. From this perspective, adequate models would be those that veridically represent certain aspects of the ontic structure of the phenomenon.

As could be appreciated, realism constitutes one of the central pillars of the onto-representational approach (Bokulich, 2016; Giere, 2008; Rice, 2021; Strevens, 2008). Although realism is part of onto-representationalism, there are crucial differences that separate both positions. The most central one is that realism does not necessarily commit itself to epistemological and semantic theses. One could adopt a minimal form of realism by accepting only the ontological one. Take, for example, Devitt (1991), Asay (2018), or Leeds (2007). On the contrary, onto-representationalism demands the unconditional adoption of these three assumptions. In fact, the validity of one depends on the validity of the others. Representationalism needs veritism because it provides a way to discriminate what representations are more adequate: those that provide explanations whose propositional elements faithfully represent certain aspects of the world. Veritism provides a standard for discriminating between good and bad representations; truth. In turn, veritism needs representationalism because having accurate representations is how we get closer to a truer picture of reality. Veritism needs realism because only by postulating the existence of an

already structured mind-independent reality is it possible to objectively differentiate good representations from bad ones. Realism requires veritism because otherwise, we would lack a way of determining whether representations genuinely refer to the world.

There is still a loose end. The advocate of onto-representationalism must still explain how we can determine whether, in fact, our representations accurately reflect aspects of reality. In other words, how the standard of evaluation delineated by veritism is implemented. One cannot appeal to pragmatic criteria, e.g., our explanations and representations are good because they satisfy our cognitive goals or social standards. This would lead to a sort of instrumentalist, pragmatist, or artifactual perspective that would violate the realist and veritistic foundations. It is necessary to make a semantic ascent by placing the idea of truth at the center of the analysis. Otherwise, veritism would be incomplete, and realism would be completely emptied of content since we would have no way of differentiating which representations reflect the ontic structure of phenomena and which do not. In the next section, I will reconstruct how onto-representationalism solves this problem.

3. The Semantic Dimension of the Onto-representational Approach

To make sense of the "representational character" of the so-called "onto-representationalist" approach we need to draw on a semantic thesis. The latter is required in order to materialize a standard of epistemic acceptability through which to differentiate operationally between true and false representations. Only then, veritist, realist, and representationalist assumptions will become intelligible. As I will show in this section, the onto-representationalist is compelled to resort to a very particular and problematic semantic theory of truth: the correspondence theory of truth.

Arguably, one might say that it is more convenient to appeal to epistemic considerations in order to avoid conceptual conundrums associated with truth. However, the latter play no substantial role in assessing the truth of a representation; they deal with justification practices taking place within a community of inquiry. Naturally, such a criterion of acceptability is unsuitable for the onto-representationalist: it makes it impossible to account for the representational character by sidelining the realist and veritist assumptions. Consequently, the representational status of scientific products can only be accounted for insofar as one shows that they stand for the things in the world to which they refer. In contrast to justification, truth is an essentially semantic concept: it points to an objective relation between certain linguistic items and an extralinguistic reality. This is the reason why the onto-representationalist needs to appeal to a semantic theory that explains how the idea of truth can have an operative materialization.

So far, the only theory that has offered a systematic explanation of how the propositions that structure the explanations that confer representativeness to scientific products can correspond to the parts of reality to which they refer, discriminating the correct representations from the incorrect ones, is the correspondence theory of truth (Rasmussen, 2014). The essential idea is that truth involves a relationship between two qualitatively different entities, a truthbearer and a truthmaker[2] (Engel, 2002; Goldman, 1999; Vision, 2004). A proposition (truthbearer) is true iff represents the corresponding state of the world (truthmaker) relevant to the content of the proposition (Marino, 2006). It should be noted that truth does not refer to the content or meaning of a proposition. It is a property that depends on the relation that a proposition maintains with a certain element or phenomenon of the world (Ingthorsson, 2019). Meaning provides the conditions the proposition must meet to be true—truth-criteria. If these conditions are fulfilled, then it is possible to claim

[2] There is a heated debate on what should be the truthbearers (ideas, beliefs, utterances, sentences, mental representations) and the truthmakers (world, facts, states of facts, tropes).

that the proposition is true (Burgess & Burgess, 2014). This demands that an adequate relation exists between the meaning of a proposition and the corresponding state of the world to which it refers. If this is the case, we can conclude that the propositions that structure the explanations derived from the model are true and, therefore, representative.

Resorting to a correspondence theory logically follows from the ontological, epistemological and representational commitments assumed by the onto-representationalist. After all, the latter is the attempt to formulate, in analytical and strictly formal terms, the fundamental intuition underlying onto-representationalism. Namely, there exists a differentiation between true and false representations, the former being those that hold an adequate relation with an objective non-linguistic reality independent of the mind. Christoph Kelp has summarized this idea as follows:

> Second, phenomena come with structure […]. After all, for every phenomenon, no matter what its metaphysical nature might be, there is a set of true propositions that describe it. Structures help regiment the set of true propositions describing a phenomenon. It is true propositions about the structural relations between its elements and true propositions about intrinsic properties of the structure of the phenomenon that matter. (Kelp, 2021, p. 101)

Explanations that confer the representational status may be partially erroneous (false items or inadequate relations are included), incomplete (items of knowledge or relations between them are missing) or idealized (only certain explanatory roles are taken into account, leaving others aside). In the first two cases, the epistemic value of this kind of explanations would simply consist in pointing out what kind of work should be done to achieve a more accurate understanding of the mechanism or causal pattern under consideration. Authors such as Craver have already addressed this issue by introducing the idea of a "mechanism sketch". In the third case, the requirement of precise representation is still maintained for the difference maker analyzed. *Accurate representation* is necessary because truth, by definition, is an absolute fact that does not admit degrees: "That truth is absolute — there is, strictly, no such thing as a proposition's being more or less true; propositions are completely true if true at all. (Absoluteness)" (Wright, 1998, p. 60). It would be odd to say that a model represents approximately a certain property, aspect, or behavior. Someone might argue, "well, statements like 'my model roughly represents the molecular mechanism by which the Warburg effect occurs' make sense and are perfectly adequate". However, if we pressed our interlocutor a bit harder and forced him to make explicit the various statements that structure "the molecular mechanism underlying the Warburg effect" we would see that, in fact, the first statement is no longer tenable. Either the model represents how a particular oncogene is involved in such a mechanism or we do not know it. Either we know the particular effects of this oncogene downstream in the signaling network or we do not.

Onto-representationalism cannot circumvent truth by appealing to the concept of accuracy. The strategy would consist in maintaining that the concept of accuracy is much more general than that of truth. Unlike truth, a representation can be more or less accurate. We can speak of a graduation in accuracy, something that does not apply to the concept of truth. A result can be more or less accurate. On the other hand, a statement cannot be more or less true. Either it is true, or it is not. Does this mean it is feasible to adopt accuracy as a criterion of correctness instead of truth? This does not seem to be the case. When we claim that a given representation accurately describes a characteristic, causal pattern, or mechanism, we are specifying under what conditions the model is true. In other words, we are detailing the representational content of the model, which is composed of a series of statements or propositions about the aspect of the world to which it is addressed (Fish, 2021, p. 38). The central point is that the statements or propositions that structure the representational content

cannot be judged as more or less true. If its truth conditions are satisfied, that is, if the aspect of the world to which it refers is how it is told to be, then it will be true. Otherwise, it will be false. The accuracy of the representation will ultimately depend on the correctness of the representational content, which will depend on the truth or falsity of the propositions that structure that content. In this case, accuracy leads us to the truth.

Similarly, it is not possible to resort to a deflationary concept of truth. As Kitcher pointed out (2012), if we assume that truth constitutes the standard to judge, objectively, the correctness of our representations and that it is reality, and not some sort of intersubjective agreement, that determines the epistemic validity of the propositions contained in our models—by virtue of being in an adequate and accurate representational relation—, then it is impossible to dissolve the problem of correspondence by appealing to some sort of deflationary theory of truth such as minimalism, redundancy, or primitivism. Otherwise, the onto-representationalist would be unable to explain the following point: What makes it possible that our models are successful and provide true information about the world or phenomena? It is not enough to show that the models are, in fact, true and provide knowledge; a reason must be given that explains why or in what sense this is so. In other words, it is necessary to specify the nature of the "representation-reality" relation. One cannot simply affirm that such a relation between propositions and the world does, in fact, take place; it is necessary to explain it. Otherwise, the knowledge or understanding of reality derived from models would be fortuitous and contingent since we would not have an objective criterion to distinguish the correct representations from the incorrect ones, thus being able to justify the epistemic value of the former. This would completely render realism and veritism meaningless.

For the sake of conceptual clarity, I find it convenient to make explicit the contributions of the semantic assumption to the development of the onto-representational approach, as well as its connections with representationalism, veritism, and realism. So, let me analytically reconstruct the theses of onto-representationalism:

1. Representationalist Assumption. There is a class of models that are more valuable: representational models. Onto-representationalist considers that a model system represents its corresponding target system iff the former holds a certain representational relationship with the latter. This relation is articulated through a particular representational parameter, such as similarity, -morphism or universal patterns, at least concerning the causally central elements that explain the emergence or stability of certain aspects or behaviors considered relevant within a given domain of investigation.

2. Epistemological Assumption (veritism). To be genuinely representational, the descriptions of the considered aspects of the target system must be articulated as explanations. To be sound—true—, the propositional elements that structure such explanations must accurately represent a certain class of mechanisms/processes or behaviors of the ontic structure of the phenomenon, those that account for the emergence of the aspect considered relevant—difference-maker. Therefore, there is an objective criterion to discriminate between correct and defective models.

3. Ontological Assumption (realism). There is an objective and structured reality whose existence is independent of the mind. The phenomena—target systems—of the world that scientists study possess an already defined ontic structure independent of any pragmatic considerations. The latter guarantees the conditions of possibility for the existence of a representational connection between our models and the world. Moreover, it is the one that sets the necessary conditions for scientists to be able to

configure an objective criterion through which to differentiate, at the epistemological level, true explanations from false ones.

As de Oliveira (2021, 2022) rightly points out, ontological and epistemological assumptions go hand in hand. Only if phenomena have an objective ontic structure that can be grasped through models is it possible to obtain knowledge of the former by studying and making use of the latter (2021, p. 2010). However, de Oliveira has overlooked the fact that these two assumptions are insufficient to articulate an adequate account that explains the representationalist character. Recall that one of the distinctive features of onto-representationalism is the indissoluble link between the representational, ontological, epistemological, and semantic theses. I have argued that the onto-representationalist must specify how we can assess whether the elements of the model systems stand in the right relation to those of the target system. Only in this way is it possible to justify why they are epistemically valuable, thus differentiating which models are genuinely representational. Onto-representationalists cannot simply remain on an epistemic plane. If so, the status of this meta-scientific stance would be in question. A semantic ascent is necessary. Correspondence theory enters into the picture to guarantee its suitability and adequacy: it allows the concrete materialization of the epistemological assumption by clarifying the role of truth in judging the correctness of representations.

> *4. Semantic Assumption (correspondence theory).* The epistemic virtues of the representations are explained because the propositional elements that structure the explanations—truthbearers—refer to the mechanisms/processes or behaviors that articulate the ontic structure of the target systems—truthmakers—, at least the difference-makers. To justify the correctness of this correspondence relation between linguistic and non-linguistic items, it is not enough to appeal to a deflationary theory of truth; it is necessary to appeal to some kind of correspondence theory. This is possible because of the prior commitment to the existence of an already structured objective reality.

On the basis of this analytical reconstruction, to offer a satisfactory account of scientific representation the onto-representationalist should provide an answer to each of the questions that structure the following scheme:

> Scientific Representation-Problem Scheme (SR-P Scheme): What is a scientific representation? It consists of:
>
> > 1. *Coordination Problem (CP):* What is the representational parameter by which a model system successfully represents its corresponding target system?
> >
> > > Classical Onto-representationalism: similarity or -morphism. Model systems represent their corresponding target systems iff there is a direct correspondence between certain components or characteristics, at least regarding the elements that are causally central to the emergence of the phenomenon under study (difference-makers).
> > >
> > > Sophisticated Onto-representationalism: counterfactual inferences. Model systems represent their corresponding target systems iff they uncover universal patterns of behavior. That is, if they allow us to obtain information about the counterfactual

(in)dependence relationships that take place between certain characteristics/parameters that are considered relevant in the production of the *explanandum*.

2. *Accuracy Problem (AP):* What makes a representation accurate? Here is where "the problem" of the "scientific representation problem" really lies. Keep in mind that accuracy leads to truth.

Classical Onto-representationalism: correspondence theory.
Sophisticated Onto-representationalism: correspondence theory.

This scheme aims to synthesize the steps that must be taken in order to account for the cognitive role of representations. Note that I do not intend to claim that all proposals must answer to this scheme. Only those framed within onto-representationalism. In fact, authors such as Chakravartty (2010), Suárez (2004), Contessa (2007) or Frigg and Nguyen (2020) have considered that both questions are logically independent. For them, a model X can be inaccurate while being a representation of the target system T. Similarly, for advocates of a non-onto-representational approach it would not make sense to speak of accuracy, but rather of justification.

4. *Classical Onto-representationalism*

In the following two sections, I will show how the versions of onto-representationalism address SR-P. Here, I will delve into the response provided by classical onto-representationalism to CP and AP, exposing its problems.

Two parameters are invoked to elucidate the connection between the model system and the target system: similarity (e.g., Craver & Kaplan, 2020; Giere, 2006; Strevens, 2008; Weisberg, 2013) or morphism (e.g., Bueno & French, 2011; da Costa & French, 2003). The reason for proposing these parameters is to circumvent any linguistic consideration, thus avoiding the correspondence theory. As I will show, this strategy ultimately fails.

Advocates of similarity acknowledge that the connection between idealized model systems and target systems is complex and indirect: they can enter into many types of relationships. What makes it possible to connect the two systems is specification and instantiation. Specification refers to how the model is described (through linguistic, diagrammatic, mathematical, or computational devices, among others). In other words, it is the step that connects the model and the description of the model, conferring the former its representational status (Godfrey-Smith, 2006, p. 733). The description of the model also needs to be instantiated. Instantiation involves determining on which aspects of the world the model system focuses (conventions are sometimes needed because models do not naturally map to parts of real phenomena), which elements of the model represent which elements of the world, and what standards of accuracy should be used to evaluate the model. Representative model systems are similar to their corresponding target systems regarding certain characteristics to some degrees considered relevant by the community. Note that the similarities established between the model and the target are ambiguous until they are made explicit. This is where hypotheses come into the picture. Giere argued that hypotheses are statements that establish how a fully interpreted and specified model fits a particular real system (Giere, 1988, pp. 81-82). In other words, they are linguistic devices that highlight the relevant similarities, specifying to what degree they satisfy the specified requirements. Otherwise, similarity relations would be epistemically ambiguous. Because of onto-

representational commitments—realism and veritism—the evaluation of these hypotheses requires a semantic ascent. The correct representation will be the one that, regardless of the pragmatic context of evaluation, stands in the proper relation to (certain aspects of) the phenomenon of the world. Consequently, even if the similarity relations are not articulated in terms of truth or falsity, since these entities (model and target system) are essentially non-linguistic, the same is not true when it comes to the hypotheses. Because of the realist and veritistic commitment, hypotheses must be evaluated by appealing to a semantic theory of truth.

Despite attempts to dissociate from any appeal to considerations of a linguistic nature, classical onto-representationalism is eventually forced to appeal to a correspondence theory to offer a substantive answer to the problem of scientific representation. Consequently, they must confront internal problems associated with correspondence theory. But not only that, they must also face another problem: the widespread use of idealizing assumptions and distortions. This issue can be easily overcome. Michael Strevens (2008, 2013, 2017) has argued that, while the elements of the model that detail the causal structure of the phenomenon must be veridical to be genuinely explanatory and representative, not all of them have to be so: only those that make the difference to the emergence of the phenomenon. Strevens seems to offer a partial answer to AP: models are genuinely representative iff they accurately reflect, at least, the elements that make a difference to the emergence of the phenomenon—difference-makers. There are, however, several problems with this solution.

As Rice (2019) has pointed out, this suggestion is based on a highly problematic assumption called "decomposition strategy". Here, it is taken for granted that: it is possible to decompose the phenomenon by isolating the contributions of those features that are central to the occurrence of the phenomenon (Target Decomposition Assumption); it is possible to decompose the model by differentiating the contributions of the precise parts from the idealized ones (Model Decomposition Assumption); and it is possible to connect the former with the latter (Mapping Assumption). However, this analytical decomposition is usually not so easy to achieve. Even when possible, one would still face the problem of holistically distorted models. Holistically distorted models are characterized by two features. First, they bear no representational relation to their respective target systems. Even the elements considered causally central to the production of the phenomenon are idealized (Rice, 2021). Second, this distortion is necessary: it allows the implementation of mathematical modeling tools to obtain information that would otherwise be impossible. This makes it infeasible to decompose the model by differentiating the contributions of the precise parts from the idealized ones, connecting the former with characteristics, causal patterns, or mechanisms in the world.

Extremely relevant proposals have been articulated around the notion of morphism. Morphism is essentially a relation between two structures. The main drawback of this approach is that, as Frigg (2023) points out, target systems, or phenomena, are not mathematical structures. To claim that a set-theoretic structure is morphic to a part of the physical world is a category mistake. What theoretical models represent are data models, which can indeed be treated as set-theoretic structures. However, to assume that our best models represent only data models, but not the corresponding phenomena, would completely empty the onto-representational perspective of its content (van Fraassen, 2008, p. 258). But not only that, theoretical models are abstract structures of set theory that lack representational content by themselves. The agent decides which structure to represent when specifying the system. Therefore, in order to acquire a representational dimension, structure-generating descriptions and interpretations are indispensable (Morrison, 2007, p. 207). These considerations bring us back to the initial problem; the interpretation of language. In

addition, the advocate of morphism should also address the problem of holistically distorted models.

5. *Sophisticated Onto-representationalism*

Acknowledging the enormous difficulties faced by classical onto-representationalism, several authors have considered that only by analyzing the SR-P problem from an alternative conceptual standpoint is it possible to offer an adequate answer to AP while maintaining the onto-representational assumptions. In other words, they have tried to accommodate the existence of holistically distorted models through a renewed representational parameter that avoids linguistic considerations. I will refer to this conceptual position as "sophisticated onto-representationalism".

What differentiates the sophisticated onto-representationalist approaches from the classical ones is their interest in separating two seemingly indissoluble theoretical assumptions: representationalism and literalism. While the classical approach holds that it is possible to literally represent certain aspects of the ontic structure of phenomena, the sophisticated one considers that the access to this ontic structure is indirect: our best models represent reality, but not literally. This approach has been motivated by the widespread use of holistically distorted models. In sum, the goal of sophisticated onto-representationalist has consisted in making sense of the existence of holistically distorted models, avoiding any invocation of a correspondence theory while preserving onto-representational commitments.

The immediate question that arises is the following: if to be qualified as representational is no longer required to literally reflect aspects of the target system, then what is the parameter of representation? In other words, what is the answer to CP? Certainly, appeals to elements such as isomorphism or similarity *must* be avoided, since these require that the model system and the target system have some *shared features*. The sophisticated onto-representationalist holds that the representational relation must be characterized in *counterfactual inferential terms*. More specifically, in counterfactual (in)dependency relations. Modal inferential reasoning becomes the representational parameter to establish the model system-target system relationship. At first glance, it might seem that, by avoiding the appeal to shared characteristics, the advocates of sophisticated onto-representationalism are in a more favorable position to deal satisfactorily with the AP problem, since they would evade correspondence theory while making sense of the holistically distorted models. To analyze whether sophisticated onto-representationalism succeeds in overcoming the problems of its classical counterpart, I will consider the proposals of Bokulich and Rice.

Bokulich has articulated an onto-representational account called "Eikonic Conception": "I grant that explanation and understanding are "success terms", in that they require getting something right about the way the world is, and more generally, I take the eikonic conception of explanation to be compatible with a broadly realist approach to science" (2018, p. 796; see also 2016, p. 261). For Bokulich, scientists never study the pure phenomenon in its complexity. When investigating a phenomenon, scientists make use of a series of conceptual, methodological, or theoretical tools framed within a particular research program to generate representations of the target system. In other words, scientists do not study the phenomenon-in-the-world but a particular conceptualization dependent on the context and research interests; a phenomenon-as-represented. The explanations derived will depend on the latter. Let me analyze what answer Bokulich gives to the SR-P scheme:

> *CP*. Models need not literally reflect the elements of the target system to be considered genuinely representational. That is, they need not share characteristics with the target system to be representative. For Bokulich, maximizing realism (in the sense of literalism) in many cases neither leads to an increase in prediction accuracy

nor to an improvement in the explanation that can be obtained. So, what are the parameters that establish the representational character? Basically two. First, the interests and epistemic resources of the scientists. Whether a model is representational depends on how the phenomenon is conceptualized and the properties scientists want to explain. These considerations derive from the distinction established by Bokulich between phenomena-in-the-world and phenomena-as-represented. Recall that it is not incompatible to offer an onto-representational account with introducing the pragmatic interests of the agents. Second, and more importantly, the model must provide scientists with modal information about patterns of counterfactual (in)dependence on the *explanandum* they aim to explain: answering how particular changes in the properties of the model would lead to specific outcomes. If the model allows us to correctly answer questions "What-if-things-would-have-been-different", then it is genuinely explanatory—not simply an *ad hoc* phenomenological model—and provides a *factive* understanding of the phenomenon[3] (2016, p. 271). This conceptual shift allows Bokulich to accommodate the use of holistic distortions and fictional models while retaining onto-representationalist intuitions. However, one question remains, how do we evaluate the degree of accuracy in capturing counterfactual dependency patterns?

AP. Bokulich states that in order to represent a phenomenon P, the counterfactual structure of the model M must be *isomorphic*, in the aspects considered relevant within the domain of investigation, to the counterfactual structure of P (Bokulich 2011, p. 43). That is, the model system must provide precise modal information on how the target system would behave if certain elements/variables of the target system were altered. This can be done only if it *reproduces* the counterfactual characteristics considered relevant to the target system within a particular domain of investigation. This answer seems to take us back to the problems that classical onto-representationalism was prey to.

Another author who has articulated a sophisticated approach is Rice. His account, labeled Realism of Understanding (2021), holds that science aims to achieve a *factive* understanding of the world. To genuinely understand a phenomenon, what is stated should be true, thus standing for the world. Like Bokulich, he argues that it is possible to achieve factive understanding through models that do not literally represent their corresponding target systems. That is, through holistically distorted models. Let us analyze Rice's response to SR-P:

CP. While it is true that holistically distorted models are unable to represent in a literal way the characteristics, causes, or mechanisms that make the difference, these models have the potential to be considered genuinely explanatory and representational. The holistic distortions in these models allow modelers to use mathematical modeling tools to access information that would otherwise be impossible to have. What kind of information? Information about the patterns of counterfactual (in)dependence. These relationships of counterfactual (in)dependence are intended to uncover patterns of universality. Rice argues that universality means: "*the stability of certain patterns or behaviors* across systems that are heterogeneous in their features" (2021, p. 155). He introduces the concept of universality classes to highlight that model systems that are heterogeneous in their characteristics can exhibit the same patterns of behavior. Thus, Rice provides us with a global representational parameter: a model

[3] Factive understanding accounts are committed to theses of a veritistic and realist nature (see, e.g., Baumberger et al., 2017).

system represents its corresponding target system iff it provides true modal information about how certain changes in the system's characteristics/parameters alter (or not) the behavior of the phenomenon of interest. That is, if it provides information about counterfactual (in)dependence relationships backed by patterns of universality.

AP. Rice, unlike Bokulich, does not offer a clear answer to the question of what it means to provide adequate information about counterfactual (in)dependence relationships. It is only possible to claim that a model represents its corresponding target system and provides factive understanding if there is some way to properly connect the behavior of the ideal case (of the system described by the holistically distorted models) with the behavior of real phenomena. Rice only states:

> The key thing to notice is that holistically distorted models can provide accurate modal information because universality guarantees that the *model system's patterns of behavior will be similar to those of the target systems, even if the actual entities, causal interactions, and processes of those systems are extremely different*. Therefore, even if the model drastically and pervasively distorts the fundamental nature of the relevant features of real-world systems in order to use various mathematical modeling techniques, it can still be used to explain because *many of the patterns of counterfactual dependence and independence that hold in the model system will be similar to those of real-world systems.* (Rice, 2021, p. 161 my emphasis; see also p. 156)

Rice, therefore, does not clearly state how it is possible to assess whether the counterfactual (in)dependence patterns are, in fact, true and provide a factive understanding, i.e., whether or not they truly reflect those counterfactual (in)dependence relationships. In other words, he does not make explicit what is the standard of accuracy that allows us to determine whether our model is genuinely representative. It might be possible to deduce the answer from his writings: there must be some correspondence between the patterns of counterfactual (in)dependence of the model and those of the world. This would mean that Rice's view is still tied to the requirement of accurate representation, slipping back into the problems associated with the interpretation of language (see Carrillo & Knuuttila, 2022). From these analyses, one can conclude the following. Either Rice's proposal is incomplete and, therefore, he has to specify how it is possible to answer the questions raised above without committing, like Bokulich, the same mistakes of classical representationalism, or simply his proposal does not offer a substantial improvement over classical representationalism since it also leads to a correspondence theory.

In sum, the sophisticated onto-representationalist seems ultimately to fail in the attempt to dissociate "representationalism" from "literalism", thus being able to provide an adequate response to SR-P. I believe that the inability of the onto-representationalist to provide a satisfactory answer to SR-P is not explained by the argumentative weakness of the concrete proposals that comprise it. Rather, it is the product of the assumptions that integrate it: representationalism, realism, and veritism. The tight linkage of these assumptions leads irremediably to a semantic question difficult to solve: How are the elements or behaviors uncovered by the model system connected to those of the target system? The answer to this question is crucial since it provides a standard to differentiate the correct representations from the defective ones and, by extension, the models that are genuinely representational

from those that are not. Ultimately, it is necessary to appeal to a semantic theory, embodied in some kind of correspondence theory. This is what makes it possible to relate the linguistic elements (the inferences/explanations associated with the model) with the non-linguistic elements (the mechanism/process or behavior of the modeled phenomenon).

The failure of onto-representationalism should not, on the other hand, lead us to a kind of skepticism about the possibility of achieving a satisfactory answer to SR-P. Delineating a concept of representation that allows us to discriminate between adequate and inadequate models is a desirable theoretical goal that can help us to articulate a more efficient scientific practice. Rather, the criticisms raised against this framework should lead us to ask ourselves whether the meta-scientific approach through which SR-P has usually been approached is adequate. At present, a plurality of authors are immersed in developing alternative meta-scientific platforms to onto-representationalism (see, e.g., de Oliveira, 2022; Knuuttila, 2011, 2021). These proposals simply do not assume the ontological and epistemological assumptions of onto-representationalism. Undoubtedly, these alternative frameworks will not be without problems and criticisms that need to be critically addressed. However, the moral that I would like to draw from this analysis is that instead of trying to articulate ever more sophisticated and complicated onto-representational proposals, perhaps we should explore the possibilities offered by these new approaches regarding SR-P.

6. Conclusion

In this paper, I have analytically structured the representational, ontological, epistemological, and semantic assumptions underlying the meta-scientific platform that the majority of accounts that have attempted to address SR-P have adopted. Namely onto-representationalism. I have shown to what extent this meta-scientific framework leads to an inadequate conceptualization of SR-P. Drawing on current literature on scientific representation, I have argued that its main weakness, and the reason why it is not suitable for addressing SR-P, lies in the semantic assumption. I have contended that it is impossible to dissociate the four assumptions that integrate onto-representationalism. But not only that, I have shown that the validity of one depends on the validity of the others. If one assumption proves to be erroneous, the contribution of the others will be invalidated. Therefore, if one wants to retain the representationalist, realist, or veritistic commitments, one must face the challenges raised by the semantic assumption. That is, the articulation of a criterion that allows one to answer the question of what makes a representation accurate. This implies facing the challenges inherent to the interpretation of language, a task in which epistemologists have been immersed for years, and which correspondence theorists do not seem to have solved so far. This leads onto-representationalist approach to a stalemate: either they face the semantic problem, or they leave aside their representational, ontological, and epistemological commitments, thus exploring new avenues. Since the former option has turned out to be a dead-end so far, nothing prevents us from exploring alternatives to onto-representationalism. I have concluded that perhaps the best way to deal efficiently with SR-P is to adopt one of the alternative approaches to onto-representationalism that are currently being developed.

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