Mεtascience
Scientific General Discourse

No 3–2024 Edited by François Maurice

Metascientific Epistemology

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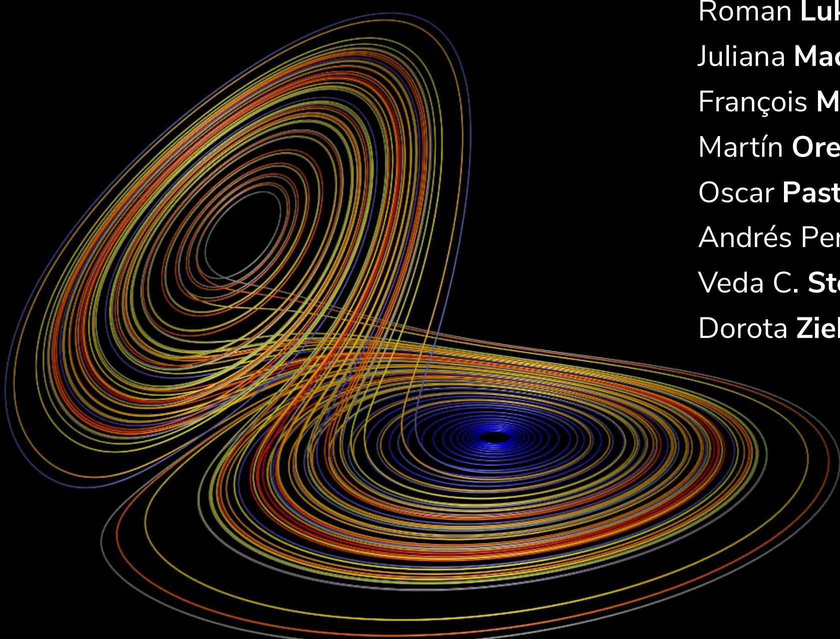

Society for the Progress of Metascience

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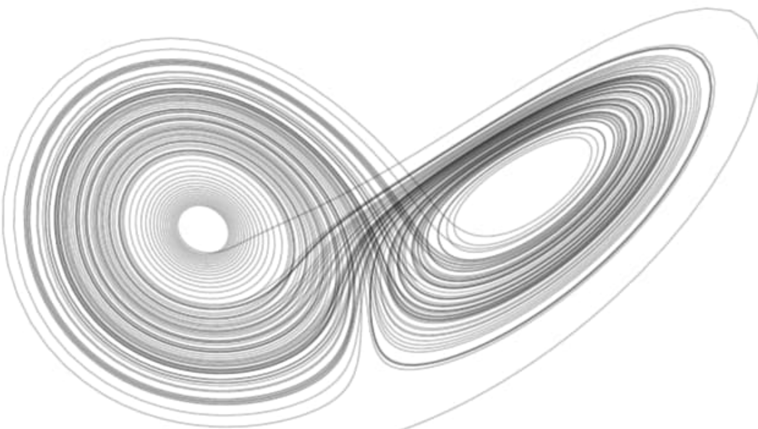

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Metascientific Epistemology

François Maurice[1]

Science and Epistemology[2]

In French, the terms "epistemology" and "philosophy of science" are sometimes used interchangeably. However, most authors recognize that epistemology has a narrower scope than the philosophy of science. The latter is interested not only in epistemological questions, but also in a wide range of other philosophical questions related to science. These may include uncovering the true nature of reality through an adequate interpretation of scientific knowledge, accounting for the relationship between science and society, understanding the ethics of science, and studying the history of science.

Epistemology, on the other hand, would not be the study of science in all its aspects, but would be limited to the study of scientific knowledge. Dominique Lecourt summarizes the situation well in the following passage:

> While the term "epistemology" is often used loosely, it can be considered more modest than "philosophy of science." Epistemology focuses on the rigorous analysis of scientific discourse, examining the modes of reasoning employed and describing the formal structure of scientific theories. Epistemologists, concentrating on the process of knowledge acquisition, often exclude reflection on its meaning. They sometimes present their discipline as a scientific one that has broken away from philosophy. (Lecourt 2010)

In this strict sense, epistemology takes scientific discourse or scientific knowledge as its object of study and sometimes conceives of

[1] **François Maurice** holds degrees in social statistics and philosophy from the Université de Montréal. Director of the journal *Metascience*, he is also the translator in French of Mario Bunge's *Philosophical Dictionary*, both published by Éditions Matériologiques.

[2] This text was originally written for a French audience.

itself as a discipline independent of philosophy. This characterization of epistemology is therefore similar to our conception of metascience (Maurice 2020, 2022a, 2022b). Have we therefore chosen an expression to designate the same activity as that practiced within epistemology in the strict sense? This is not the case if we recognize that scientific knowledge is a construction of the mind, but that this particular construction takes several forms. Scientific constructs are for example concepts, statements, classifications, theories and scientific models. These types of constructs can themselves be divided into subtypes depending on whether one studies a construct from a semantic, ontological or epistemological angle. It is because scientific constructs have several conceptual properties that they are at the same time an object of study for metascientific semantics, ontology and epistemology[3].

While epistemology can be interested in various types of constructs, it pays particular attention to those that Mario Bunge calls epistemic operations, distinct from cognitive processes. Examples of epistemic operations include definition, reduction, description, subsumption, explanation, demonstration, prediction, questioning, problematization, observation, experimentation, classification, theorization, problem-solving, analysis, synthesis, planning, etc., operations that deal with concepts, propositions, theories, etc. These operations contribute to epistemic transformations, that is, to the acquisition, creation, and transformation of scientific knowledge.

Epistemic operations are constructs or abstractions or, in Bunge's terms, fictions. As constructs, epistemic operations possess no properties of a concrete object, notably that of energy. They cannot therefore be studied by factual sciences. The latter, notably cognitive neuroscience, studies the cognitive processes that enable us not only to create or abstract an epistemic operation, but also to transmit it to others, receive it from others, reactivate it with a view to studying or using it, and so on. Cognitive processes are facts of the world that occur in brains, while epistemic operations are constructs produced by these same brains. This is the position we defend in our article "What is Metascientific Epistemology?"

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[3] The nature of metascientific ontology was addressed in our article "What is Metascientific Ontology?" published in the second issue of *Metascience*. Metascientific semantics will be treated in the fourth issue.

Metascience would be very poor without metascientific practice. We are fortunate to be able to draw on the work of Mario Bunge, the first accomplished metascientist, but a living discipline is one that discovers and invents. This same work has shown us that metascience is a varied activity that can be practiced in many different ways. Let's follow our common thread, Bungean or metascientific epistemology, and take a brief look at the few articles in this third issue of *Mεtascience* devoted in whole or in part to metascientific epistemology.

The links between epistemology, science education and science teaching are numerous. In an article with the explicit title, "Making Sense of Models and Modelling in Science Education: Atomic Models and Contributions from Mario Bunge's Epistemology", Juliana Machado explores some of these links. She takes as her starting point the fact that students encounter an obstacle in their learning of scientific models. The model is seen as a mere copy of reality. A better understanding by students of the notion of model and of modeling, an epistemic operation par excellence, could therefore prove useful in learning scientific models. The notion of model she explores is that of Mario Bunge. She puts this notion of model to the test by examining several models of the atom proposed at the beginning of the 20th century. She concludes that the notion of the Bungean model provides a good account of the development of models of the atom, or, more precisely, that the properties Bunge attributes to scientific models can be found in models of the atom and in the way the atom is modeled. Students could thus benefit from a coherent and relevant notion of models when learning about a scientific model.

In recent years, researchers have revealed the existence of a group of philosophers who contribute to the solution of scientific problems. These philosophers use classical tools, methods or epistemic operations from philosophy, such as conceptual clarification, critical evaluation of scientific hypotheses, analysis of the coherence of arguments, the formation of new concepts, theories or research programs, and the search for links between different disciplines. The researchers in question do not deny that these epistemic operations are also used by scientists, but maintain that this practice, which they call philosophy *in* science, is nevertheless a philosophical one, more precisely, a pragmatic one. François Maurice challenges this assertion in his article "What's Left of Philosophy?"

This way of defending philosophy, by severely restricting its nature to be of any use to science is a widespread strategy. It suffices to limit epistemic operations to those shared by science and to pragmatically redefined philosophy. In his article "On Philosophical Heuristics", Andrés Pereyra Rabanal adopts such a conception of philosophy as "a type of conceptual research subjected to the usual standards of rationality and capable of raising questions considering the best available knowledge with the help of formal tools such as mathematics and logic". This strategy makes it possible to conceive of philosophy on an epistemic continuum that also includes common knowledge and scientific knowledge. There is no difference in nature, only in kind, between the various types of knowledge.

Language is the subject of bitter debate about what it is and how to study it. The epistemic status of linguistics is also under debate. Can linguistics be an empirical science on a par with the natural sciences? Dorota Zielińska answers in the affirmative in her article "In Defence of Linguistics as an Empirical Science in Light of Mario Bunge's Defence of the Scientific Treatment of Biology". She argues that a right conception of science, such as Mario Bunge's, makes it possible to conceive of linguistics as an empirical science on a par with biology. To achieve this, she debunks a number of myths about the nature of linguistics.

These articles all have an epistemological component, but we mustn't lose sight of the fact that metascientific disciplines, like scientific disciplines, don't operate in a vacuum, that metascientific epistemology, ontology and semantics study the same conceptual object—scientific knowledge—and not the concrete world, which is the preserve of science, nor a metaphysical world, which is the preserve of philosophy.

Contributions

The ten contributions to this issue come from authors of different backgrounds, as befits a general thought that aims to be useful to all fields of knowledge. It should be noted, however, that the contributors to this issue of *Mεtascience* do not necessarily support the research program of Society for the Progress of Metascience, nor the editorial policy of the journal. They are authors interested in various aspects of Bunge's thought. Although epistemology is a common thread linking some of the articles in this issue, we distinguish four types of contribution: 1) Studies on Bunge's System; 2) Metascientific Contributions; 3) Applications of Bungean Thought; 4) Around Metascience.

1] Studies on Bunge's System

François Maurice in "What is Metascientific Epistemology?" pursues the characterization of metascience begun in his articles in the first and second issues of *Mεtascience*. Metascientific epistemology differs from philosophical epistemologies in its aims, objects and methods. Its general aim is to build conceptual knowledge about science through the study of scientific constructs. More precisely, metascientific epistemology studies the *epistemic operations* necessary for scientists to acquire factual knowledge. Consequently, it does not study *cognitive processes*, which are the domain of cognitive neuroscience. Notably, this epistemology does not propose a theory of knowledge, as is common in philosophy. Metascientific epistemology is therefore not a naturalized epistemology; it distinguishes the concrete objects studied by the sciences from the constructs used to represent these objects. Metascience and its constituent disciplines, such metascientific semantics, metascientific ontology and metascientific epistemology, are concerned only with scientific constructs.

Martín Orensanz examines in "Difference Between the Existential Quantifier and the Existence Predicate According to Mario Bunge" the contradictions and paradoxes that arise when philosophers grant an ontological scope to logic, more specifically to the "existential quantifier" ∃. Orensanz reviews the solutions proposed by Frege, Russell and Quine as part of this ontological interpretation of logic. The contradictions or paradoxes that arise from this interpretation of the "existential quantifier" are avoided if ∃ is read "for some…" and not "there exists…" and if the quantifier is named "particular quantifier" following Mario Bunge. In this way, the quantifier remains a logical concept. To account for the property of existence, it is then sufficient to introduce two existence predicates to account for real existence, E_R, and conceptual existence, E_C, so that contradictions and paradoxes vanish.

2] Metascientific Contributions

Martín Orensanz and François Maurice, in "Advancing the Metascientific Program. First Dialogue", propose an initial dialogue on the possibility of a metascientific research program. This dialogue is an opportunity for two Bungeans of different orientations to exchange views on several notions and problems found in Mario Bunge's work: is it possible to prove that the external world exists? What is matter? Is the part-whole relation transitive? What's the difference between systems and assortments? Do fictitious objects have a function in ontology? While Maurice defends his metascientific interpretation of Bunge's thought, notably by refusing to use philosophy to examine the problems addressed, Orensanz does not hesitate to call on analytic metaphysics to solve a number of these problems.

3] Applications of Bungean Thought

Juliana Machado, in "Making Sense of Models and Modelling in Science Education: Atomic Models and Contributions from Mario Bunge's Epistemology", addresses the problem of teaching scientific models, as these are often perceived as mere copies of reality. Machado draws on Mario Bunge's epistemology and model theory to solve this problem. Bunge distinguishes several types of models, each with its own characteristics and its relationship to reality, to general theories and to other types of models. Bunge also emphasizes the role of abstraction and idealization in modeling reality. Machado uses the history of atomic models to illustrate the application of Bunge's epistemology and model theory, demonstrating that scientific models are abstract, idealized constructs that evolve over time to better explain and predict phenomena. In this way, the joint use of Bunge's model theory and the history of science makes it possible to achieve pedagogical objectives in science education. Machado also argues that Bunge's model theory can be used directly for modeling activities in the classroom, without the need for historical examples.

In "System: A Core Conceptual Modeling Construct for Capturing Complexity", Roman Lukyanenko, Veda C. Storey and Oscar Pastor continue their research into the development of an ontology suited to information technology and conceptual modeling. In a previous article, "Foundations of Information Technology Based on Bunge's Systemist Philosophy of Reality", which appeared in the second issue of *Metascience*, they introduced us to Bunge's Systemist Ontology (BSO), inspired by Bunge-Wand-Weber (BWW) ontology, widely used for nearly four decades for conceptual systems modeling. Whereas BWW is based on the notion of thing or concrete object, BSO puts forward the notion of system. BSO uses Bunge's CESM schema to analyze any system in terms of *components*, *environments*, *structures* and *mechanisms*. For the authors, the CESM schema is too restrictive. They therefore propose a CESM+ schema, which they see as a checklist "to help designers describe and model the essential aspects of a system". Thus, at the start of a project, in addition to considering a system's components, environments, structures and mechanisms, the CESM+ schema reminds the designer to consider other essential aspects of a system, including emergent properties and the history of the system. The authors examine a practical case of conceptual modeling using the CESM+ schema.

Dorota Zielińska, in "In Defence of Linguistics as an Empirical Science in Light of Mario Bunge's Defence of the Scientific Treatment of Biology", defends a conception of linguistics that makes it an empirical science on a par with the natural sciences insofar as one adopts an adequate conception of science along the lines of that proposed by Mario Bunge. The author had offered a defense of this conception of linguistics in a first article, "Linguistic Research in the Empirical Paradigm as Outlined by Mario Bunge", which appeared in the second issue of *Mεtascience*. In the latter article, Zielińska, after outlining Bunge's scientific methodology and asserting the self-regulating and self-organizing nature of language, presented a linguistic law she established as part of this approach. In the present article, the defense of the empirical nature of linguistics begins with a brief overview of the history of laws in linguistics in order to show that the failure of linguists to establish *deterministic laws* led them to deny the possibility of conducting empirical research in linguistics that would be akin to research in the natural sciences. Zielińska argues, on the contrary, that linguistics is an empirical science whose *probabilistic laws* can be subjected to testing. The author then tackles eight myths about the nature of linguistics, appealing both to Bunge's conception of science and to examples of empirical laws in linguistics, including his own quantitative law on the order of adjectives in a sentence.

4] Around Metascience

Andrés Pereyra Rabanal, in "On Philosophical Heuristics", argues that science and philosophy form a continuum of concepts, from the most general to the most specific. There is therefore a difference in degree, not kind, between philosophical and scientific statements. From a heuristic point of view, philosophy is seen as a second-order reflection whose specific presuppositions in the science it studies must be evaluated in terms of their informativeness, appropriateness, relevance, generality and originality. In the same way, philosophical theories must be subjected to Bungean evaluation criteria according to the way in which they contribute to knowledge, and help us to learn, ask and resolve new questions.

Martín Orensanz in "Object-Oriented Ontology and Materialism" challenges the idea that matter does not exist according to Graham Harman's object-oriented ontology (OOO). Orensanz argues that matter can be conceptualized both as a sensual object and as a real object within the framework of object-oriented ontology. He also argues that matter is not a fiction, against Mario Bunge and Gustavo Romero, and that the term "matter" can be understood as grammatically singular but referentially plural, i.e., as a disguised plural, borrowing the latter notions from Daniel Z. Korman. Orensanz conceives matter as a plurality of real things, each of which possesses energy.

Graham Harman responds to Martín Orensanz's criticisms and suggestions in his article "Matter and Society. Response to Orensanz". Harman immediately accepts that matter can be conceived as a sensual object within the framework of his object-oriented ontology, because in OOO's sensual domain everything is permissible, since sensual objects must be in relation to other objects in order to exist, which is not the case with real objects, which exist independently of any other entity that may encounter them. However, he denies that matter is a real object if by matter we mean the prime matter of the philosophers. But since sensual objects have real qualities in the context of OOO, he concedes to Orensanz that matter also has real qualities as a sensual object, although the concept of "matter" is a fiction, but a fiction conceived differently from Bunge and Romero. Harman rejects Orensanz's proposal to consider the term "matter" as a disguised plural whose referent would be a plurality of things, i.e., in the case of matter, the plurality of all things.

In "What's Left of Philosophy?" François Maurice takes another look at the idea of philosophy *in* science. This philosophical discipline would provide solutions to scientific problems using philosophical tools. While in a first article "Philosophy in Science: Can Philosophers of Science Permeate through Science and Produce Scientific Knowledge?" Pradeu, Lemoine, Khelfaoui and Gingras define philosophy *in* science and identify several philosophers who practice it, in a second article, "Reuniting Philosophy and Science to Advance Cancer Research", Pradeu and thirty-six collaborators demonstrate the usefulness of philosophy *in* science using cases drawn from cancer research. Maurice reiterates that thinkers of philosophy *in* science practice a metascience unrelated to philosophy.

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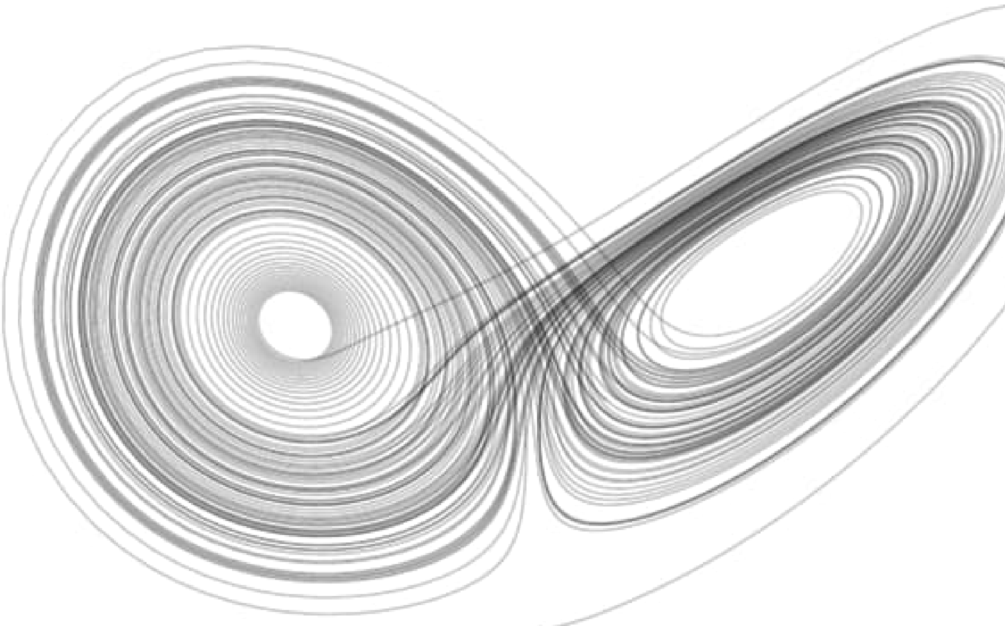
1
Studies on Bunge's System



What is Metascientific Epistemology?

François Maurice[1]

Abstract—Metascientific epistemology differs from any philosophical epistemologies in its aims, objects and methods. Through an examination of Mario Bunge's epistemology, we will show that the main objective of metascientific epistemology is the development of a unified representation of the epistemic transformations of scientific knowledge through the study of the epistemic operations necessary for its acquisition, creation and validation, that its objects of study are scientific constructs, and that its methods do not differ from those expected to be found in any rational activity. Metascientific epistemology is therefore not transcendent, since it takes for granted that the sciences study concrete objects with the help of natural faculties, and that it itself studies scientific constructs with the help of natural faculties, and therefore does not resort to special faculties or methods to carry out its research.

Résumé—L'épistémologie métascientifique se distingue des épistémologies philosophiques par ses objectifs, ses objets et ses méthodes. Par un examen de l'épistémologie de Mario Bunge, nous montrerons d'abord que le principal objectif de l'épistémologie métascientifique est l'élaboration d'une représentation unifiée des transformations épistémiques de la connaissance scientifique par l'étude des opérations épistémiques nécessaires à son acquisition, sa création et sa validation, puis, en second lieu, que ses objets d'étude sont des construits scientifiques, et finalement que ses méthodes ne diffèrent pas de celles qu'on s'attend à trouver dans toute activité rationnelle. L'épistémologie métascientifique n'est donc pas transcendante puisqu'elle tient pour acquis que les sciences étudient des objets concrets à l'aide de facultés naturelles, qu'elle-même étudie les construits scientifiques à l'aide de facultés naturelles, et que, par conséquent, elle n'a pas recours à des facultés ou à des méthodes spéciales pour mener à bien ses recherches.

We undertook a characterization of metascience in general terms in our article "Metascience: for a scientific general discourse" (Maurice 2020), which appeared in the first issue of *Mεtascience*. We

[1] **François Maurice** holds degrees in social statistics and philosophy from the Université de Montréal. Editor of the journal *Mεtascience*, he is also the translator in French of Mario Bunge's *Philosophical Dictionary*, both published by Éditions Matériologiques.

pursued this characterization in more precise terms through the study of Mario Bunge's metascientific ontology in our article "What Is Metascientific Ontology?" (Maurice 2022a), which appeared in the second issue of *Metascience*. Just as we identified a metascientific ontology in Bunge's work, it is also possible to extract from it a metascientific epistemology distinct from any philosophical epistemology[2].

We will therefore examine Bunge's epistemology as set out in volumes 5 and 6 of the *Treatise on Basic Philosophy*. This exposition will make clear the non-philosophical nature of Bunge's theories if we take the trouble to focus on what he does and not on what he says–that is, if we examine the way he proceeds and the results he achieves, without allowing ourselves to be distracted by what Bunge believes to be his epistemology. Note that the type of exposition employed by Bunge in these two volumes of the *Treatise* differs from that of the first four volumes devoted to semantics and ontology. Bunge has abandoned the use of mathematical formalism and the organization of these concepts in a protoaxiomatic format, even though, as with any argumentative text, the two works are sufficiently coherent and the exposition is epistemically progressive, almost didactic, Bunge favoring an order to facilitate understanding rather than a logical order from the most elementary to the most elaborate concepts. We shall also see that the exposition differs on another level, since Bunge puts forward, alongside his own metascientific results, scientific and therefore factual results. We'll explain this latter situation by exposing Bunge's inconsistency between his conception of epistemology and his practice of epistemology.

In this article, we focus on the objects of study of this epistemology. This examination of the referents of this discipline will enable us to expose a tension in Bunge, a tension already present in his ontology (Maurice 2022a): at times he seems to maintain that there is a strong link between, on the one hand, epistemology and, on the other, psychology, biology and neuroscience, while at other times he defends the idea that epistemological research is autonomous.

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[2] We have taken up the structure of our article "What Is Metascientific Ontology?" which appeared in the second issue of *Metascience* published by Éditions Matériologiques. We have also reproduced several passages from that article, making the necessary changes to facilitate the reading of the present article.

As with his ontology, Bunge oscillates between a conception of epistemology as a factual science, a naturalized epistemology, and a conception of epistemology as a conceptual science. As we shall see, in practice, Bunge develops an "autonomous" epistemology of the factual sciences. The objects of study of epistemology are the constructs of the factual sciences, i.e., epistemological constructs refer to scientific constructs and not to concrete objects.

This muddled conception of epistemology does not, fortunately, affect Bunge's epistemological practice, which is mostly clear: Bunge clearly distinguishes epistemological from psychological, biological and neuroscientific propositions when elaborating his positions.

In addition to the referents of epistemological theories, we'll look at the methods, techniques and tools Bunge uses to construct these theories. We'll see that Bunge doesn't use any approaches associated with philosophical doctrines. In short, we follow Bunge's advice: "When in doubt about the authenticity of an intellectual endeavor, the right thing to do is to perform a candorous [*sic*] reexamination of its three components: subject matter, method and goal" (Bunge 1973, p. 1).

To help us in our characterization of metascientific epistemology, in the next section we will refer to Bunge's definition of science (Bunge 2003, see entry "Science, Basic")[3].

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[3] The definition of science is based on the more general notion of epistemic or cognitive field. Using this notion, Bunge deals with several other notions, such as paradigm, epistemic revolution, field of research, research project, etc. (Bunge 1982, sections 2 and 3, 1983a, pp. 90-93, 1983b, chaps. 13 and 14, 1984, 1985a, pp. 21-28, 1985b, pp. 242-252, 1989, pp. 296-300, 1996, chaps. 7, 2001, sections 8.3 and 8.4, Bunge & Ardila 1987, sect. 3.5). Bunge's attempt to demarcate science from pseudoscience based on the notion of epistemic field would seem ineffective because it is impossible to identify sufficient and necessary conditions to distinguish what is scientific from what is not (Mahner 2021). This is the problem of finding one or more demarcation criteria. For an elaborate treatment of the demarcation problem and the Bungean notion of epistemic field, see "*Demarcating Science From Non-science*" (Mahner 2007). Like Mahner, we believe that the notion of epistemic field is important because it nevertheless clarifies our representation of science, which in principle makes it easier to identify pseudoscience "so as not to surrender to relativism, arbitrariness, and irrationalism" (Mahner 2007, p. 571). This characterization of science also makes it easier to identify objects of study for the metasciences, and to raise issues that would otherwise go unnoticed.

1] The Components of a Factual Science

A factual science is characterized in Bunge by ten criteria, to which we add an eleventh criterion, V. The set of these criteria can be represented by $\mathcal{R} = \langle C, S, V, D, G, F, B, P, K, A, M \rangle$, where each component is detailed as follows:

(1) C, the *research community* of $\mathcal{R}$, is a social system composed of persons who have received a specialized training, hold strong communication links among themselves, share their knowledge with anyone who wishes to learn, and initiate or continue a tradition of inquiry (not just of belief) aiming at finding true representations of facts;

(2) S is the *society* (complete with its culture, economy, and polity) that hosts C and encourages or at least tolerates the specific activities of the components of C;

(3) the *domain* or *universe of discourse* D of $\mathcal{R}$ is composed exclusively of (actual or possible) real entities (rather than, say, freely floating ideas) past, present, or future;

(4) The *values and norms* V adopted by the members of C, such as (a) rationality values (non-contradiction, non-circularity of arguments, etc.); (b) semantic values of precision, clarity and maximum truth; (c) methodological values of testability, explanatory power, predictability, reproducibility and fecundity; (d) moral values of universalism, objectivity, critical thinking, open-mindedness, sincerity, and recognition of the work of others (these moral values correspond roughly to Merton's notion of scientific ethos)[4, 5];

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[4] Our subcomponent V d) is in Bunge a subcomponent of *G*. Mahner (2007) adds three subcomponents to *G*, which we take up to make our subcomponents *V* a), b) and c). Thus, we separate the values from the general principles of *G* because, in Mahner's own words, "to stress the fact that science has an internal system of values and corresponding norms, it may be useful to treat them all together." (Mahner 2007, p. 532). The separation is important, as values and norms cannot be treated in the same way as *G*'s general principles or postulates. The latter are general hypotheses, whereas values and norms are not. General assumptions are abandoned if they are inconsistent with the results of science, while values and norms are abandoned if they do not lead to adequate results.

[5] Here's a clarification from Mahner that underlines the collective aspect of this value system:

> […] the system of logical, semantical, methodological, and attitudinal ideals constitutes the *institutional rationality* of science […], even though individual scientists may more or less often fail to behave rationally. (More

(5) The *general outlook*[6] G of $\mathcal{R}$ is made up of general principles or postulates, which are all metascientific hypotheses, such as (a) the ontological principle that the world is made up of concrete things subject to nomic change, things that exist independently of the researcher (rather than being unreal, imaginary or miraculous entities that undergo no change); (b) the epistemological principle that the world can be known objectively, at least in part and gradually; (c) the methodological principles of parsimony, fallibility and the improvability of knowledge; (d) the semantic principle of correspondence between our representations and the world[7];

(6) the *formal background* F of $\mathcal{R}$ is the collection of up-to-date logical and mathematical theories (rather than being empty or formed by obsolete formal theories);

(7) the *specific epistemic background* B of $\mathcal{R}$ is a collection of up-to-date and reasonably well confirmed (yet corrigible) data, hypotheses, and theories, and of reasonably effective research methods, obtained in other fields relevant to $\mathcal{R}$;

(8) the *problematics* P of $\mathcal{R}$ consists exclusively of cognitive problems concerning the nature (in particular the regularities) of the members of D, as well as problems concerning other components of $\mathcal{R}$;

(9) the *fund of knowledge* K of $\mathcal{R}$ is a collection of up-to-date and testable (though rarely final) theories, hypotheses, and data compatible with those in B, and obtained by members of C at previous times;

> on the problems of the rationality of science in [Kitcher, 1993].) And, however biased the individual scientist may be, the above values are also the basis for the *institutional objectivity* of science. As a consequence, basic science is value-free only in the sense that it does not make value judgments about its objects of study. In other words, basic science has no external value system. (Mahner 2007, p. 533)

[6] Bunge uses the expression “philosophical background” as a synonym, which we can dispense with since, for us, philosophy is not to be confused with a scientific general discourse or metascience.

[7] Philosophers have failed to develop a satisfactory correspondence theory of truth. Bunge has repeatedly returned to this problem without finding a solution that he considers adequate. We will be proposing such a theory in the next issue of *Mεtascience*, which will focus on metascientific semantics. Note that we will be moving away from approaches, such as Bunge’s, which attempt to develop a notion of “approximate truth” or “partial truth”.

(10) the *aims* A of the members of C include discovering or using the regularities (in particular laws) and circumstances of the Ds, systematizing (into theories) general hypotheses about Ds, and refining methods in M;

(11) The *methodics* M of $\mathcal{R}$ consist exclusively of procedures that are accessible (can be verified, analyzed or criticized) and justifiable (can be explained), starting with the general scientific method. According to Mahner (2007), procedures can be concrete (use of instruments), as in electron microscopy, or conceptual (formal), as in statistical methods. Other examples of conceptual procedures are epistemic procedures or *epistemic operations*, such as definition, reduction, description, subsumption, explanation, demonstration, prediction, questioning, problematization, observation, experimentation, classification, theorization, problem solving, analysis, synthesis, planning, etc., operations that deal with concepts, propositions, theories, etc., and contribute to *epistemic transformations*, i.e., the acquisition, creation and transformation of scientific knowledge.

To these eleven criteria, Bunge adds two necessary conditions for a field of research to be scientific, which Mahner (2007) refers to as the systematicity condition and the progressiveness condition respectively:

(1) the *systemicity condition* stipulates that there is at least one other *contiguous* research domain in the same $\mathcal{R}$ system of factual research domains, such that (a) the two domains share certain items of their general perspective, formal context, specific epistemic context, fund of knowledge, aims and methodics; and (b) either the domain of one of the two domains is included in the domain of the other, or each member of one of the domains is a component of a concrete system of the domain of the other;

(2) the *progressiveness condition* stipulates that the elements of the D, G, F, B, P, K, A, M components of $\mathcal{R}$ undergo *changes*, sometimes quite slowly, as a *result of research* in the same field (rather than as a result of ideological or political pressure, or as a result of "negotiations" between researchers), as well as a result of research in the associated (formal or factual) scientific fields[8].

[8] The changes we are talking about does not concern changes in concrete objects due to their energetic activity, but rather conceptual changes, such as the abandonment of a concept or rule, the replacement of one concept or rule by another,

Based on this characterization, Bunge defines the *material framework* and the *conceptual framework* of a factual science. The material framework is made up of the first three components, C, S and D, while the conceptual framework is made up of the last seven components, G, F, B, P, K, A and M[9]. Between these two frameworks, we insert the values and norms framework, component V. If we reason in terms of objects of study, i.e., the referents of a discipline, the concrete objects of component D are the objects of study of a particular factual science, be it physics, chemistry, biology, psychology, sociology, etc., while the concrete objects of components C and S, i.e., scientists, scientific communities and the societies that host them, are the objects of study of the history, sociology and psychology of science.

Next, the conceptual objects or scientific constructs of the G, F, B, P, K, A and M components are the objects of study for metasciences, be they semantics, ontology, epistemology or metascientific methodology. Thus, some scientific constructs lend themselves to either semantic, ontological, epistemological or methodological research, and others, perhaps the majority, are studied using two or more of these metascientific disciplines. In other words, the same scientific construct can be studied from several angles, not to mention logically analyzed and mathematically synthesized if incorporated into a mathematized metascientific theory. Finally, component V deals with the values and norms, implicit or explicit, that are necessary for the proper functioning of scientific activity. Thus, the factual sciences study the material objects of components C, S and D, the metasciences study the conceptual objects of components G, F, B, P, K, A and M, and the convivence disciplines, essentially ethics and praxeology, study the values and norms of component V.

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and so on. In the case of the D component, the abstract set of concrete objects that form the objects of study of a factual science, it is the elements of D that can change over time, i.e., be replaced by a simple, possibly arbitrary operation of the mind, whereas the objects themselves change naturally in a nomic way, i.e., according to the concrete links between the properties of these objects, and also because they are endowed with energy. For example, abandoning the idea that phlogiston exists in nature removes this concept from D components of all fields of factual research R that studied it as a concrete object. On the other hand, the concept can be an object of study in the history of science and in diachronic metascience.

[9] Bunge recognizes that the term “material framework” is a misnomer, since component D is made up of conceptual objects in the case of the formal sciences, but also, we add, in the case of the conceptual sciences, the metasciences.

As fields of research, the metasciences can be characterized in a similar way to the factual sciences. At this point, the constructs or conceptual objects of the G, F, B, P, K, A and M components of the factual sciences are found as D elements of the metasciences, i.e., the objects of study of a scientific general discourse. In this article, among the components D, G, F, B, P, K, A and M of a metascientific epistemology, we will therefore focus in the next section on component A, the aims of such an epistemology, then in section 3, we will examine component D, the objects of study of this epistemology, and, finally, in section 4, we will look at component M, the methodics of metascientific epistemology. In short, our purpose is meta-metascientific, that is, we discuss the nature of metascience, rather than practicing metascience, and we will use the Bungean epistemology to illustrate what a metascientific epistemology is.

2] Goals of Epistemology

Bunge's characterization of epistemology and the goals he assigns to it are ambiguous and inconsistent with the way he practices his epistemology. Bunge's tension concerning the role and objects of study of epistemology seems to stem from his desire to create a scientific epistemology, i.e., an epistemology in line with scientific findings, which often leads him to closely associate cognition, a concrete process, and knowledge, a construction of the mind:

> Many disciplines besides descriptive and normative epistemology[10] study cognition and its outcome, i.e., knowledge. (Bunge 1983a, p. 10)

The disciplines referred to in this passage are factual sciences such as psychology, sociology, neuroscience and so on. In this way, epistemology and certain factual sciences would have the same objectives and the same two objects of study (referents): the study of cognition and the study of knowledge. This close association between cognitive processes and knowledge stems from Bunge's error in believing that the referents of epistemology are the same as those of the cognitive sciences:

[10] To add to the confusion, Bunge sometimes identifies descriptive epistemology with psychology (for Bunge, normative epistemology is synonymous with methodology). In other words, descriptive epistemology is a naturalized epistemology.

> All the members of cognitology[11] have a *common referent*, namely the inquiring system (individual or group). Therefore there is-inevitably and happily-some overlap between the various sciences of cognition and knowledge. However*, a common reference does not ensure identity, for one and the same subject matter can be studied from different viewpoints-i.e., one can ask questions of different kinds about one and the same entity*. This holds, in particular, for the scientific and the philosophical approaches to cognition and knowledge. (Bunge 1983a, p. 11 ; italics ours)

It's true that the same object or concrete process can be studied by different disciplines, but here we're dealing, on the one hand, with a concrete process, cognition, and on the other, with an abstract result obtained through epistemic operations, knowledge. These are not two aspects of the same object. Scientific knowledge is made up of constructs, fictions in Bunge's terms, while cognition is a concrete process that takes place in our brains. The inconsistency of this passage becomes clear when we recall that Bunge supports the methodological postulate of the dichotomy between concrete and conceptual objects (Maurice 2020, 2022a). Postulate 3.4 of volume 3 of the *Treatise* states, "Every object is either a thing or a construct, no object is neither and none is both." (Bunge 1977, p. 117) Bunge makes the following clarification:

> Postulate 3.4 is an axiom of *methodological dualism*. It does not commit us to metaphysical dualism: we are not claiming that there are two kinds of thing, the *res extensa* and the *res cogitans*, or things proper and ideas. We take it that constructs, whether useful or idle, scientific or mythical, are fictions not entities. Hence they are not part of the real world even when they take part in our representations of the latter. (Bunge 1977, p. 118)

So, on the one hand, there are concrete objects, real objects, studied by the factual sciences; on the other hand, there are conceptual objects, constructs, or fictions in Bunge's terms, studied by the metasciences. We must emphasize that this methodological postulate is one of Bunge's most important ones, perhaps the most important of all. Bunge takes great pains to implement it rigorously, but when it comes to discussing the nature of his approach, he

[11] Bunge uses cognitology four times in *Exploring the World* as a quasi-synonym for cognitive science, in which epistemology is included (Bunge 1983a, pp. 10-12).

momentarily forgets that two objects of different natures—one real, the other fictional—require different disciplines to approach them. In short, the factual sciences study concrete objects endowed with energy and, among conceptual objects, logic and mathematics study formal objects, while the metasciences study the constructs of the factual sciences[12].

Thus, epistemology cannot have the same objects of study as the factual disciplines of cognitology in the second-to-last quotation, since these disciplines study "inquiring system (individuals or groups)". These systems are concrete, and therefore belong to the factual sciences. The fact that these systems can be approached from *different viewpoints* by different factual disciplines is possible because these disciplines study concrete objects. But since epistemology studies constructs, it cannot then study inquiring system from a different viewpoint, as Bunge asserts in this passage.

Bunge makes it clear that cognitive processes are concrete, and knowledge is a human-created abstraction. It cannot therefore be, as the passage suggests, a question of two approaches to the same object of study, as is the case with cognitive psychology and cognitive sociology, two ways of studying the same concrete objects. Cognitive science studies cognitive processes, while epistemology and other metascientific disciplines study knowledge and the epistemic operations involved in acquiring, creating and transforming that knowledge.

The inquiring systems referred to in the previous passage are concrete systems (scientists or scientific communities) that can only be studied by factual sciences such as psychology, neuropsychology, sociology and so on. In other words, the referents of the factual sciences are concrete objects, whereas knowledge is not a concrete object, but a set of constructs, i.e., concepts, propositions, classifications, models, theories, etc. Knowledge cannot therefore be studied by the factual sciences, but rather by the conceptual sciences that are the metasciences.

To make it clear that Bunge's confusion about the nature of his epistemology does not prevent him from distinguishing

[12] The constructs of logic and mathematics are studied by metalogic and metamathematics, respectively.

epistemological from scientific questions, let's complete the second-to-last quotation:

> […] whereas the scientist may study perception and perceptual illusion as sources of knowledge and error respectively, the philosopher may also study the scope of perception, the nature of perceptual knowledge and its differences from conceptual knowledge, as well as the contrast between appearances (as presented in perception) and reality (as conjectured by theory). Whereas the scientist may be interested in the way children come to know about objective constancies (e.g. conservation laws), *the philosopher may puzzle the nature of law statements, their relation to objective patterns, and the role of such statements in science and technology*. And whereas the scientist may investigate the origin-psychological or historical-of theories, *the philosopher may study the very nature and role of finished theories, as well as the conceptual (rather than psychological or cultural) differences between them*. (Bunge 1983a, p. 11; italics ours)

Despite this last passage, which is fairly clear as to which questions belong to the cognitive sciences and which to epistemology, Bunge asserts a few lines further on:

> […] there is no clear demarcation between scientific and philosophical epistemology, and none should be invented. (Bunge 1983a, p. 11)

Not only does Bunge argue that there is continuity between cognitive science and epistemology, he also uses "scientific epistemology" as a synonym for "cognitive science". Yet, fifteen years before the publication of volume 5 of the *Treatise*, Bunge had a clear idea of epistemology and even metascience:

> The *internal* approach to science has, since its inception, been a philosophical subject. It is philosophers—and occasionally scientists on holidays—who have studied the general pattern of scientific research, the logic of scientific discourse, and the philosophical implications of method and outcome. This internal study of science bears on scientific knowledge apart from its psychological origin, cultural setting and historical evolution, whereas the external approach is concerned with the activities of the men involved in the production, consumption, waste, and corruption of science: the external sciences of science are as many branches of the sciences of

> culture. The internal study of science on the other hand, steps above its object, in the semantical sense that it is a discourse on a discourse. Just as a statement about a statement is called a metastatement, so the internal study of science may be called *metascience*, itself part of the theory of knowledge (*epistemology*)[13]. (Bunge [1967] 1998, p. 35-36 ; italics in original)

Similarly, twenty years after the publication of volume 5 of the *Treatise*, Bunge clearly distinguishes cognition, a concrete process[14], from knowledge, an abstract result, as well as the disciplines that study both:

> [A cognition is a] process leading to knowledge. Perception, exploration, imagination, reasoning, criticism, and testing are cognitive processes. Cognition is studied by cognitive psychology, and cognitive neuroscience, whereas knowledge is studied primarily by epistemology and knowledge engineering. (Bunge 2003, p. 43)

Thus, Bunge's discourse on his own epistemology suggests that he will develop a naturalized epistemology: "In this work epistemology is conceived as a merger of philosophy, psychology, and sociology: it describes and analyzes the various facets of human cognitive processes […]." (Bunge 1983a, p. xiv) A few lines later, he returns to a conception of epistemology as metascience: "Epistemology is concerned with inquiry in general."

Bunge sometimes identifies his epistemology with a theory of knowledge, a practice that is widespread in English and somewhat less so in French. Yet Bunge's epistemological practice has not produced a theory of knowledge, at least not a philosophical theory of knowledge, nor a theory that embraces all types of knowledge. In

[13] Here, Bunge makes metascience a branch of epistemology, the latter being a theory of knowledge in general or a gnoseology. However, we have argued that Bunge's "philosophy" is concerned *only* with science, which implies that there is no semantics, ontology or epistemology of common knowledge in Bunge's work, for example, which implies that there is no theory of knowledge in Bunge's work, as we shall see later in the article. Similarly, philosophy of science as a discipline distinct from semantics, ontology and epistemology is redundant in Bunge, since the latter disciplines are concerned only with science, in particular scientific constructs (Maurice 2020, 2022a). In short, Bunge has developed a metascience, a science of science, by studying the semantic, ontological, epistemological and methodological constructs of scientific conceptual knowledge, without concern for ordinary language or common sense.

[14] A pleonasm since a process is concrete by nature.

the first place, if the theory of knowledge is the study of the relationship between subject and object in the act of knowing (Lalande [1926] 1997a, [1926] 1997b), then Bunge has not conceived a theory of knowledge, since he does not problematize this relationship philosophically. Bunge takes for granted the concrete existence of both objects in cognitive relationship, but since they are concrete objects, then their relationship can only be studied by the factual sciences. Secondly, if the theory of knowledge is an inquiry into the *origins*, *nature*, *value* and *limits* of knowledge or the faculty of knowing (Lalande [1926] 1997a, [1926] 1997b), and even if we restrict this inquiry to scientific knowledge, then, once again, Bunge has not conceived a theory of knowledge, since the *origins* or "sources of knowledge" are for Bunge a problem of cognitive mechanisms (Bunge 1983a, pp. 1-2), and therefore a problem studied by the factual sciences such as cognitive psychology, cognitive sociology, cognitive neuroscience, etc.

The study of the *nature* of knowledge can fall within either the factual sciences or epistemology, depending on what we mean by "nature". If it is the "concrete nature" of knowledge that interests us, then we need to study cognitive mechanisms; if it is rather the "conceptual nature" of knowledge that interests us, then we need to study epistemic operations. It is the latter task that Bunge tackles in volumes 5 and 6 of the *Treatise*, because he is essentially, if not exclusively, interested in *scientific conceptual knowledge*.

The *value* of knowledge, whether scientific or not, can be evaluated internally or externally. External evaluation is part of a general discourse on convivence or togetherness. For a society, this involves firstly assessing the possible consequences, beneficial or otherwise, of some kind of research, and secondly, when scientific results are available, evaluating the consequences of basing decisions and actions on these results, particularly with regard to technological development. Internal evaluation, in the case of science, is a task for the metasciences, most often implicit among scientists. These values may be logical, semantic, methodological or attitudinal (moral), adopted because they constitute the way members of scientific communities consider appropriate to acquire and manage knowledge (Mahner 2007, p. 524).

As for the *limits* of knowledge, they can be studied from a scientific point of view (physical and biological limits of knowledge), but they can also be imposed following an ethical evaluation of knowledge, i.e., of the consequences of the ways in which knowledge is acquired and used, which comes under a discourse of convivence. In any case, neither philosophy nor metascience has anything to add on this subject. Thinkers engaged in "philosophical reflection" on the limits of knowledge, particularly scientific knowledge, are, for the most part, ethicists without a philosophical doctrine to guide them, from which they could deduce the limits of scientific knowledge from an ethical and therefore external point of view. These ethicists are therefore no longer philosophers, since they do not adhere to any philosophical doctrine, they do not use any particular faculty to "see" their object of study, these objects of study are not those of philosophical ethics, and they do not use any approach, technique or method specific to philosophical ethics. In short, contemporary ethics is gradually becoming autonomous from traditional philosophical ethics, to form a general discourse of convivence.

We discuss the notions of "general discourse", "scientific general discourse" and "general discourse of convivence" in our article "Metascience: for a scientific general discourse", which appeared in the first issue of *Metascience*. In it, we defend the idea that philosophy is only one general discourse among others, and that it is possible to develop general discourses that are neither philosophical, nor religious, nor mystical; the non-philosophical, non-religious and non-mystical character of these general discourses has the consequence that they cannot be total, hence the existence over the last few decades of an ethics independent of philosophical ethics, of a metascience independent of the philosophy of science, but, above all, independent of each other.

We have thus deconstructed the philosophical conception of the theory of knowledge as an inquiry into the *origins*, *nature*, *value* and *limits* of the faculty of knowing or knowledge. Each component of this conception of the theory of knowledge finds a place in either science, metascience or a discourse of convivence. This analysis is an example of the possibility of constructing non-philosophical, non-religious and non-mystical general discourses. The results of the analysis only make sense if we adopt a number of general postulates, logically unprovable, empirically unverifiable, but obtained as a result of reflection on our experience of the world, including our scientific experience of the world (Maurice 2020, 2022a). The adoption of general postulates is not a defect, since it is a necessity for any discourse. Bunge has therefore not conceived a philosophical theory of knowledge for his epistemology, just as he has not conceived a philosophical theory of matter for his ontology (Maurice 2022a, 2022b)[15, 16]. Just as he takes for granted the existence of concrete objects, especially those studied by science, Bunge does not question the existence of concrete cognitive processes involved in the acquisition, creation and validation of knowledge.

What, then, are the objects of study of metascientific epistemology? As with his ontology, Bunge is much more consistent and clear about his practice. If we rely on the epistemology Bunge has produced and not on what he says about it, we find that it studies scientific constructs, notably epistemic operations, and not concrete objects or concrete processes, such as neurons and cognitive processes, which are a type of neural processes[17]. We might be tempted to hastily conclude that epistemology studies scientific knowledge, in one of the traditional senses sometimes retained by Bunge in the passages quoted, but in fact all metascientific disciplines study scientific knowledge. However, each of them focuses on certain scientific constructs rather than others, since scientific constructs possess semantic, ontological and epistemological properties. For example, ontology is concerned with scientific constructs such as general postulates, e.g., the world is independent of us and is knowable, but it is also concerned with constructs explicitly used by scientists

[15] With regard to the differences in nature between philosophical and scientific theories of matter, we refer the reader to Stephen Gaukroger (2006, 2010, 2016) and Alan Chalmers (2009). In particular, Chalmers argues that scientific atomic theories owe nothing to philosophical atomic theories. More generally, Chalmers argues that philosophy and science are two distinct activities. While science is independent of philosophy, the latter must accommodate or adapt to the results of science on all subjects where the latter excels, such as atoms and perception. But, for Chalmers, a philosophical theory that adapts to science is still a philosophical theory, because it explores its subject beyond what science allows (Chalmers 2009, p. 9). For us, Chalmers is a good example of a historian and philosopher of science who is no longer interested in philosophy, but who nonetheless tries to create an epistemic nook for it, because there are nonetheless questions that science cannot answer.

[16] Note that a philosophical theory of knowledge is often linked to a philosophical theory of sensation and perception, which we do not find in Bunge. Bunge takes for granted the scientific results of disciplines that study sensation and perception.

[17] Note that the same linguistic sign, here “neuron”, is used to name both the object and the concept that represents it.

without them defining them or studying their conceptual nature, such as the notion of an object's property (Maurice 2022a).

Metascientific epistemology, on the other hand, is concerned with the scientific constructs that enable us to produce a unified representation of the *epistemic transformations* of scientific knowledge through the study of the *epistemic operations* required for its acquisition, creation and validation, as opposed to psychological, sociological or neurological research into *cognitive processes* at all levels. If we return to the definition of a factual science set out in Part 1, these constructs (epistemic operations are constructs; they do not exist in nature) are to be found mainly among the constructs that make up component M of the conceptual framework of factual sciences, i.e., methodics. Other constructs also belong to metascientific epistemology, such as the postulates, principles, values and epistemic norms of the G component.

Finally, there are other conceptions of epistemology close to the one we defend:

> Although it has to be admitted that usage remains rather vague, it can be said that the term "epistemology" is intended to be more modest than "philosophy of science". Epistemology applies itself to the rigorous analysis of *scientific discourse*, examining the modes of reasoning it employs and describing the formal structure of its theories. By concentrating on the process of knowledge, epistemologists often exclude reflection on its meaning. *They sometimes present their discipline as a scientific one that has broken with philosophy* (Lecourt 2010; italics ours).

Similarly, Romero, a long-standing Bungean, and even if his terminology is ambiguous, since he distinguishes a "general epistemology" from a "philosophical epistemology", he attributes to the latter the role of the internal study of science, i.e., the study of scientific knowledge:

> Epistemology is the general study of cognitive processes and their outcome, i.e., knowledge. Specific mechanisms of knowledge acquisition are investigated by neurosciences and psychology. Philosophical epistemology, instead, has a general problematics that includes the nature of knowledge and understanding, the characterization of science, theories and models, the ways of explanation,

> interpretation problems of specific sciences and theories, and so forth. (Romero 2018, p. 51)

On the other hand, Paty, a reader of Bunge, proposes an epistemology centered on the internal study of the sciences, i.e., a "critical examination of their concepts and propositions":

> I'll confine myself to mentioning, albeit very briefly, an idea that I've called an "epistemological program", and which, while taking into account certain elements such as those mentioned (a certain degree of falsifiability, the notion of a rational research program, the solidarity of propositions, even representations, etc.), inserts them into a complex whole that includes instances as heterogeneous (but ordered in relation to each other in a chain of connections) as concepts, theoretical models, principles, categories of thought, epistemological presuppositions and general conceptions […]. (Paty 1990, p. 54)

This epistemological program proposed by Paty is similar to the Bungean program as found in volumes 5 and 6 of the *Treatise on Basic Philosophy*. Notably, in both cases, "scientific knowledge is taken as a fact" (Paty 1990, p. 52), just as the progress of theories and the possibility of comparing theories are taken as a given (Paty 1990, p. 25). Paty, like Bunge, takes a set of general postulates associated with science for granted (Maurice 2020).

3] Objects of Epistemology

We have pointed out an inconsistency in Bunge's conception of his epistemology. At times, it is conceived as a scientific discipline, as a naturalized epistemology, forming a single body with psychology, sociology, and cognitive neuroscience, sharing with them the same objects of study. At other times, it is seen as an autonomous discipline with its own objects of study.

> […] we recognize the need for studying the "product" of the cognitive process regardless of the idiosyncrasies of the learning subject and her environment-i.e. the need for the study of knowledge. (Bunge 1983a, p. 72)

We have eliminated the inconsistency by appealing to principles or postulates supported by Bunge himself, notably the methodological postulate that states the dichotomy between concrete objects (things) and constructs, one of the fundamental postulates of

Bunge's thought. In other words, Bunge cannot both support this postulate and defend a conception of naturalized epistemology. Since this postulate lies at the heart of the Bungean system, the inconsistency can be eliminated in favor of a conception of epistemology whose objects of study are constructs, not concrete objects.

The set of scientific constructs is what Bunge calls *conceptual* scientific knowledge (propositional, ideational, fictional). Even in science, however, there are other forms of knowledge, notably *perceptual* knowledge (Bunge 1983, p. 72, Romero 2018, p. 52). Although the various types of knowledge complement each other, Bunge supports, more discreetly, another methodological postulate, that of the dichotomy between conceptual and perceptual knowledge:

> Perception gives us only perceptual knowledge, which is egocentric and limited to appearances. *Only conceptual knowledge can be objective and deep*: only conceptual maps give us a glimpse of things in themselves. (Bunge 1983a, p. 196-97; italics ours)[18]

Since conceptual knowledge is the only kind that can be objectified, it is the only kind that can be the subject of a discipline independent of the factual sciences, metascience. However, this conceptual knowledge does not exist in itself:

> Just as there is no motion apart from moving things, so there are no ideas in themselves but, instead, ideating brains. To be sure we may *feign* that there are ideas in themselves and in fact we must often make such pretense. We do so whenever we abstract from the real people who think up such ideas as well as from the personal and social circumstances under which they ideate. (Bunge 1983a, p. 23 ; italics in original)

On the other hand, it is not possible to proceed *as if* perceptual knowledge existed in its own right, since it is limited to

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[18] The two dichotomies are intimately linked. The first dichotomy emphasizes the ontological nature of real objects (concrete objects in Bunge's case) and conceptual representations of them (fictions in Bunge's case). The second dichotomy focuses on the epistemological nature of the perceptual knowledge and conceptual knowledge we have of these concrete objects. Only conceptual knowledge is objective, or enables an objective, albeit incomplete, representation of concrete objects. In fact, a philosophical doctrine can be characterized by its conception of these three poles and the links between them: reality, perception (appearance) and representation.

appearances. These types of knowledge can only be studied by factual sciences, although the latter can also study the cognitive processes of conceptual knowledge. Only conceptual knowledge can be the subject of metadiscourse. This possibility depends not only on the possibility of objectifying conceptual knowledge, but also on accepting the postulate of the dichotomy between reality and its representation, and thus not attributing existence to ideas, concepts and conceptual knowledge. Although conceptual knowledge is not limited to science, since it can be found in practically all human activities, even the most common ones, it is *scientific conceptual knowledge* that Bunge is most interested in. Moreover, because it is easier to study, notably because it is more precise, more systematic and better validated, a better knowledge of scientific conceptual knowledge should enable us to access a better knowledge of conceptual knowledge produced by other human activities.

The way Bunge does and practices epistemology gives meaning to the above. Thus, another way of eliminating inconsistency in Bunge's conception of his own epistemology is to examine what he does, i.e., how he proceeds, or, alternatively, determine the objects he studies. Examining the aims of epistemology gave us a first opportunity to specify the objects of study of metascientific epistemology. Thus, in order to study epistemic transformations in science, epistemology must focus on the epistemic operations that lead to these transformations. These operations, however, do not take place in an epistemic vacuum, which is why epistemology is also interested in epistemic postulates, principles, values and norms. Is this what we find in volumes 5 and 6 of the *Treatise*?

The oscillation in Bunge's thinking on the nature of epistemology structures the presentation of volumes 5 and 6. Volume 5, *Exploring the World*, consists of Chapters 1 to 9, while Volume 6, *Understanding the World*, comprises Chapters 10 to 15. Chapters 1, 2, 3 and 4 describe the cognitive processes of perception, learning, communication, sensation, observation, cognitive development and evolution, etc., from the perspective of the cognitive sciences (psychology, sociology, neurology, etc.). However, the introduction to Chapter 2 reminds us that knowledge can be studied independently of cognitive processes:

> […] although we cannot detach the outcome (knowledge) from the corresponding process (cognition), we may distinguish them.

> Moreover for some purposes we may *feign* that cognitive processes have a “content” that can be communicated to other brains or externalized as artifacts such as inscriptions and tapes. To be sure actually there is no such content and, a fortiori, no such transfer. Acquiring knowledge is learning something, i.e. going through a certain brain process, hence not the same as acquiring a book or some other commodity. Likewise exchanging information is not like trading things but is interacting with another animal in such a way that each party elicits certain learning processes in the other’s brain. Yet from a methodological point of view it is convenient to feign that cognitive processes do have a transferable content, so that we may think of the latter separately from the former. This convenient fiction amounts to supposing that, for certain purposes—such as checking validity or usefulness—it does not matter what or who went through the cognitive process in question. (Bunge 1983a, p. 61; italics in original)

Bunge appeals here to the dichotomy between concrete and constructed objects, or fact and fiction (postulate 3.4, mentioned earlier). Right from the start of chapter 2, Bunge reaffirms the autonomy of epistemology, a position already advanced in the introduction to volume 5 and in the first chapter. This position is constantly reiterated, despite Bunge’s idea of developing a naturalized epistemology.

From Chapter 5 onwards, epistemology as a discipline that studies constructs gradually asserts itself, without Bunge abandoning psychological or neuropsychological considerations. Thus, epistemological notions are often preceded by an account of the psychological, sociological or neurobiological aspects associated with the constructs and epistemic operations examined by Bunge. This organization of Bunge’s presentation is apparent in the titles of certain sections of Chapters 5 to 8. Thus, sections 1.1 and 2.1 of chapter 5 are entitled “From Percept to Concept” and “From Thought to Proposition” respectively, since percepts and thoughts (or judgments) are cognitive processes, while concepts and propositions are constructs. Similarly, section 1.1 of chapter 6 is entitled “Natural Reasoning”, and section 1.2 “Formal Reasoning”, since natural reasoning is a psychobiological field, while formal reasoning is a logical one. The titles of sections 1.1 of chapters 7 and 8 are even more eloquent: “Psychobiology of Problems” and “Psychobiology of

Conjecturing". Even when epistemological research dominates, and no section is devoted to the psychobiology of a construct or epistemic operation, Bunge peppers his discussion with findings from cognitive neuroscience, notably in chapters 9 to 14.

Bunge tells us that his epistemology "is conceived as a merger of philosophy, psychology, and sociology" (Bunge 1983a, p. xiv). This is not what we find in volumes 5 and 6 of the *Treatise*. We're dealing with two presentations that are always distinct from one another, although they may be intertwined in the same chapter or paragraph. In other words, there are two distinct discourses and a confused metadiscourse. There is a psychological, sociological and neurological discourse, and then an epistemological discourse. The statements of these two discourses may intermingle, but they never merge. In particular, there is no single psycho-epistemological, socio-epistemological or neuro-epistemological statement, i.e., one and the same statement that refers to both concrete objects and epistemological constructs. The inconsistency or confusion is thus to be found in Bunge's metadiscourse when he discusses the nature of his epistemology. So, even though his metadiscourse asserts that epistemology is naturalized, the two parallel discourses, one scientific, the other metascientific, prove that this is not the case. It's impossible to interweave two discourses of different natures and magically create a new discipline. Naturalized epistemology is a chimera.

In section 2 of our article, we ruled out the idea that Bunge's epistemology is a philosophical theory of knowledge. We have just ruled out the idea that his epistemology is a naturalized epistemology. We have quoted extensively from volumes 5 and 6 to show that Bunge consistently supports the idea that constructs can be studied in themselves, objectively. We can now answer our previously formulated question: like volumes 1-4 of the *Treatise*, volumes 5 and 6 study constructs, be they epistemic operations, postulates, principles, values, norms or rules. These are the constructs that enable epistemic transformations in science, i.e., the acquisition, creation and validation of scientific knowledge. The number of these epistemic constructs is unknown, and it may be impossible to draw up an exhaustive inventory:

> […] there are as many mechanisms of epistemic change as there are types of epistemic operation. Some workers go out into the field

> whereas others stay at the laboratory; some make observations and others experiment; some classify and others calculate; some draw blueprints whereas others build theories; some solve problems with the help of existing theories, and others criticize the latter; some delight in specificity, others in pattern; some split and others lump- and so on. The growth of knowledge requires that all of these and more epistemic operations be carried out concurrently in the scientific and technological communities. (Bunge 1983b, p. 170-71)

With regard to epistemic postulates, principles, values, norms and rules, Bunge takes care to draw up two lists in Chapter 15, Section 3, "Maxims of Scientific Realism", one devoted to descriptive epistemology or epistemology proper, the other to prescriptive epistemology or methodology. But since these lists each contains fifty items, Bunge has taken care to summarize his scientific realism in sixteen isms in the conclusion to the same chapter 15. We will not examine these principles further, although a major task of analysis and synthesis remains to be done, as much for epistemic principles as for semantic and ontological principles–in short, for all metascientific principles. Do certain principles derive from others? Can they be classified under more general principles? Can they be incorporated into metascientific theories? Bunge stresses the importance of studying epistemic postulates, principles, values and norms:

> [...] if we care for science, technology, and the humanities, we should also care for their epistemological presuppositions–such as that there is an independent reality and that it can be known if only in part. We should dig up, cleanse, analyze, and systematize such principles. [...] It would seem obvious that, the better we know how we can get to know, the better we can improve (or block) the learning process, particularly in science, technology, and the humanities. So, a study of the epistemological presuppositions of research, as well as of any other tacit assumptions of scientific and technological research, should payoff in practical results[19]. (Bunge 1983a, p. 14)

However, in chapters 5 to 14 of volumes 5 and 6 of the *Treatise*, Bunge's effort is directed essentially towards the study of *epistemic operations*, operations which relate to concepts, propositions, classifications, models, theories, etc., and which contribute to *epistemic*

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[19] Translating the results of metascientific research into useful results for science is what we call the Bungean wager.

transformations, that is to say to the acquisition, creation and transformation of scientific knowledge from a conceptual point of view, that is to say independently of any particularities of the learner subject and his environment, and consequently without taking into account the cognitive processes studied by cognitive neuroscience.

These operations are definition, reduction, description, subsumption, explanation, demonstration, prediction, questioning, problematization, observation, experimentation, classification, theorization, problem solving, analysis, synthesis, planning, hypothetization, validation and so on. These constructs form an important part of the methodics of a factual science, i.e., the *M* component of the characterization of a factual science.

Thus, these operations are the objects of study of metascientific epistemology. They are treated *as if* they existed in themselves, in the same way that metascientific ontology studies constructs in themselves (Maurice 2022a). This practice is possible because conceptual knowledge can be abstracted from its contexts in order to make it objective. Naturalized epistemology is therefore non-existent in Bunge's work, just as naturalized ontology is non-existent in his work (Maurice 2022a). Despite his metadiscourse on his own ontology and epistemology, Bunge did not attempt to naturalize them, in the sense of transforming them into disciplines of the factual sciences, i.e., disciplines that study concrete objects. On the contrary, both his ontology and epistemology study the constructs of science, making them radically different from the factual sciences, turning them into conceptual sciences or metasciences. Bunge's naturalization is therefore not to be found in the object of study of his ontology and epistemology, but rather in the methods and cognitive faculties required to study scientific conceptual knowledge. We first dealt with this naturalization of general discourse in Bunge in our articles "What Is Metascientific Ontology?" (Maurice 2022a) and "Bunge's Metascience and the Naturalization of the General Discourse" (Maurice 2022b). We return to this subject here in the specific context of metascientific epistemology.

4] Methods of Epistemology

Bunge has said little about his method of constructing semantic, ontological and epistemological theories, perhaps because for the author of the *Treatise* it is obvious that his approach, methods and techniques of analysis and synthesis fit naturally into the way things are done in science, logic and mathematics. Bunge's method is not philosophical. Thus, he does not favor a logic or mathematical formalism a priori on the basis of a philosophical doctrine, but rather on the basis of what scientists commonly use. And since scientists use predicate logic and standard mathematics, Bunge will use predicate logic and standard mathematics. Nor does Bunge suggest that special skills are needed to explore the world. He calls on the whole arsenal of cognitive faculties, starting with reflection[20].

Discussing the nature of philosophy of science (metascience), Bunge clarifies what its object, method and purpose are:

> The object should be real science (both natural and social), and the method should be essentially the same as the method of science–since in either case one tries to know *something given*. The goal should be to dismount and then to reassemble the mechanism of science in order to expose its structure, content, and functions. (Bunge 1973, p. 21 ; italics ours)

In the case of science, what is given are the concrete objects of the world; in the case of metascience, what is given are the constructs of science. For his ontology, Bunge made the following clarification:

> Any means should be permitted in constructing a metaphysical theory as long as it leads to a good theory: pinching from another field, analogizing, extrapolating, looking for models of abstract theories, and of course inventing radically new ones. Here, as in science and in mathematics, there is no royal road, and theories are judged by their works not by their scaffoldings. (Bunge 1971, p. 509)

This is also true of the metascientific epistemology we were able to extract from volumes 5 and 6 of the *Treatise*. Thus, in terms of methods and techniques of analysis, metascience, like Bunge, claims a methodological conservatism and opportunism. Many philosophers, including Bunge, make little or no use of the tools or methods of reflection and analysis recognized by philosophers. These methods seem to cause more problems than they solve, which

[20] Ordinary or natural thinking, which we all have, not philosophical thinking. Thinking, even in a general way, does not prove that we are philosophers. Philosophers do not have a monopoly on general reflection (Maurice 2020).

may explain why they are not used in the formal and factual sciences. Here, then, is a non-exhaustive list of tools, methods and approaches, essentially associated with philosophy and not used by Bunge[21]: transcendental argument, *philosophical* counterfactuality, *philosophical* thought experiment, *philosophical* logical analysis, *philosophical* conceptual analysis, *philosophical* linguistic analysis, *philosophical* necessity and possibility, *philosophical* conceivability, *philosophical* intuition, dialectics, epoché, as well as analyses using possible worlds (modal techniques), and so on[22]. Nor did Bunge seek to develop a doctrinal method, a method associated with a philosophical doctrine, as is the case with many philosophers: Plato developed dialectics, Aristotle syllogistic, Descartes wrote the *Discourse on the Method*, Husserl proposed phenomenological reduction, and the Vienna Circle, logical analysis. That said, there is a Bungean style to metascience, just as there is an Einsteinian style to physics. Bunge also developed methods for analyzing scientific theories, such as the double axiomatization, made up of a syntactic axiomatization, and therefore more conventional, and a semantic axiomatization, Bunge's original contribution to this method (Bunge 1967).

Throughout his work, Bunge constantly criticized these philosophical approaches or methods, and always denied the existence of any particular cognitive faculties required for philosophical practice. It would be futile to look for *the* Bungean method, linked to a philosophical doctrine, as we are wont to do in the case of great philosophers, the method then coming to characterize the philosopher. In this way, a Platonist cannot surpass Plato, a Cartesian cannot surpass Descartes and a Kantian cannot surpass Kant. The method is inseparable from the philosopher. If you modify the method too much, you develop another philosophical doctrine. In Bunge's case,

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[21] We have to qualify the majority of the approaches listed here as *philosophical*, because some of them also have meanings and utilities outside philosophy, but without being used philosophically.

[22] For an account of a number of philosophical methods, see the *Oxford Handbook of Philosophical Methodology* (Cappelen, Gendler & Hawthorne 2016) and the *Cambridge Companion to Philosophical Methodology* (Overgaard & D'Oro 2017). Both books, like similar works, appropriately use an encyclopedic style that fails to capture the scope of philosophical methods. Only by reading a few philosophical works is it possible to understand that philosophical discourses differ radically from rational discourses, scientific or otherwise, and that they are designed to differ radically since the aim is to know a reality that would escape the sciences.

a general discourse on science does not require a particular approach that is different from what is practiced in any rational activity, be it science, management, law, education, health, etc. It is therefore possible to continue Bunge's research in the same way as it was possible to continue Newton's research. This is an important, even essential, quality of the Bungean approach to the discourse on science, which distinguishes it, once again, from the philosophical approach.

The fundamental aspect of the Bungean approach has been clearly noted by Cordero: all rational activity makes use of experience, reason, imagination and criticism (Cordero 2019, pp. 94-96). It should be pointed out that the experience, reason and imagination in question have no transcendent scope. In other words, we are talking about the experience of the concrete world, including and especially the concrete world revealed by the factual sciences, and the use of reason and imagination as natural faculties and not as faculties that would give us access to a philosophical reality. Both the cognitive psychology of science and the cognitive neuroscience of science, which study cognition and cognitive processes in scientists, take it for granted that these processes are of the same nature for all humans: "[…] scientific thinking involves the same general-purpose cognitive processes—such as induction, deduction, analogy, problem solving, and causal reasoning—that humans apply in non-scientific domains" (Dunbar & Klahr 2013). The same applies to metascientific thinking.

Bunge differentiates himself from philosophers because the latter believe that there are special faculties to bridge the "gap" between reality and appearances, or if these faculties don't exist, then reality is unknowable. But from the outset, this is a false problem[23].

5] Conclusion

To understand the distinction between metascience and philosophy, it's useful to remember that we don't have direct access to reality, that there is no general proof or demonstration of the existence of things, that we must then take for granted the existence of the "external world", that there is no possible answer to the

[23] The dichotomy established by philosophers between appearance and reality is discussed in section 3 of our article "Bunge's Metascience and the Naturalization of the General Discourse" in the second issue of *Metascience*.

question of the existence of one property rather than another. It is through reflection and our experience of the world that we come to this conclusion. We have argued that our representation of the world comes through the study of scientific constructs, which is the task of metascientific ontology (Maurice 2020). If we also believe that a general discourse on science is valuable, useful for the advancement of knowledge, then we can study science itself, which is the task of epistemology, but also of metascientific semantics and methodology.

Bungean epistemology is essentially concerned with scientific conceptual knowledge, despite Bunge's desire to be part of the philosophical tradition. For Bunge, doing does not follow saying. And if a discipline is characterized by its objects and methods, then Bunge's metascientific epistemology bears little resemblance to any philosophical epistemologies. Bunge does not problematize science in the same way that philosophers of science do, and he excludes from epistemology certain traditional problems such as belief:

> The vulgar definition of knowledge as "justified belief" provides a useful albeit ephemeral starting point. To start off, it involves the reduction of epistemology to psychology, since beliefs are mental states, whereas knowledge, unlike cognition, is tacitly assumed to be impersonal–that is, valid for everyone […]. (Bunge 2018, p. 136)

Or the problem of perception:

> Adequate models of perception can be produced only by neuropsychology (or physiological psychology): they will not come from pure psychology, let alone from philosophical psychology, which has been at it for over two millennia without ever getting hold of that which does the perceiving, namely the central nervous system. (Bunge 1983a, p. 137)

In philosophical jargon, Bunge is a materialist, but his materialism is reduced to accepting the existence of concrete objects studied by the sciences, notably those studied by cognitive neuroscience. He therefore relies on science to determine the "furniture of the world", but especially on cognitive neuroscience to determine the furniture of the world involved in cognitive processes. It would be a mistake, then, to reduce Bunge's thinking to a materialist doctrine, since even such doctrines, because they are philosophical, postulate the existence of objects and processes foreign to science, and use methods unknown to scientists. And because they are philosophers, materialists have to argue for the existence of matter and develop a sophisticated philosophical concept of it to counter critics from idealism, empiricism, phenomenalism, etc., whereas scientists have long since lost interest in a general or philosophical theory of matter, of which, incidentally, there is no trace in Bunge's work. We don't need materialist doctrines, we just need to adopt the same general postulates as the sciences, analyze and interpret their constructs, then abstract and generalize, all using our natural faculties. The role of Bungean epistemology, but also of semantics, ontology and methodology, is similar to that of metalogic and metamathematics. And since the scientific beast is just as complex as the logical or mathematical beast, it's not surprising that Bunge had to compose a treatise of almost 2,400 pages to lay the foundations of metascience[24].

An object of study like science cannot be dealt with in a single *Treatise*. And even if we add the hundreds of articles and books in Bunge's oeuvre, it's not enough. There is an enormous amount of work to be done in clarifying metascientific categories (semantic, ontological, epistemological and methodological), as well as a better understanding of the nature of scientific constructs, such as the various types of general postulates, concepts, propositions, classifications, models, theories, rules, norms. This is what we call the Bungean challenge.

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[24] We exclude here volume 8 of the *Treatise* on ethics because for us metascience, a scientific general discourse, is dissociated from a general discourse of convivence or togetherness. There is no such thing as metascientific imperialism as there is philosophical imperialism (Maurice 2020).

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Difference Between the Existential Quantifier and the Existence Predicate According to Mario Bunge

Martín Orensanz[1]

Abstract—Most analytic philosophers believe that the existential quantifier, ∃, has ontological import. Mario Bunge was one of the first thinkers to challenge this view. He traces a distinction between the quantifier ∃ and a first-order existence predicate. Furthermore, he acknowledges two kinds of existence: real and conceptual. One of the reasons for accepting Bunge's proposal is that it can do justice to statements about fictional entities, which is something that rival proposals do not seem to be capable of doing. Additionally, I will also discuss the issue of the ontological argument, and the problem of material constitution.

Résumé — La plupart des philosophes analytiques croient que le quantificateur existentiel, ∃, a une portée ontologique. Mario Bunge a été l'un des premiers penseurs à contester ce point de vue. Il fait une distinction entre le quantificateur ∃ et un prédicat d'existence de premier ordre. De plus, il reconnaît deux types d'existence : réelle et conceptuelle. L'une des raisons d'accepter la position de Bunge est qu'elle peut rendre justice aux énoncées portant sur des entités fictives, ce que les positions rivales ne semblent pas capables de faire. Je discuterai également de la question de l'argument ontologique et du problème de la constitution matérielle.

Keywords— Existence; Existential quantifier; Existential predicate; Ontological argument; Material constitution.

Bunge claims that the quantifier ∃ doesn't have ontological import. He argues that ∃ only means "for some...", just as ∀ only means "for all...". For this reason, he suggest that ∃ should be called "the particularizing quantifier" instead of "the existential quantifier", and that in order to talk about existence, we

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need a first-order existence predicate.[2] Furthermore, he indicates that the standard view among philosophers leads to a problem if we consider the case of fictional entities:

> Surely most contemporary philosophers hold that ∃ formalizes both the logical concept "some" and the ontological concept of existence. I shall argue that this is a mistake. Consider the statement "Some sirens are beautiful", which can be symbolized "(∃x)(Sx & Bx)". So far so good. The trouble starts when the formula is read "There are beautiful sirens". The existential interpretation is misleading because it suggests belief in the real existence of sirens, while all we intended to say was "Some of the sirens existing in Greek mythology are beautiful". (Bunge, 1977: 155)

I would like to propose a different example in defense of Bunge's idea. It relies on the use of individual constants. Recall that in predicate logic, there are individual variables, which are usually symbolized with the letters "x", "y" and "z", and there are also individual constants, which are typically symbolized with other letters, like "a", "b", and "c". With this in mind, take a look at the following argument:

(1) $\forall x(x = x)$ Principle of Identity.

(2) $p = p$ From (1), by universal elimination.

(3) $\exists x(x = p)$ From (2), by existential introduction.

The translation of that argument is this:

(1') Everything is identical to itself.

(2') So, Pegasus is identical to Pegasus.

(3') So, Pegasus exists.

If the quantifier ∃ has ontological import, as most logicians believe, then the statement that Pegasus is identical to itself leads to the conclusion that Pegasus exists in the real world. This is a problem because we know that Pegasus doesn't really exist.

But this is only a problem if we believe that ∃ has ontological import. If we agree with Bunge that it doesn't, then there is no

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[2] Some other philosophers also trace this distinction. Meinongians usually use the symbol E! as the existence predicate, different from the quantifier ∃. See, for example, Parsons (1980), Zalta (1983), Linksy & Zalta (1991), and Jacquette (1996).

problem. It's true that (3) can be deduced from (2), but (3) should be read as "Some x is identical to Pegasus", instead of reading it as if it said "There exists some x in the real world that is identical to Pegasus".

On the other hand, if we say "Pegasus does not exist", that statement is also problematic. If we formalize it as $\neg\exists x(x = p)$, then it can be shown that this formula leads to a contradiction. The following argument indicates why this is the case:

(4) $\neg\exists x(x = p)$ Premise.

(5) $\forall x\neg(x = p)$ From (4), by change of quantifier.

(6) $\neg(p = p)$ From (5), by universal elimination.

Informally, here's what the argument says:

(4') Pegasus does not exist.

(5') So, nothing is identical to Pegasus.

(6') So, Pegasus is not identical to Pegasus.

And we know that from a contradiction, anything follows. This is the Principle of Explosion, also known as *ex falso sequitur quodlibet*, or the rule of EFSQ for short. So, if we say that Pegasus does not exist, we can end up saying that Pegasus *does* exist. In other words, it can be shown that $\neg(p = p)$ leads to $\exists x(x = p)$, which is what we were supposed to deny in the first place.

The upshot is that there are good reasons for rejecting the idea that $\exists$ has ontological import. From a purely logical point of view, the formula $\exists x(x = p)$ can't fail to be true, and its negation, $\neg\exists x(x = p)$, must be false. In other words, we have arrived a the wrong result: that the statement "Pegasus exists" is true, while its negation, "Pegasus does not exist", is false. The result should be exactly the opposite of this.

As we'll see later, from a Bungean perspective there's a simple and elegant solution to this problem. But before we examine it, we need to consider the possibility of avoiding individual constants.

1] Getting Rid of Individual Constants

Recall that the formulas $\exists x(x = p)$ and $\neg\exists x(x = p)$ both use an individual constant, a lower-case "p" that stands for Pegasus. If one believes that this is the root of the problem, then it seems that the solution would be to avoid using an individual constant in the first place. This type of solution draws its support from the works of Frege, Russell and Quine, though the details differ in each case.

From a Fregean point of view, the statement “Pegasus exists” can be paraphrased as “The concept ‘Pegasus’ is instantiated”, and it can be symbolized like this:

(7) $\exists x(Cx)$

Similarly, the statement “Pegasus does not exist” can be paraphrased as “The concept ‘Pegasus’ is not instantiated”, and we can formalize it like this:

(8) $\neg\exists x(Cx)$

While (7) is false, (8) is true. What’s interesting about these formulas is that they’re contingent. In other words, they are not necessarily true nor necessarily false. Unlike $\exists x(x = p)$, the formula $\exists x(Cx)$ can’t be deduced from $p = p$. And the formula $\neg\exists x(Cx)$, unlike $\neg\exists x(x = p)$, does not lead to $\neg(p = p)$. So, the Fregean proposal is quite sound, at least from a purely formal point of view.

But the solution is not entirely free from problems of its own. In particular, it does not seemed to be able to handle statements like the following one: “The concept ‘Pegasus’ is not instantiated in Aztec mythology but it is instantiated in Greek mythology”, which can be symbolized like this:

(9) $\neg\exists x(Cx \wedge Ax) \wedge \exists x(Cx \wedge Gx)$

Is that statement true or false? From a Bungean point of view, that statement is true. But Fregeans will have a hard time with this example. Since they believe that ∃ has ontological import, they are forced into the awkward position of having to say that the statement in question is false. However, it seems reasonable to say that Pegasus does not belong to Aztec mythology, but that it does belong to Greek mythology.

Let’s take a look at the Russellian solution. It’s structurally similar to the Fregean one. The only difference is that the name “Pegasus” should be replaced by a definite description, like “the winged horse”. In that case, the statement “Pegasus exists” can be paraphrased as “There exists an x, such that x has the property of being a winged horse”. Formally:

(10) $\exists x(Wx)$

Contrary to $\exists x(x = p)$, which is necessarily true, $\exists x(Wx)$ is false. Likewise, the statement "Pegasus does not exist" can be paraphrased as "There does not exist an x, such that x has the property of being a winged horse". Formally:

(11) $\neg\exists x(Wx)$

The Russellian solution[3] has the same advantages that the Fregean one has. But it also has the same problems. If we want to say that Pegasus is not among the list of fictional creatures of Aztec mythology, but that it is one of the fictional creatures of Greek mythology, then we would have to paraphrase it like this: "There are no winged horses in Aztec mythology but there is a winged horse in Greek mythology", which can be symbolized in the following way:

(12) $\neg\exists x(Wx \land Ax) \land \exists x(Wx \land Gx)$

Russellians would have to claim that (12) is false. But, as I've mentioned a few paragraphs back, one can argue that it's true that Pegasus is not part of Aztec mythology but that it is indeed part of Greek mythology.

Lastly, there's Quine's solution, which is similar to the Fregean and the Russellian ones in terms of its structure. From a Quinean viewpoint, the statement "Pegasus does not exist" should instead be paraphrased as "There is no individual that has the property of being Pegasus", or more briefly, "Nothing pegasizes".[4]

The idea is that, unlike the Russellian proposal, we don't need to know anything about Pegasus in order to say that nothing has whatever properties that fictional creature might have. All that we need to do is to turn a proper name, like "Pegasus", into a predicate. Symbolically, instead of a lower-case "p", we use an uppercase "P". This being so, the statement "Nothing pegasizes" can be formalized like this:

(13) $\neg\exists xPx$

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[3] The formulas (10) and (11) are actually too simplistic. The former should be $\exists x(Wx \land \forall y(Wy \rightarrow (x = y)))$. Likewise, the latter should be $\neg\exists x(Wx \land \forall y(Wy \rightarrow (x = y)))$. I will simply ignore these complications here. Similar considerations apply to the Fregean and Quinean formalizations.

[4] See Quine (1948). For an early critique, see Hochberg (1957).

And the statement “Pegasus exists” should be paraphrased as “Something pegasizes”, which can be formalized like this:

(14) ∃xPx

Predictively, I believe that Quine’s solution has the same advantages and the same drawbacks that its Fregean and Russellian equivalents have. So, we can ask if the following statement is true: “Nothing pegasizes in Aztec mythology, but something pegasizes in Greek mythology”. Quineans would have to say that it’s false, even though one can argue that the contrary is the case. In the next section, we’ll examine the Bungean alternative to this problem.

2] Bunge and Pegasus

There are several things to note about Bunge’s proposal. Firstly, unlike the ones we just saw, Bunge doesn’t believe that the individual constants of predicate logic should be avoided. It’s entirely legitimate, and useful, to use a lower-case “p” that stands for Pegasus. Secondly, as I’ve mentioned before, Bunge rejects the idea that the quantifier ∃ has ontological import. This symbol does not refer to existence in an ontological sense. All that it means is “for some…”, just as the quantifier ∀ means “for all…”. Thirdly, in order to talk about existence, Bunge says that we need a first-order existence predicate. In his own words:

> We need then an exact concept of existence different from ∃. Much to the dismay of most logicians we shall introduce one in the sequel. In fact we shall introduce an *existence predicate*, thus vindicating the age-old intuition that existence is the most important property anything can possess. (Bunge, 1977: 155)

This not only goes against Frege, Russell and Quine, it also goes against Kant, who famously claimed that existence is not a predicate. At this point, one may wonder if Bunge’s idea means that the ontological argument should be accepted. The answer is negative. But we’ll discuss this point later. For now, it’s necessary to indicate that Bunge traces a distinction between two types of existence: real and conceptual. Accordingly, he uses two types of existence predicates: E_R stands for real existence, while E_C stands for conceptual existence. From this point of view, if the statement “Pegasus exists” means “Pegasus really exists”, it can be formalized like this:

(15) $E_R p$

(15) is false, because Pegasus doesn't really exist. The negation of that statement is "Pegasus does not really exist", and it can be symbolized like this:

(16) $\neg E_R p$

(16) is true. Pegasus does not exist in the real world. Let's take a look now at conceptual existence. If we say "Pegasus exists in a conceptual sense", then this can be formalized in the following way:

(17) $E_C p$

From a Bungean point of view, (17) is true. Pegasus does exist conceptually, because it's a fictional creature from Greek mythology. The negation of (17) is this:

(18) $\neg E_C p$

Which means "Pegasus does not exist conceptually". This last statement is false, at least from a Bungean perspective, because in Greek mythology there is indeed a fictional creature called "Pegasus".

With this in mind, the Bungean proposal manages to achieve something that the Fregean, Russellian and Quinean ones don't: it can handle the statement "Pegasus does not exist conceptually in Aztec mythology, but it does exist conceptually in Greek mythology". The three proposals that we saw before must claim that the statement in question is false. By contrast, from a Bungean perspective, that statement is true, and it can be formalized like this:

(19) $\neg E_A p \wedge E_G p$

As (19) shows, whenever we need to distinguish different conceptual contexts, like the difference between Aztec mythology and Greek mythology, we can replace the subscript "C" in E_C with another letter. So, in (19), the subscript "A" in E_A stands for "Aztec mythology", and the subscript "G" in E_G stands for "Greek mythology".

The upshot is that the Bungean proposal is preferable to the Fregean, Russellian and Quinean ones, if only because the former does justice to fictional discourse in a way that the other three can't. But there's an objection that can be raised against the Bungean account, which we need to address.

3] An Objection and a Reply

Opponents of the existence predicate usually raise an objection here. The objection is that the acceptance of an existence predicate commits us to non-existing objects. More precisely, to claim that a certain entity doesn't exist entails, by existential introduction, that there is some entity that does not exist. Here's the argument:

(20) $\neg E_R p$ Premise.

(21) $\exists x(\neg E_R x)$ From (20), by existential introduction.

Informally, (20) and (21) can be translated like this:

(20') Pegasus does not really exist.

(21') So, there is something that does not really exist.

This is an objection that is usually raised against Meinongians. The charge is that the idea that there are non-existing entities is not intelligible. Where are these entities located? They would seem to float around in fantastical place, which is usually called "Meinong's jungle", a sort of parallel dimension filled with unicorns, square circles, and wooden iron. So, one could raise a similar objection against Bunge. If Pegasus doesn't really exist, then -by the rule of existential introduction-, there is a non-existing entity. Where is it located? Presumably, it would be floating around in what could be called "Bunge's jungle", the Bungean version of Meinong's jungle.

Bungeans can meet this objection quite easily. Firstly, a statement like (21) poses no problem to the Bungean, because that statement simply says "Some particular x does not have the property E_R". It doesn't say "There exists an x such that x does not exist", because the quantifier ∃ does not have ontological import to begin with. It's true that there is some x, such that x doesn't really exist, and this claim is not contradictory. Secondly, fictional entities, like Pegasus, are not located in some parallel dimension or otherworldly jungle, instead they are brain processes. As he explains:

> Ideas, then, do not exist by themselves any more than pleasures and pains, memories and flashes of insight. All these are brain processes. However, nothing prevents us from *feigning* that there are ideas, that they are "there" up for grabs - which is what we do when saying that someone "discovered" such and such an idea. We pretend that there are infinitely many integers even though we can

> think of only finitely many of them - and this because we assign the set of all integers definite properties, such as that of being included in the set of rational numbers. (Bunge, V4: 169)

Real existence is the property of being somewhere in the world. Conceptual existence is the property of belonging to a conceptual context, such as Greek mythology. For a Bungean, the statement "Pegasus exists in the context of Greek mythology" is true, because Pegasus does indeed belong to that context. Likewise, the statement "Pegasus does not exist in reality" is also true, because Pegasus is not a living creature located somewhere in the real world.

We turn now to the issue of the ontological argument, and how it can be refuted even if one claims that existence can be conceptualized as a first-order predicate.

4] The Refutation of the Ontological Argument

Kant famously claimed that existence is not a predicate. One of the upsides of that idea is that it allows us to reject the ontological argument. But here's the question: if we claim, following Bunge, that it makes sense to use an existence predicate, different from the existential quantifier, does this mean that we should accept the ontological argument? In other words, does the ontological argument prove that God exists?

Of course not. But the reason why the ontological argument fails is not because existence is not a predicate, as Kant claims. Here's what Bunge has to say on this issue:

> Let us now use the existential predicate introduced above to revisit the most famous of all the arguments for God's existence. Anselm of Canterbury argued that God exists because He is perfect, and existence is a property of perfection. Some mathematical logicians have claimed that Anselm was wrong because existence is not a predicate but the ∃ quantifier. I suggest that this objection is sophistic because in all the fields of knowledge we tacitly use an existential predicate that has nothing to do with the "existential" quantifier, as when it is asserted or denied that there are living beings in Mars or perpetual motion machines. (Bunge, 2012: 174-175)

One possible way to formulate the ontological argument using Bunge's real existence predicate, E_R, is this:

(22) $\forall x(Px \rightarrow E_R x)$ Premise.

(23) Pg Premise

(24) ERg From (22) and (23), by implication elimination.

Informally, here's what the argument says:

(22') For all x, if x is perfect, then x really exists.

(23') God is perfect.

(24') So, God really exists.

Of course, Bunge rejects that argument. After all, he was an atheist. However, what he argues is that the argument shouldn't be rejected in the way that Kant and some modern logicians do:

> Hence the atheist will have to propose serious arguments against it instead of the sophistry of the logical imperialist. An alternative is to admit the existence of God for the sake of argument, and add the ontological postulate that everything real is imperfect: that if something is perfect then it is ideal, like Pythagoras' theorem or a Beethoven sonata. But the conjunction of both postulates implies the unreality of God. In short, Anselm was far less wrong than his modern critics would have it. (Bunge, 2012: 175)

In other words, Bunge rejects premise (22). It's not true that if something is perfect, then it must really exist. On the contrary, it's possible to say that if something is perfect, then it exists only in a conceptual sense. In other words, one could say that God doesn't exist in reality, but He, or She, or They, exist in the context of a certain religion, just as Pegasus exists conceptually in the context of Greek mythology. This being so, the ontological argument fails.

5] Existence and the Problem of Material Constitution

Bunge's distinction between the existential quantifier and the existence predicate is also useful for tackling some other philosophical topics, such as the problem of material constitution. Here's the gist of this problem. Imagine that on Monday, there exists a piece of clay in Jane's atelier. On Tuesday, she sculpts it, turning it into a statue of the Greek goddess of wisdom. Intuitively, there seems to be only one object where the sculpture is located. But a moment's reflection indicates that this claim is problematic, since the statue has different properties from the piece of clay. For example, if the statue is flattened, then it ceases to exist, but the piece of clay doesn't. The statue didn't exist on Monday, but the piece of clay did. The statue is Romanesque, but the piece of clay isn't. And so forth. So, contrary to our intuitions, we have to say that on Tuesday there are two distinct material objects where there seems to be only one. In other words, there are two numerically distinct objects that coincide with each other. This is the problem of material constitution.

A popular solution to this problem is to claim that the piece of clay exists, but that the statue doesn't. There's no such thing as a statue, -the idea goes-, there's only a piece of clay arranged statuewise. Korman provides one of the best reconstructions of this argument:

> Here is an argument from material constitution for the elimination of clay statues. Let Athena be a clay statue, and let Piece be the piece of clay of which it's made.
>
> (MC1) Athena (if it exists) has different properties from Piece.
>
> (MC2) If so, then Athena ≠ Piece.
>
> (MC3) If so, then there exist distinct coincident objects.
>
> (MC4) There cannot exist distinct coincident objects.
>
> (MC5) So, Athena does not exist. (Korman, 2016: 9-10)

Korman believes that statues do exist. So, in order to reject the preceding argument, at least one of the premises must be denied. After reviewing the available options, he decides to reject MC4. As he suggests, this solution is not optimal, but for anyone who accepts a realist account of artifacts, the denial of MC4 is the least of the available evils.

I won't attempt to provide a solution to the problem of material constitution here. I leave that for another article. This is an incredibly difficult problem, which is why I think that any small step that can be taken towards its resolution should be counted as a victory. And I believe that the small step that can be taken here is the following one. Focus on the statements "Athena exists" (which is the antecedent in MC1) and "Athena does not exist (which is what MC5 says). What would be the best way to formalize them? At first glance, it might seem that we should translate them as $\exists x(x = a)$ and $\neg\exists x(x = a)$. But this can't be the case. Because if it was, then how could $\exists x(x = a)$ fail to be true given that it can be deduced from a = a, by the rule of existential introduction? It's the same problem that we saw at the beginning of the article in regards to Pegasus. If we replace the name "Pegasus" with "Athena", then the argument looks like this:

(25) $\forall x(x = x)$ Principle of Identity.

(26) $a = a$ From (25), by universal elimination.

(27) $\exists x(x = a)$ From (26), by existential introduction.

Which can be translated like this:

(25') Everything is identical to itself.

(26') So, Athena is identical to Athena.

(27') So, Athena exists.

The only case in which $\exists x(x = a)$ could be false is in the context of some non-classical logic, such as free logic. So, if we want to formalize the statement "Athena exists" using classical predicate logic, then $\exists x(x = a)$ is not an option. Otherwise, the argument for the elimination of clay statues has no bite.

Likewise, the statement "Athena does not exist", which is what MC5 says, shouldn't be formalized as $\neg\exists x(x = a)$, because that formula leads to $\neg(a = a)$:

(28) $\neg\exists x(x = a)$ Premise.

(29) $\forall x\neg(x = a)$ From (28), by change of quantifier.

(30) $\neg(a = a)$ From (29), by universal elimination.

Informally, the argument says this:

(28') Athena does not exist.

(29') So, nothing is identical to Athena.

(30') So, Athena is not identical to Athena.

And, since anything follows from a contradiction, if we start with $\neg\exists x(x = a)$, then we could end up deducing $\exists x(x = a)$. In other words, if we say that Athena does not exist, we can conclude that Athena *does* exist. Once again, if this is acceptable, then the argument for the elimination of clay statues has no bite.

One possible option would be to avoid the use of the individual constant "a", and to formalize the statement "Athena exists" as $\exists xAx$. It's open to debate what that formula means, exactly. From a Fregean perspective, it means that the concept 'Athena' is instantiated. From a Russellian point of view, it would mean "There is an x, such that x is the statue created by Jane on Tuesday". And from a Quinean viewpoint, it would mean "Something has the property of being Athena", or "Something athenizes". Similar considerations apply to the statement "Athena does not exist", which would have to be formalized as $\neg\exists xAx$. But I have argued that these viewpoints are questionable. Even if they can account for real entities, they can't do justice to fictional discourse.

A second option is to simply refuse to formalize the argument for the elimination of clay statues. The idea here is that the argument doesn't need to be translated into the language of predicate logic to have bite. Granted, but it can be shown that it *lacks* bite if the statements "Athena exists" and "Athena does not exist" are translated respectively as $\exists x(x = a)$ and $\neg\exists x(x = a)$.

The remaining option is to translate those statements using an existence predicate, and to claim, as Bunge does, that the quantifier $\exists$ does not have ontological import. This being so, the statements "Athena exists" and "Athena does not exist" can be formalized, respectively, as $E_R a$ and $\neg E_R a$.

There might be reasons for *not* accepting those Bungean formulas. But, in any case, I hope to have shown that the formulas $\exists x(x = a)$ and $\neg\exists x(x = a)$ should not be accepted either. And, when one deals with an issue as difficult as the problem of material constitution, I believe that what I have shown is no small victory.

6] Concluding Remarks

I have show that there are good reasons for accepting Bunge's idea that the existential quantifier should be distinguished from a first-order existence predicate. This is because if $\exists$ has ontological import, then existence claims about fictional entities, like Pegasus, become problematic. Specifically, from the claim that Pegasus is identical to Pegasus, we can conclude -by the rule of existential introduction- that Pegasus exists. And the statement that Pegasus does not exist, if it's formalized as $\neg\exists x(x = p)$, leads to the contradictory claim that Pegasus is not identical to Pegasus.

One possible solution would be to avoid individual constants, such as "p". In that case, the statements "Pegasus exists" and "Pegasus does not exist" can be formalized as ∃xPx and ¬∃xPx, respectively. The philosophies of Frege, Russell and Quine support this idea. However, those proposals don't seem to do justice to fictional discourse. In particular, they would have to claim that the following statement is false: "Pegasus does not exist conceptually in Aztec mythology but it does exist conceptually in Greek mythology". By contrast, from a Bungean point of view, that statement is true, and it does not commit us to the claim that Pegasus exists in the real world.

I have also answered a possible objection against the Bungean proposal, which is the same objection that is usually raised against Meinongians. The charge is that the use of an existence predicate commits us to the claim that there are entities that do not exist. Where are they located? In Meinong's (or Bunge's) jungle? I have argued that Bungeans can meet this objection by arguing that fictional objects exist conceptually, and that what this means is that they are just brain processes. So, there is no otherworldly "jungle" where fictional entities dwell.

Next, I addressed the problem of the ontological argument. The acceptance of an existence predicate does not mean that the ontological argument manages to prove that God exists. This argument can be resisted by saying that God exists conceptually in the context of some religions, in the same way that Pegasus exists conceptually in the context of Greek mythology, but that neither of them exists in the real world.

Lastly, I have indicated that the Bungean proposal is useful for clarifying some aspects of the problem of material constitution. Specifically, the statements "Athena exists" and "Athena does not exist" should not be formalized as ∃x(x = a) and ¬∃x(x = a), respectively. This is because the former can't fail to be true, while the latter leads to a contradiction.

Acknowledgments

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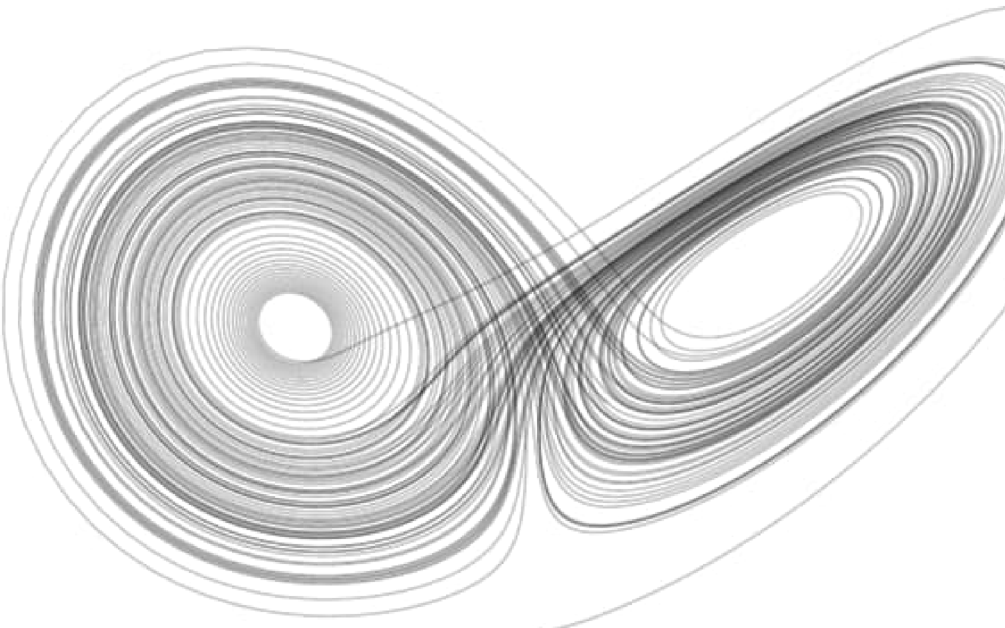
Metascientific Contributions



Advancing the Metascientific Program First Dialogue

François Maurice[1], Martín Orensanz[2]

Abstract—What follows is a dialogue between Maurice and Orensanz, in which they will discuss some key topics stemming from Bunge's *oeuvre*. The objective of this dialogue is to advance the metascientific program even further. The main points that will be discussed can be presented as a series of questions: Is it possible to prove that the external world exists? What is matter? Is the part-whole relation transitive? What is the difference between systems and assortments? Do fictional objects have a function in ontology? Although those are the main topics, several other points will be discussed throughout this exchange.

Résumé—Dans le présent article, Maurice et Orensanz dialogueront sur quelques thèmes clés de l'œuvre de Bunge. L'objectif de ce dialogue est de faire avancer le programme métascientifique. Les principaux points abordés peuvent être présentés sous la forme d'une série de questions : est-il possible de prouver que le monde extérieur existe ? Qu'est-ce que la matière ? La relation partie-à-tout est-elle transitive ? Quelle est la différence entre les systèmes et les assortiments ? Les objets fictifs ont-ils une fonction dans l'ontologie ? Bien qu'il s'agisse des sujets principaux, plusieurs autres points seront abordés tout au long de cet échange.

Keywords—Metascience; Ontology; Metaphysics, Matter; Objects.

1] Dialogue

MARTÍN ORENSANZ: François, your position among the Bungeans is unique, since you suggest that Bunge ceased to be a philosopher and became a metascientist instead. In this sense, you have begun

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[2] **Martín Orensanz** is a *Doctor en Filosofía* from Argentina. His work focuses on three main topics: Argentine philosophy, contemporary philosophy and philosophy of science. He won two scholarships (doctoral and postdoctoral) from the National Scientific and Technical Research Council of Argentina (CONICET).

a journal, Mεtascience, dedicated to the advancement of the Bungean program. While I'm admittedly rather unconventional for a Bungean, I nevertheless believe that the metascientific project should be further developed. But let's start from scratch: What are the metasciences, and why should we work on them?

FRANÇOIS MAURICE: Martín, in a nutshell, metasciences are a group of disciplines that study sciences, but from a specific angle. They are interested in scientific knowledge, i.e., the concepts, statements, theories, classifications, models, etc. that science produces. They are therefore interested in the products of science, but not only. Metasciences are also concerned with general statements that science takes for granted, often implicitly. These statements have traditionally been the province of philosophy, but they can also be dealt with from a metascientific point of view. The metasciences also take on the task of formalizing "common sense" concepts such as "property". These concepts are often used in discussions between scientists. Finally, metasciences are concerned with epistemic or conceptual operations, such as reducing one theory to another. And why work on metascience? Because science deserves its own general discourse, independent of philosophy.

M. O.: I think that almost all metascientists would agree with those definitions. However, I wonder how many of them would also identify as Bungeans. In that sense, your position is not only unique among Bungeans, it's also unique among metascientists. What is it about Bunge's oeuvre that initially caught your attention? And why should metascientists in general take an interest in his works?

F. M.: It's true that most metascientists would agree with the way I've just summarily characterized metascience, but the devil is in the details. Apart from the methodological movement known as "metascience" that took shape following the publication of an article by John Ioannidis in 2005, prior to this date, metascience is associated with philosophy, notably that of logical positivism and structuralism in the philosophy of science. The aim is to reconstruct scientific theories and models by logical-mathematical means. But these approaches are based on philosophical doctrines such as empiricism or, more generally, anti-realism. Since Bunge rejects all these doctrines, the metascientists associated with these doctrines cannot in fact identify themselves as Bungeans. They practice what we might call philosophical metascience, whereas I advocate scientific metascience. For this reason, these philosophers-metascientists have no interest in Bunge's work. With regard to the methodological movement mentioned earlier, it should be noted that philosophers of science and epistemologists did not initiate the questioning of the problem of reproducibility in science, and hardly participate in it at all. Will Bunge-style metascientists be able to do better? This is what I call the Bungean wager. Now, what drew my attention to Bunge's *oeuvre*? For reasons that are difficult to pin down, I used to associate philosophy, a rational discourse, with science, another rational discourse. When I began studying philosophy, I was shocked to discover that the vast majority of philosophical doctrines were irrational. A friend of mine described philosophy as secular theology. I started looking for philosophers who took science seriously, and that's how I came across Bunge's *Philosophical Dictionary*. The freshness of the approach, the closeness to science, the rejection of irrationalist doctrines, which I later interpreted as an implicit rejection of philosophy, were just a few of the many elements that convinced me that Bunge was on the right track to account for science and build a global worldview.

M. O.: That's a very interesting answer. I definitely agree that Bunge was on the right track. And, while it's true that he published many books and articles, I also think that there's still a lot of work to do, metascientifically speaking. Would you agree with that assessment? If so, what do you think are some of the main topics or problems that metascientists should focus on?

F. M.: Yes, definitely, there's still a lot of work to be done. In a way, everything needs to be done, since most of the thinking about science is done within a philosophical framework. On the other hand, Bunge shows us a way of doing metascience. So we have a starting point. Also, Pradeu and colleagues, in an article from 2021, have uncovered a small number of philosophers of science who, in my opinion, are no longer philosophers. There are philosophers who are moving away from philosophy to devote themselves to what I call metascientific research. Elliott Sober is just one example. So, these are other studies we can draw on to help us build a metascience. As Bunge points out, there are also nuggets in the work of some philosophers that we are entitled to pick up and integrate into metascience. As far as tools and approaches are concerned, we're not starting from scratch. Firstly, we have to use our natural faculties of reflection and reasoning, but applied to the scientific constructs and epistemic operations that take place in the sciences, such as establishing a definition or a classification. But this is only possible if we take it for granted that scientific knowledge is a representation of a concrete world. Secondly, we have abstract logic and mathematics at our disposal to help us refine our thinking and thus our metascientific constructs. But logic and mathematics can only play their full role if—and I stress, only if—we take it for granted that they have no representational function of their own, either concrete or philosophical. In other words, they have no ontological commitment of their own. At this stage, it's difficult to say which are the main themes and issues that metascientists should be addressing. Surely, one can bet on the classic themes of the progress of scientific knowledge, and thus the change that this knowledge undergoes, and its accumulation over time. These themes are so general that they probably encompass all the other themes and problems that arise when studying science.

M. O.: You've mentioned several points, which I'd like to address one by one. The first one is that there are some philosophers of science who are moving away from philosophy, towards metascience. This idea intrigues me because I wonder if it applies to myself. As things stand, I think it doesn't. What I think is going on in my case is that I'm trying to do both things at the same time, philosophy and metascience, though I gravitate more towards philosophy. In that sense, you also mentioned that metascientists take the existence of the concrete world for granted. As you know, the question of whether or not we can demonstrate that the external world exists is an old philosophical problem. We certainly don't need to address it in our everyday lives, or even when we do science. It's a purely philosophical problem. But it's a problem that interests me, because I'm of the opinion that it can be solved. I know that this is not what Bunge believes, since he says the following in the third volume of his *Treatise*:

> Another reason for having to postulate the existence of things is that, if we want to prove anything about existents, we must posit them. We cannot prove the existence of concrete things any more than we can prove the existence of deities or of disembodied minds. What can be proved is that, unless there were things, other items—such as acting on them and investigating them—would be impossible. (Bunge, 1977: 112)

And I'm aware that you agree with Bunge on this point, since you eloquently expressed this idea in one of your works:

> A demonstration or logical proof of existence is impossible. It is through reflection, experience, and knowledge that we can convince ourselves of the existence of the world and the concrete objects that form it. And much of this reflection, experience and knowledge are fueled by science. More precisely, we cannot demonstrate the existence of the general concrete object because it does not exist. Only the existence of a particular concrete object postulated by the factual sciences can be the subject of empirical proof (in fact, it suffices to find only one) (Maurice, 2022)

I completely understand what Bunge and you are saying here. But I disagree. I think it's entirely possible to prove that the external world exists. It's not easy, but I believe that it can be done. In fact, I have been working on a proof of my own for some time now, which I hope to publish in the near future.

F. M.: It is, of course, possible to practice both metascience and philosophy, regardless of whether we think of them as two autonomous discourses that have no connection, or whether we think of them as two autonomous discourses that feed off each other, or whether we think of them as two discourses that have connections, such as metascience being a branch of philosophy, or any other kind of connection. In the same way, it was not uncommon for scholars of the modern era to practice science, philosophy, astronomy, astrology, alchemy, mathematics, numerology, etc., all at the same time. In the rare cases where metascience is mentioned since its appearance in the 19th century, according to my preliminary research, it is often in a philosophical context, apart from the recent methodological movement mentioned above. In fact, metascience was absorbed into philosophy of science. We see this, for example, in Bunge. While he used the expression "metascience" in the '60s, we find almost no trace of it thereafter. He also changed the title to *Philosophy of Science* when *Scientific Research* was republished. For philosophers, metascience is either redundant, being synonymous with philosophy of science, or uninteresting, because it is not sufficiently philosophical. But that's certainly not your position since you want to practice both philosophy and metascience? What role do you reserve for philosophy and metascience?

Now, one question that is sufficiently philosophical is that of the existence of the external world. You're right to say that this is a purely philosophical problem, since for science and metascience this is a pseudo-problem. And since it's a purely philosophical problem, the solution should be purely philosophical, i.e., a solution that fits into a philosophical doctrine that has philosophical methods for studying philosophical objects of a philosophical reality. Here, I take "philosophy" in its strongest sense. For the term "philosophy" to have any meaning, this approach must be distinct from scientific, theological or mystical approaches, and it must then postulate, not prove, the existence of a philosophical or metaphysical reality to which science has no access. So, Martín, either your proof of the existence of the external world is metascientifically satisfactory, and then philosophers won't be interested in it, or it's philosophically satisfactory, and then metascientists and scientists won't be interested in it. It's worth noting here that, from the outset, there's no difference between the various approaches. All of them, without exception, must postulate the existence of a reality: factual or concrete, philosophical or metaphysical, divine or supernatural, and so on. Once a postulate of reality has been adopted, each approach produces arguments and proofs concerning items of this reality.

For example, the scientific *proof* of the existence of the atom is not based on a philosophical *proof* of the existence of the external world, but rests on the *postulate* of the existence of this world. Once the postulate has been admitted, it is the scientific context that determines the validity of the proof, and this context includes the idea of the existence of a world independent of the representations we have of it. However, for a philosopher, the scientific context is problematic, scientific knowledge is problematic, which means that evidence based on this context is unsatisfactory for this philosopher. Yes, it's true that some philosophers, notably the scientific realists, admit the existence of the external world and are satisfied with scientific evidence, but this is only to get bogged down in a defense of scientific realism instead of producing results like the researchers of the methodological movement mentioned above, or like the researchers of the philosophy *in* science revealed by Pradeu and his collaborators, or like Bunge.

M. O.: I like your attitude. Your defense of realism and science is unapologetic and uncompromising, like Bunge's, and that's very refreshing, because the vast majority of thinkers who share the same ideas tend to be very soft-spoken and apologetic in their defense of realism and science.

Regarding your question about the relation between philosophy and metascience, I think that they're different disciplines. I don't see metascience as a branch of philosophy of science, nor as a branch of philosophy in general. It's a unique field in its own right. So, on this point, I'm inclined to agree with your definition of metascience. On the issue of postulates and proofs, I'm not sure that I agree with you, at least not entirely. There are two problems, I think, with the position that Bunge and you are defending on this point.

The first problem is that if you postulate the existence of the external world instead of proving it, then that's simply a belief, it's something that you take on faith. If someone else postulates that deities exist, or that disembodied minds exist, then there are no significant differences between believing in the external world or believing in deities, or in disembodied minds. All of these beliefs would be on an equal footing, and here is where I disagree. Believing that there is an external world is not comparable to believing in deities or disembodied minds. And it seems to me that the best way to justify this difference is to prove that there is an external world, instead of postulating that there is one.

The second problem is that if you try to justify your postulation of the external world in any other way, you end up with a non-realist line of defense, which undermines your postulate. For example, suppose that you argue that the postulate of the external world has more explanatory power than the postulate that there are deities. But then your reasons for accepting that postulate are merely pragmatic. To use an analogy, Tycho Brahe's astronomical postulates had more explanatory power than Ptolemy's. That doesn't mean that those postulates were therefore true.

F. M.: Bunge has shown us how to conceive a general discourse on concrete reality and the sciences that study it, and to do so without any compromise with philosophy. Compromises can only be made within the same universe of discourse, or within the same conceptual or theoretical context, because each universe, each context, or each general discourse, is based on a set of assumptions and undefined concepts. Since I see philosophy as a general discourse distinct from the general discourse of metascience, there is no need to seek a compromise between them. They are incommensurable. Hence a sense of frustration when reading the authors you mention, especially the scientific realists. They are very soft-spoken and apologetic in their defense of realism and science because they try to have it both ways. They no longer question science, which for all intents and purposes is an anti-philosophical position, and they have also learned the lessons of the many failures of empiricist doctrines, but believe they are able to develop a philosophical doctrine, realism or scientific realism, which would serve as a foundation for science. But the search for a foundation for science is illusory. Hence the need for a pragmatic component (practical or pragmatical, not pragmatist), not only for science, but also for many human activities. The proof is in the pudding. For example, government laws and regulations must be enforceable, whether for the good of all, to favor certain groups, or to silence political opponents. And it is a conquest of the scientific revolution that ideas in science must be validated by empirical tests, which does not justify resorting to an empiricist doctrine of science in an attempt to justify this essential aspect of science.

Similarly, believing in the existence of the "external world" is not based on a philosophical doctrine, even if it were called realism or scientific realism. Nor is it an act of faith. Quite the opposite, in fact. Belief in the existence of the external world is based on a complex reflection on our experience of the world, notably the experience of the world offered by science. Philosophers see it as an act of faith because they are looking for indubitable knowledge, and if knowledge is not indubitable, then it is not knowledge. This sophism is widely used by philosophers against science, and by philosophical skeptics against any form of discourse, including philosophy, but not skepticism itself! Complex thinking, in all human endeavors, requires the evaluation of a multitude of elements. Complex thinking in science accumulates evidence, in much the same way as evidence accumulates in a court case. Similarly, on a more abstract level, some philosophers, notably scientific realists, have produced arguments—some rather weak, others much stronger—for the existence of the external world. These arguments are evidence that we can put on the record, but they do not constitute proof, either in the logical sense or in any sense imagined by philosophers.

M. O.: There's a passage in Bunge's book *Evaluating Philosophies* that I think is relevant to the issue that we're discussing here. It's the one in which he discusses Anselm's argument for the existence of God. Allow me to quote it:

> Using the existence predicate defined a while ago, we may reformulate Anselm's argument as follows.
>
> | | |
> |---|---|
> | God is perfect | Pg |
> | Everything perfect exists in R [really] | $\forall x(Px \rightarrow E_{\mathrm{R}}x)$ |
> | God exists in R. | $E_{\mathrm{R}}g$ |
>
> Both premises are controversial, particularly the first one since it presupposes the existence of God. Hence the atheist will have to propose serious arguments against it instead of the sophistry of the logical imperialist. An alternative is to admit the existence of God for the sake of argument, and add the ontological postulate that everything real is imperfect: that if something is perfect then it is ideal, like Pythagoras' theorem or a Beethoven sonata. But the conjunction of both postulates implies the unreality of God. In short, Anselm was far less wrong than his modern critics would have it. (Bunge, 2012: 175)

It seems to me that this passage from *Evaluating Philosophies* contradicts what Bunge says in the third volume of his *Treatise*, the part in which he says that the existence of the external world can't be proved any more than the existence of deities or disembodied minds. So I think that Bunge changed his mind on this issue. Which isn't surprising, since he changed his mind on other topics as well. For example, in the third volume of his *Treatise* he says that there can't be a general theory of objects, while in an appendix to *Matter and Mind*, he provides an outline for such a theory.

But let's focus on what Bunge says about Anselm's proof. Clearly, the proof in question is not a fallacy, it's a valid argument, since it's a *modus ponens*. If one wishes to resist it, it must be shown that the argument is unsound, even if it's valid. And for the argument to be unsound, at least one of the premises must be false. Bunge argues that the second premise is the false one. So, Anselm's argument fails. However, as Bunge says, Anselm was "far less wrong than his modern critics would have it", not because his argument for the existence of God is sound, since it isn't, but rather because he was right in believing that it is entirely legitimate to offer an argument for the existence of this or that, whether it be deities, disembodied minds, or the external world. A proof for the existence of any of these things will always be an argument, that is, a group of premises from which a conclusion is deduced. This is the sort of proof that I have been working on for some time, in which I argue for the existence of the external world, and as far as I can tell, all of the premises of my argument are true, which means that the argument is not only valid, it is also sound. And I also show why skeptical arguments, while valid, are unsound, because they contain at least one false premise.

Back to Bunge's ideas, even though I agree with many of the things that he says, I nevertheless disagree with him on some other specific points. Take, for example, his definition of matter. In his book *Scientific Materialism*, as well as in *Chasing Reality*, he says that matter itself is not real, it's fictional. This is because he defines matter as a mathematical set, and all mathematical sets are fictional. To be sure, he's a materialist, because he says that concrete objects (such as a certain hydrogen atom or a certain person) are material. But he also says that hydrogen, understood as the set of all hydrogen atoms, is merely conceptual, and the same goes for humankind, understood as the set of all human beings. What are your thoughts on this?

F. M.: I see your point about the kind of argument you develop to prove the existence of the external world, but I remain skeptical about the possibility of proposing a set of premises that are all true without producing a circular argument, i.e., without presupposing the very existence of the external world. That said, I'd like nothing more than to be convinced, and I look forward to reading your argument.

Bunge is right to say that the refutation of the ontological argument for the existence of God on the basis of the existential quantifier is not a valid refutation. Existence is a real property that can be represented by an existential predicate like any other property. But in the excerpt you quote, Bunge changes the argument for God's existence. We could say that he puts forward an ontological argument against the existence of God within its own system of thought. And this argument contains implicit premises. For example, to say that "everything that is real is imperfect" can be debated by religious people and theologians for whom the spiritual or divine is real and perfect. But, for Bunge, what is real are concrete objects that exist in the "external world" (which exist even if we don't think about them), and traditionally, the concrete or material world is imperfect, whereas conceptual or ideal objects would be perfect. Bunge grants to theologians this point for the sake of argument (even if the notions of perfection and imperfection don't apply to concrete objects), in order to appeal to his dichotomy between real and conceptual or ideal objects. He can then conclude that God does not exist, since (real, concrete) existence implies imperfection.

So, I don't think Bunge has changed his mind since the third volume of the *Treatise* on the impossibility of proving the existence of the external world (but he has certainly changed his mind about the impossibility of producing a general theory of objects). Here, he has merely asserted the idea that a predicate of existence is an acceptable concept, and then concocted an argument that takes for granted the real existence of God and his perfection, that (concrete) reality is "imperfect", and therefore, that God does not exist (besides, the mere fact that for Bunge reality is concrete, implies that God cannot exist). We are dealing here with different and incommensurable discourses. And each discourse must have a starting point and must take for granted some premises, like the existence of the external concrete world in Bunge's argument.

Now, back to Bunge's famous (or infamous) idea that *matter is immaterial*. As formulated, this statement is in keeping with Bunge's provocative style. But Bunge usually makes it clear that it is the concept of matter that is immaterial, as any other constructs. As you mention, the concept of matter is defined using a simple mathematical structure, a set whose elements satisfy a predicate. In that case, the predicate is read "is material". So "matter" is the set of all material objects or entities: $M =_{df} \{x \mid \mu x\}$, where μ reads "is material" or "is changeable" (we can also read "is energetic" or "is concrete".). So we "place" all the concrete objects in this set. This is an operation of the mind. What really exists are these individual concrete objects. This is what Bunge calls the reference class of a construct. So the reference class for the concept of matter is made up of all individual material or concrete objects. So, constructing a set using a factual predicate also means constructing the reference class for that predicate. So the reference class is also a construct, and so it is also immaterial. We're trapped in our own heads. We must therefore take the existence of the external world for granted, and the referent of a predicate becomes a hypothesis for Bunge that must be validated by science. So the reference relation is not a concrete relation like a relation between two concrete objects, but an operation of the mind (in fact, an abstraction, which is a brain process). The reference relation is a semantic relation, and therefore immaterial (which makes any causal theory of reference impossible). So, the concept of matter is immaterial, but the objects to which it refers are material.

M. O.: I'm still working on the proof, but I can share a few ideas about it. One of my main claims is that skeptical scenarios are impossible. For example, recall that Descartes says that the external world could be an illusion created in our minds by an Evil Genius. As far as logic goes, we could reconstruct his argument in many different ways. One such reconstruction might be the following one:

(DES1) If it is possible that there exists a Cartesian Evil Genius, then it is possible that the external world does not exist.

(DES2) It is possible that there exists a Cartesian Evil Genius.

(DES3) So, it is possible that the external world does not exist.

I claim that DES2 is the false premise in this *modus ponens*. It is impossible that there exists a Cartesian Evil Genius. But this is where defenders of the skeptical argument can push back. How? Usually they will say that there can exist an Evil Genius because we can think or imagine that such an entity could exist. In other words, they would advance a new argument in support of DES2, which is now a conclusion instead of a premise:

(DES4) If we can think that there could be a Cartesian Evil Genius, then it is possible that there exists a Cartesian Evil Genius.

(DES5) We can think that there could be a Cartesian Evil Genius.

(DES2) So, it is possible that there exists a Cartesian Evil Genius.

I suggest that the false premise here is the first one, DES4. A statement of the form "if p, then q" can only be false if the antecedent is true while the consequent is false. In this case, it's true that we can think that there could be a Cartesian Evil Genius. I have no problem imagining such a mischievous entity, even if most of the details have not been specified. But this does not entail that it's possible that such an entity actually exists. There are many things that can be imagined. But just because we can imagine something, that does not entail that whatever we can imagine, can really exist. For example, I can imagine that the Moon is made of cheese. But this does not mean that it's possible that the Moon is really made of cheese.

Skeptics will probably want to challenge this last claim. They would ask: How do we know that it's impossible that the Moon is really made of cheese? For all we know, it could indeed be made of cheese. And here is where I would push back, by advancing the following *modus tollens*:

(DES6) If it is possible that the Moon is made of cheese, then contemporary science is fundamentally wrong.

(DES7) It is not the case that contemporary science is fundamentally wrong.

(DES8) So, it is impossible that the Moon is made of cheese.

Once again, skeptics (and presumably not just skeptics) will want to know what I'm talking about when I say that it is not the case that contemporary science is fundamentally wrong. What, exactly, am I referring to here? A substantial part of my proof for the existence of the external world is dedicated to developing this point. What I can say here, in relation to the example of the Moon, is that if it is truly possible that the Moon is made of cheese, then some of the most basic statements of the sciences (including astronomy, biology, history, anthropology, etc.) are false. For example, it would be false that the Moon has existed long before the invention of cheese, and that cheese was first made by human beings, here on Earth, around 8000 BCE.

These are just some of the ideas that I'm trying to develop in my article about the existence of the external world. Whether or not it's enough to refute skeptical arguments is up for debate. Some readers might agree with my refutations, but they might also demand that I offer an argument of my own for the existence of the external world. In that case, one such argument could be the following one:

(EXT1) If the external world does not exist, then contemporary science is fundamentally wrong.

(EXT2) Contemporary science is not fundamentally wrong.

(EXT3) So, the external world exists.

Notice that EXT2 is the same premise as DES7, they both state the same thing, although with a slightly different wording. Once again, the mostly likely point of discussion will be about contemporary science. Another thing that I would like to say about this proof is that it's not question-begging. It doesn't presuppose what it is trying to prove (i.e., that there exists an external world). This can be seen by looking at its propositional structure:

(EXT1) $\neg p \rightarrow q$

(EXT2) $\neg q$

(EXT3) p

If this argument presupposed the conclusion, then "p" would have to be one of the premises. But it isn't. My argument is not fundamentally different from other arguments that have the structure of a *modus tollens*. If it presupposed the existence of the external world, then every argument that has the structure of a *modus tollens* would be question-begging as well.

F. M.: Regarding your argument about the existence of the external world, you're right that your argument will be attacked by questioning your conception of contemporary science (DS7 or EXT2). At this point, I could point out that, by definition, science studies what philosophers call the "external world". And it is precisely for this reason that scientific knowledge is dubious in the eyes of philosophers, since the object of this knowledge, the 'external world', is not well founded philosophically. The fact that science takes the external world for granted means that science is not philosophy. But I understand that you're working on an argument which doesn't take the existence of the external world for granted, but on the contrary has to prove its existence, and at this point you have to develop an argument whose conclusion is "contemporary science is not fundamentally wrong".

Now, regarding the sceptical argument for the possibility of the non-existence of the external world, by attacking proposition DS4, you are attacking the conceivability argument, a monumental fallacy at the foundation of philosophy: whatever is conceivable is possible. This fallacy allows anyone to say anything and its opposite. To accept this fallacy is to reject the principle of noncontradiction. No rational discourse is possible if we accept this fallacy in our arsenal of argumentative tools. So you are right when saying: "I have no problem imagining such a mischievous entity, even if most of the details have not been specified. But this does not entail that it's possible that such an entity actually exists." But your refutation of the conceivability argument will never appeal to philosophers and philosophical sceptics. The argument has been attacked many times and from many angles without any effect on philosophical practice. This is to be expected, since philosophical discourse is based on this argument. Your general discourse has nothing to do with a philosophical discourse because when you think of "possible" or "exists", you think of "factually possible" or "exists concretely". But for philosophers, anything can exist. And since your arguments are not part of a philosophical discourse, they will have no weight for philosophers, just as they would have no weight for religious or mystical people, since your discourse is not part of a religious or mystical discourse.

It should not be forgotten that scepticism, as a philosophical doctrine, is also based on philosophical postulates or suppositions. For example, philosophers traditionally maintain that knowledge worthy of the name is certain, indubitable knowledge. Sceptics accept this conception of knowledge. By conceiving knowledge in this way, it is easy for philosophical sceptics to refute or cast doubt on all philosophical doctrines. And, in an attempt to exclude their own doctrine from sceptical criticism, sceptics suspend their judgment. But it is too late. They should have kept their mouths shut from the start, but they have accepted the idea that knowledge is indubitable. How do they know this? How can they justify it? On the other hand, if we no longer conceive knowledge in this ancient and outmoded way, if we withdraw from philosophical discourse in the same way that we withdraw from religious discourse and mystical discourse, the conceivability argument is seen for what it is, a fallacy.

M. O.: Turning now to the issue of matter, I agree that the concept of matter is fictional, since it's a mathematical set. But I don't think that matter itself should be identified with its concept. Instead, it should be identified with concrete material objects. In other words, Bunge's distinction looks like this:

(the concept of matter = matter itself) ≠ material objects.

Whereas I would switch the signs "=", "≠", like this:

The concept of matter ≠ (matter itself = material objects)

The nice thing about Bunge's distinction, as you pointed out, is that it keeps up with his provocative style. On this point, his skills as a polemicist and provocateur were unmatched, and that is one of the things that makes his works so entertaining. But I think that the distinction that I propose has a different advantage. If we identify matter itself with material objects, then our discourse gains clarity, since we are able to say that matter itself exists, literally instead of figuratively. Matter itself exists because it is many things, it is all of the concrete material objects that exist, from galaxies to atoms, from mountains to rivers, from whales to ants, from houses to tables.

If this is so, then one burning question is if matter itself is a single composite object or a plurality of objects instead. This question is not exclusive to matter, because it pertains to other objects as well. Take, for example, the case of the Supreme Court. As Korman argues in his book *Objects: Nothing Out of the Ordinary*, if the Supreme Court is a composite object, then it's a single fleshy object with nine tongues and eighteen elbows, assuming that the part-whole relation is transitive. So, he instead suggests that the Supreme Court is a plurality of objects, specifically nine judges. These nine judges do not compose anything, there is no object that they compose, but this does not mean that the Supreme Court does not exist. It does, because it is identical to those nine judges. I would make a similar case for matter itself. It exists, not as a single object, but rather as a plurality of material objects. Indeed, it exists as the largest plurality of all. What do you think of all this?

F. M.: I'd like to offer an initial response, although I haven't yet read Korman and so I don't have a clear idea of some of the concepts he uses, such as "an assortment", "a plurality" and "a composite". In other words, I'm going to answer from a strictly Bungean perspective. The short answer is that matter cannot exist because it is not a concrete individual object, and only concrete individual objects exist. You mentioned the notion of hydrogen, since Bunge understood it as the set of all hydrogen atoms, which makes it merely conceptual. It's easy to be confused because we use the same word, the same linguistic expression to talk about all hydrogen atoms as well as to talk about each hydrogen atom as an individual concrete object. The same thing happens with the word "family". The members of a family, which is a set, cannot be confused with a family as a concrete social system (in this last case, a family "member" is a part or a component of a concrete family, not a member of set). So the words "hydrogen" and "family" are used either to designate a set or to designate a concrete system. In the case of "matter", the word does not designate any concrete object or system. We cannot say "this matter" as we say "this hydrogen atom" or "this family". So the only way to define matter, if we want to use it at all, is as the set of all concrete objects.

Now, as far as the Supreme Court is concerned, it is a social system that has its own properties and this social system, as any other social systems, does not have tongues or elbows. So, in Korman's terms, it is not a composite because, I presume, it seems strange that a composite like the Supreme Court would have nine tongues and eighteen elbows. So, according to Korman, the Supreme Court is a plurality of objects identical to the nine judges. Here, I don't know what "being identical" means. But, from what you report, the nine judges are not the components of anything. Yet the Supreme Court is made up not only of the nine judges, but also of a host of people, all interacting with each other in a mesh of processes that maintains the integrity of the system.

Korman seems to belong to the tradition of analytic metaphysics, which is not good news. A quick search for the terms "system" and "science", in his book *Objects: Nothing Out of the Ordinary*, shows that he uses "system" only in the expression "solar system" and, worse, he never uses the word "science". Korman outlines his objective: "My target of inquiry is the way the world is, not our way of thinking about the world" (Korman 2015, 25). It's impossible to achieve this without science. It is science that tells us in what circumstances two or more material objects make up another object. There may be a few nuggets to be extracted from his work, as Bunge would say, but it certainly has little to offer for the elaboration of a general scientific discourse, which is the lot of all philosophical doctrines.

M. O.: Let's recall Bunge's definition of a system. He says that every system has three elements: some components, an environment, and a structure. In later writings he added a fourth element: a mechanism. Bunge says that elementary particles, such as electrons, photons, and quarks are not systems, because they don't have components. What he doesn't say is that according to his definition, the Universe can't be a system either. Not because it doesn't have components, but rather because it doesn't have an environment. In other words, if X lacks one of the elements that define a system, then X is not a system, no matter what X is. So, either an elementary particle and the Universe are both systems, or neither of them is. It can't be the case that one of them is a system and the other one is not, because that would be arbitrary, unless a reason is given for why one of them would be a system and the other one would not.

By comparison, it is just as arbitrary to say that the Supreme Court does not have nine tongues but that your body has twenty fingers. In other words, the topic of discussion here is the transitivity of the part-whole relation. The only way to claim that the Supreme Court is a composite object (i.e., a system) that doesn't have nine tongues is to deny that parthood is a transitive relation. But if you deny that, then you also have to deny that your body has twenty fingers. Why? Because if your fingers are parts of your hands and feet, and if your hands and feet are parts of your body, and if you deny that parthood is transitive, then it follows that your fingers are not parts of your body, just as the tongue of each judge is not a part of the Supreme Court. Just as in the case of elementary particles and the Universe, in which we must declare that neither of them are systems or both of them are, here we must declare that parthood is (or is not) transitive for the Supreme Court as well as for your body.

I think that the best strategy for solving this problem is to claim that there is a difference between the Supreme Court and a human body. The latter is a composite object, while the former is not. Parthood is transitive, and your fingers are certainly parts of your body. But the tongue of each judge is not a part of the Supreme Court because the Supreme Court, unlike a human body, is not a composite object. The Supreme Court is comparable to, for example, a group of students. When I say "the students surrounded the building", to use one of Korman's examples, I don't mean to say that there is a single object composed of the students and that such an object is surrounding the building. What I mean to say is that there are many people (i.e., a plurality of students), that are collectively surrounding the building. Or, to use a different example, when I say that there are some fruits on my table, I don't mean to say that there is a single, large composite multi-flavored fruit on the table, I simply mean that there is a plurality of different fruits there.

Otherwise, I would be committed to the claim that any two objects whatsoever compose a third object. Bunge himself made such a claim in the third volume of his *Treatise*:

> Indeed, an individual on our planet and another in a distant galaxy may be taken to associate to form a third individual, so that each component will be a part of the whole, just as much as the two components of a miscible fluid poured into a glass. (Bunge, 1977: 30)

I disagree with Bunge here. In the field of analytic metaphysics, a position like Bunge's would be characterized as permissivist. Proponents of permissivism typically hold that any two objects compose a third, no matter what the objects in question are. David Lewis used the example of a troutkey or trout-turkey, which is an object composed by the front half of some trout and the back half of some turkey, even if these animals are several kilometers apart and are not interacting with each other in any way. Or, to use one of Korman's examples, permissivists are committed to the claim that some dog and some tree compose a trog, no matter if they are interacting with each other or not. In fact, one of Korman's critics, Louis deRosset, argued that trogs exist as physical systems, and he appealed to science in order to justify that claim. Korman examined that critique (as well as other critiques) in an article that he published in 2020:

> let us turn to arbitrary physical systems. Take some particular dog and trunk and let us ask: is there a physical system comprising the atoms arranged dogwise and the atoms arranged trunkwise? A dilemma looms. If the conservative agrees that this system exists, then that is tantamount to accepting that trogs exist. Yet denying that there is such a system, deRosset tells us, "is implausible in light of the results of settled science" (Korman, 2020: 566)

Korman denies that there is a system composed of a dog and tree, and I agree with him on this point. He adds the following remarks:

> What, then, are these "results of settled science" that are supposed to make this denial so implausible? If deRosset just means that scientific investigation has resulted in a consensus among practitioners that there are such systems, this in itself carries no more weight than a consensus among biologists that Pando exists and is a single

> object that is identical to some aspens. Not even if we can get scientists to clarify that they really do think of a system as a single composite object and that they do not regard "systems"-talk as a roundabout way of talking about pluralities. What matters is whether they have produced any evidence in support of the metaphysically loaded conclusions they draw, and which tells against less-metaphysically loaded counterparts. (Korman, 2020: 567)

In other words, if I have to choose between agreeing with Bunge when he says that "an individual on our planet and another in a distant galaxy may be taken to associate to form a third individual", or agreeing with Korman in denying that arbitrary physical systems exist, then I most certainly agree with Korman on this point, which doesn't entail that I agree with him on other points.

How about you? Do you think that Bunge is right in claiming that any two objects whatsoever compose a third?

F. M.: Your last reply deserves a more detailed response than I can give in a first reply. But here are a few points I can make in response. I agree that a physical (material, concrete) system is not arbitrary, and I'm sure that Bunge would agree too, since he strongly defends the lawfulness principle. Concrete objects can't do just about anything and therefore can't associate in just any way. So, Bunge is not claiming that any two objects whatsoever compose a third. Having said that, how to interpret the passage you quote, which I've reproduced here for greater clarity:

> Indeed, an individual on our planet and another in a distant galaxy may be taken to *associate* to form a third individual, so that each component will be a *part of the whole*, just as much as the two components of a miscible fluid poured into a glass. (Bunge, 1977: 30; italics by me)

This passage is found in chapter 1 of volume 3 of the *Treatise*, a very abstract chapter influenced by mereology. Chapters 1 and 2 of this volume are intended to serve as a foundation for the notion of a thing or concrete object dealt with in Chapter 3. In other words, neither Chapter 1 nor Chapter 2 deals yet with concrete objects or systems. I have not yet formed a clear idea of the usefulness of these two chapters, but what is clear is that such abstract results, to be of any use, are to be obtained by studying the products of science or scientific constructs, whether by axiomatizing scientific theories or by any other method of analysis. But, traditionally, the approach to mereology is a priori. According to Bunge, this is not the case with his own mereology. He constructed his own mereological theory from the axiomatization of some physical theories. He also points out that the part-whole relationship is not formal. So, if the part-whole relation is neither formal nor metaphysical (a priori), what is it? It is a useful fiction:

> […] we shall be concerned with concrete objects such as atoms, fields, organisms, and societies. We shall abstain from talking about items that are neither concrete things nor properties, states or changes thereof. Any *fictions* entering our system will be devices useful in accounting for the structure of reality. (Bunge 1977, 3:xiv; italics by me)

For Bunge, constructs are fictions. A construct can refer to a concrete object or to another construct, i.e., a conceptual object. In the same way as Bunge's notion of the naked individual and that of the null individual, the notion of a part of a whole and that of the part-whole relation are nothing more than useful fictions, not only in the sense that the concept of "part-whole relation" is a fiction, but also in the sense that this concept refers to a conceptual object that is also called "part-whole relation". In other words, the concept of "part-whole relation" does not refer to a concrete relation. So the passage you quote from Bunge is highly ambiguous. The association relation and the part-whole relation are fictions in this passage, but a planet, a galaxy, a fluid and a glass are concrete objects. Another difficulty in this passage arises from the expression "may be taken", which changes meaning depending on the context. Bunge probably means "can be brought together" to form a third individual. That said, the difficulties of interpreting Bunge's mereology remain. Is the part-whole relation the same as the relation of "being a subsystem of a system"? (Note that for Bunge, the two relations have the same logical properties: they are reflexive, asymmetrical and transitive.) Or is the relation of "being a subsystem of a system" a specification of the more general part-whole relation? But, if we refer to volume 4 of Bunge's *Treatise* on systems theory, we can see that the notion of part-whole is used to define the notion of atomic composition of an object, but this relation is not transitive:

> Let us start by defining the composition of a system. A social system is a set of socially linked animals. The brains of such individuals

> are parts of the latter but do not qualify as members or components of a social system because they do not enter independently into social relations: only entire animals can hold social relations. In other words, the composition of a social system is not the collection of its parts but just the set of its atoms, i.e., those parts that are *socially connectible*. (Bunge 1979, 4:5 italics by me)

According to this notion of atomic composition, the US Supreme Court does not have nine tongues. Each tongue is a part of a judge as a living organism, and each judge is a part of the Supreme Court as a social system. Each judge is a part of the Supreme Court because each judge is *linked*, *connected* or *coupled* to the other judges through social ties. So, you are right, there is a difference between the Supreme Court and a human body: they are two different kinds of systems, each with its own *coupled parts*. You are also right when you say that the Supreme Court is comparable to a group of students around a building because in both cases they are social systems and not because in both cases we are dealing with a plurality of objects. The people who are the judges and the people who are the students are coupled parts of the Supreme Court and of an education system respectively. (It is interesting to note here that a single person is part of several social systems, which is not the case for an organ, which belongs to a single body. The lesson here is that physical, chemical, biological and psychosocial systems are not organized in the same way, which requires not only different sciences, but also different metasciences.) What about some fruit on a table? These fruits are part of several social systems. The main role of some social systems is to pick or produce fruits and then distribute it. These fruits end up in the stomachs of certain biological systems, human beings, to keep them alive and allow them to maintain social links in several social systems.

Thus, while analytical metaphysics gives a large role to mereology, Bunge sees his own mereological theory as an important but tiny part of his own ontology. From a few mereological notions, he constructs much richer and more powerful ontological notions which allow him to give a more accurate account of a general (metascientific) representation of the world because it accords better with more specific (factual) representations of each science.

M. O.: Given how abstract the initial chapters of the third volume of the *Treatise* are, it's certainly possible that the parthood relation is fictional according to Bunge. But if this is so, then it leads to a contradiction if we take into consideration his definition of reality:

> Our definition of "reality" cannot be other than this:
>
> DEFINITION 3.30 Let Θ be the set of all things and $[\Theta]$ its aggregation. Then
>
> *Reality* $=_{\mathrm{df}} [\Theta] =$ □ $=$ *the world.*
>
> The reality of an object consists in its being a part of the world. (Bunge, 1977: 161)

Notice that Bunge is using the term "reality" in two different senses here. Firstly, he says that reality is identical to the world. And by "world" he means the Universe. In other words, Bunge believes that the Universe and reality itself are the same thing, they're identical. Secondly, he says that an object is real if it's a part of the world. And when he says "part" here, it should be understood in a mereological sense, he's talking about the part-whole relation. This can be seen by taking a look at Postulate 1.2 and Definition 1.3, in the same book:

> POSTULATE 1.2 There exists an individual such that every other individual is part of it. I.e., $(\exists x)[x \in S \ \&\ (y)(y \in S \rightarrow y \sqsubset x)]$.
>
> DEFINITION 1.3 The universal individual introduced by Postulate 1.2 is called *the world* and is denoted by □.
>
> *Remark 1* Note again that the world, i.e. □, is an individual not to be confused with the set S of all individuals, which is a concept not a physical object. (Bunge, 1977: 30)

The symbol □ is a construct, but what that symbol denotes is not a construct, it's the Universe, which is identical to reality itself, according to Definition 3.30. And, according to Postulate 1.2, every concrete object is a part of the Universe. Here's the problem: if the reality of an object consists of being a part of the Universe, then this contradicts the idea that the part-whole relation is fictional. How can it be fictional, if it's supposed to guarantee the reality of every concrete object, insofar as every concrete object is a part of the Universe?

This isn't the only contradiction in Bunge's ontology. Despite the admiration and respect that I have for him and his work, there are some problems with some of his ideas. Consider, for example, his comments on geometrical shapes:

> Another obvious consequence of the preceding considerations is that concrete objects (things) have no intrinsic conceptual properties, in particular no mathematical features. This last statement goes against the grain of objective idealism, from Plato through Hegel to Husserl, according to which all objects, in particular material things, have ideal features such as shape and number. What is true is that some of our *ideas* about the world, when detached from their factual reference, can be dealt with by mathematics. (For example, by analysis and abstraction we can extract the constructs "two" and "sphere" from the proposition "That iron sphere is composed of two halves".) In particular, mathematics helps us to study the (mathematical) form of substantial properties. In short, not the world but some of our ideas about the world are mathematical. (Bunge, 1977: 118, emphasis in the original)

In other words, Bunge is saying that concrete objects do not have shapes, since shapes are mathematical objects (specifically, they're geometrical objects), and he says that such objects are constructs. Yet this contradicts another passage from the same book, in which he says that shapes are real:

> *Remark 3* Shape, hardly a property of basic things, emerges rather definitely at the macromolecular level and becomes the more definite, the bulkier the thing. It is therefore a derivative property. Moreover it emerges from nongeometric characteristics. Thus the helicoidal configuration of a DNA molecule results from chemical forces such as the hydrogen bonds between an NH group and a carbonyl group, and it is influenced by the environment of the molecule—to the point that the pattern disintegrates at high temperatures. Likewise the shape of a macrobody is determined jointly by the inner stresses and the external forces. In general, shape or geometric pattern, when it exists at all, is an outcome of the interplay of internal forces and environmental constraints. *Remark 4* Although shape is a secondary property, once acquired, it conditions the acquisition or loss of further properties, which are called *steric properties*. Suffice it to recall that the specific activity of enzymes depends upon their shape. (Bunge, 1977: 294, emphasis in the original)

The contradiction here is quite evident. On page 118 he suggests that concrete objects do not have geometric shapes, while on page 294 he says that shape is a derivative property that emerges from nongeometric characteristics.

Another contradiction arises from the passage on animal societies that you quoted, from the fourth volume of the *Treatise*, on page 5. I've quoted this passage myself in my article on Harman's philosophy and materialism (Orensanz 2024). But before recalling it here, the contradiction that I mentioned is the following one: if the part-whole relation is fictional, then this contradicts the claim that a system has an atomic composition. How can it be the case that the brain of an animal is one of its parts if the part-whole relation is fictional?

As for the problem that I pointed out in my discussion with Harman, it can be summarized as a question: does an animal have molecules? The answer is obviously affirmative. Yet, if the animal's brain is not part of a social system, then why are the molecules part of the animal's body? Unless an explanation is given for this differential treatment, then this is just metaphysical arbitrariness. To be coherent, we would have to say an animal body does not have molecules, since molecules are not part of what Bunge calls the "atomic composition" of the animal's body. The genuine parts would be, for example, the animal's brain, limbs, stomach, etc., but not the molecules. So, if we want to say that molecules are parts of an animal's body, then we also have to say that the animal's brain (and tongue, and elbows, if it has any) are parts of the animal's society. To put it more succinctly: If the Supreme Court does not have tongues, then an individual judge does not have molecules. And if the judge in question has molecules, then the Supreme Court has tongues.

I believe that these contradictions arise because Bunge usually wants to have his cake and eat it too. He wants to say that the part-whole relation is fictional, but at the same time he wants to use that relation to define the reality of concrete objects. Likewise, he wants to say that shapes are fictional (because they're geometrical concepts) and at the same time he wants to say that they're real (because they arise from nongeometric characteristics).

As far as I can see, the best strategy for resolving these contradictions is to trace a distinction between conceptual parthood and real parthood, and between conceptual shapes and real shapes. This would be similar to the distinction that Bunge already traces between conceptual existence and real existence. So, for example, we can say that an iron sphere does indeed have a real shape (which is something that you once suggested to me in an email, but I wasn't entirely sure about it at that moment. Now I'm inclined to agree with you). It's not a perfect sphere, but it's close enough. The same goes for parthood. You can say that conceptual parthood is fictional, it's a construct, but that construct denotes a real relation, just as the symbol □ is a construct that denotes a real thing (the Universe).

But if this is so, then we're back at the beginning of our discussion about parts and wholes. Specifically, is it true that an individual on our planet and another one in a distant galaxy can associate to compose a third individual, as Bunge says? I think that is not true. You might say, in Bunge's defense, that Chapter 1 of the third volume of the *Treatise* deals with abstractions, since it's mostly about bare individuals. But the problem with that idea is that in Chapter 3, which is dedicated to fully qualified real things, he says that the postulates and theorems about bare individuals apply to fully qualified real things as well, and this includes what he had previously said about association and composition. In his own words:

> We can retrieve for things everything we defined or proved for bare individuals (or things deprived of their properties other than the property of associating and the properties, such as composition, derived from associability). (Bunge, 1977: 114)

So, his ideas about any two objects composing a third are not limited to his discussion on bare individuals. They also apply to his ideas on fully qualified real things. And this, to me, is highly questionable. It's the same claim that analytic permissivists make when they say that a trout and a turkey compose a troukey, or that a tree and a dog compose a trog. Perhaps Bunge was not fully aware of all of the ramifications and consequences of his ideas on composition, just as he probably was not aware of the contradictions that I mentioned before. But that is one of the reasons why we're having this conversation in the first place: to correct any mistakes that Bunge might have made, so that we can advance his program even further. We're both Bungeans, you and I, though I'm admittedly less orthodox. But we both admire his work, and we agree with most of his ideas. To use a metaphor, Bunge's *oeuvre* is like a good car that just happens to have a few problems. We don't need to replace the entire car, all that we have to do is to lift the hood and look at the engine and the other components and replace just a few faulty pieces. At least that's my opinion. How about you? Do you think that Bunge's ideas need some replacements and corrections, or do you think that he hasn't made any mistakes and that we should instead focus on adding more ideas?

F. M.: It's clear that Bunge hasn't said everything, that he's made mistakes, and that his thinking contains inconsistencies and contradictions. But what struck me most about Bunge was the way he reasoned. Bunge doesn't problematize conceptual problems inherent in science in the same way that philosophers do. He attacks these problems in the same way as scientists would if they took the trouble to do so explicitly. Not that scientists don't solve conceptual problems, but they often do so informally, on the spot, without elaborating on how to go about it. Many philosophers have claimed to take care of this or to take science into account, but most of the time it's either wishful thinking, a naive approach, a bad joke, or an intellectual scam. In short, they problematize the conceptual problems of the sciences as philosophers, which is of no use in understanding science and building a general picture of the world based on scientific knowledge.

Now, what's the best way to introduce the concept of a thing or concrete object, or the richer concept of a concrete system? I'm not in the best position to resolve this question, and many others related to it, but here are a few remarks and suggestions, in order to help in the constitution of a Bungean program, or, better yet for me, a metascientific research program.

The difference between a scientific representation and a metascientific representation is that the former refers to real things or concrete objects, while the latter refers to scientific constructs, whether these are explicit, like the concept of mass of a particular theory, or implicit, like the concept of property used by all sciences. There are other cases, such as the implicit general postulates upheld by scientists, e.g., that objects obey laws, that these objects really exist, not just in a metaphysical world, that they are knowable and representable up to a certain point, and so on. What I'm getting at is that all Bungean constructs, and therefore metascientific constructs for my part, refer to other constructs. It's not the role of the metasciences to refer to concrete objects, it's the role of the factual sciences. Thus, metascience is a system of representation that studies another system of representation, science, while the latter studies concrete reality. This paragraph describes a situation which, and you mentioned it in your last intervention above, derives from the dichotomy between real existence and conceptual existence, between the thing and the concept, between reality and fiction, or between reality and the representation of it. This is fundamental. Either a construct refers to another construct or it refers to a concrete object. There is no room, of course, for ghosts and gods, but neither for any metaphysical entity imagined by philosophers. But it is difficult to keep a cool head and not slip between reality and fiction by creating a fictional reality, a metaphysical world, which would reconcile reality and the conceptual representation of it.

Science is a construction of the mind. All scientific knowledge is made up of constructs. So, if metascience studies scientific knowledge (explicit or implicit), then it only studies constructs and not concrete objects. And precisely, the concept of thing or concrete object that you mentioned, introduced by Bunge in chapter 3 of volume 3 of the *Treatise*, does not refer to concrete objects, but to other constructs, as in the case of the formal sciences, except that metascience is not a formal science (contrary to what Bunge thinks for its semantics, because the semantics of the factual sciences depends on the constructs of the sciences, whereas logic and mathematics are autonomous). Bunge has constructed a conceptual object, which he has named "thing", just as he has constructed an object named "property", "fact", "event" and so on. There is no general or universal thing, property, fact or event in nature, any more than in a metaphysical world. There are only singular things, properties, facts or events, which scientists try to represent by constructs (concept, proposition, classification, theory, model, etc.), but these constructs have to be worked out in such a way that they can be confronted with reality. If Bunge's theories were to refer to concrete objects, they would be empirically testable. In fact, Bunge maintains that it is not possible to test his own theories empirically.

So, you are right, "the best strategy for resolving these contradictions [in Bunge's ontology] is to trace a distinction between conceptual parthood and real parthood, and between conceptual shapes and real shapes." What form a solution should take, I do not know precisely. But it must necessarily exclude the possibility of "troutkey" and "trog". There is no scientific theory that makes the formation of such monsters possible by predicting the existence of such objects, just as gravitational waves were predicted long before they were detected. And if we think we don't have scientific theories mature enough to settle the question, then let's appeal to the expertise of scientists. I doubt we'll find a single scientist who will take the existence of these monsters seriously. My point is that the question of the existence of concrete objects is best left to science, which is also Bunge's position. Metascience should only deal with scientific knowledge, not with reality, and, above all, it must not invent a more fundamental "metaphysical reality", which according to philosophers would make it possible to bridge the gap between concrete reality and the representation we have of it.

It is interesting that you quote the following passage from Bunge: "We can retrieve for things everything we defined or proved for bare individuals (or things deprived of their properties other than the property of associating and the properties, such as composition, derived from associability)." (Bunge, 1977: 114) It was this passage that first made me doubt about the necessity of chapters 1 and 2 of volume 3 of the *Treatise*. And while we're at it, why not drop the notion of a concrete thing or object and move straight on to that of a concrete system? We could drop the notion of parthood, develop a notion of subsystem that takes into account the way scientists represent things, because my nose tells me that sociologists don't consider the Supreme Court to have nine tongues, at least not in any interesting sociological sense. I know it's not your position, but it's a fine example of the kind of pseudo-problems decried by Bunge. If we look at dozens of examples from various scientific disciplines, we may realize that the relation "being a subsystem of" is not represented as transitive by scientists? Whatever solutions may be proposed by future metascientists, we must remember that when we encounter a paradoxical or strange situation, we must be wary not only of ourselves, but also of those who propose it. This is a heuristic rule that in no way guarantees the success of our research. It is simply the famous rule of reasonable doubt. But philosophers love paradoxes, they cultivate paradoxes, and the discovery of a paradox can be the high point of a philosophical career.

I don't think Bunge's contradictions arise from the fact that he wants his cake and eat it. It is simply difficult to maintain a clear separation between metadiscourse and discourse, between metascience and science, between reality and its scientific representation, and between this scientific representation of the world and the metascientific representation of this representation. Not to mention that Bunge uses formal tools to elaborate his metadiscourse, just as science does to elaborate its discourse on reality. This makes it very easy to write ambiguous passages that mix metascientific, scientific and mathematical constructs. But of all the philosophers who have attempted to construct a metadiscourse on science, Bunge is by far the one who navigates best between levels of discourse, and who almost always keeps in mind the difference between reality and the representation of reality.

I understand that you are not a permissivist in analytic metaphysics, the view that "troutkey" and "trog" exist (Where? How? Permissivists don't say), and you don't believe that the Supreme Court has nine tongues. But if we come across paradoxical or contradictory results, the conclusion is that it's quite possible that our metadiscourse doesn't adequately account for scientific knowledge. So, the contradictions you point out in Bunge's work are right, but they can't be resolved by analytic metaphysics. At best, philosophers can inspire us with ideas. The only way to overcome the contradictions that arise in our metadiscourse on science is to keep in mind the difference between reality and its representation, not to mix metascience, science and formal science, and, very importantly, to study the sciences. But this is not the approach of analytic metaphysics in general, nor that of Korman in particular. It's important to look at the notions of part-to-whole, composition, subsystems, etc., but Korman's a priori, intuitive and commonsense approach, with the help of linguistic and grammatical categories, won't provide interesting answers to the sciences.

I assume that the Supreme Court is a social system. It's wrong then to claim that the Supreme Court is a plurality of objects, unless you maintain that "plurality of objects" is synonymous with "system", but then the Supreme Court possesses properties that the judges do not, but in that case the Supreme Court cannot be identical to the nine judges. I don't have a final answer here, but any metascientific solution must take into account the fact that there are systems composed of subsystems, and then study how scientists implicitly and explicitly account for the relationship between systems and subsystems. This is the opposite of an a priori approach that defines, for example, the part-whole relation without taking scientific knowledge into account.

As far as matter is concerned, your Korman-inspired solution is to treat that word as a collective noun, which seems to me to be a category mistake since a collective noun is a linguistic or grammatical notion, which is not surprising since Korman is an analytic philosopher. Furthermore, we can't draw a parallel between matter and the Supreme Court, since the Supreme Court is clearly a social system, whereas matter doesn't refer to any particular system. So, it's easy here to treat the collective noun "Supreme Court" as denoting the concept "Supreme Court", which refers to the concrete object that is the Supreme Court, a social system. Now, does matter refer to a plurality of objects? I couldn't say. The way in which we express ourselves vaguely in everyday life by designating without too much precision certain groupings of objects is not an appropriate way to express ourselves in science and metascience. So, I don't know how to deal with a collective noun that doesn't refer to a concrete system, in a way that makes the concept relevant to science and metascience, other than to retain Bunge's solution of defining matter as the set of all concrete objects, which is only an operation of the mind, that of gathering all concrete objects into an abstract set. In short, a collective noun can be interpreted in a variety of ways in everyday life, and must be carefully interpreted when we want to extract from it a scientific or metascientific concept.

2] Concluding Remarks

Throughout the preceding dialogue, Maurice and Orensanz have discussed several topics which are important to both metascience as well as philosophy, such as the possibility (or impossibility) of proving that the external world exists, how best to conceptualize matter, the transitivity of the part-whole relation and its associated paradoxes, the difference between systems and assortments, the status and role of fictional objects in ontology, and Bunge's monumental contributions to the development of metascience. In the next part of this dialogue, to be published in a future volume, Maurice and Orensanz will continue their discussion of key topics for the advancement of the metascientific program.

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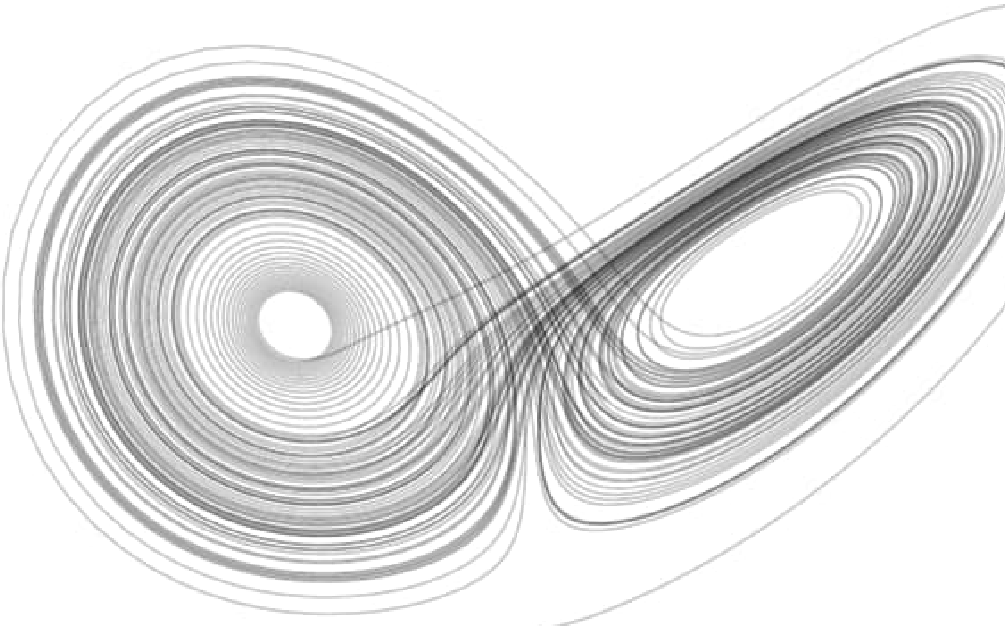
Applications of Bungean Thought



Making Sense of Models and Modelling in Science Education: Atomic Models and Contributions from Mario Bunge's Epistemology

Juliana Machado[1]

Abstract—Conceptions about the nature of scientific models held by science students frequently involve distorted views, with a tendency to consider them as mere copies of reality. Besides encompassing an untenable view about the nature of science itself, this misconstruction can effectively be a pedagogical impediment to learning. **Objectives**: We evaluate whether Mario Bunge's epistemology might contribute to tackling issues related to the nature of models in science education contexts. **Design**: After identifying Bunge's main model categories, we employ them to examine aspects of the historical development of atomic models and contrast the resulting framework with issues about model conceptions in science education, as pointed out in the literature. **Setting and participants**: Due to this research's theoretical nature, this study did not include human participants other than authors from the literature and the theoretical framework. **Data collection and analysis**: We performed a constant comparative analysis to identify patterns of meanings shared between the historical case and the theoretical framework. **Results**: Features of models pointed out by Bunge were identified in the development of atomic models and could provide consistent and explanatory viewpoints about key issues related to model conceptions in science education. **Conclusions**: Bunge's framework might help to clarify aspects of the nature of models relevant to science education contexts.

Résumé — Les conceptions que les étudiants en sciences ont de la nature des modèles scientifiques conduisent à une image inexacte de ceux-ci, notamment lorsque les modèles sont vus comme de simples copies de la réalité. Outre le fait qu'elle entretient une conception fausse de la nature de la science, cette façon de se figurer les modèles peut constituer un obstacle pédagogique à l'apprentissage.

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Objectifs : Nous évaluons l'épistémologie de Mario Bunge afin de déterminer si elle peut contribuer à résoudre les problèmes liés à la nature des modèles dans un contexte d'enseignement des sciences. **Approche** : Après avoir identifié les principales catégories des modèles chez Bunge, nous les employons pour examiner divers aspects du développement historique des modèles atomiques, puis nous appliquons le cadre théorique ainsi obtenu aux problèmes liés aux diverses conceptions des modèles en enseignement des sciences. **Participants** : En raison de la nature théorique de cette recherche, cette étude ne fait pas appel à des participants autres que les chercheurs des recherches mentionnées. **Collecte et analyse des données** : Nous avons effectué une analyse comparative constante afin d'identifier les schémas de signification communs au cas historique et au cadre théorique. **Résultats** : Les caractéristiques attribuées aux modèles par Bunge ont été identifiées dans le cas des modèles atomiques. Ces caractéristiques forment un point de vue cohérent et permettent d'aborder, dans le contexte de l'enseignement des sciences, plusieurs questions liées aux diverses conceptions des modèles.

Keywords—Models, Modelling, Epistemology, Nature of Science, Atomic Models.

The value of models and modelling in science teaching has long been recognised in the literature. Despite their widespread use, researchers have a variety of viewpoints on the nature of models. This paper does not deal with this plethora of model conceptions. Instead, we turn to one specific view about models and modelling, potentially fruitful to deal with issues in science education, such as their idealized and abstract character, and we discuss its implications in interpreting an important sector, that of atomic models.

To reach this aim, in the following pages, we firstly provide a context to describe the issues above-mentioned, after which we present Mario Bunge's framework for the analysis of models and modelling, which gives special attention to the relationship between scientific knowledge and reality. Subsequently, we deepen the discussion about abstractions and idealizations, which are at the core of that relationship. Then we employ these ideas to interpret aspects of the development of atomic models, from J. J. Thompson to A. Sommerfeld. Finally, we discuss teaching implications, showing how Bunge's framework helps to clarify aspects of the nature of models relevant to science education contexts.

1] Background

In his critique of the Nuffield project, then just recently published, Gebert (1969) appeals only to his own teaching experience to state that, in general, secondary school students are not able to understand and work properly with models, mainly because they see them as "physical realities". By attributing this fact to student immaturity and fearing that early modelling will have detrimental effects on learning, Gebert (1969) proposes to avoid the topic altogether until students reach an age where they can properly understand it—which would happen, according to the author, around the age of 17 or 18.

Gebert's (1969) diagnosis has been consistently confirmed by science education research: it seems that students tend to understand models more as copies of reality than as conceptual, partial, and approximative representations. However, the treatments that have been proposed to address this problem diverge from the suggestions of Gebert (1969). Grosslight and colleagues (1991), for example, interviewed students in the seventh and eleventh grades of compulsory schooling in the United States to investigate their conceptions of models and highlighted—as did Gebert (1969)—the difficulty presented by both groups in distinguishing scientific models and realities they are supposed to represent. Rather than proposing to abandon teaching with models, the authors offered three suggestions: (1) to provide students with intellectual problems that require the use of models; (2) to explore multiple models for the same phenomenon by modifying and revising them; and (3) to invest some didactic work in metaconceptual reflection on the nature of the models.

Regarding the possible causes for the symptoms highlighted by Gebert (1969) and others, Harrison and Treagust (2000) pointed out reasons for students' lack of understanding of the nature of science and of the scientific content itself. One point emphasised by the authors is the absence of discussions about the representational character of scientific models in textbooks, which can be extended to classroom educational practices: usually, discussions about the nature of the models and their use, and opportunities to develop provisional models and assess them, remain absent in teaching situations (Gilbert & Osborne, 1980). This may be partially due to the teacher's difficulties distinguishing the scientific model from the modelled object or event (Coll et al., 2005). Thus, the school curriculum traditionally neglects the approximative character of the models, tending to present them as mere copies of reality (Lefkaditou, Korfiatis & Hovardas, 2014).

Consequently, it is possible to understand students' perplexity when models of the same phenomenon are presented throughout the educational process, one after the other. If the scientific model holds a one-to-one correspondence with its object, there could not be multiple valid models for the same phenomenon. Therefore, students assume that the most recently studied model must be the "correct" one, which naturally frustrates students who have dedicated efforts to learn the "wrong" models in earlier stages of schooling. This distorted character of scientific knowledge is not only epistemologically misconstrued but can also be a pedagogical impediment to learning (Taber, 2012).

So, contrary to Gebert's (1969) suggestions, models are currently regarded in science education contexts as constructs to be used and understood by scientists and students as an integrated part of their learning processes. These processes include learning science's contents, practices and nature (Hodson, 2014). However, there is no single, universally accepted definition of a scientific model, but several distinct understandings (Krapas et al., 1997; Machado & Fernandes, 2021), mostly influenced by ideas drawn from psychological and philosophical frameworks (Justi & Gilbert, 2016).

2] Theoretical Framework

Mario Augusto Bunge (1919-2020) was an Argentine-Canadian philosopher and physicist who wrote or edited around 80 books and 500 scientific or philosophical papers. As he was a scientific philosopher and a philosophical scientist, Bunge's prodigious academic output was always committed to studying the interaction between science and philosophy and defending the best of both. Teaching first physics and philosophy at the Universities of La Plata and Buenos Aires during the 1950s, Bunge also taught those subjects in the USA during the early 1960s. In 1966, he was appointed professor of philosophy at McGill University in Montreal, where he became Frothingham Professor of Logic and Metaphysics until his retirement at age 90. Besides always being a socially engaged intellectual—even founding a college for workers, *Universidad Obrera Argentina*—, Bunge played a key role in giving international relevance to Latin American philosophy. In an international philosophical congress held in 1956 in Santiago (Chile), he was particularly noticed by Quine, who later wrote in his autobiography:

> The star of the philosophical congress was Mario Bunge, an energetic and articulated young Argentinian of broad background and broad, if headlong, intellectual concerns. He seemed to feel that the burden of bringing South America up to a northern scientific and intellectual level rested on his shoulders. He intervened eloquently in the discussion of almost every paper. (Quine, 1985, p. 266)

In a book published in 1959, *Causality*, Bunge criticized the empiricist conception of causality and developed a realist account of it. The book soon gained international recognition and marked a turning point, because after its publication, " … books one may call 'classics' were now coming out of Latin America and finding a place in mainstream reading lists in the English-speaking world and Europe" (Lombardi et al., 2020)

Being a realist, Bunge sees scientific models as fundamental entities in the quest for conceptual understanding of reality. They would play the role of mediators, similar to the one proposed later by Morgan and Morrison (1999), between reality and the theories that deal with it. But what does "reality" mean in this context? The concept of reality maintained by Bunge consists of the aggregation of all things that hold spatiotemporal relations with each other: "The reality of an object consists in its being a part of the world" (Bunge, 1977, p. 161). In other words, a "real thing" in the context of physical knowledge would be the intended referent of a physical theory (Bunge, 1977).

This definition leaves out conceptual objects, such as scientific constructs. These are not endowed with reality, although they do exist conceptually. In addition, Bunge emphasises that reality is not reducible to observation, since it postulates the existence of unobservable entities such as waves and forces, let alone to experiment, because it accepts components that cannot be extracted from the latter, such as electrons and inertia (Bunge, 1973a). Finally, to him, the reality is changeable, i.e., there are possibles that may not yet be actualized. Thus, reality can be divided into two classes: actualities and real possibilities (Bunge, 1977).

Bunge claims that science does search for reality, but can never attain it perfectly or completely, only approximately. This means that scientific knowledge does make actual progress in its quest, even though never fully accomplishing it. The author expresses such an idea, which is characteristic of critical realism:

> […] things in themselves are knowable, though partially and by successive approximations rather than exhaustively and at one stroke […] this knowledge (factual knowledge) is hypothetical rather than apodictic, hence it is corrigible and not final… (Bunge, 1973b, p. 86)

As a result, Bunge dismisses both scepticism and dogmatism, claiming that incremental and tentative access to knowledge is feasible, thereby subscribing to a perspective on the problem of knowledge's possibility known as criticism (Hessen, 1997; Niiniluoto, 2002). Furthermore, the author expresses his support for ontological realism, a viewpoint that refers to the essence of knowledge and is opposed, for example, by the Vienna Circle's logical positivists (Niiniluoto, 2002).

Little has been stated on the problem of knowledge's origins thus far. Bunge (1973a) opposes rationalism and empiricism, claiming that neither reason nor experience can be the single or primary basis of scientific knowledge (Bunge, 1985). Bunge also argues that our knowledge of reality is something we create, by stressing that theories and models do not have reality as an immediate reference, but rather conceptual versions of real objects, invented by the epistemic subject: "Epistemological constructivism is correct, but the ontological one is false" (Bunge, 1991, p. 51).

2.1] Concepts of Model

In trying to elucidate the relation between reality and scientific knowledge, Bunge pointed out that such knowledge does not refer directly (or immediately) to real objects and events. This reference is mediated by constructs, which he called "model objects" (Bunge, 1973a). These consist of conceptual representations of the targeted real objects. For instance, a fluid can be represented by a continuum possessing specific attributes, such as viscosity and compressibility. Such model-object will inevitably

> […] miss certain traits of its referent, it is apt to include imaginary elements, and will recapture only approximately the relations among the aspects it does incorporate. In particular, most individual variations in a class will be deliberately ignored and most of the details of the events involving those individuals will likewise be discarded". (Bunge, 1973a, p. 92)

All fields of mature natural sciences, claimed Bunge, are full of model objects. So, for instance, physics has mass points, light rays, ideal threads, photons, Carnot heat engines, and so on; chemistry has, e.g., atomic models, pure substances, ideal gases, orbitals, molecular models, valence shells; and biology encompasses model objects such as cells, species, genes, Watson and Crick's DNA model, among many others. It is also possible to develop different model objects to represent the same referent: for example, we can model the Moon as a point mass, as a sphere or as an oblate spheroid, homogeneous or non-homogeneous in each case. These would all be distinct constructs, with different degrees of approximation, but none would be identical to the actual Moon, because epistemic subjects create model objects through idealizations and abstractions, thus modifying the objects' aspects to a certain extent.

An important distinction between model objects and real objects is that the former are ideas, while the latter are things. This property makes model objects able to be grafted onto theories, unlike real ones. More appropriately, Bunge used the term "general theories" to allude to wide-ranging theoretical frameworks, potentially applicable to all phenomena under its domain, e.g., classical mechanics and electromagnetism. When embedding a model object in a general theory, we can create theoretical models, i.e., hypothetical-deductive systems concerning the model object. Unlike the model object and the general theory, theoretical models have explanatory power, which can be used to make predictions about the targeted system and to establish relations among its variables, as well as being subjected to empirical testing.

Bunge explains that any model object can be implanted into different general theories, thus forging different theoretical models. For example, the ideal gas can be combined with classical or relativistic mechanics, bringing forth two different theoretical models for the gas. Reciprocally, varied model objects (concerning the same real object) may be inserted in a single general theory to engender distinct theoretical models. An example could be to replace the ideal gas for Van der Waals's model.

All philosophers, including Bunge, concur that general theories alone cannot be tested. This is due to the fact that, precisely by their generality, they do not make any specific prediction without having more hypotheses or auxiliary statements (or model objects) added to them. Thus, they do not generate, by themselves, propositions which could be compared to actual empirical data (theoretical models). Another way to put it is to consider that any general theory may produce an infinite number of predictions of the same situation, according to the specific hypotheses that would be added to them. Conversely, empirical refutation of a given theoretical model does not imply the refutation of the general theory that took part in its construction (if there was any). In short, general theories can be supported or weakened by testing their theoretical models, but cannot be proved or refuted conclusively (Bunge, 1973a).

2.2] Throwing Light Into Our Models

In some cases, there is simply no general theory available at the time when scientists are trying to develop new theoretical models in their fields. This was the case when Galileo was undertaking his famous works in mechanics. Working before Newtonian synthesis and against Aristotelian dynamics, Galileo did not have any comprehensive theory on which to root his propositions. That did not stop him from creating many theoretical models, though. What Galileo did was to search for and establish relations among variables—distances, times, speeds, lengths, periods and so on—in different experimental or imaginary settings, while suspending judgment on why the relations were that way. This is an example of what Bunge called black box models. Black boxes relate input and output without allowing us to see the "internal mechanism" responsible for such a relation. Boyle-Mariotte's law, geometrical optics and classical behaviourism are also examples of models following this approach. Even if they are, in some sense, more superficial than other approaches, black box models also extensively use abstractions and idealization. In particular, the case of Galileo's models was the object of many studies in this regard (e.g., McMullin, 1985; Palmieri, 2003; Machado & Braga, 2016).

Black boxes are useful, important, and fruitful, especially in the beginning stages of modelling, but they have low or no explanatory power. To foster deeper explanations requires letting more light traverse the box, meaning searching for its inner structure and mechanism. In so doing, we would be constructing translucent boxes, which can be done with the help of general theories. Translucent boxes help promote deeper explanations and connect the new model to the rest of our knowledge, avoiding its isolation. However,

> [...] in general, whether we have to do with light or with chemical bonds, with thought or with institutions, the task is hard and probably open-ended. The reason for this is that most of the structures

> and mechanisms responsible for appearance are hidden to the senses. Hence, instead of attempting to see them we must try to imagine them. (Bunge, 1973a, p. 103)

Our daily lives are full of black boxes. Bunge exemplifies this fact by noting that a car is a black box to most drivers, in that they operate levers and switchers predicting successfully what these will do, without any knowledge about how engines or transmission mechanisms work. Yet to the mechanical engineer, the car is more like a translucent, perhaps almost transparent box. In concluding this brief synthesis of the Bungean box approach, it is necessary to emphasise that it is not a question of framing all possible approaches in one or the other extreme (black box or translucent box), but of realising that these approaches are distributed in a continuum, in which the intensity of light that passes through the box varies according to the research objectives and the contexts within which it takes place.

3] Idealization and Abstraction in Scientific Models

In the previous section, the concepts of idealization and abstraction were pointed out as thought processes performed by the epistemic subjects to create model objects. However, what are idealizations and abstractions? How do they take part in creating scientific knowledge? In what follows, we discuss some of the contributions of philosophy of science to such and related problems and situate Bunge's view in this context.

Suppe (1989) defines the selection of which variables and parameters of the real object are to be considered in the models as a process of abstraction. For instance, in discussing the motion of a pair of bodies under mutual gravitational attraction, one may disregard gravitational forces exerted by other bodies from outside this system. The fact that some aspects are being left aside in the case of this "pure" abstraction does not change the nature of the aspects considered in the model (Suppe, 1989).

But some parameters, when abstracted, produce situations that are impossible for any phenomena to meet. As an example, we can consider the case of point masses in classical mechanics: by ignoring the extension of a body, an object can be modelled as a unique point in space. Of course, this is an impossible condition for any body to satisfy, since it would require infinite density. Making certain assumptions that could never be achieved in a real object is what Suppe calls an idealization. Therefore, in Suppe's account, any case of idealization also involves some abstraction, since it implies ignoring some of the factors that influence the object or phenomena (Suppe, 1989, p. 96).

Similarly, in discussing the relationship between models and reality, Cartwright (1989) proposes two thought processes: idealization and abstraction. The author notes that what the philosophers mean by using the term "idealization" is usually a mixture of the two. For her, in idealization one starts from a concrete object whose inconvenient properties are "rearranged" before attempting to write a law for the behaviour of that object. The paradigmatic example of the idealization pointed out by the author is the inclined plane without friction. On the other hand, abstraction involves the exclusion of specific properties or characteristics that the object possesses, such as the omission of intermolecular forces in the ideal gas model. Therefore, abstraction involves a subtraction, while idealization involves modification (Cartwright, 1989).

While Suppe (1989) emphasised that idealization involves some form of abstraction, since it implies ignoring some influencing factors, Cartwright (1989) states, in a similar perspective, that idealization would be useless if abstraction was not possible. Such considerations indicate that both concepts are closely related. Even though Suppe's, Cartwright's, and McMullin's accounts are not identical, we can see that all of them identify two main processes performed by the epistemic subject: the omission of some aspects—abstraction, for Suppe and Cartwright, or causal idealization, for McMullin—and the simplification of aspects being considered: idealization and construct idealization, respectively. Morgan and Morrison (1999) hold basically the same views as Cartwright. Alternatively, Portides (2013) maintains that abstraction and idealization are actually two different modes of the same thought process, which he calls conceptual control of variability.

Within the context of modelling, Portides (2007) analyses the relationship between notions of idealization and approximation and how they work together to bring models closer to their actual referents. Portides calls "idealization" a fusion of the processes of idealization and abstraction as understood by Cartwright (1983) and Morgan and Morrison (1999). He defines approximation as a process of mathematical simplification of parts or of a whole theoretical description. This is the case, for example, when it is assumed that the intensity of a resistive force is linearly proportional to its velocity, or to its square. The approximation relation would be given by the proximity between the predictions made by these equations and the experimental measurements. Portides (2007) then shows that the logical properties of the approximation are different from those of the idealization.

In this context, one of the functions of idealization is to broaden the generality of our representations of phenomena. Thus, when we speak of a simple harmonic oscillator, we refer to a wide class of objects and not just some pendulums. The idea—or, in Bunge's (1973a) terms, the model object— "simple harmonic oscillator" represents so many objects because it is an idealization of this class of objects, not because it is an approximation, since many pendulums can be subject to very intense resistive forces, so that its behaviour in almost nothing approaches the prediction of a harmonic oscillator.

In his analysis of the representational role of models, Portides (2007) proposes a distinction between ideal models—which would be the class of theoretical models about an object in the form of mathematical structures that can be elaborated following the laws of theory—and concrete models, which would be the class of models proposed to represent the modelled physical system. The concrete models would be the entities that allow capturing the properties and attributes of this system. Ideal models need to be enriched with some concrete models in order to represent some physical system. Portides (2007) then argues, similarly to Morgan and Morrison (1999), that the class of concrete models is beyond theory, so theoretical models are not derived solely from the latter.

Another way of expressing this idea is to point out, as Morrison (2007) has, that models often involve ingredients that are not contained in theories. Thus, it is possible that the same theory leads to different models of the same referent, according to the choice of these "ingredients". This cannot be ignored if one tries to understand the relationship between the model and its referent. In our interpretation, Morrison's (2007) "ingredients" are mainly the model-objects in the Bungean sense. This view coincides with Bunge's in that he conceptualizes and explains such "ingredients" as model-objects and shows how these choices lead to different theoretical models.

Even though Bunge himself does not emphasise the definitions of abstraction and idealization in his accounts for models and modelling, in his *Dictionary of Philosophy* he defines: "A construct or symbol is epistemologically abstract if it does not invoke perceptions" (Bunge, 2001, p. 1). He states that idealization refers to " … the schematization or simplification of a real object in the process of its conceptual representation" (Bunge, 2001, p. 102). Such definitions are consistent with those described above in that all imply some detachment from the real object, whether by omission or simplification. In this sense, these two thought processes—abstractions and idealizations—take part in the construction of model-objects, as Bunge defined them.

4] Some Connections With Science Education Literature

As shown above, Mario Bunge's epistemology places models as central elements of scientific practice. Accepting this perspective also leads to considering the centrality of models in science teaching. In fact, science education scholars became more interested in models' importance in science teaching and learning as the relevance of such entities in cognitive psychology and the philosophy of science became more widely acknowledged. For instance, Taber (2013) stresses the need to recognise the modelling processes that are indispensably at the core of any depiction of student thinking, knowledge, or learning.

In a similar perspective, Schwarz et al. (2017) claim that the main goal of "Developing and Using Models" is to identify and apply specific ideas about theoretical and actual objects, as well as the connections between them, to explain how systems behave. Such an outlook is very akin to Bunge's theoretical framework, which focuses exactly on these elements: theoretical and actual objects (i.e., model objects and real objects) and in how the relations with each other (i.e., theoretical models) can help us to figure out the world in which we live. According to these authors, modelling should be at the very core of the science classroom precisely because it is at the basis of science's intellectual efforts, therefore being closely related to our fundamental desire to make sense of the world.

Additionally, Schwarz et al. (2017) raise another interesting point:

> Sometimes we're happy that we can reliably predict the actions of our world, but often we want to know why something behaves the way it does. Knowing why can help us become even better at figuring out what will happen in the future. As we do this, we are searching for underlying reasons and mechanisms that help us make sense of our experience and of the world around us (Schwarz et al., 2017, p. 111).

This passage resonates with Bunge's account of scientific models as opaque or translucent boxes, besides acknowledging that deeper sense-making involves searching for underlying mechanisms (i.e., letting more light pass through the initially black box). In addition, when attempting to explain the essential features of models, these authors claim that "models are distinct from the representational forms they take" (p. 114). This is clear from Bunge's insistence that models are ideas —in a sense, they have to be ideas, not things (as diagrams, equations, pictures, words, and so on) in order to be incorporated into general theories.

The question is, then, how to develop and use models in science teaching contexts to foster sense-making. Many researchers in the field have widely addressed this issue with several different approaches. In general, modelling in science education can be viewed as an effort to explain reality through a creative dynamic in which scientific knowledge serves as a bridging conceptual framework. Some of the most prevalent approaches for implementing modelling in science education typically involve creating analogues and metaphors, using mathematical concepts to structure relations among variables or performing some sort of experimental task. However, history and philosophy of science (HPS) have also been suggested as a potential strategy for discussing models in science education (Justi & Gilbert, 2000; Matthews, 2007).

According to this viewpoint, science instruction can be improved by taking into account scientific models that are pertinent to important curriculum areas. The idea is that if students have a better understanding of how scientific knowledge develops and how historical, philosophical, and technological settings affect that development, they will have a more complete understanding of the nature of science and will be more interested in learning about it (Justi

& Gilbert, 2000). Gilbert et al. (2000) described the issue of modelling in science education in terms of the relations between reality and theory, with models being the mediators. In these authors' opinion, Bunge's framework

> […] is very helpful in that it deals with the relationship between the notions of "model" and "theory" in some detail. The scheme would seem to be applicable to scientific enquiry at any stage in the process of change from the situation (in Kuhn's terms) of "normal science" to that of "revolutionary science". With suitable examples, it should be intelligible to students. (Gilbert et al., 2000, p. 36)

Similarly, Matthews (2007) highlights that being clear about the distinction to be made in science between real things and theoretical objects is a step toward a better understanding of the role of models and theories in science. As discussed in the *Theoretical Framework* section above, such a distinction is a major theme in Bunge's ideas, constituting the very core of the model-object concept. Following Bunge's notions along these lines, Matthews (2007) then advocates for the process of progressively refining models as a part of our search for a deeper understanding of reality.

5] Methodology

Given this study's theoretical nature, to answer the research question, we developed a constant comparative analysis, a method appropriate for analysing qualitative data. In this approach, the researcher can make conceptual comparisons among distinct contexts, allowing for an account of the phenomenon that transcends the individual settings in which data was originated. According to Glaser and Strauss, in this method, " … the analyst jointly collects, codes, and analyses his data and decides what data to collect next and where to find them in order to develop his theory as it emerges" (Glaser & Strauss, 1967, p. 45). Glaser (1965) points out that the constant comparative method aims to generate and plausibly suggest many properties and hypotheses about a general phenomenon, but considering that it does not search for universal proof, it does not require consideration of *all* available data.

In addition, this approach is suited for this study because it has the potential to link together elements coming from different contexts, which would otherwise remain scattered, thereby fostering trans-situational and cross-contextual relevance (Pawluch, 2005).

For this study, the analytical categories were taken from the theoretical framework, as developed in the previous section: *model objects; theoretical models; general theories; black box; translucent box; abstractions* and *idealizations*. These constructs were then connected to aspects of the historical development of atomic models to help form a coherent explanation of the modelling process, which could, in turn, contribute to enlightening how scientific knowledge relates to reality. This account is presented in the next section.

6] A Model-Based View of Atomic Models

Identified as small indivisible corpuscles in ancient Greek philosophy, atoms started to be related to specific undecomposed chemical elements in Dalton's time, subsequently encouraging further explanations for chemical compounds and reactions. To let more light pass through the "black box" would then mean starting to speculate about what was inside the very atom. This speculation was undertaken by J. J. Thomson in 1904 after he explained the nature of cathode rays, which he imagined as negatively charged subatomic particles, i.e., electrons. Since the electrons would have to be matter components, Thomson pictured the atom as a positively charged uniform sphere with embedded electrons. Albeit simple, this was clearly not a purely black box approach anymore, since it concerned the unobservable internal structure of the atom.

With this idea about the atom, Thomson explained that the scattering of charged particles through matter was caused by a significant number of collisions with a significant number of atoms. A single collision would produce only a minimal deviation, but after many collisions, there would be a cumulative effect. The main new idea contained in Thomson's contribution was a conceptual counterpart of the actual object under study. Therefore, what Thomson initially proposed was a new model object for the atom, meaning a representation of this object that could, a priori, be grafted in general theories to form theoretical models, which, in turn, could be used to foster explanations of many natural phenomena. At least, so expected Thomson. In 1904, he wrote to Ernest Rutherford:

> I have been working hard for some time at the structure of the atom, regarding the atom as built up of a number of corpuscles in equilibrium or steady motion under their mutual repulsions and a central attraction: it is surprising what a lot of interesting results come out.

> I really have hopes of being able to work out a reasonable theory of chemical combination and many other chemical phenomena. (Thomson in Davis & Falconer, 1997, p. 153)

Although Thomson could explain valence, radioactivity, and periodic properties of chemical elements, his hopes were not fulfilled. Subsequent experiments showed that the number of corpuscles in atoms was much smaller than necessary for Thomson's atom to be stable.

Ernest Rutherford and his collaborators subsequently made a new attempt to find out more about atomic structure. Rutherford proposed a series of experiments, conducted by Hans Geiger and Ernest Marsden, in which beams of α and β particles were pointed at a thin piece of gold foil, and the consequent deflections were measured. Data was collected relating the input and output variables, i.e., the beam rectilinear path directions before and after they passed through the atoms of matter. Therefore, instead of assuming the atom could be modelled as Thomson proposed earlier, they initially treated it like a black box again. In so doing, they made it possible not only to test whether Thomson's model was empirically adequate, but also to describe and predict the behaviour of the atom regarding how it scatters α and β particles. In fact, observations made by Geiger and Marsden were incompatible with Thomson's atomic model-object. For example, they found that a small percentage of the α particles experienced a deviation of 90 degrees or more. This would be extremely unlikely to happen in an atom such as the one imagined by Thomson, since the gold foil used as target by Geiger and Marsden was very thin and would not allow for so many collisions to occur.

So, to explain the scattering patterns shown in his black box approach, Rutherford had to draw a new picture of the inner structure of the atom. Possessing an initially superficial, simplistic and opaque model of the atom, which basically just related input and output, Rutherford proceeded to hypothesise the internal structure of this object. To do so, he also used knowledge from electromagnetic theory, such as the relation of electrical forces and potentials. However, that was not enough: he had to invent a different model-object for the atom. In fact, in Rutherford's model-object for the atom, a unobservable new entity was created: the nucleus, a small, dense, positively charged, discrete part of the atom, located at its centre.

In this model, negatively charged particles surrounded the nucleus. Since the nucleus was so small compared to the atom as a whole, Rutherford's atom would be constituted mainly of empty space. Right-angle or more deviations of α particles could then be explained as being caused by a single collision with the atomic nucleus.

In this new model-object known as Rutherford's atom, the effects of electrical fields created by these negative particles were abstracted, as well as the possibility of deviations of α particles due to a single collision with electrons. In addition, the dimensions of α particles and electrons are idealized to be considered concentrated at a point. Therefore, the scattering phenomenon is reduced to an interaction between a rapidly moving particle and the nucleus of the atom being traversed. Other abstractions in Rutherford's analysis include the consideration of the nucleus as being initially at rest and the disregard for possible energy and momentum losses by radiation.

Notwithstanding such departures from the real object, the theoretical model developed by embedding the model-object for the atom invented by Rutherford in previously existing general theories (mainly electromagnetics and dynamics) made it possible to develop a theoretical model which demonstrated good agreement with experimental results. But the crucial challenge to Rutherford's model-object was not an empirical issue, but rather a theoretical one: it was in open contradiction with classical electrodynamics. Rutherford's atom could not be stable because the attractive forces between electrons and the nucleus would drag the former into the latter, hence collapsing the entire atom. Rutherford was aware of this, but explicitly chose to disregard the issue for the time being: "The question of the stability of the atom proposed need not be considered at this stage…" (Rutherford, 1911, p. 3).

While the path from Thomson's to Rutherford's atomic model consisted of a change of model-object, this new challenge would require a change in the general theory. Such a programme was put forward by Niels Bohr shortly thereafter. He identified the problem of atomic stability as due to " … inadequacy of the classical electrodynamics in accounting for the properties of atoms from an atom model as Rutherford's" (Bohr, 1913, p. 3). As did Rutherford, Bohr imagined the atom as a massive nucleus at rest with electrons in circular orbits around it. However, Bohr's proposal relied upon

Planck's theory to state that energy emissions by atoms could not occur in the continuous way implied in classical electrodynamics, but only in quanta. This meant that amounts of energy lost or gained by any particle—including atomic electrons—could exist solely in quantities equal to entire multiples of Planck's constant. As a consequence, just specific electron orbits—meaning specific energies—would be permitted (Bohr, 1913).

By having Planck's theory of radiation as a general theory and Rutherford's atom as a model object, Bohr was then able to derive a new theoretical model predicting the energy levels of atoms containing few electrons. Bohr's theoretical model was quite successful—albeit not perfect—in explaining the atomic spectrum of hydrogen. Spectral hydrogen lines were already known and put in a formula by Johannes Rydberg, but this formula had been developed only empirically, in a black box approach, limited to relating each line's number with the respective wavelengths. The intervening variable—Rydberg's constant—was known empirically, but there was no explanation for its value before Bohr's model, which allowed the calculation of it from known values such as the electron mass and charge and Planck's constant.

Like the previous models, Bohr's atom was teeming with idealizations and abstractions. Initially, the nucleus was assumed to remain at rest; electronic orbits were assumed to be circular and relativistic effects due to the high velocity of moving electrons were omitted. Yet, the resulting theoretical model's success was realised not only for having solved the theoretical problem it originally addressed—i.e., atomic stability—, but also for shedding light on Rydberg's black box for hydrogen spectrum by endowing it with an explanation and situating it inside a contemporary physics framework. Moreover, this theoretical model allowed for the prediction of tBrackett and Pfund series, which had not yet been observed.

Similar to previous atomic models, Bohr's had its limitations. It failed to account for energy levels in atoms with higher atomic numbers and could only predict hydrogen's spectrum in the absence of external electrical and magnetic fields. The latter issue was tackled later by Arnold Sommerfeld, who applied quantum mechanics and relativity as general theories where classical mechanics were applied by Bohr; this resulted both in a new version of Bohr's model-object of the atom (adding elliptical orbits, for instance) and a new theoretical model for the energy of the hydrogen atom, which, in turn, provided an explanation for the fine structure in this atom's spectrum.

This highly summarised account of atomic model development illustrates some of the features of models pointed out by Bunge. First, it shows the possibility of identifying the three basic elements of the modelling process—i.e., model-objects, general theories and theoretical models—, as it exemplifies their dynamics in scientific knowledge construction. Second, it demonstrates how new theoretical models can be created by conjoining the same model object with a different general theory and associating different model objects with the same general theory. In any case, the resulting theoretical model " … is bound to fall short of the complexity of its referent" (Bunge, 1973a, p. 100), since it inherits abstractions, idealizations and approximations present in the other modelling elements to which it relates.

In addition, this brief report shows the relevant roles of black boxes and translucent ones. While Rutherford's atom arose mostly as a model-object invented to help to explain a black box by creating a new unobservable, idealized construct, even more light could be shed throughout the box when Bohr and Sommerfeld enriched it with new general theories. By the same token, the success of theoretical models also helped to pave the way for its related general theories, as was the case for atomic models in relation to quantum mechanics (Eckert, 2014). Finally, the history of atomic models also illustrates how theoretical models constituted the bridges between "pure" theory—contained in general theories—and reality—or, more precisely, our ideas about real objects, i.e., model-objects.

7] Teaching Implications

Throughout the historical development of atomic models, it is possible to witness the construction of several theoretical models for the same object and multiple model-objects for it. The advantage of making explicit the role of some ideas as theoretical models and other ideas as model-objects are: i) to foster the understanding of scientific knowledge as referring immediately to conceptual versions of the real objects, not to real objects themselves; ii) to denote the role of theoretical models as mediators between theory and our ideas about reality; iii) to make explicit how it is both possible and coherent to have multiple theoretical models for the same object, once one understands how these are created; iv) to demonstrate how theoretical models can have different explanatory potentials; and v) to bring up idealizations, abstractions and approximations as creative thought processes, not merely demerits of models. These features consist of possibilities to deal with the teaching issues pointed out at the beginning of this article.

By having Bunge's modelling theory as a framework, the didactic use of the history of science can offer an alternative for implementing modelling goals in the classroom by making it possible to discuss different model-objects, theoretical models, and general theories created by philosophers and scientists through time in their attempts to explain nature. In the preceding section, we illustrated this possibility through the historical case of the development of atomic models, showing how distinct theoretical models to explain atoms' behaviour emerged by inventing new model-objects or adopting different general theories.

This indicates that Bunge's account of scientific models can be helpful when trying to understand several aspects of models, which have been problematic in science education contexts. For example, the notion of a model-object highlights an essential characteristic of scientific knowledge, i.e., that it does not consist of a mirror, a photograph or an exact description of reality: on the contrary, it is a partial representation, idealized and approximate, at best. In addition—what is perhaps the most important thing—this does not constitute a demerit, given that the role of the model object is a productive one, since it has the indispensable role of making our theories testable. Furthermore, when we think about the possible processes of construction of theoretical models in these terms, it is possible to understand why multiple models of the same thing can exist, all of which are legitimate and acceptable within their limitations and contexts. Moreover, the notion of general theory as something different from theoretical models makes the search of science for systematization evident while demonstrating the fecundity of this systematization in producing theoretical models.

Although the transposition of Mario Bunge's ideas to science education made here was exemplified with the use of history of science, the framework developed is also applicable to teaching activities using modelling in the classroom, which does not necessarily have a historical approach. The case of the simple pendulum, for example, can be object of a modelling with an initial black box approach, by empirically obtaining the relations between variables and pendulum regularities (obviously, through the direction of the teacher) and that could be made progressively more translucent through the articulation with the corresponding general theory and the conceptual discussion of the model-object created.

This type of approach could be a way to construct models de novo (Gilbert & Justi, 2016). The model-object and the general theory employed there could be made explicit in other situations to contribute to the formation of new theoretical models that use them. The point to highlight here is the portability of the modelling elements, because it can help develop students' cognitive flexibility, i.e., their recognition and mobilization in other, new situations. This is possible because elements such as model-objects (e.g., point masses) and general theories (e.g., Newton's law) can be articulated in various ways in order to construct a large number of theoretical models—including ones intended for different situations—within a given conceptual domain (such as mechanics).

8] Concluding Remarks

Portides argues that understanding "how scientific theories relate to experiment" is a key meta-scientific component in enhancing the ability to think scientifically (Portides, 2007, p. 700). In this paper, we also claimed that this was a relevant issue for science education contexts, especially in enabling students to assign meaning to scientific concepts and theorisations. In addition, we expanded the question of "how scientific theories relate to experiment" to "how scientific theories relate to reality", since reality is ultimately the reference of scientific knowledge. As we pointed out, students tend to conflate real objects with the knowledge produced about these objects. As with Portides (2007), we also identified the link between reality and scientific knowledge as being performed by models.

To deal with the problem of the relation between scholarly scientific knowledge and reality, it is necessary to have as foundational a framework that allows for understanding this relation, as well as the roles of theory, models, and other elements that take part in the process of modelling. To the extent that the Bungean theory of models offers a consistent and well-articulated framework for these relationships, the transposition of his ideas into the educational context may provide such a basis and potentially contribute to solving this pedagogical problem. Teaching the history of science, along with experimental activities and mathematical skills, can also constitute an alternative method to foster modelling practices in the classroom. In particular, we argued that Bunge's views on models and modelling could offer a potentially fruitful framework to help overcome the separation between scientific theories and reality in science education.

Finally, it must be noted that any proposals whether educational or epistemological, have limitations. In this sense, we want to emphasise that the defence of the framework presented here does not imply the rejection of other possible references. Its development is intended to address specifically the problematic of models exposed at the beginning of this article. As Bunge himself teaches, it is always possible, at least a priori, to approach a problem under different theoretical starting points without this meaning an inconsistency or mutual exclusion. Therefore, adopting other frameworks to address the problem is possible and can complement the contributions we seek to develop here. Besides, the relation between theory and reality focused in this work is not the only role that models play, as already observed by Morgan and Morrison (1999). Thus, other modelling aspects can be discussed and explored, perhaps even more appropriately, by conceptual lenses different from those of Bunge. This means that we understand such lenses as a model of models, among other possible ones.

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System: A Core Conceptual Modeling Construct for Capturing Complexity

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Abstract—The digitalization of human society continues at a relentless rate. However, to develop modern information technologies, the increasing complexity of the real-world must be modeled, suggesting the general need to reconsider how to carry out conceptual modeling. This research proposes that the often-overlooked notion of "system" should be a separate, and core, conceptual modeling construct and argues for incorporating it and related concepts, such as emergence, into existing approaches to conceptual modeling. The work conducts a synthesis of the ontology of systems and general systems theory. These modeling foundations are then used to propose a CESM+ template for conducing systems-grounded conceptual modeling. Several new conceptual modeling notations are introduced. The systemist modeling is then applied to a case study on the development of a citizen science platform. The case demonstrates the potential contributions of the systemist approach and identifies specific implications of explicit modeling with systems for theory and practice. The paper provides recommendations for how to incorporate systems into existing projects and suggests fruitful opportunities for future conceptual modeling research.

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Résumé—L'informatisation de la société se poursuit à un rythme effréné. Cependant, pour développer les technologies modernes de l'information, la complexité croissante du monde réel doit être modélisée, ce qui nécessite de revoir la façon de réaliser une modélisation conceptuelle. Cette étude propose que la notion souvent négligée de « système » devrait être un construit distinct et fondamental pour la modélisation conceptuelle, et argumente en faveur de son intégration, de même que l'intégration de concepts connexes, tels que l'émergence, dans les approches existantes de la modélisation conceptuelle. L'étude procède à une synthèse de l'ontologie des systèmes et de la théorie générale des systèmes. Ces éléments fondamentaux de la modélisation sont ensuite utilisés pour proposer un modèle CESM+ pour la modélisation conceptuelle fondé sur des systèmes. Plusieurs nouvelles notations de modélisation conceptuelle sont introduites. La modélisation systémique est ensuite appliquée à une étude de cas sur le développement d'une plateforme de science citoyenne. L'étude de cas montre le potentiel de l'approche systémique pour la théorie et la pratique. L'article avance des recommandations sur la façon d'intégrer des systèmes dans des projets existants et suggère des voies de recherche sur la modélisation conceptuelle.

Keywords— System; Systemism; Conceptual modeling; Complexity; CESM+; Emergent properties; Ontology; Bunge Systemist Ontology (BSO); Retrospective case study; Citizen science.

1] Introduction

With continued human development, social, economic, political and technological systems are growing more complex (Clark and Cohen 2017; Dietz 2006; Fayoumi and Williams 2021; Harari 2016). Complexity in systems refers to the number of component-parts along with the way in which these parts are structured and interact with one another and with other systems (Johnson 2002; Luhmann 1995). Systems are the complex entities which constitute the world, such as atoms, animals, airplanes, universities, stock markets, and galaxies. Generally, the more complex the system, the more difficult it is to fully predict its behavior. To create and effectively manage complex systems, improved methods, machinery and knowledge are necessary. This "complexity challenge" opens new opportunities for information technology (IT) development to support, create and manage complex systems and their users.

Conceptual modeling is a phase of information technology (IT) development. It traditionally focuses on capturing user requirements, facts and beliefs about an application domain (Burton-Jones et al. 2017; Mayr and Thalheim 2020; Storey, Trujillo, and Liddle 2015; Yair Wand and Weber 2002). Since the 1970s, database design, especially in large organizations, relied on conceptual models

– the products of conceptual modeling – to model the data to be stored in relational databases (Chua et al. 2022; Teorey, Yang, and Fry 1986; Thalheim 2000). Another important application of conceptual models is to support business process management and engineering (Curtis, Kellner, and Over 1992; Dumas et al. 2013; Recker 2010). More broadly, conceptual models are used to improve domain understanding, to facilitate communication among IT developers and stakeholders, and to help visualize and solve IT design challenges (Khatri et al. 2006; Mylopoulos 1998; Siau 2004; Yair Wand and Weber 2002; Woo 2011). Our growing reliance on information technologies and their increased sophistication necessitates an ever greater ability of conceptual modeling to represent both physical (including mental and social) and digital systems (Recker et al. 2021).

To appreciate the challenge in creating and managing complex systems, consider one of the unrealized solutions for tackling the COVID-19 pandemic, namely, the development of a social (physical) distancing app. Such an app would sense an approaching person and vibrate, thereby alerting the user of the need to keep distance. The anonymized and aggregated data from such app could be used by governments to support data-driven policies and facilitate smarter pandemic response[4]. If widely practiced, physical distancing leads to significant reductions in respiratory disease transmissions (Ahmed, Zviedrite, and Uzicanin 2018; Caley, Philp, and McCracken 2008; Matrajt and Leung 2020). However, an effective physical distancing technology is incredibly challenging, not only because of its many technological obstacles, but importantly, because of a host of social, ethical, legal, medical, and psychological challenges (Storey, Lukyanenko, and Grange 2022). Precise and accurate conceptual modeling of facts and opinions in this domain could assist in the development of effective solutions. Since distancing technology involves personally sensitive usage by millions of people in real time, and, assuming such usage is not mandated, but is voluntary, we need to accurately model values, intentions, motivations and needs of different people in order to align the technology with these needs. The use of such technology is fundamentally

[4] Attempts to develop such technology have been made, but the resulting apps not been widely embraced by society. See, https://spectrum.ieee.org/news-from-around-ieee/the-institute/ieee-products-services/social-distancing-heres-an-app-for-that.

collective, involving coordinated efforts on the part of citizens, governments, and medical establishments (Tabourdeau and Grange 2020). To create and sustain an app at such scale amounts to the development of a highly choregraphed complex socio-technical system. Worse still, such a system might behave in potentially unpredictable and even, possibly, dangerous ways. Inadvertently, such app could cause undesirable changes in patterns of human movements and socializing or trigger an expansion of mass surveillance. Measures need to be put in place (including at the level of technical design) to proactively detect and curb any negative outcomes, while promoting the positive ones. Conceptual modeling then becomes a valuable tool to help engineer effective IT solutions to the expanding challenges of humanity.

The objective of this research is to examine existing conceptual modeling capabilities with respect to the challenges of the modern world and suggest a path for better handling of its complexities. We rethink conceptual modeling theory and practice by investigating a thus far overlooked conceptual modeling concept, namely that of "system". Specifically, we propose that the construct of "system" should be regarded as a basic conceptual modeling construct, on par with constructs such as "entity", "attribute", "role", "event" or "relationship".

Amending conceptual modeling languages with the construct, "system", follows a long line of research that introduced additional constructs to increase the expressive power of modeling languages. From early research on conceptual modeling, until present, researchers have been proposing new constructs (e.g., Chen 1976; Gottlob, Schrefl, and Rock 1996; T. Halpin 2007; Limonad and Wand 2008; Sapia et al. 1998; Teorey, Yang, and Fry 1986; E. Yu 2002). Some of these became ingrained in widely used conceptual modeling languages, such as the entity-relationship diagram (ER), Unified Modeling Language (UML), Business Process Model and Notation (BPMN), and Object-role modeling (ORM), which are now staple elements in practice. The sub/super classes (i.e., generalization/specialization relationships) is one such example (Goldstein and Storey 1992; Smith and Smith 1977). Similarly, we argue that the construct of "system" has the potential to become another basic and indispensable construct in the world of ever-increasing complexity.

Of course, it is already possible to model system components (e.g., parts of a whole) using conventional approaches, such as ER diagrams or UML. However, as we demonstrate in the paper, traditional conceptual modeling approaches struggle to model many aspects of systems such as *emergence*. Furthermore, even though the notion of system is ubiquitous in the conceptual modeling discourse, there is little guidance for modelers on how to appropriately model systems. This problem is exacerbated by the lack of consensus and clarity on what constitutes a system and its related constructs.

To keep up with the relentless pace of digitalization of business and society, it is important to continue refining conceptual modeling to make it more expressive for cases when more explicit and comprehensive modeling of systems is beneficial. Since these scenarios are pervasive, modeling systems more explicitly is becoming pressing.

In this research, we propose a set of basic notions that are related to the *system* construct, position system as a core conceptual modeling primitive, explain the limitations of existing modeling languages, and outline research initiatives that could further incorporate the system construct into conceptual modeling. Based on theoretical foundations, we propose a CESM+ template for conducing systems-grounded conceptual modeling. Several new conceptual modeling notations are introduced for practitioners and as input into future academic research. The systemist modeling is analyzed in a case study of the development of a citizen science platform. We then provide methodological guidelines for designers and a future conceptual modeling research agenda.

2] Background

2.1] Conceptual Modeling Constructs

Conceptual modeling research and practice is now over 50 years old, with popular conceptual modeling languages, such as the entity-relationship model (Chen 1976) appearing in the 1970s. During this lengthy period, numerous constructs have been proposed as hundreds of different conceptual modeling languages and approaches were introduced, evaluated and applied (Aguirre-Urreta and Marakas 2008; Davies et al. 2006; Dobing and Parsons 2006; Terry Halpin 1995; Peckham and Maryanski 1988; Song, Evans, and Park 1995).

For example, a core modeling construct, which emerged as early as the first conceptual modeling languages, is that of an *entity type* (Chen 1976). Entity types or classes (used in entity-relationship diagrams and UML Class Diagrams, respectively), are commonly used to represent groups of objects of interest in the domain of the information systems being developed (Jeffrey Parsons and Wand 1997; Storey 1991b; Thalheim 2000). Debates related to these constructs centered on how to appropriately select (Jeffrey Parsons and Wand 1997; Castellanos et al. 2020) and apply them (Lukyanenko and Samuel 2017; Jeffrey Parsons and Wand 2012; Evermann and Wand 2001), such as identifying the relationship between classes or entity types and the objects they represent (Jeffrey Parsons and Wand 2000; Lukyanenko, Parsons, and Samuel 2019; Eriksson, Johannesson, and Bergholtz 2019; Eriksson and Agerfalk 2010; Goldstein and Storey 1994). Debates also focused on the nature of instances themselves; for example, whether classes can be instances of other classes (Guizzardi et al. 2015; de Cesare et al. 2015; de Cesare and Partridge 2016).

Other focal constructs in conceptual modeling dealing with entities include "attributes" (characteristics, dimensions, or features of entities), "relationships" (associations among entities) (e.g., Chen 1976), and "roles" (behaviors and functions of entitles) (Gottlob, Schrefl, and Rock 1996; Terry Halpin 1995). These are common in conceptual models representing the form and structure of domains (Burton-Jones and Weber 2014; Mylopoulos 1998). Modeling approaches representing processes and dynamics of domains include such constructs as "events", "activities", or "gateways" (Dumas et al. 2013; Soffer, Kaner, and Wand 2008; Wahl and Sindre 2006; Recker, Rosemann, and Krogstie 2007). Those dealing with goals, values, intentions, have also became popular, having such constructs as "goal", or "actor" (Bider et al. 2005; Yan et al. 2015; Monu and Woo 2005; E. Yu 2002).

There have been many debates about the value and limitations of various constructs, as well as proposals for how to use them effectively in conceptual modeling diagrams (Andrew Gemino and Wand 2005; Bodart et al. 2001; Shanks et al. 2008; Yair Wand, Storey, and Weber 1999). An overlooked, but extremely important construct is that of "system" and its associated constructs, including emergent properties, mechanism, environment, among others.

2.2] Conceptual Modeling Foundations and the System Construct

The absence of an explicit "system" construct in mainstream conceptual modeling languages (e.g., UML, BPMN, ORM, ER, *i**) is surprising given the ubiquity of the system concept in discourse related to conceptual modeling.

First, systems notion is synonymous with the product of IT — the software or computer applications are widely recognized to be *information systems*. This is well understood in conceptual modeling. As Mayr and Thalheim (2020, 2) remind us: "from the very beginning, conceptual modeling was propagated as a means to improve the design and implementation of whatsoever *software system*, especially with regard to a comprehensive and as clear as possible elicitation and analysis of *system* requirements". (p. 2; emphasis added).

Second, when IT get implemented in real-world settings, they become part of socio-technical systems (Chatterjee et al. 2021; Lyytinen and Newman 2008; Winter et al. 2014). *Socio-technical systems* are composed of technical systems (processes, tasks, and technological infrastructure) and social systems (humans, their relationships and social structures). The two systems, when put together and begin to interact, produce joint outputs (e.g., information, furniture, raw materials, services) (Bostrom and Heinen 1977; Mumford 2006; Orlikowski and Barley 2001). For example, implemented into organizational settings enterprise resource planning, customer service, electronic payments, e-commerce IT become parts of socio-technical systems created by the fusion of humans and technology. Hence, enterprise diagrams, such as a UML class diagram, BPMN model or ArchiMate diagram (Lankhorst, Proper, and Jonkers 2010), commonly model socio-technical systems (Atkinson, Gerbig, and Fritzsche 2015; Azevedo et al. 2015; Dietz 2006; Fayoumi and Williams 2021). Often enterprise models comprise of layers (e.g., Atkinson, Gerbig, and Fritzsche 2015; Dietz 2006), which can be understood as systemic levels (discussed later).

Third, the domains that are managed by IT are commonly understood as *systems*. For example, a conceptual model may represent facts about an inventory control system to facilitate a more efficient inventory management by an ERP developed with the help of this conceptual model (Weber 1997). Similarly, in an *i** framework, modelers can represent social systems, which contain potential users of technology and their goals and intentions (E. S. Yu 2009).

Technologies, including IT, are also viewed as components of *work systems;* that is, systems in which human participants and/or machines perform work using information, technology, and other resources (Alter 2013; 2021; 2015). Similarly, *design* and *use* of information technologies are considered to be ingrained and inseparable from the broader social systems in which they reside (Burton-Jones and Grange 2012). These ideas are accepted in conceptual modeling. Hence, Yu (2009, 100) explains the benefits of *i** as follows: “unlike traditional systems analysis methods which strive to abstract away from the *people aspects of systems*, i* recognizes the primacy of social actors” (emphasis added).

Fourth, theoretical foundations of conceptual modeling engage with the notion of system. Hence, as we already discussed, work systems theory is positioned as a foundational theory underlying information systems (Alter 2013; 2021; 2015). Another theoretical foundation of conceptual modeling is ontology (Burton-Jones and Weber 2014; Gonzalez-Perez 2015; Guarino 1998; Guarino, Guizzardi, and Mylopoulos 2020; Guizzardi 2005; S. T. March and Allen 2014). Ontology is a branch of philosophy that studies what exists. A popular ontology in conceptual modeling, the Bunge Wand Weber (BWW), contains the notion of system. In BWW, “a set of things is a system if, for any bi-partitioning of the set, coupling exist among things in the two subsets” (Yair Wand and Weber 1993, 222). Some extensions of this ontology, namely Bunge Systemist Ontology (BSO) (Lukyanenko, Storey, and Pastor 2021) and Realist Ontology of Digital Objects and Digitalized Systems (Lukyanenko and Weber 2022), extend and modify BWW by incorporating additional systems constructs, including emergent properties, mechanism, and levels.

In addition to the ubiquity of systems notion in discourse related to conceptual modeling, as these examples show, there is a great diversity of ideas, approaches, and theories related to systems. Hence, if a given conceptual modeling project were to explicitly adopt a “systemist perspective”, it is not clear which approach the modeler should choose and what the basic elements of systems are that need to be represented.

2.3] Conceptual Modeling Languages and the System Construct

Beyond the general presence of systemist notions in conceptual modeling discourse, aspects related to systems are present in conceptual modeling languages themselves. Many conceptual modeling languages, such as UML Class Diagrams or Extended ER diagrams, contain constructs such as "*part of* ". These are systemic notions because they deal with composition of complex entities (i.e., systems). Other languages may not contain explicit system constructs but can be interpreted as being systemist. Thus, the dependencies in *i** can be considered emergent properties, which emerge as a result of the interactions among actors.

Some niche modeling languages provide greater support for systems; most notably, the Systems Modeling Language (SysML), a modeling language for systems engineering applications (Balmelli 2007; Friedenthal, Moore, and Steiner 2014). Although it uses the term "system", SysML lacks precise, well-grounded definition of system. The references to "system" are generic and vague. That is, SysML supports the specification, analysis, design, verification, and validation of a broad range of systems, without providing a precise conceptual characterization of what, exactly, a system is. As an extension of a subset of the Unified Modeling Language (UML), SysML inherits the conceptual imprecision of significant concepts. The SysML language's extensions were designed to support systems engineering activities from a generic methodological perspective. Furthermore, SysML does not engage with basic systemic notions, such as emergent properties, except in a very incidental manner (e.g., Friedenthal, Moore, and Steiner 2014, 335).

Overall, the construct of system and its related constructs have been surprisingly underrepresented in conceptual modeling theory and practice, including in popular conceptual modeling approaches (Burton-Jones and Weber 2014; Davies et al. 2006; Dobing and Parsons 2006; Fettke 2009). Furthermore, there is considerable ambiguity when referring to systems in IT (Dori and Sillitto 2017). Remarkably, if one could ask systems engineering experts for a precise definition of a "system", it is most likely that many different definitions would be provided. Indeed, such is the case among scientists as well (M. A. Bunge 1996).

Next, we seek to better understand the notion of system and provide an ontologically supported characterization of the "system" construct and its related constructs.

3] Understanding the Nature of Systems

The term system is Greek in origin (*systema*), with original meanings of "organized whole, body" as well as "standing together, standing in relation, or togetherness" (Dori and Sillitto 2017, 209). It may, however, have an even older Sanskrit root, from the cognate word *samsthana*, which also means "being, existence, life" and "standing together"[5].

Once introduced in the 17th century English, the term eventually became an integral part of the vocabulary in philosophy, natural and social sciences, engineering, humanities, and medicine. It acquired an additional sense, subsuming an old saying commonly attributed to Aristotle: "The whole is something over and above its parts, and not just the sum of them all" (Corning 2002).

3.1] General Understanding of Systems in Science

Today, system is among the basic scientific notions. Indeed, progress in sciences often occurred when what was once considered indivisible (e.g., atom) was later understood to be complex and was conceptualized as systems (von Bertalanffy 1968; M. A. Bunge 2017; Checkland 1999; Luhmann 2018). It is also notable that, in the field of information systems research, which deals with the design, use, and impact of IT on individuals and collectives, there have been repeated calls for *more* systemist theorizing (Burton-Jones, McLean, and Monod 2015; Chatterjee et al. 2021; Lee, Thomas, and Baskerville 2015; Nan 2011).

System is considered to be a unifying scientific construct (von Bertalanffy 1968). Unfortunately, each discipline, and even sub-disciplines, understand the notion of system in a somewhat unique way, leading to over 100 different definitions and senses of the term (Dori and Sillitto 2017). Considering the interdisciplinary nature of a system-based view of reality, general systems theory (GST) was developed by von Bertalanffy (1968) and became widely applied (Alter 2021; von Bertalanffy and Sutherland 1974; Hammond 2010; Kast and Rosenzweig 1972; Mele, Pels, and Polese 2010; Skyttner

[5] https://sanskritdictionary.com/?q=sa%E1%B9%83sth%C4%81na.

1996). The basic tenets of GST are as follows. The GST views systems as a grouping of interdependent parts of a common whole. Thus, Ackoff (1971, 662) defines a system as “an entity which is composed of at least two elements ... each of a system’s elements is connected to every other element, directly or indirectly. No subset of elements is unrelated to any other subset”. Some systems exhibit emergent behavior. This common whole tends to be resilient to change, or homeostatic, giving systems their stability. In some systems, such as organic or certain artificial systems, support feedback loops exist, wherein the outputs of the system become its inputs, and hence can modulate or amplify the system’s behavior. Systems may be closed or open, depending upon whether components of the system may interact with the components of other systems.

3.2] Foundations of Ontological Systemism

Owing to the adoption and further development of general systems theory and its applications to different scientific domains, many theories and models of systems emerged (Russell L Ackoff 1971; Russell Lincoln Ackoff and Emery 2005; Arnold and Wade 2015; Bailey 1991; M. A. Bunge 1979; Hammond 2010; Luhmann 1995).

We adopt the theoretical lens of *general ontology,* which has been amongst the most important theoretical foundations for conceptual modeling (Burton-Jones and Weber 2014; Guizzardi 2005; Henderson-Sellers 2015; Partridge, Gonzalez-Perez, and Henderson-Sellers 2013; Yair Wand et al. 1995). It is a source of theoretically grounded, consistent, formalized, and rigorous meaning for the basic notions of what exists. Indeed, conceptual models via concepts and their relationships (i.e., constructs) seek to represent facts and beliefs about the world by using constructs assumed to be capable of representing these facts and beliefs.

We use the ontological theory of the philosopher physicist Mario Bunge as our guiding ontological theory. The ideas of Bunge are especially relevant for four reasons. First, they encapsulate the recent advances in sciences, including the debates around the notion of system. Being a scientist himself, Bunge contributed to these debates, publishing his work in physics, chemistry and biology outlets (e.g., M. A. Bunge 1945). Second, Mario Bunge, mainly via BWW, has been fruitfully used as a reference (or benchmark) in past conceptual modeling research (Burton-Jones et al. 2013; Dietz 2006;

Guizzardi 2005; Pastor and Molina 2007; Yair Wand and Weber 1990a; 2017; cf. Wyssusek 2006). Hence, his ideas have already been considered as relevant for the development of conceptual modeling. Third, Bunge's approach to systems is a general one, mostly compatible with the views held by other proponents of systems thinking and of GST.

Finally, Bunge's objective was the development of a consistent, formalized, and rigorous ontology of systems. This is very important considering the many disagreements and debates surrounding the notion of system. Furthermore, even Bunge was at times inconsistent, owing to the great volume of research and evolution of views (M. A. Bunge 2016; M. A. Bunge et al. 2019; Lukyanenko, Storey, and Pastor 2021; Matthews 2019). In this paper, we adapt and extend Bunge's ontology by formalizing it further. In addition, since Bunge did not engage with certain systemist notions which could be germane for conceptual modeling (e.g., systems as *optional* mental abstractions), we synthesize the views of Bunge with select tenets from GST.

Much of familiarity with Bunge in conceptual modeling stems from the BWW ontology developed by Wand and Weber (1995; 2017) based on Bunge's *Treatise on Basic Philosophy* (M. A. Bunge 1977; 1989). However, this ontology did not offer extensive elaboration of systems and its related constructs (although, in addition to the system construct, the ontology contained the construct of emergent properties). Upon review of Bunge's broader works, Lukyanenko et al. (2021) proposed a new ontology, called the *Bunge Systemist Ontology (BSO),* based on the writings of Bunge later in his life (M. A. Bunge 2006; 2016; 2017). This ontology, as the name suggests, deals with systems more extensively. However, some germane constructs were still left out (e.g., system level, semiotic systems). Recently, Lukyanenko and Weber (2022) developed a *Realist Ontology of Digital Objects and Digitalized Systems* by combining Bunge's ontological notions (including that of systems, levels and emergent properties) with his theories of semantics and semiotics (M. A. Bunge 1974). To develop the foundations of systems-grounded conceptual modeling, we adopt and extend these, more recent and extended ideas of Bunge.

The BWW ontology postulates that *reality* is made of *things*, which have properties (M. A. Bunge 1977, 26–29). Things are “substantial individuals”, which could be *composed* of other individuals or be *simple*, structureless and atomic (Yair Wand and Weber 1990a, 126). In his more recent works, Bunge proposed that every object of existence is likely a ***system***. According to the later Bunge, ***the world is made of systems***. Lukyanenko et al. (2021) provide three explanations of this, somewhat radical, ontological position.

First, *the notion* of system allowed Bunge to reason about constituents of reality that would be difficult to call *things*. Bunge found that system is more consistent with the scientific and day-to-day discourse. Scientists routinely refer to fields or atoms as “systems”, and rarely call them “things”. Second, this linguistic practice, for Bunge, reflected deeper ontological reasons. Bunge argued that *there are no simple, structureless entities* — all constituents of reality are complex. Third, as follows from the premise that the world is made of systems, Bunge asserted that ontological systemism provides a more faithful approach for describing reality, and better maps to reality (M. A. Bunge 2003a; 2017).

The claims by Bunge have been increasingly supported by modern quantum physics, including the candidate for the unifying theory, the M-theory, which considers fields (e.g., electromagnetic field) as being made of particles, such as *bosons* (Veltman 2003). Hence, fields, which give rise to the physical forces (e.g., electromagnetism), can indeed be considered systems. The notion of known elementary particles likely being complex is also supported by other quantum theorists (Hawking and Mlodinow 2010).

Bunge provides a broad definition of a system as a “complex object every part or component of which is connected with other parts of the same object in such a manner that the whole possesses some features that its components lack – that is, emergent properties” (M. A. Bunge 1996, 20). We adopt the same definition for our analysis. In essence, this definition suggests that, for something to be considered a system, it needs to be composed of other components. These components need to be connected to one another and, through these bonds, emergent properties arise.

Bunge defines *emergent properties* as properties of systems which the components lack, and which only appear once the components become part of the whole by interacting with one another (M. A. Bunge 2003a). What makes systems especially important and challenging to investigate is that the emergent properties are not directly derivable from the knowledge of the properties of the components. These properties emerge in an organic way once the components become part of the whole. For example, humans individually lack the property "cohesive". This property emerges when the humans form a team or family (both, social systems), and the team is identified as being "cohesive". Similarly, the concept of "commitment" arises as a result of bonding between several people. The same holds true for human-made systems. A house can be "cozy" when furniture is put together in a particular manner. Likewise, music can be considered "soothing" despite individual soundwaves lacking this property.

It should be noted: while all entities per Bunge are complex, they do not necessity bond with *all* other systems to form bigger systems. An electron somewhere on the Moon does not form a system with a bird on Earth. A pile of laptops does not make a socio-technical system with the humans in its vicinity. Still, these systems can be grouped together in a mind, for some purpose. These unrelated groups of systems can be called *aggregates* (or *collections*). For example, we can group together Jupiter's moons, Australian marsupials, Mario Bunge, and the ER (Entity-Relationship) 2022 conference, to make a point about systemist ontology. This group, seemingly unrelated, can have properties in common (such as *located in the Solar system*). However, it is an aggregate, not a system. What distinguishes systems from aggregates is the presence of emergent properties resulting from the systemic interactions among components. Hence, it is not ontologically consistent to treat *Jupiter's moons, Australian marsupials, Mario Bunge,* and *the ER 2022 conference* as a system and thus seek a system-based conceptual modeling construct to show it in a diagram[6].

In addition to the emergent properties, systems have *hereditary* or *aggregate properties*. These properties are also the properties of the whole, that is the entire system, but they are directly derivable from the properties of the components. For example, *total family income* is a property that is the sum of individual incomes of the family members. Similarly, *mass* of an organism is the sum of masses of all organs and tissues.

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[6] Still, as human knowledge expands, what is considered an unrelated aggregate may later be found to be a system, a point Bunge also makes.

Bunge distinguishes two kinds of system: *conceptual* and *concrete* (M. A. Bunge 1996, 270). *Concrete* systems are systems made of energy-harboring material components and may undergo change. Concrete systems change in the virtue of energy transfer. Atoms, organisms, and societies are concrete systems. Humans, Jupiter moons and flowers are concrete systems. Bunge views social systems as concrete, since they are made of concrete components (i.e., marriage involves two or more physical systems) (M. A. Bunge 1996).

A *conceptual* or *construct-system* (see, Lukyanenko and Weber 2022) is a system in which all of the components are mental ideas bound together in the mind of a thinking system (e.g., human being) via mental rules. Propositions, classifications, and theories are conceptual systems. Unlike concrete systems, conceptual systems do not harbor energy and change when they are changed by concrete systems.

Bunge suggested that, to represent a concrete system, four elements need to be described, namely, Composition, Environment, Structure and Mechanism of the system, which are referred to as the ***CESM model***. The *composition* of the system is its components; the *environment*, the external systems (some of which may be ill-understood or ill-defined) with which the system and its subsystems interact; and the *structure*, the relationships among its components as well as among these and the environment (M. A. Bunge 1979, 4). Finally, *mechanism* is the "characteristic processes, that make [the system] what it is and the peculiar ways it changes" (M. A. Bunge 2006, 126). To illustrate how to describe systems using CESM, Bunge (2003b, 39) offers among several examples, a manufacturing plant, which is a type of socio-technical system:

> a manufacturing plant is composed of workers, engineers, and managers; its environment is a market; it is held together by contracts and relations of communication and command; and its mechanisms are those of manufacturing, trading, borrowing, and marketing.

Conceptual systems can be represented with the condensed Composition, Environment, and Structure or the ***CES model***. Since conceptual systems do not change by themselves, they do not have mechanisms of their own. The mechanism component is not applicable to conceptual systems (M. A. Bunge 2003a; 2003b). For example, a theory has components (e.g., propositions, axioms, concepts), environment (e.g., other theories that use the components of the theory in their theories, or other concepts that refer to the concepts of the theory), and structure (e.g., logical relationships linking the axioms).

Systems can also be described in terms of the *level structure* — the relationships of composition between system components (M. A. Bunge 2003a). Systems at one level (e.g., socio-technical, assume level 1) are composed of systems at a lower level (i.e., technical, and social, assume level 2). The social level, in turn, can be decomposed into a biological, and then chemical and psychical levels. The workers, engineers, and managers in the preceding example of a manufacturing plant illustrate the level structure as level 2 components. If necessary, we may decompose the plant example further by considering the parts of the workers, engineers, and managers such as their organs (level 3), which can be further decomposed still.

Systems have a variety of relationships with other systems beyond composition. Thus, a system can be a type of another system (e.g., bird is a type of animal, stock market is a type of social system). In this case birds share the properties of animals (e.g., multicellularity), in addition to having bird-specific properties (e.g., feathers, laying eggs).

The systems that interact with the environment are *open systems*. Likely, all systems are open, as even experimental artifacts cannot be fully isolated. However, some systems are more open and susceptible to environmental forces than others (the isolated tribes of the Andaman Islands interact with other cultures less frequently than the country of Turkey (Turkiye) which historically been the meeting grounds of different cultures).

Open systems have *boundary* — those components of the system that directly interact with the environment, whereas components that only interact with other subsystems of its parent system are *internal components*. For example, a manufacturing plant is an open system, whose boundaries include legal, HR, public relations and supply and customer service employees, among others. The internal components of a manufacturing plan include its line workers, security, and control operators, among others. These people generally do not interact with the environment as members of this system. By interacting with other systems, the systems may alter the properties, components, structure, or mechanisms of these systems.

For example, when a plant produces a car, it may trigger a desire to buy the car on the part of prospective consumers.

According to Bunge, mechanism harbors the clues for why a system behaves in a particular way. To reveal the mechanism of a system is to provide an explanation for *how and why* the system works as it does, which is referred to by Bunge (2017; 1998) and others (Gerring 2008) as *mechanismic explanation*. For concrete systems, the mechanismic explanations involve the description of the inner working of the system. For Bunge, this entailed detailing the different kinds of energy transfers in concrete systems, such as mechanical, thermal, kinetic, potential, electric, magnetic, gravitational, chemical (e.g., in M. A. Bunge 2006). Energy transfer leads to change in states of systems, as they acquire or lose their properties, resulting in *events* and *processes* (sequences of events). These changes may also occur as feedback loops, which, from the GST, are harbingers of natural systems.

In contrast to concrete systems, conceptual systems do not change since they, themselves, do not possess energy. However, energy transfer occurs within and between concrete systems (e.g., humans who are thinking and communicating about these conceptual systems). Conceptual systems may be externalized into some medium (e.g., paper, hard drive) in order to be communicated and shared with others, thus becoming inputs into the design of concrete systems. In this case, the *intent* to realize a conceptual systems triggers change (i.e., via energy transfer) in some concrete system, which then acts in the world to implement or instantiate the conceptual system into properties of concrete systems (M. Bunge and Ardila 2012). This can be accomplished by direct manipulation or by linguistic declarations, such as commands and requests, or *speech acts* (Austin, Urmson, and Sbisà 1975; Searle 1983; 1995). For example, architectural blueprints, engineering models, and conceptual modeling diagrams, among others, originate in conceptual systems of humans. In thinking about these systems and mentally relating their properties to properties of concrete systems, humans devise means of realizing them as buildings, bridges and software code stored on a hard drive or as electrical pulses.

Note that Bunge mainly focused on changes due to energy transfer (e.g., M. A. Bunge 2006). Whether all mechanisms can be understood and modeled as energy transfer is debatable. For example, such concrete systems as governments or universities may undergo state changes driven by speech acts (Chang and Woo 1994; Eriksson and Agerfalk 2021; Janson and Woo 1995; 1996; Yair Wand et al. 1995). To describe such mechanisms, we suggest institutional ontologies that seek to understand social systems in terms of social and psychological dynamics (Searle 1995; S. March and Allen 2012; Eriksson and Agerfalk 2021). Thus, a mechanism can be represented by physical, as well as social and psychological explanations (e.g., a contract was terminated because one of the parties *felt* dissatisfied with the terms).

Some of the energy transfers follow stable and recurring patterns, hence leading to *systemic interactions among components;* that is, those interactions that give rise to the emergent properties. For example, the working relationship among employees within an organization, such as managing and reporting functions, are systemic relationships. If removed, an organization itself may cease to function[7].

In contrast, *ad hoc interaction among components* happen by chance, and do not follow discernible or predefined patterns. These, typically, do not give rise to the emergent properties within a system, but are still important to account for, in order to capture the full complexity of the system. For example, lending a lawnmower to a coworker is an example of such ad hoc relationship. It must be noted, however, that systems are not static, and they change, in part, when ad hoc relationships become more systemic. New systems can be born out of these ad hoc interactions.

3.3] Implications of Ontological Systemist for Conceptual Modeling

Consistent with efforts to put conceptual modeling on stronger theoretical foundations, we suggest greater consideration of systems during conceptual modeling. First, systems of all kinds may need to be represented in a conceptual model using one or more constructs leading to the notion of *system as a conceptual modeling construct*. System as a conceptual modeling construct is a representation in a conceptual modeling artifact (diagram, narrative, use case) of a system as perceived by the designer or elicited from relevant stakeholders. For example, a conceptual modeling diagram may

[7] This is why some scholars define systems as assembly of components which interact with each other on a regular basis (e.g., Dubin 1978; Post et al. 2020).

contain a system construct which is assumed to represent a manufacturing plant (a real-world system).

Second, to represent aspects of a system, one or more systemist conceptual modeling constructs may be used. These are ***systemist conceptual modeling constructs***. These constructs may present different views of the same system, as per, CESM/CEM model. For example, a conceptual modeling diagram may contain a construct (e.g., part-of association), which is assumed to represent a component of a manufacturing plant.

Third, to ensure the systemist conceptual modeling constructs cover important aspects of systems, we suggest a formalism called ***CESM+***. CESM+ adapts the CESM (CES) models of Bunge together with other populates about systems. CESM+ is a conceptual modeling template or checklist aimed to help designers describe and model essential aspects of systems of all kinds. It suggests that for a concrete system, its Composition, Environment, Structure and Mechanism should be modeled; for conceptual systems the elements to be modeled include Composition, Environment and Structure. The *plus* suggests that, in addition to modeling the above elements, the properties (hereditary and emergent) as well as other valuable or deemed relevant facts about systems (e.g., history of the system) should be considered for modeling. Among the latter, attempts to anticipate and model emergent properties should be made.

Modeling with CESM+ amounts to providing a comprehensive view of focal systems in a domain from different and converging perspectives (i.e., knowing properties of systems allows to better understand how these systems change). As we demonstrate through a case study below, this description should guide the project development toward more appropriate database, user interface and process choices. The more we understand the relevant facts about the systems of interest, the more we are able to manage their behavior, including the possibility of anticipating the elusive emergent properties.

To realize CESM+ for a given system, multiple systemist conceptual modeling constructs are needed and multiple conceptual modeling diagrams may be required. This is consistent with the growing trend toward multi-model and multi-representation conceptual modeling (Green et al. 2011; Hvalshagen, Lukyanenko, and Samuel Forthcoming; Jabbari et al. 2022; Malinova and Mendling 2021;

Recker and Green 2019) and model-driven architecture (Pastor and Molina 2007; Pourali and Atlee 2018).

At the same time, note that, although Bunge admits that every constituent in reality may be a system, it is important to underscore that conceptual modeling is a social activity. It models reality as perceived by human stakeholders, reflecting their needs and views of the domain. Therefore, even though every*thing* may indeed be a system from a strict materialist point of view, this does not imply that human stakeholders would conceptualize these entities as systems (mental abstractions) or automatically benefit from modeling these entities using system and its related constructs.

We suggest a more nuanced perspective, in line with, for example, Skyttner (1996) and Luhmann (1995). Skyttner (1996, 16), suggests that "[a] system is not something presented to the observer, it is something to be recognized by him/her. Usually, this word does not refer to existing things in the real world but, rather, to a way of organizing our thoughts about the same". These mental models are effectively conceptual systems glued together by mental rules. The conceptual systems may or may not accurate or completely map to properties of the concrete systems, nor even have concrete counterparts. Ptolemaic and Copernican models of the universe are example of these systems-mental abstractions. Both proved useful, despite one being less accurate than the other. Likewise, organizational stakeholders who provide information systems requirements, may have different models of systems which may be important to capture. These models of systems may not agree with one another. An open challenge is to reconcile these differences into a unified conceptual model which is effective and acceptable by the stakeholders for facilitating development and use of technology (e.g., see J. Parsons and Wand 2003).

Although we appreciate Bunge's basic postulate of the world of systems and maintain that a systemist approach is fruitful but underutilized in conceptual modeling, we do not suggest the system construct be immediately applicable to all modeling scenarios. Systems as modeling constructs are only useful when the systemist properties of emergence, CESM and other system-related notions are valuable to consider and, when possible, represent. Table 1 details the key systems concepts adopted and adapted in the paper within the context of conceptual modeling.

Table 1: Key definitions related to systems as used in this paper

Concept and its sense, where applicable	Definition	Reference(s)	Examples
System "Ontological System" or "system out there" *an object in the world*	Complex object every part or component of which is connected with other parts of the same object in such a manner that the whole possesses some properties that its components lack – that is, emergent properties	Bunge (1996, 20), Weber (1997), Wand and Weber (1990b)	atom, animal, airplane, university, stock market, galaxy, ERP, Google
System "System-mental abstraction", "conceptual system" or "construct-system" *a potentially useful abstraction to reason about the world*	A mental model of some part of reality which *refers to* some ontological system, existing or imaginary. *Note*, conceptual systems are part of reality, being property of humans who conceptualize these systems to organize and act in the world	Skyttner (1996), Luhmann (1995), Bunge (1979), Lukyanenko and Weber (2022)	Ptolemaic model of the universe, Copernican model of the universe, model of local biodiversity as understood by a biologist, model of Tolkien's lore as understood by a reader, theory of gravity, CESM model of a factory, the periodic table of the (chemical) elements
System "System-conceptual modeling construct" *a proposed here conceptual modeling construct*	A representation in a conceptual modeling artifact (diagram, narrative, use case) of a system as perceived by the designer or elicited from relevant stakeholders	The definition proposed in this paper; implicitly adopted in some conceptual modeling languages (see Section 2.3)	Level Structure Model (LSM) components, modeling a system using UML stereotype, proposed later in the paper
Systemist conceptual modeling constructs or systems-constructs	Conceptual modeling constructs which represent different aspects of systems, such as CESM or emergent properties	The definition proposed in this paper	*part-of* construct in UML and SysML, modeling aggregate and emergent properties, proposed later in the paper

Property and attribute	Feature, trait or characteristic possessed by a system Note: attributes are human conceptualizations of properties of systems; here, used synonymously with properties	Bunge (2003b), Bunge (2017), Lukyanenko and Weber (2022)	Mass of human, word count of a novel, color of vehicle, age of university, shape of a mathematical function
Hereditary or aggregate property	A property of a system that belongs to a component of the system	Bunge (1979), Bunge (2003b)	Income of a family member, mass of airplane components
Emergent property	A property of a system that does not belong to any of the composing parts of the system that arises when the components are bonded together	Bunge (2006), Bunge (2003a)	Cohesiveness of water, productivity of firms, consistency of theory
Aggregates or collections	To the best of existing knowledge, unrelated (i.e., not directly and continuously interacting) things and systems	Bunge (1979), Bunge (2003a)	{Jupiter's moons and Mario Bunge}, {ER 2022 conference and 3}, pile of cellphones thrown into a recycling bin
CESM and CES Models	Ontological postulate that to effectively describe a system, one needs to represent Composition, Environment, Structure and Mechanism of concrete systems and Composition, Environment and Structure of system-constructs. The *composition* of the system are its components; the *environment*, the external systems with which the system and its subsystems interact; the *structure* is the relationships among its components as well as among these and the environment, the *mechanism* is the characteristic processes, that make the system what it is and the peculiar ways it changes	Bunge (2017), Bunge (2006)	composition, environment, structure and mechanism of a biological family or composition, environment, and structure of a theory of thermodynamics

CESM+ Modeling Template	A conceptual modeling template used to describe essential aspects of systems of all kinds. A systems-grounded conceptual modeling should strive to represent Composition, Environment, Structure and Mechanism, properties (hereditary and emergent) as well as other relevant facts about systems	Adaptation of CESM/CES ontological models of Bunge	CESM+ is discussed and illustrated later in the paper

4] Illustration and Further Elaboration: Modeling With and Without Systems

Equipped with the basic ontological notions, we now discuss further the implications of these ideas for conceptual modeling. We use a case study to elaborate the representational benefits of systems and to illustrate the implications of not representing systems explicitly.

4.1] Method

We draw on a real case of information systems development within the context of online citizen science. The first author of this paper has been the primary developer of a citizen science platform, NLNature (formerly, www.nlnature.com), between 2009 and 2022. This author developed the platform, initially as a developer, hired by a biology department at a mid-sized North American university. Consequently, the author conducted the initial planning, requirements elicitation analysis, prototype development, conceptual modeling, design and implementation, maintenance, and several redesign phases of the project. Later, the author joined the research team of the project. These emic experiences permit a rich insider account of modeling with and without systems. At the same time, the two remaining authors were not part of the project, hence, adding a less involved and biased perspective to the following analysis.

The NLNature project did not adopt the ontological systemism perspective, as described earlier, and used traditional (as well as experimental) systems analysis and design approaches. We, thus, engage in *retrospective analysis* — a common method in project management and systems analysis and design which draws insights from post-mortem evaluations of the successes and failures (Nelson 2008; 2021). Specifically, we evaluate the outcomes of the project in light of the systemist ontology provided earlier and suggest implications for conceptual modeling research and practice.

4.2] Project Description

The NLNature project began in 2009 with the aim to develop a citizen science platform for a region in North America. Citizen science refers to participation of the members of the general public (citizens) in scientific research, including data collection, analysis, and, more rarely, project ideation and publishing of scientific articles together with the scientists (Bonney et al. 2014; Burgess et al. 2017; Levy and Germonprez 2017; Lukyanenko and Parsons 2018).

Since the advent of the Internet, online citizen science is emerging as a major societal movement and research approach. For example, Zooniverse.org is a citizen science platform with over 1.6 million registered users. The citizens, members of Zooniverse, work on over 50 research projects, ranging from classification of galaxies and identification of animals in the African savannah to deciphering ancient texts and locating craters and boulders of the Moon. While Zooniverse is the largest citizen science platform, it is estimated that there are over 3000 active citizen science projects. These are mainly local projects interested in specific research questions[8]. One such platform is NLNature — a representative example of a mid-sized regional citizen science platform. Indeed, the project was the regional node of a national citizen science network and the principal citizen science platform for its region of North America.

The objective of NLNature was to collect sightings of plants, animals, and other taxa in the local region (area of over 400,000 km2). The aim was to create an evolving database of citizen-reported wildlife to support research and policy making related to plant and animal distributions, environmental change, impact of anthropogenic factors on natural habitats, and monitoring and conservation of specific species of interest, such as endangered lichens. Another goal was to raise awareness of local natural history among the residents and tourists of the region.

To support NLNature's objectives, a target list of species was identified, which became the focus of the first development stage. Upon subsequent analysis, it was clear that non-experts struggled

[8] The estimate is based on the projects listed on SciStarter, the world's largest database of citizen science projects; see https://scistarter.org/about.

to report their sightings using this list, so a new development philosophy was pursued whereby the citizens were permitted to report their observations without classifying the phenomena as specific species. The species could later be identified using artificial-intelligence-based techniques, such as machine learning and natural language processing. Indeed, this second phase was when one of the co-authors of the paper switched roles from developer to co-investigator to spearhead this approach to citizen science.

The project was sponsored by academia, which is typical of citizen science projects (Fortson et al. 2011; Sullivan et al. 2009). What makes this setting especially interesting is the nearly full transparency of the project development — part of the general commitment to open science (of course, guided by ethical protocols and appropriate participant consent) (Bowser et al. 2017; Groom, Weatherdon, and Geijzendorffer 2017; Vicente-Saez and Martinez-Fuentes 2018; Woelfle, Olliaro, and Todd 2011). This permits the kinds of revelations that might be difficult to achieve when working in corporate settings.

The project has been active from 2010 to 2022. During this period, over 10,000 members registered an account on the platform. They contributed over 10,000 observations of wildlife, making nearly 3000 comments on existing observations and posting over 15,000 photos to accompany the sightings. These sightings received over 10 million user-views. Some of the observations led to scientific discoveries and resulted in several publications in scientific journals (Fielden et al. 2015; Lukyanenko, Parsons, et al. 2019).

Over the years, NLNature underwent two major redevelopment phases with the aim to better meet the project's objectives. Consistent with prevailing approaches to citizen science development (Wiggins et al. 2013; Prestopnik and Crowston 2012; Lukyanenko and Parsons 2012), initially the project was developed by focusing on the needs of the project sponsors: the scientists. Consequently, most of the requirement elicitation and analysis efforts concentrated on capturing the requirements of the scientists. Early-stage interviews and focus groups with the citizens were also conducted.

The scientists insisted on the major unit of data collection and analysis of the project — *biological species* (e.g., Lung lichen, American robin), which became the focal entity type of the platform. Consequentially, the citizens were asked to report their observations in terms of the biological species observed. Fig. 1 shows a fragment of the conceptual model of the project showing how birds are classified per requirements of the scientists, and the resulting user interface options.

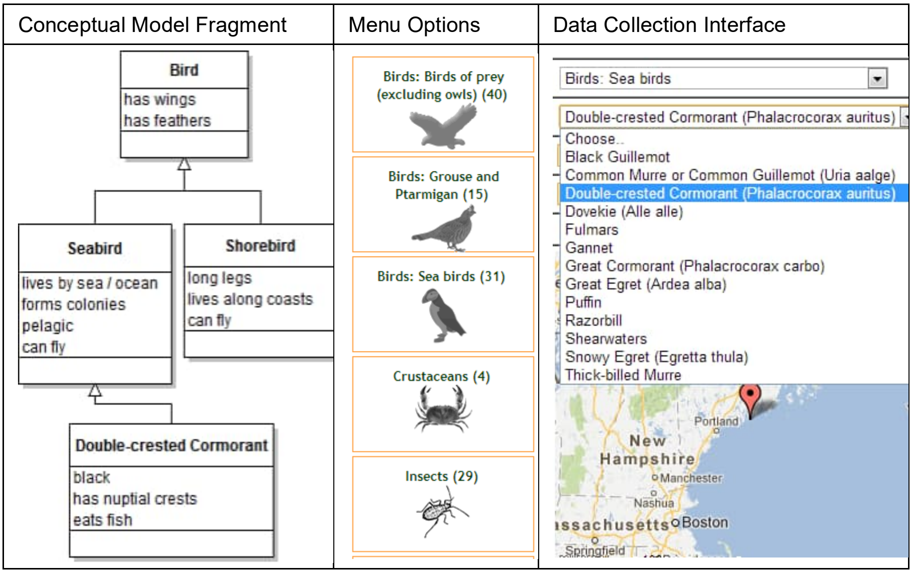


Figure 1: Connection between a conceptual modeling fragment (showing how birds are classified per requirements of the scientists) and user interface design in Phase 1 of NLNature.

An evaluation phase began as soon as the project was launched and revealed limitations and negative consequences of approaching citizen science by privileging the views and requirements of the scientists. Specifically, non-experts could not always positively identify what was observed. Hence, while non-experts could confidently identify familiar species, such as American robins, they struggled to positively identify lichens, or unfamiliar plants and birds. The analysis of the project logs revealed that often users resorted to guessing, which was evidenced by frequent changes of the species field while reporting the sightings. This evidence was further supported through the analysis of user comments and interviews with the existing users (Lukyanenko et al. 2017).

In 2013 the project was redesigned, but this time consistent with an underlying ontological foundation. We chose the BWW ontology

(Yair Wand and Weber 1993) as a guide for this redesign[9]. Following BWW, the new platform eschewed collecting observations using a pre-defined list of species and instead collected reports as unique instances, which citizens could describe using attributes or classes of their choice. After the data were captured, the scientists could infer species, using, for example, machine learning approaches. Fig. 2 depicts a data collection interface of NLNature developed following these ontological foundations. Fig. 3 shows a basic conceptual model of the redesigned NLNature's database to accommodate the new redevelopment philosophy.

To evaluate the utility of these ideas, we conducted a series of experiments and focus groups with the prospective and existing NLNature users. Collectively, these studies showed that data collection focusing on instances resulted in more observations being recorded, with less guessing and user frustration.

4.3] Systemist Analysis of the Project

The systemist perspective enables us to better understand the shortcomings of modeling agnostic to systems. First, we briefly analyze the first phase of the project, before turning attention to the second one and offering a deeper systemist analysis.

4.3.1] Phase 1. Systemist Analysis

The benefits of modeling with systems can be evident in the simple case of Fig. 1 from the first phase of the project. Equipped with the systemist ontology (Section 3), we can now interpret this figure in systemist terms. Fig. 1 is an externalized *conceptual* system realized as a UML diagram (concrete system, captured on paper and then in software). The diagram represents concepts and hierarchies, or conceptual classification systems, of the domain of interest of NLNature, elicited mainly from the scientists.

[9] Specifically, the central tenet of BWW is that the world is made of things — substantial individuals. Things possess properties, which people can conceptualize as attributes. Things form classes when they share common properties. These ideas have been interpreted by researchers as the need to model individuals (instances) irrespective of the classes they belong to Parsons (1996) and Parsons and Wand (2000). The redesign of NLNature was inspired by these ideas and interpretations.

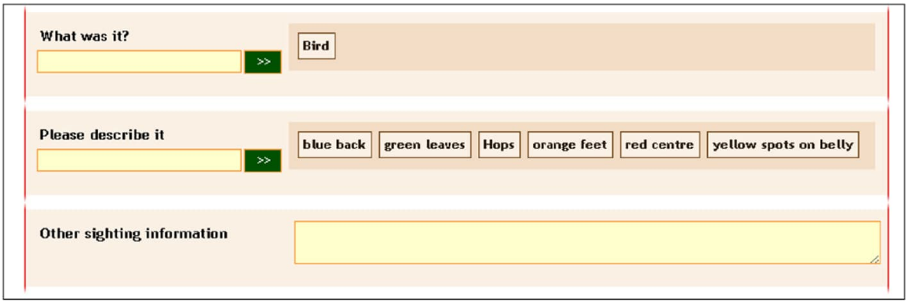


Figure 2: User interface in Phase 2 of NLNature project with a sample observation (taken from www.nlnature.com).

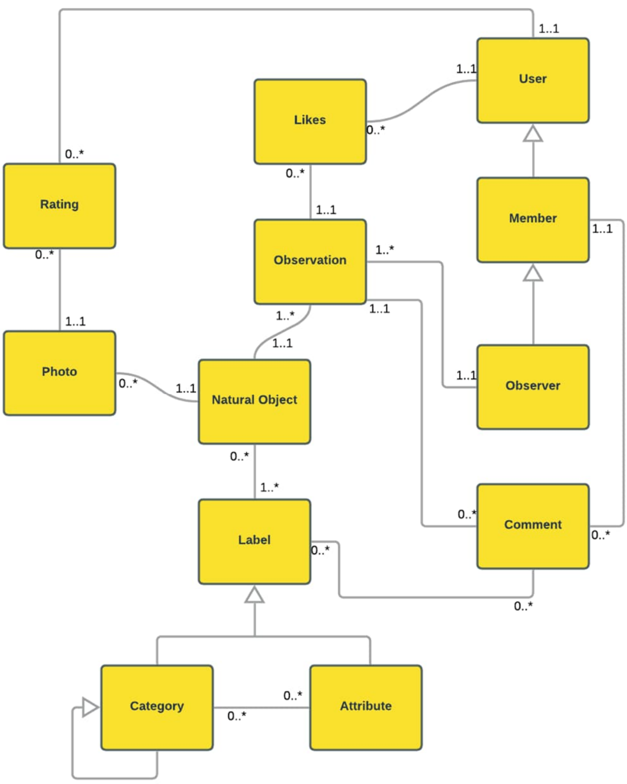


Figure 3: A conceptual model in Phase 2 of NLNature.

This diagram ultimately informed the development of *concrete technical sub-systems* of NLNature, a complex *socio-technical* system. These included psychical *user interface* and *database structures* (electric and magnetic charges representing binary instructions and containers) for processing and storing citizen observations of nature, developed in accordance with the concepts and hierarchies shown in Fig. 1.

Assume Fig. 1 fragment is representative of a complete model of the conceptual classification system upon which the user interface is built to collect sightings. From the systemist perspective such model shows some of the composition and structure of this conceptual system. The composition are the classes in the diagram (e.g., bird, seabird). The structure is the type of mental rules connecting these classes — that of inheritance where each class is a type of another and shares the properties of its parent.

The diagram does not show the environment. In particular, the diagram does not show the citizen scientists and others contributing or using the information organized by these classes. It neither models these systems, nor shows which part of the conceptual system (and hence, the user interface), with which they interact. In systemist terms, Fig. 1 does not show the system boundaries; that is, the classes that become the entry points for the citizen scientists (and others) into this conceptual hierarchy. The figure also does not show any emergent properties of the conceptual system, or the components of the socio-technical systems shaped by this diagram.

The lack of modeling of system boundaries and of emergent properties may complicate building accessible and usable interfaces. This realization became apparent to the project development team only after several years of NLNature's deployment. When the first phase of NLNature was launched, much of the user frustration and attrition was attributed to the lack of domain expertise on the part of less knowledgeable citizens. This, we reasoned, manifested in the inability to positively identify the observed organisms as predefined biological species. Several laboratory and field experiments, along with user interviews, corroborated this hypothesis (Lukyanenko, Parsons, and Wiersma 2014; Lukyanenko, Parsons, et al. 2019; Lukyanenko and Parsons 2020b). However, systemist perspective reveals additional causes of negative user experience, due to unexpected emergent properties and underappreciation of the systemist boundaries.

The classification system in Fig. 1 of the project contained several emergent properties. In particular, one emergent property was *overall accessibility*. In the context of the project, *overall accessibility* can be understood as the extent to which the *entire* arrangement of the classes accords with expectations and knowledge of its users, and hence is usable and accessible for reporting sightings. This is an emergent property of the sightings reporting sub-component of the NLNature socio-technical system, which was designed in accordance with the classification conceptual system of the scientists. This property emerged when all of the classes were arranged in a particular way in the user interface under the guidance of the conceptual model in Fig. 1. However, while the list of species was carefully considered (e.g., those species deemed completely inaccessible and esoteric were removed), the overall arrangement was not.

Indeed, much of research on accessible citizen science deals with a single (e.g., generic or species level of classification), not the overall arrangement of different classes (Burgess et al. 2017; Castellanos et al. 2020; Gura 2013; Lewandowski and Specht 2015; Jeffrey Parsons, Lukyanenko, and Wiersma 2011). In addition, consistent with the species focus, the impact of intermediate classes, such as Seabird or Land Mammal, was also not taken into consideration, despite these classes becoming data collection options (or, in systemist terms, system boundary).

The later analysis of the project showed that some of the negative experiences of the users were caused not by the familiarity with the individual classes, but by the overall accessibility of the classification system. For example, when reporting on a *polar bear* sighting, it was initially assumed that non-experts would be familiar with this class (which, for the most part, is a reasonable supposition). However, to get to the polar bear class, a user had to first select other top-level classes. In the project, following standard biological nomenclature (Stirling 1998), polar bears were modeled as a subclass of "*marine mammals*".

However, for many non-experts in biology, polar bears are first and foremost, bears, and hence, land-dwellers. Hence, some users became lost upon failing to find a polar bear under the "*land mammal*" higher-level category. This and similar examples (e.g., puffins are *seabirds*, rather than *shorebirds* despite commonly being observed by the shores) reveal how the knowledge of a single system component (e.g., of a given species) may still preclude from a successful or friction-free observation due to issues in overall accessibility and failure to account for the boundary of the system. These realizations, although somewhat intuitive, escaped the original analysis.

A possible alternative to Fig. 1 diagram is shown in Fig. 4. It modifies a standard UML class diagram to depict the classification structure as a system (here: a call-out bubble); the boundary objects of the system are shown as classes with bold outlines; the main environment objects are shown as icons of citizen scientists and project partners. We call it a System Boundary Model (SBM), as its goal is to show the boundary components of systems. Boundary objects are especially valuable to model since often unanticipated events occur when components of one system begin interacting with the components of another system (Bowker et al. 2016). This gives rise to the emergent properties of the new system that forms as a result of these interactions. As a popular adage goes, innovation happens at the seams.

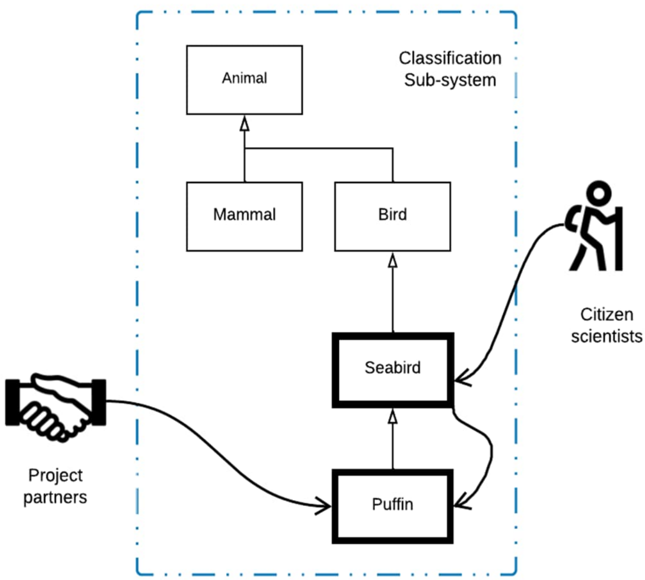


Figure 4: Example of a System Boundary Model (SBM) fragment. Classification structure as a conceptual system (call-out bubble); boundary objects of system shown as classes with bold outlines; important environment objects shown as icons of citizen scientists and project partners.

4.3.2] Phase 2. Systemist Analysis and CESM+ Example

In the second iteration of NLNature, a new conceptual system was developed, shown in Fig. 3 (see earlier). The changes appeared to have addressed the shortcomings of the first design. We now apply the CESM+ modeling template to offer a general systemist analysis of NLNature as a whole.

Table 2: Analysis of NLNature based on CESM+ template

System Name and Type	***NLNature, an information system, a socio-technical system***
Components	NLNature technology, composed of such components as programing code, database, application programming interfaces (APIs, such as Google Map, social media connections), and a series of hardware components (e.g., a webserver), and the social systems (scientists and citizens)
Environment	NLNature partners, media, conservation agencies, and government, as well as physical systems - objects of observation - plants, animals and other taxa observed and reported by the citizens which are analyzed by scientists
Structure	Reporting a sighting, emailing another member and asking questions, and the relationships between the users of the project and the objects in the environment
Mechanism	Making and posting of observations, reporting on information using the features of the project, communicating among project members, helping others to identify species, using the data for scientific analysis
Emergent properties (select)	• Shared sense of the project's purpose (discussed later) • Observations-anchors (i.e., existing observations which provided strong examples and influenced citizens for future observations, discussed later) • Socializing (use of platform features in unanticipated ways to elicit off-line encounters) • Research productivity • Discoveries

We suggest following a CESM+ checklist at the onset of a project. Effectively, it guides designers in considering what systems are under consideration and what components of these systems need to be considered and, possibly, represented in conceptual modeling diagrams. As with most conceptual models, CESM+ template can be applied retrospectively, to better understand an existing system (much like an entity-relationship diagram can be used to describe an existing database). Thus, Table 2 uses CESM+ template for post-hoc analysis of an existing system. By glancing at the table, the scope and essence of NLNature become more apparent.

CESM+ Analysis of NLNature. We also use the CESM+ checklist to guide the discussion on the readiness of existing conceptual modeling approaches for systems modeling. Guided by the structure and contents of CESM+ as shown in Table 2, we now: (a) offer a systemist analysis of the diagrams in Figs. 1 and 3, and (b) conduct a general assessment of existing conceptual modeling capabilities for modeling systems.

Components, Environment, Structure and Mechanism. First, without an explicit systemist perspective, many projects would lack a diagram which represents all the components of the system. Indeed, Fig. 3, which is the structure of the database, does represent some of the components of NLNature. Its vast coverage, however, may give a false impression that most focal components about which information is stored are captured. However, this is not the case. Not all informational components are shown in the conceptual model, and thus either need to be inferred, or found in other diagrams. For example, we do not see such NLNature components as the *scientists*. It should be noted that NLNature had dedicated software elements focused on scientists, such as analysis and reporting and project administration. Hence, they were objects of a database, but were modeled separately and informally. The database schema for scientists was created in an ad hoc manner without formal conceptual modeling. Not modeling some database objects is a common practice that often complicates documentation and may undermine security (Jukic et al. 2019). Had the explicit systemist perspective been adopted, such omission would be inconsistent with systemist philosophy and constitute a methodological error. *Hence, adopting a systemist perspective makes modeling more disciplined and systematic.*

Of course, it is possible to envision additional diagrams, which could represent these components. For example, an *i** Strategic Dependency Model (E. Yu 2002; E. S. Yu 2009) may include scientists together with citizens. Such a diagram may be particularly useful for understanding the goals, dependencies, and resources involved in the interaction between citizens and scientists. However, absence a systemist approach, there is no reason to expect that, for a specific project, the system is modeled as a whole and its components are analyzed and represented. The result is a lack of a holistic view of the entire system. Among other limitations, not having the holistic view of a system makes it is even more difficult to predict the emergent properties.

Absent an explicit systemist perspective (and a checklist such as CESM+), there is no guarantee that the focal objects of the environment of NLNature are modeled. These include such important entities as the federal agencies which sponsored the project, several departments within the university, and public agencies which relied on the data from the project. Among the important environment entities are other socio-technical systems that are partners of the NLNature project. For example, one such partner had an agreement to extract data related to oceans (such as ocean currents and pollution). Having this information in the model, for example, would alert systems developers as to which objects are boundary. Inattentive changes to code of such objects may undermine interoperability between NLNature and its partners. As shown in Fig. 4, it is generally possible to represent the environment, with modifications to existing conceptual modeling grammars (constructs and rules for how to use them for a particular conceptual modeling language). However, very little is known how to do so effectively, while balancing other competing objectives of conceptual models, such as parsimony and clarity.

Existing conceptual modeling languages offer support for the structure of systems. The structure is commonly modeled as relationships among system components. These can be represented using, for example, an ER diagram or UML object or class diagram. Hence, in Fig. 3, some of these relationships are shown by the associations among classes (e.g., Observer and Observation implies an *observe* relationship). Existing conceptual modeling languages can make these relationship links more explicit by naming them, as well as identifying their directions.

However, no method exists for showing the impact of these relationships on the growth and evolution of a system — a key point in describing these relationships under a systemist approach. Indeed, some of these relationships may be more important than others for ensuring system stability, whereas some relationships may be more transient and ad hoc, with less impact on the longevity of the system. Intuitively, we can reason that the posting of comments is less important than the posting of observations. Knowing this, suggests additional care and resources dedicated to the observation (technical) sub-system of the project, compared to the comments sub-system. This could be an important information for developers who lack deep domain knowledge (which can be the case in outsourcing) (Daneva et al. 2013; Moe et al. 2014; Sahay, Nicholson, and Krishna 2003).

The final CESM component is mechanism. For example, the making and posting of observations is a key mechanism, which, if absent, or substantially impeded, nullifies the entire project. For the NLNature system, this is a foundational mechanism. Indeed, the evolution of this mechanism accounted for most of the code changes during the different iterations of the project. Again, such realization could help prioritize development efforts and resources. In contrast, the mechanisms involved in contacting other members are secondary to the project, and thus, are on the periphery of the NLNature system. Hence, any changes to this mechanism may occur without affecting the functioning of the entire system, and may not require as much care.

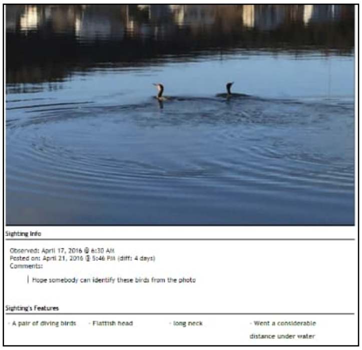
Modeling of mechanisms is possible using, for example, process oriented conceptual modeling languages, such as BPMN, EPCs, or statecharts. However, these notations are not specifically designed for representation of mechanisms, as understood by the ontological theory. Rather, they are focused on the representation of information flow or decision logic. From the point of view of systems theory, mechanisms are the explanations for *how* and *why* the system works and evolves. The process models are presently equipped at handling the *how* part (see, e.g., Harel 1987). They do not deal with the why. For example, these models would not explain why some observations by one member were similar to observations by another, which, we hypothesized were due to anchoring effects, as discussed below. Potentially, other conceptual modeling languages, such as goal-oriented, or actor-oriented, languages and narratives (Hvalshagen, Lukyanenko, and Samuel Forthcoming; Segel and Heer 2010), may be used for the why question. The challenge then becomes to combine the how and why in an effective manner. There is no answer to this in the extant conceptual modeling theory.

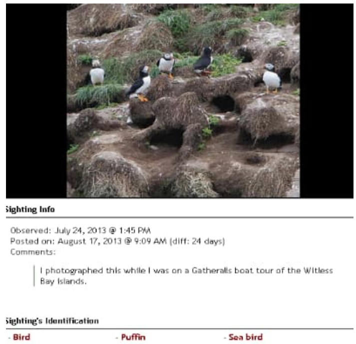
Sub-systems. Many components of the NLNature system can themselves be modeled as systems following own CESM+ template. Fig. 3 shows some of these distinguishable sub-systems, such as user observation system, user communication system, or classification system, among others. Of course, even users themselves are systems. However, it is difficult to imagine a scenario where modeling them as systems may be advantageous for this project; yet this may become important for other projects. Indeed, such crowdsourcing platforms as PatientsLikeMe (www.patientslikeme.com), the world's largest personalized health network that helps people find new treatments (Dissanayake et al. 2019; Frost and Massagli 2008; Kallinikos and Tempini 2014; Wicks et al. 2010), may benefit from modeling human organs and tissues. When beneficial, CESM+ can be applied recursively, to model these subsystems. Notable here is existing conceptual modeling language do not explicitly have an ability to connect these different *CESM*+ representations together.

We now illustrate modeling challenges related to one specific sub-system: user observation system and its referent objects in the NLNature environment. It was implicitly clear to the development team and the scientists that the plants, animals and other taxa represented by Natural Object in Fig. 3 are complex; that is, systems. However, they were all modeled as individuals, atomic entities, since, for a project which had hundreds of species, it was not practical to have hundreds of conceptual models of puffins, lung lichens, polar bears, and others.

Still, it could have been useful to indicate that the organisms of the project were systems, without engaging in full-blown complexity modeling. As a result of modeling entities in Fig. 3 as structureless classes, neither the database structures nor the user interface supported the collection and storage of the attributes based on the parts of the organism (system) being described. Hence, some of the attributes reported were applicable to the entire organism (e.g., large, beautiful), whereas other attributes were attributes of the parts (e.g., blue beak, yellow feet). This meant that interpreting these attributes was difficult, because it was not intrinsically clear (especially when the processing was done automatically, without human interpretation) whether this was an attribute of the entire organism or its parts.

Furthermore, frequently, the organisms reported were observed as part of larger biological systems. This too escaped the appropriate capturing by the interface which implemented the conceptual model in Fig. 3. To illustrate, Fig. 5 provides three observations. Since the project was modeled on the premise of representing individuals, it was very difficult to represent the object of these sightings as systems.

<table>
<tr><th>Observation 1</th><th>Observation 2</th></tr>
<tr><td>


</td><td>


</td></tr>
<tr><td>A user recognizes a potential system (i.e., a bird family), but the interface lacks ability to describe the interaction among its components. Hence, for example, it is unclear which of the birds the tags belong? Both? Only 1? If so, which one?</td><td>A puffin colony is a system. Note that the user, primed by the individualist perspective, uses labels which suggest that only a single bird was sighted.</td></tr>
<tr><th colspan="2">Observation 3</th></tr>
<tr><td colspan="2">


</td></tr>
<tr><td colspan="2">Potential for describing interaction between one system (i.e., bird) and the environment (e.g., buildings, cars, railway tracks), which the interface does not support.</td></tr>
</table>

Figure 5: Real observations where users intended to provide more descriptions of systemic aspects but could not do so (taken from www.nlnature.com).

Modeling all NLNature organisms as systems was not necessary. However, had there been an ability to simply convey that the Natural Object in Fig. 3 was a system, it could have sent a signal that more complexity needed to be represented in the database. This could have been achieved by having flexible interface choices permitting, for example, key–value pairs of attribute-system parts. These could be stored following a key–value pair data model, such as that of AmazonDB or MongoDB, which permits unbounded variation, thus supporting the system diversity of NLNature (DeCandia et al. 2007; Idreos and Callaghan 2020). As we can see from this analysis, adopting a systemist perspective does not always entail elaborate system modeling. Small signals from a conceptual modeling diagram, when appropriately interpreted, can be valuable. However, to create and appropriately interpret these small changes to modeling diagrams, an update to conceptual modeling methods is needed.

Emergent properties. Finally, the CESM+ checklist suggests to consider and attempt modeling emergent properties. To appreciate the benefits of such modeling, we now consider some emergent properties of NLNature (see Table 2). Two notable emergent properties, which became apparent after the implementation, are the *shared sense of the project's purpose* and *observations-anchors*. Specifically, by design, the project was intentionally broad and accepted all kinds of organisms in the specified geographic area. Over time, as citizens reported thousands of organisms, it became clear that the project began to acquire a crowd-generated identity.

We further hypothesized, this *emerged* project identity was based on certain popular observations that acted as psychological anchors (Gigerenzer and Todd 1999; Gilovich, Griffin, and Kahneman 2002). These observations shaped the perception of what is interesting to observe, how to describe organisms, and potentially affected subsequent observations (Lukyanenko, Parsons, et al. 2019). An analysis showed that most of the observations on the project were of charismatic species, such as fox, eagle, moose, coyote, bear, mink, and seagulls. We suspected having these observations publicly visible created a grass-roots project identity and biased future observations.

This is not what the project owners wanted. They had hoped to observe a more uniform and representative map of sightings. The *shared sense of the project's purpose* emergent property was not modeled in advance, and hence no mechanisms for promptly detecting and correcting the drift toward charismatic species was envisioned during the development of the project. The paucity of systemist thinking during conceptual modeling dissuaded the conversations about emergent properties of the entire project, as well as its subsystems.

Presently, conceptual modeling lacks established and robust abilities to detect and model emergence. In the context of the project, for example, observations-anchors can be shown as asterisks after the names of classes in a UML diagram. However, this does not permit to quantify the bias due to these anchors. A more comprehensive representation could be based on the visualization of Markov chains (Markovits and Vachon 1990) known as *Markov network* (Sherrington and Kirkpatrick 1975). Markov network is an undirected graphical model used to visualize stochastic processes as a sequence of possible events where the probability of an event depends on the previous event (Ethier and Kurtz 2009). Applied to NLNature, Markov networks could model how a user viewing a set of popular observations, then has a certain probability of reporting observation with similar properties[10]. The analysis of the entire network can then shed the light on the emergence of the shared sense of project's identity. While Markov networks as a solution would not work for all scenarios, it offers a glimpse of the opportunities involved in modeling emergent properties.

Level Structure Model. To ensure complex objects are considered in modeling, it would have been helpful to have a map of components conceptualized in a project as systems. Presently, established conceptual modeling approaches do not permit such explicit expositions. To appreciate how such diagram could be constructed, we introduce a systemist diagram designed to show the components of a target system. We call it, *Level Structure Model* (LSM) of systems with the representation adapted from a formalism in (1997, Chapter 2). The LSM shows the main higher-level systems in a project. The goal of LSM is to depict the horizontal relationships between system components related via composition.

There can be multiple versions of an LSM diagram[11], as the project progresses from the problem to the solutions space. To illustrate the usage of level structure models, Fig. 6 shows an LSM of NLNature before and after its creation. Indeed, before NLNature is

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[10] We showed this effect through a controlled field experiment on NLNature (Lukyanenko, Parsons, et al. 2019), although it did not involve visualizing using Markov networks.

[11] The LSM envisioned here is based on structural decomposition — based on hierarchical relations among sub-systems. Other variations of component diagrams are possible, such as those based on functional decomposition — the modeling of systems based on the functions they perform (Dietz 2006). In organizational design, which also deals with systems, it was found fruitful to combine structural and functional models (of firms) into matrix models (Galbraith 2014) — a solution which may prove useful for conceptual modeling as well.

implemented, the corresponding socio-technical system does not exist. The socio-technical system arises only when technology and people begin to work together to contribute observations of wildlife, as well as to use these observations in their research activities. Hence, an early LSM version (left) shows two disparate systems — the scientific group and a single box for citizens, as although a citizen is a socio-biological system, citizens are not organized into cohesive systems. With respect to one another, they are aggregates. Once NLNature is born, citizens become linked with other systems via the technological platform. These observations enabled by the simple LSM fragment are striking because they help explain some of the future dynamics of NLNature, such as the difficulty in reaching citizens, attracting them and motivating them to join and continue contributing. Furthermore, the LSM also shows that citizens in this domain do not form a supersystem with the wildlife, which means they are not intrinsically connected with the plants and animals. Once NLNature is put in place, it calls upon the people to go out and observe their surroundings.

Finally, this simple diagram underscores the critical importance of design choices for these types of technologies. With the weak links between citizens and scientists, the technology is a key mediator between them. Any technological barriers in communication become difficult to detect and overcome. Furthermore, absent NLNature, the incentives for citizens to make observations may be removed. The second LSM model reinforces these observations.

The post-implementation LSM model offers a high-level overview of the new socio-technical system. From LSM, we can quickly ascertain the components of NLNature we choose (e.g., based on stakeholder input and domain analysis) to conceptualize post-hoc as systems in order to reveal their complexity. Hence, Fig. 6 shows that the scientists formed a social system of their own, broken down into two departments, biology and information systems. Indeed, the scientists created a tightknit network around the project, shepherding its development and evolution.

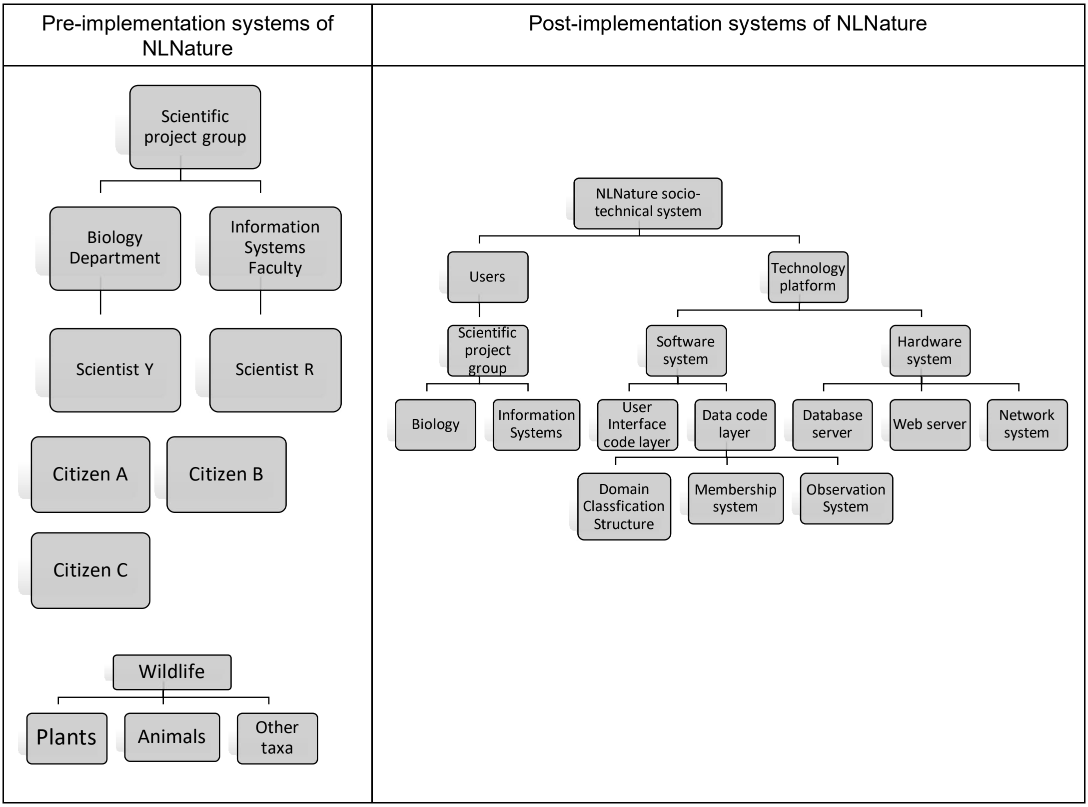

Figure 6: Level Structure Models of pre-NLNature systems (left) and NLNature socio-technical system (right) (adapted formalism from Weber (1997)); boxes represent systems at different levels; lines represent composition relationships. Note: in NLNature user interface and data code layers were designed as separate and interacting subsystems, to permit implementation on multiple devices.

In contrast, citizens were geographically dispersed, and largely anonymous to each other (and, to a degree, to the scientists). Unlike other Internet platforms, such as social media websites Facebook, Twitter or Youtube (Kitchens, Johnson, and Gray 2020; Levina and Arriaga 2014; Susarla, Oh, and Tan 2012) or collaborative crowdsourc-ing, such as Wikipedia (Arazy et al. 2011; Arazy and Nov 2010; Hansen, Berente, and Lyytinen 2007), *by design*, citizens never had an organizing system of their own. Any networks and connections grew organically by finding secondary uses of the design platform features. LSM shows this by not modeling a separate citizens sub-system of NLNature. Effectively, citizens, unless self-organized, were aggregates, parts of NLNature individually.

By analyzing the LSMs in Fig. 6, we better appreciate the interaction dynamics of the project, including its information and power imbalances. The development decisions taken in the past can be better understood with this hindsight model. Indeed, for the developers, it was much more straightforward to adopt a scientist view of reality (as in Phase 1 development), when the scientists were a tightknit and well-organized group. In contrast, conducting requirements, and then reconciling and modeling goals, values, needs of the highly dispersed, heterogeneous, and unorganized citizens presented a significant challenge. With no organization of their own, the voices of citizens were *systematically* ignored. This is a notable hindsight, which matches findings on power imbalances and conflicts in online communities, open source software, and other development settings (Björgvinsson, Ehn, and Hillgren 2012; Bratteteig and Wagner 2014; Fang and Neufeld 2009; Iivari 2011; van Wendel de Joode 2004).

4.4] Case Conclusions and Further Implications for Conceptual Modeling

From the analysis of the case of NLNature development, the following conclusions can be drawn, with implications for conceptual modeling. First, we conclude that just about any entity can be conceptualized as a system. Based on Bunge and modern science, systems are considered omnipresent, and can be found in almost any conceptual modeling diagram. In Fig. 3, strictly speaking, this includes all classes of the diagram. This, of course, does not mean that every class needs to be shown with a system construct. However, as the case illustrates, when the complexity of some of these objects becomes important to capture, representing these as systems becomes valuable.

Second, representing systems appears to go beyond merely showing the components. Hence, the tacit assumption that existing conceptual modeling constructs are sufficient for representing systems, may not hold. Note that popular conceptual modeling languages have used the composition construct to depict the relationship between parts and wholes (Yair Wand, Storey, and Weber 1999; Storey 1991a; Albert et al. 2003). Representing systems also involves capturing the environment, the structure and mechanism of a system, the system's boundary, the internal components and emergent properties, among other things. This is not often done in projects, hence, the CESM+ checklist can make modeling more disciplined and methodical.

Third, a key notion of emergence carries implications for conceptual modeling. As the ontology suggests, emergence is something that happens when the components are put together and begin to operate as a whole. Emergent properties are not directly, or easily, deducible from the properties of the components, because they emerge over time, as shown in the NLNature case. Herein lies a grand challenge: conceptual modeling occurs at the early stages of information technology development — before the IT is put to use. This means that, as information systems development shapes systems (e.g., work systems, enterprise resource systems, e-commerce systems), the a priori modeling of emergent properties may be extremely challenging, if not impossible. Hence, potentially critical properties of the systems developed with the help of conceptual modeling may escape modeling, and emerge afterwards.

Fourth, an important aspect of systems is the mechanism which, according to Bunge, gives the system its essence and is responsible for the interaction among the components as well as between the components and other systems (the environment). To capture mechanism is to explain how and why an event or process happened. For example, what is the mechanism by which social cohesion among members emerged on NLNature? Why did some observations reach identification consensus and others did not? Presently, this is an unchartered territory for conceptual modeling.

Finally, the systemic analysis does not mean that the last design iteration of NLNature was a failure. The ontological perspective taken by the project, which focused on the individuals, appeared to have addressed many of the important shortcomings of the previous approach. By focusing on the individuals, it allowed users with different backgrounds, levels of motivation, as well as familiarity and expertise with the natural history domain, to contribute observations using attributes and their own categories. Still, by ignoring systems, many valuable contributions were not appropriately captured, and many complex nuances lost. Hence, the adoption of the systemist modeling perspective, while still permitting the users to describe what they observed in terms of attributes and categories, appears to be a fruitful future design strategy.

5] Systems-Aware Methodological Guidelines for Conceptual Model Designers

The implicit treatment of systems ignores the fundamental ontological, and related cognitive and social status of systems in reality. While there are many outstanding questions regarding how to incorporate systems in conceptual modeling, existing conceptual modeling languages and methods already permit greater consideration of systems. By synthesizing the theoretical foundations, as well as the results from the analysis of the case study, we propose the following guidelines for conceptual model designers.

Guideline 1: Every modeling project may entail modeling systems. As the ontological theory claims, as well as evident in our case study, every entity type (or object, class), can be potentially conceptualized as a system, and hence, can be modeled using systemist constructs. Furthermore, systems may span multiple entity types or classes (discussed below), so there could be more systems that are valuable to model than there are classes or entity types. Systems are more ubiquitous than assumed by traditional conceptual modeling languages, approaches, and methodological guidelines. For some scenarios, such as those found in biology, complex engineering, or medicine, it may be prudent to assume a default status of all entities as systems. Nevertheless, *not every actual system should be conceptualized as a system*. This leads to Guideline 2.

Guideline 2: Model systems when complexity needs explicit representation. Modeling involves abstracting from irrelevant information that does not advance the purpose of modeling. The same applies to systems. Modeling something as systems should be beneficial when: the internal complexity of an entity needs to be shown; the emergent properties are important to capture; or when different system details (belonging to different levels) must be considered. In such scenarios, the additional cognitive and learning effort, as well as a potential increase in diagrammatic complexity, or the need to develop and consult additional diagrams, may be offset by the benefits of exposing the system complexity.

As we showed in the NLNature citizen science case, a useful tool for scoping the systemist analysis is the Level Structure Model (LSM) as introduced in this paper. An LSM depicts horizontal relationships between system components and provides a high-level overview of the entire system. It can be used to delineate the scope of the systemist analysis for projects, which then guides the subsequent deeper inquiries covered by the Guidelines 3–5.

Guideline 3: Follow CESM+. Once systemist conceptual modeling is adopted, analysts can follow the CESM+ checklist. Bunge's conception of systems entails describing them using the CESM model. We adapted this idea into conceptual modeling as CESM+. This new conceptual modeling formalism should act as a guide for modelers on how to approach systems-grounded conceptual modeling. It is a roadmap that can help ensure the conceptual modeling diagrams end up with a comprehensive view of focal systems in a domain from different and converging perspectives.

To realize CESM+ for a given system, multiple systemist conceptual modeling constructs are needed and multiple conceptual modeling diagrams may be required. To develop CESM+ conceptual models, analysts are advised to seek most effective and reasonable (Guizzardi and Proper 2021; Op't Land et al. 2009) ways to represent each element of CESM+.

Producing CESM+ conceptual models can partially be accomplished without the need to modify existing conceptual modeling grammars. Hence, the composition of the system can be shown using a *part-of* relationship in languages that support it (e.g., UML, ArchiMate). The environment may be shown as other entities that interact with the focal system (as in the example in Fig. 4).

The structure can be shown using relationships. For this, relationship-focused languages, such as ER, ORM, or UML may be used, but some extensions to these languages may be required. For example, it could be helpful to indicate whether these are *systemic* vs. *ad-hoc* relationships.

Finally, although no direct strategy appears to fully support showing mechanisms and their explanations, elements of mechanism can be shown using existing methods. For example, to show how systems conditionally react to different inputs, process models (e.g., BPMN, EPCs, petri nets) can be used. For technical systems, data flow diagrams (DFDs) could be applicable. For discrete-event systems (such as electric devices), statecharts can be applied (Briand, Labiche, and Cui 2005; Harel 1987).

To understand why systems change, languages that take a social or agent-oriented perspective are best suited. These include actor, intention and goal models (e.g., Telos, i*) (Habli et al. 2007;

Mylopoulos 1992; Paja et al. 2016; Yan et al. 2015; E. S. Yu 2009). Finally, auxiliary conceptual modeling tools, such as narratives (Burton-Jones and Meso 2008; Hvalshagen, Samuel, and Lukyanenko 2017), can also be used to capture the nuances of mechanismic explanations. Other aspects of CESM+, such as emergent properties, can be represented following the considerations provided in the next guideline.

Guideline 4: Anticipate and model emergence. The *plus* component of CESM+ suggests to model emergence. Emergent properties are not straightforward to derive and may not even manifest themselves at the time of modeling. At the same time, some strategies can be effective for anticipating and modeling emergent properties.

We suggest that designers should simulate the lifespan of a system, using tools or imagination. This can be, for example, the imagination or simulation of the implementation and usage of the artifact built with aid of a conceptual model. Here, such techniques as agent-based modeling and dynamic system simulation can be useful (Bandini, Manzoni, and Vizzari 2009; Burton-Jones, McLean, and Monod 2015; Nan 2011; Railsback and Grimm 2019).

Some emergent properties can already be modeled using existing grammars. The dependencies in *i** (E. Yu 2002; E. S. Yu 2009) are indeed emergent properties that arise from the agents interacting together. Hence, at least for some domain semantics, such as those dealing with goals, tasks and resources, a Strategic Dependency models may be used.

Another potentially relevant technique is *disciplined imagination* proposed by Weick (1989; 1995) within the context of theory development. Indeed, the anticipating of the application and use of a theory corresponds to the challenge of capturing emergent properties. In this context, the technique implies a deliberate, and persistent mental simulation of a development or use of the modeled system as an attempt to foresee its emergent behavior.

Finally, although not definitive, another approach is small-scale “pilot” or “beta” realization and deployment of the technology based on the conceptual model, in order to observe its emergent behavior *in vivo*. This technique may prove useful for some scenarios; however, the behavior of a scaled-down system may not always match the behavior of the full-blown system. As Bunge explains, simulations can be valuable, but they cannot definitively capture all possible emergent properties of systems (M. A. Bunge 2003a). Generally, artificial systems, such as software components of socio-technical systems, under idealized and controlled conditions, are more amenable to simulation. However, the knowledge resulting from simulations of natural systems (including human social and socio-technical systems) will not offer a full view of the system since complete reduction of natural systems to its components is impossible. For a full understanding of the behavior and impact of a system, the system as a whole in its natural setting needs to be observed (see also, Bedau 1997). Still, even limited understanding of system's emergence can be much more helpful than complete ignorance.

Guideline 5: Model systems by re-interpreting or modifying existing notations Although a comprehensive conceptual modeling support for CESM+ does not yet exist, there are, in fact, many possibilities for

modeling systems by re-interpreting or making minor modifications to existing conceptual modeling languages. Below we highlight some of the possible options.

Option 1: Model using patterns or templates. Patterns and templates can be used with many existing conceptual modeling languages (e.g., UML class diagrams) to show typical, representative or anomalous systems in a domain. Hence *part-of* associations can be used to show composition; relationships can be used to show structure; activities and gateways can be used to show some aspects of the mechanism. For example, typical, or most common, species of NLNature can be modeled using patterns. For *birds*, a pattern could indicate parts, such as wings, beak, legs, and breast, which are the most common components that users describe using attributes. For *flowering plants*, stalk, leaves, and flowers could be modeled as parts. Such models could dictate the database structures and user interface features to accommodate a more nuanced user input. Hence, when a user attempts to enter an observation of a bird, a system could present a systemic schema showing the bird components and elicit attributes of the parts as well as the whole.

Option 2: A basic system construct in the diagram. In cases where is too much variations, an option is to alert the interface developers of the complexly by representing a particular class using an explicit system construct. This may or may not require significant modifications to the existing conceptual modeling grammars; that is, rules for creating conceptual models (discussed below). For example, a simple way to show a system could be based on a UML stereotype, as shown in Fig. 7. This may be sufficient in some cases as a simple way to signal complexity and potential emergence, although none are explicitly shown. Such a construct could be interpreted as, for example, the need to provide flexible database and user interface capabilities. For example, this modeling approach could indicate the need to provide key–value pairs or ontology-based data collection to better relate the part attributes to the whole; or emergent properties that are also expected as attributes of such classes.

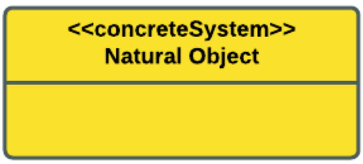

Figure 7: Modeling a system using UML stereotype.

Option 3: Extended system construct in diagram. To show emergent properties, more nuanced representations may be needed, which would go beyond merely indicating that something is a complex object. To illustrate, we propose a tentative ***multi-entity system*** construct shown in Fig. 8. The multi-entity system construct allows to represent cases when a system covers multiple entities, which in addition to being able to show system components and their relationships (or structure in CESM+), permits distinguishing between aggregate and emergent properties. Naturally, the introduction of the multi-entity system construct requires a deeper reengineering of existing conceptual modeling grammars. This is a point we revisit later.

Summary. As evident from the guidelines provided here, adopting a systemic perspective in conceptual modeling can be achieved

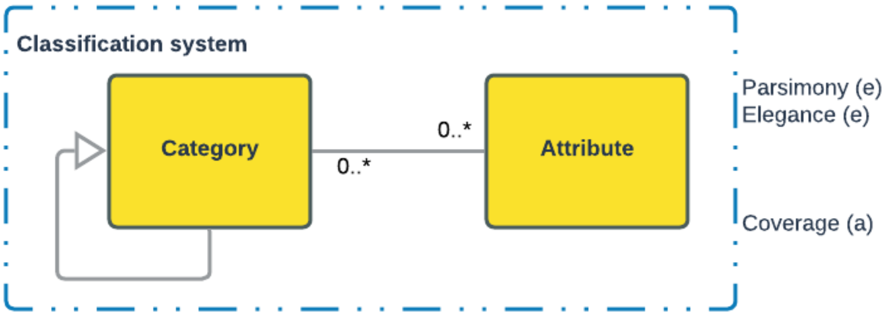

Figure 8: Modeling a system by extending UML grammar to distinguish aggregate (a) and emergent (e) properties.

without waiting for more extensive research on the various aspects of representing systems. Table 3 summarizes the above approaches to introducing systemist-constructs into conceptual modeling and their expected benefits. The table also outlines the general the benefits of systems-grounded conceptual modeling, based on the preceding discussion and examples. This is by no means an exhaustive list of possible constructs to represent systems. One area of future research is to investigate these additional means of representing systems, producing an entire agenda for future conceptual modeling scholarship, which we highlight in the following section.

Table 3: Examples of systems-related constructs and their expected benefits along with the benefits of systems-grounded conceptual modeling

Diagram or Pattern Name	**Description and Possible Implementation**	**Suggested Common Use Cases and Modeling Benefits**
System Boundary Model (SBM)	Representation of the boundary components of systems. These can be shown using a proposed System Boundary Model (e.g., Fig. 4) or by annotating existing structural diagrams, such as an entry-relationship or UML object or class diagram	• Boundary objects can be valuable to model since unanticipated events often occur when components of one system begin interacting with the components of another system • The potential impact of the boundaries on the ways humans interact with them can be made more explicit

Level Structure Model (LSM)	The LSM shows the main higher-level systems in a project. The goal of LSM is to depict the horizonal relationships between system components related via composition	• Provides scope of the systemist analysis (i.e., what are the systems in the domain or the system-to-be-built worthy of systemist analysis) • Offers an overview of the larger system • Can be used both before and after the system is being implemented
Systems design templates	Representations using existing conceptual modeling constructs (e.g., part-of associations) to show CESM+ components of typical, representative or anomalous systems in a domain	• When the diversity of systems is large and it is impractical to model every system, design patterns can be used for typical, representative or anomalous systems • Modeling typical or representative systems allows to signal typical use case scenarios in a domain
UML <<system>> stereotype	Shows that a class or object in question is complex, without revealing the complexity	• Alerts the interface developers of the complexly of the object, and hence, the need to have flexible input • Allows to reduce diagram complexity • Useful when diversity of systems can be large (e.g., many kinds of products), but this diversity does not need to be explicitly modeled
Multi-entity systems construct	The multi-entity system construct allows to represent cases when a system covers multiple entities	• Shows emergent properties • Shows system components and their relationships • Permits distinguishing between aggregate and emergent properties
CESM+	Roadmap and checklist for systems-grounded conceptual modeling. It is a template which reminds modelers to represent Composition, Environment, Structure and Mechanism and other facts about systems	• A guide for modelers on how to approach systems-grounded conceptual modeling • Ensures key facts about systems are considered for representation • Allows to briefly summarize key facts about systems
General benefits of systems-grounded conceptual modeling	• Greater systematization of conceptual modeling activities, especially related to representation of systems • Common concepts and vocabulary for communicating about systems of various kinds • Greater appreciation of the boundaries of systems, and the potential opportunities and challenges at the project's "seams"	

	• Explicit representation of the often-tacit facts in a domain (e.g., systemic interactions, key mechanisms), which could help guide and prioritize development efforts • More systematic examination of emergence, with potential to anticipate potentially harmful or challenging emergent properties • More explicit understanding of the relationships between the components of systems and the emergent and aggregate properties and behavior of these systems • Better guidance for user interface and database design (e.g., by suggesting which complex objects require flexible design choices) • Increased ability to understand, create and manage social and organizational complexity

6] Agenda for Systems-Focused Conceptual Modeling Research

Systems are the ontological primitives upon which, one could argue, other conceptual modeling constructs can be built. This, we propose, is a new approach to conceptual modeling, which brings exciting opportunities for future conceptual modeling research. Below we suggest several fruitful research directions to better incorporate systemist notions into conceptual modeling.

6.1] Research Direction 1. When to Use the System Construct?

Under the ontological assumption that virtually every entity in existence (even admitting a few exceptions, such as photons or quarks[9]) are systems, any object could be conceptualized by stakeholders as a system and hence may need to be represented using one or more system constructs. This applies both to modeling using abstractions (such as entity types or classes) (Peckham and Maryanski 1988; Smith and Smith 1977) and to instance-based modeling, in which individual occurrences or instantiations of things form the basis for the modeling (Lukyanenko, Parsons, and Samuel 2019; Jeffrey Parsons and Wand 2000; Saghafi, Wand, and Parsons 2021; Samuel, Khatri, and Ramesh 2018). Yet, as stated earlier, physics and philosophy notwithstanding, "[a] system is not something presented to the observer, it is something to be recognized by him/her" (Skyttner 1996, 16). Indeed, the NLNature case demonstrated that. Over the course of ten years, multiple systems could be identified in the project (see LSM in Fig. 6). Still many more classes in the Phase 2 diagram (Fig. 3), for example, do not appear to benefit from the exposure of hidden complexities (e.g., Rating, Like, Attribute, Comment). Indeed, such unpacking of the CESM+ elements would add much overhead and complexity to the conceptual model for little evident gain.

It is likely that not every entity or object could benefit from being represented as a system. The very idea of conceptual modeling is to deliberately abstract from unnecessary, irrelevant details, and to focus only on those aspects of the domain that are important to represent for a particular purpose (Mayr and Thalheim 2020; Olivé 2007; Smith and Smith 1977; Motschnig-Pitrik and Storey 1995; Goldstein and Storey 1999). In many modeling applications, it is sufficient to represent an entity as an atomic, singular unit, rather than a complex object. It is then necessary to understand the design principles underlying the distinction between modeling parts of reality as singular entities versus modeling them as complex objects, systems.

In this paper we provided suggestions for when explicit modeling of the system may be beneficial: in cases where the consideration and representation of CESM+ components is warranted. Still, this does not exhaust the issue. Emergent properties are difficult to anticipate in advance. How would an analyst know that, for example, the innocent looking Like class, does not harbor important and consequential emergent properties? More generally, how does the analyst know that what stakeholders describe as system-abstractions (see Table 1) are indeed worthy of modeling using a system construct? By considering these questions, future research can offer a more formalized set of procedures for determining the need for system modeling and systems-driven requirements elicitation, contingent upon the specific parameters and constraints.

Once the principles for how to identify the scope of systemist analysis are established, they can inform the rules for developing the Level Structure Model (LSM diagram) introduced in this paper. Equipped with these rules, this diagram can then be interpreted with less ambiguity, as definitively representing the scope of the systemist analysis.

It may be true that there are no simple, structureless entities, and even elementary particles are complex objects/systems (i.e., composed of other systems). Therefore, this possibility implies an infinite recursion. For the majority of applications, it is not a practical challenge because it is not necessary to model elementary particles such as quarks, and then seek to model its components and then the components of these components. Yet, for those cases where modeling such entities could be needed (e.g., Ali, Yue, and Abreu 2022; Seiden 2005), some representations of the system construct may be inappropriate. Hence, further work is needed that focuses on the problem of recursion and ways to address this issue without introducing infinite loop possibilities into conceptual modeling grammars. Such work may benefit from a long-standing debate in philosophy on the nature of infinite regress (Aikin 2005; Bliss 2013; Cameron 2008; Nolan 2001; Smart 1949).

6.2] Research Direction 2. Development of the Representation of Systems

Representing a system involves more than simply identifying the component parts, as currently supported by the popular conceptual modeling languages, such as UML. Systems indeed appear to require a dedicated representation. For example, Bunge proposed the CESM model, which is also incorporated in the BSO ontology. We suggested this ontological idea could become a design template for representing systems in a conceptual model, termed CESM+. While CESM+ can immediately be a useful checklist for considering different aspects of systems (as we showed in Table 2), finding the most effective ways of representing the different components of CESM+ would require additional design work in conceptual modeling to determine how to incorporate the CESM+ components into conceptual modeling diagrams.

A pressing question is how to represent the individual elements of CESM+. Many existing conceptual modeling grammars (e.g., UML Class Diagrams) contain provisions for representing, for example, system components (via part-of relationship). However, a more challenging issue is how to represent the environment (by showing what a system is and what it is not, which requires an explicit focal system/other systems distinction among constructs). Virtually all systems are open (meaning that boundary components may interact with the environment directly), so it may be helpful to depict this explicitly.

The challenge further becomes how to represent the structure that captures the dependencies among the components. Here, for example, an objective may be to distinguish between systemic interactions (e.g., work or payment relationships between employers and employees), versus ad hoc interactions that occur as part of the system, but do not define its structure (e.g., a one-time invitation from an employee to assist with a house move). Although the *i** was developed to support modeling of actor goals and intentions (E. Yu 2002; E. S. Yu 2009), an intriguing possibility is to use this framework to capture the dependencies among systemic components.

Another challenge is how to incorporate the mechanism, which is an aspect of the system that provides its essence and carries an explanation for why the system behaves in a particular way. This provides a new avenue in conceptual modeling thinking, which expands the objective of conceptual modeling from that of representation, to also include an explanation.

Assuming additional provisions to represent CESM+, research is needed to consider the increased complexity of the diagrams so that the introduction of additional elements is clearly identified and effective visual representation of the elements is found. Such research would benefit from guidance on: managing complexity (Batra 2007; Andrew Gemino and Wand 2005; Kaul, Storey, and Woo 2017); the physics of conceptual modeling notations (Moody 2009); cognitive mechanics in diagram processing (Malinova and Mendling 2021; Topi and Ramesh 2002); and the evaluation of different conceptual modeling design choices (Burton-Jones, Wand, and Weber 2009; Lukyanenko, Parsons, and Samuel 2018; Jeffrey Parsons and Cole 2005).

Although CESM+ can be a series of textual descriptions describing various system components (see Table 2), based on multimedia learning theory (Mayer 2002; Mayer and Moreno 2003), we can predict additional benefits from the CESM+ template if it could be depicted graphically. This could be a kind of ***Systems Canvass***, an idea akin to Business Model Canvass by Osterwalder and Pigneur (Avdiji et al. 2020; Osterwalder and Pigneur 2010; 2012). Future research could elaborate on the idea of a Systems Canvass as a graphically-organized high-level description of a system following the CESM+ template.

The extensions of CESM+ can be investigated. For example, CESM+ does not consider the functions systems perform. Since many systems designed with the support of conceptual models are functional artifacts (Chatterjee et al. 2021; Kroes 2012; Lukyanenko and Parsons 2020a), future studies could extend CESM+ to take into account the functionality of these systems and, possibly, relate it to the other elements of CESM+ (e.g., mechanism).

We followed Bunge and suggested CESM+ as a guide for describing systems. The CESM+ model is general and can be used to model natural and artificial systems. However, other systemist models can be more applicable, especially for specific kinds of systems. An opportunity for research is investigating different approaches to representing systems, beyond the CESM model. For example, one such model is Checkland's CATWOE (customer, actor, transformation, world view, owner, environment) (Checkland 1999; Smyth and Checkland 1976). This model can be an effective representational template especially for purposeful systems that have defined owners, customers, and a world view, which is something that CESM does not distinguish (for analysis of CATWOE, see, e.g., Basden and Wood-Harper 2006; Bergvall-Kåreborn, Mirijamdotter, and Basden 2004). Future studies can evaluate the strengths of different systemist modeling templates, which would be akin to comparisons between different general ontologies or modeling formalisms. These comparison studies are well-established in conceptual modeling research (e.g., Aguirre-Urreta and Marakas 2008; A. Gemino and Wand 1997; Andrew Gemino and Wand 2005; Guizzardi 2005; Terry Halpin 1995; Kim and March 1995; Recker et al. 2011; Shanks et al. 2008; Verdonck et al. 2019) and have developed methodological bases (Bera, Soffer, and Parsons 2019; Burton-Jones, Wand, and Weber 2009; Delcambre et al. 2021; Lukyanenko, Parsons, and Samuel 2018; Jeffrey Parsons and Cole 2005; Purao and Storey 2005; Saghafi and Wand 2014; Siau and Rossi 1998; Söderström et al. 2002), which could be applied to the systemist model comparisons.

6.3] Research Direction 3. Modeling of Emergence

A key notion of the systemist approach to modeling is that of emergence, which is captured as the *plus* in CESM+ modeling template. As argued and shown in the case of the development of a real information technology, emergence is an omnipresent phenomenon when dealing with complexity of real-world domains. The problem, however, is that conceptual modeling happens typically at the early stages of the information systems development and assumes a static representation of the domain.

The prevailing approaches to conceptual modeling appear ill-equipped to capture the emergence and provide the requisite support for the technology development. As already noted, in certain cases, emergent properties can be evident, especially for large complex systems, such as the entire NLNature. However, how do we know which object of modeling is void of consequential emergence? A major future research direction is how to simulate emergence, and incorporate it into conceptual modeling diagrams, methods, and techniques. There is an exciting opportunity for conceptual modeling research to collaborate with disciplines that have dealt with dynamic systems, such chemistry, physics, engineering, medicine, and social science. Solutions may be potentially found in such techniques as agent-based modeling and dynamic system simulation (Railsback and Grimm 2019; Bandini, Manzoni, and Vizzari 2009).

We already discussed Markov networks for some emergent properties within the context of NLNature. Markov networks have been popular in the artificial intelligence community for visualizing and modeling complex stochastic processes (Domingos 2015; Sherrington and Kirkpatrick 1975). Leveraging Markov networks in conceptual modeling (e.g., as graphs supported by data produced by model simulations) may create synergies between artificial intelligence (machine learning) and conceptual modeling, which is an emerging conceptual modeling frontier (Bork 2022; Fettke 2020; Lukyanenko, Castellanos, et al. 2019; Maass and Storey 2021).

The application of such emergence-inspired notions as disciplined imagination (Weick 1989; 1995) can also be investigated. Finally, such frameworks as dependencies in *i** (E. Yu 2002; E. S. Yu 2009) may also be effective means of modeling certain emergent properties.

6.4] Research Direction 4. Analysis of Existing Conceptual Modeling Constructs Based on Ontological Systemism

Existing conceptual modeling constructs can be subjected to ontological analysis, as in prior research on conceptual modeling languages (Evermann and Wand 2006; Guizzardi and Wagner 2008; Hadar and Soffer 2006; Reinhartz-Berger, Sturm, and Wand 2012; Sales et al. 2017; Y. Wand 2008; Yair Wand, Storey, and Weber 1999; Welty and Guarino 2001). Indeed, both the entity and attribute constructs may suffer from construct overload when systems are taken into consideration. The entity construct often represents atomic, as well as complex, objects. Likewise, an attribute construct may denote intrinsic, aggregate, or emergent properties. Future research can consider the implications of these cases of construct overload for domain understanding, model expressiveness, and other dependent variables of interest.

This ontological analysis could be extended to specific applications for evaluation of the effectiveness within a domain. Such research could provide an ontological explanation for existing constructs, such as dependencies in *i**, pools in BPMN, because both constructs implicitly represent aspects of systems. The new approach to explicit modeling of systems proposed in this research, can serve as a basis for further refinement of these constructs.

6.5] Research Direction 5. Expansion of Existing Conceptual Modeling Languages

Accepting the merit of using a dedicated system construct implies that existing conceptual modeling languages can be enriched through the addition of a dedicated system symbol. For example, the entity-relationship diagram could now include another major construct (system), making it a diagram that represents entities, attributes, relationships, and systems. A system can be represented as a dashed box surrounding the entity types, which are deemed as components or parts of the system (e.g., as done in Fig. 8).

The addition of the system construct leads to the rethinking of the ontological status of the entity. Once system is added to the entity-relationship model, the "entity" construct can be understood as an atomic, simple object. Everything can be deemed to be a system. However, in practical cases, where showing system complexity is irrelevant for the task at hand, we can model systems as entities; that is, structureless systems (an oxymoron, of course). For these scenarios, the construct of an entity can be uniquely reserved, and contrasted with the construct of a system, which is a construct exclusively reserved for entities conceptualized as complex. Future research is needed so systems can be incorporated into the grammars. As suggested with our analysis of the entity-relationship diagrams, this may require rethinking the definitions of existing constructs within these languages.

6.6] Research Direction 6. A Systems Perspective for Model-Driven Development and MDA-Based Approaches

The use of a system notion can be a novel solution to the lack of a conceptual integration for the different systemic components of a real world MDD/MDA (Model-Driven Development/Model-Driven Architecture) specification (Ambler 2003; Beydeda, Book, and Gruhn 2005; X. Yu et al. 2007). In MDA terms, different models are at different levels of abstraction, such as Computation-Independent Model (CIM), Platform Independent Model (PIM), or Platform Specific Model (PSM). These focus on different relevant conceptual granularities, each covering a specific system dimension, whose integration is not a simple task. This is not as evident as it should be when we consider the system as a holistic conceptual unit. For instance, an i* organizational model (CIM level) (Giannoulis and Zdravkovic 2011; Horkoff and Eric 2008) represents a goal model, whose task dependencies between actors should be described in detail using BPMN model components (PIM level dealing with system functionality). The data participating in those BPMN processes must be identified and represented in a data model (e.g., an ER model, conforming to a PIM level from the data structure point of view).

These different levels are really representing different perspective of the whole. Preserving this unified systemism perspective is crucial. This is because a conceptually grounded, sound traceability between the different levels of abstraction used in the process of describing the system is essential to achieve a sound IT design. The notion of system can help to conceptually deal with MDA-based model transformation processes, and assess their quality by providing a holistic perspective, which is too frequently omitted. Further research could explicitly consider the benefits and limitations of adopting a systemist perspective in MDD/MDA contexts.

7] Conclusion

In response to the increasing demands on IT development, this paper has argued for the need to model an overlooked notion of a system as a basic conceptual modeling construct. The system construct is firmly based on ontological principles that serve as its fundamental justification. The proposed systemist approach was illustrated through application to a case study for developing a citizen science application. Doing so has shown that modeling with greater, and explicit, consideration of systems appears to be a fruitful way to deal with our ever-changing, and increasingly complex, reality. Recommendations for future research are based on a set of specific modeling needs, namely, the need to model the complexities of the physical and digital realities. Overall, the systemist approach will require revisiting well-known and well-accepted modeling constructs to progress conceptual modeling of contemporary and future applications and, in doing so, provide new opportunities for conceptual modeling research and practice.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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In Defence of Linguistics as an Empirical Science in Light of Mario Bunge's Defence of the Scientific Treatment of Biology

Dorota Zielińska[1]

Abstract—Although few linguists currently embrace the empirical paradigm, there are increasing calls for the development of tools for studying language that resemble those in exact sciences. This trend can be observed even in top mainstream linguistic journals, such as the *Journal of Pragmatics*, as exemplified by Xiang (2017). Today, however, linguists who adapt the methodologies from more advanced sciences face isolation from the mainstream linguistic community. This is because the majority of linguists in philological and philosophical departments remain convinced that the object of their studies is fundamentally different from those studied by physicists. Therefore, they argue that linguistic methodology cannot resemble that used in empirical sciences. As a result, linguistics is often seen as requiring interpretation rather than an explanation, and evaluation of linguistic research is based on acceptance within the scholarly community rather than empirical testing.

Résumé — Bien que peu de linguistes adoptent actuellement le paradigme empirique, il y a une demande croissante pour le développement d'outils d'étude du langage similaires à ceux des sciences exactes. Cette tendance peut être observée même dans les principales revues linguistiques, telles que le *Journal of Pragmatics*, comme l'illustre Xiang (2017). Aujourd'hui, cependant, les linguistes qui adaptent les méthodologies des sciences plus avancées sont isolés de la communauté linguistique. En effet, la majorité des linguistes des départements de philologie et de philosophie restent convaincus que l'objet de leurs études est fondamentalement

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différent de ceux étudiés par les physiciens. Par conséquent, ils soutiennent que la méthodologie en linguistique ne s'apparente pas à celle utilisée dans les sciences empiriques. Par conséquent, la linguistique est souvent perçue comme une science interprétative plutôt qu'explicative, et l'évaluation de la recherche en linguistique se fonde alors sur le consensus au sein de la communauté scientifique plutôt que sur des tests empiriques.

Keywords—Language laws, Empirical paradigm, Mario Bunge, Expectation field, Operationalization.

> Follow the evidence wherever it leads, and question everything.
>
> NEIL DEGRASSE TYSON

In this article, we will critically analyse several common arguments used to support the misconception that linguistic methodology cannot resemble that used in established empirical sciences and show that they do not hold up to scrutiny. To accomplish this, we will draw inspiration from Mario Bunge's famous defence of biology as an empirical science articulated in the '60s of the previous century, during a time when many biologists vehemently opposed a scientific treatment of their discipline.

1] Part One: The History of Language Laws

Half a century ago, mainstream biologists still strongly opposed introducing the scientific method to their discipline. Groups of biologists put forward a plethora of arguments against treating biology in the same way that physicists approach physical phenomena. The arguments ranged from the objection that live organisms cannot be studied in the same way as inanimate matter, to pointing out the special role of the comparative method in biology. Today, no biologist questions the value of molecular biology, biotechnology, genetics or epigenetics—disciplines firmly placed in the empirical paradigm—despite the continual use of the comparative method when classifying newly discovered species of plants and animals.

A similar dispute had also taken place among psychologists and sociologists before many of them embraced the empirical paradigm. And what about linguistics? Must linguistics and empirical sciences belong to two distinct cultures with incompatible research methods and evaluation criteria, as Snow (2001) framed the question? While scientists and a growing number of maverick linguists adapting the scientific method to study language answer “no” to this question, mainstream professors of linguistics in high places still advocate for there being a chasm between sciences and linguistics. Why?

According to Grzybek (2006), many contemporary linguists oppose the treatment of linguistics in parallel to empirical sciences due to the vehement criticism received by the Neogrammarians for their allegedly similar approach to studying the history of Indo-European languages. For quite a while, the Neogrammarians attempted, unsuccessfully, to find exceptionless rules of the sound changes taking place in languages over time. As a result, the idea that language can be captured with linguistic laws—as laws were understood by linguists at that time—was widely criticized and rejected by the linguistic community. However, this conclusion was drawn only because the linguists at that time, just as most mainstream linguists today, understood the concepts of a law differently from physicists.

Before explaining what distinguishes the concepts of the law in natural sciences from that entertained by the Neogrammarians and other mainstream linguists, first let me note that physicists search for two types of laws: summarizing and explanatory. Summarizing laws, such as Kepler’s laws, are descriptive laws that summarize patterns from observed data, as algebraic formulae, to answer the question of **how** things behave. For instance, Kepler discovered patterns in the movements of planets using data collected by Tycho Brahe and expressed them as formulae for ellipses. Explanatory laws, on the other hand, hypothesize the material causes of such patterns by positing the causative role of some material characteristics of the observed phenomena. Newton’s laws, for instance, which explain the movement of material bodies, are such explanatory laws. They can be used to explain Kepler’s summarizing laws, elucidate **why** planets orbit the Sun in elliptical paths.

The Neogrammarians searched solely for summarizing laws, which is the first difference in understanding the concept of law in physics and traditional linguistics. However, it should be noted that looking exclusively for summarizing laws is a legitimate goal of proper scientific research, too. The crucial difference in understanding the concept of law in those two disciplines concerned the fact that all linguists at that time believed in the exceptionless nature of all laws and assumed that laws are always deterministic and thus can always be expressed as algebraic formulae. In this sense, these potential linguistic laws were meant to resemble Kepler's laws. Therefore the Neogrammarians, searching for sound change laws in language viewed as an abstract structure (*langue,* to use Saussure's terminology), hoped to discover laws that fit the data (consisting of sound types, not sound tokens) perfectly and could be expressed with algebraic formulae.

By the end of the 19th century, having failed to find such laws, the Neogrammarians and other mainstream linguists observing them, began to develop an aversion to linking linguistics to the empirical sciences. The linguistic community began to embrace the view that language differed so significantly from physical phenomena that linguistic studies required a methodology completely different from that employed in the natural sciences. These scholars believed that linguistic research required interpretation rather than an explanation, and thus, it was necessary to assess the merit of such research based on acceptance within the discipline-specific scholarly community, rather than through empirical testing.

It was not until the second half of the 20th century that Noam Chomsky, the most cited linguist ever, acknowledged the importance of considering the material causes of language (*langue*) and proposed that language has its origins in psychological processes. However, he also held the view that the task of linguists is to find algebraic-like, exceptionless algorithms that generate various **types**, not **tokens,** of sentences, and he delegated the task of discovering the causes of such linguistic laws to psychologists. In other words, Chomsky and his followers, known as generativists, just like the Neogrammarians, sought to find linguistic laws expressed as algebraic formulae perfectly summarizing the observed data consisting of **types** of linguistic items. This assumption of the existence of an algorithm that captures the generation of every sentence type in a language, made the generativists' effort destined to fail, for reasons that will be explained soon.

At the end of the 20th century, in reaction to generativists' efforts falling short of expectations, linguistics witnessed a cognitive turn. Cognitivist linguists, among them prominently, Ronald Langacker and George Lakoff, independently proclaimed that language mechanisms cannot be captured with laws understood in the same way since the Neogrammarians. Lakoff (1987) illustrated his claim by arguing that there cannot be a general semantic law concerning the meanings of compound words that, for instance, can derive the meaning of the lexeme *overlook* from the meanings of the lexemes *over* and *look*. The meanings of *over* and *look* can only "motivate" the meaning of the lexeme *overlook*. In other words, these meanings can only indicate that there is SOME relationship between the meaning of *overlook* and the meanings of its components and thus, it makes sense that *overlook* means what it does.

While this observation is true, it is important to note that the reason why these linguists failed to find exceptionless laws was because these linguists were concerned only with language as an abstract structure (Saussure's *langue*), and they understand the concept of law as an exceptionless algebraic formula summarizing data. Bunge explains below why such assumptions prevented these scholars from succeeding:

> Languages [treated as *langue*—D.Z.] do not develop or evolve by themselves and there are no mechanisms of linguistic changes, in particular evolutionary forces. Only concrete things, such as people can develop and evolve. And, of course, as they develop or evolve, they modify, introduce, jettison linguistic expressions. The history of mathematics is parallel: mathematicians do come up with new mathematical ideas, which are adopted or rejected by the mathematical community, but mathematics does not evolve by itself. (Bunge 2003: 62)

In other words, Bunge argues that since abstract systems, such as *langue*, cannot change by themselves, therefore there cannot be empirical laws of *langue* describing such change or its results. However, Bunge's argument implies that, within an empirical paradigm, one may legitimately search both for explanatory and summarizing language laws concerning *situated parol*. *Situated parol* refers to utterances pronounced on a specific occasion by specific interlocutors involved in a specific communication process, which means it is a verbal aspect of the communication[2] process taking place in the system of material bodies of people participating in verbal interactions in specific socio-natural contexts, also known as

[2] It is important to note that since *situated parole* is an aspect of the communication process, describing it fully must involve comprehension. A similar view was already expressed by Dummett (1993: 12), who stated: "a theory of meaning must also be a theory of understanding" (cf. Searl 1983).

situated speech acts. Because *situated parole* is an aspect of a material system, a psycho-socio-natural phenomenon of communication, it can be researched within an empirical paradigm, and described with language laws. At this point an open question remains, as to whether language laws searched for in the empirical paradigm can always be captured in terms of exceptionless algebraic formula. This depends solely on the characteristics of the "material system" that produces *situated parole,* or more precisely, on our knowledge of those characteristics.

So what do we know about that material system generating *situated parol*? Since human cognitive capabilities are the result of self-organising and self-regulating, non-linear processes, it is reasonable to assume that the human ability to form and use language is also shaped by such processes. Consequently, an explanatory theory of a person's idiosyncratic language must be a theory of language acquisition and use by that individual. Such a theory must reflect **the history** of the interlocutor's solving specific communicative challenges in specific situations based on socio-cognitive mechanisms operating against the background of the correlations between language forms and meanings already engraved in their memory.

Assuming language has self-organised and keeps self-regulating, similar to all natural, self-organising, non-linear systems, we cannot expect to be able to predict the occurrence of a particular utterance, a novel sentence pattern, or the meaning of a novel compound word with exceptionless algebraic laws. Just as much, as we cannot predict the exact characteristics of a specific volcano eruption, the shape and timing of a specific avalanche, or of a specific tornado. This is because these outcomes depend on the specific history of the development of the "material system" in question, which can never be known with sufficient precision. Furthermore, being non-linear implies that even slight imprecision in their measurement makes any long-term predictions futile. Therefore, all we can say about such systems is describing trends in their development and results, meaning we can only define stochastic laws for them.

In the same vein, the only type of language laws that can be discovered and tested within the empirical paradigm are **probabilistic** laws that model **trends** in the occurrences of such specific utterances (i.e., trends in *situated parole*). In other words, we cannot hope to ever find exceptionless algebraic laws concerning *langue* (understood as trends, dominant patters in language use), which is what the Neogrammarians, and the Chomskyians sought to uncover.

Given that the vast majority of linguists still hold the view that *langue* is the object of the science of language and that laws can be expressed as exceptionless algebraic formula, the prevailing belief in mainstream linguistics is that "there can be no language laws". This belief is supported by several accompanying myths, akin to those Mario Bunge dispelled in his defence of biology as an empirical science over half a century ago. In the following sections, I will address some myths in linguistics that discourage many linguists from embarking on the empirical paradigm.

2] Part Two: *Myths*

2.1] Myth One: Linguistic rules are non-nomothetic, while empirical sciences are concerned with natural phenomena describable with nomothetic laws.

One of the most prominent arguments for the belief that linguistic laws differ fundamentally from physical laws has been the assertion that the latter have exclusively nomothetic character, while the former are non-nomothetic. However, this argument is flawed because not all laws in physics are nomothetic.

The term "nomothetic" was introduced by Windelband in the 19^{th} century, meaning "deterministic, based on deduction." A few years later, Windelband, along with his disciple Ricket, proposed that sciences differ from non-empirical disciplines by being concerned with the phenomena describable with nomothetic laws. In the late 19^{th} century, William Dilthey used this distinction to exclude sociology from the family of disciplines that can be studied within an empirical paradigm. He also declared that the objective of the humanities are singularities and individualities of socio-historical reality.

Let us examine this claim in some detail. First and foremost, we must remember that when we discuss laws in empirical sciences, whether deterministic (nomothetic) or not, we are really talking about **our knowledge of these systems, and not some objective laws of nature**. Furthermore, such knowledge changes with time. When the Neogrammarians presupposed that linguistic sound laws are deterministic[3] (mechanistic), exceptionless like the laws of Newtonian physics, they were not aware that the situation in physics had undergone a profound change in 1877. That year, Boltzmann introduced a non-deterministic law into the realm of physics by redefining the Second Law of Thermodynamics in terms of probability.

To explain the significance of that shift and to provide the essence of the new interpretation of the Second Law of Thermodynamics, it is necessary to start by introducing the First Law of Thermodynamics. The First Law states that the energy of a closed system, one without external influences, cannot change. However, there may be many states of a given system with the same energy, and the First Law does not indicate which of these states will be realized. The Second Law of Thermodynamics addresses this issue by stating that the entropy of processes occurring in closed systems cannot decrease. Loosely speaking, it means that the system cannot become more orderly without receiving energy from outside.

To illustrate the idea behind the Second Law of Thermodynamics, we can use the analogy of the Law of Messy Rooms, describing the mess in our rooms. This Law can be formulated as follows: “We never make rooms tidier accidentally—without our conscious effort to do so”. This law corresponds, to some degree, to the Second Law of Thermodynamics, which states that the entropy of closed systems does not decrease. Why? From a probabilistic perspective, the answer is straightforward. There are a vast number of states (potential arrangements of things in our room), that we would consider messy, but only a few that we would classify as tidy. For example, placing socks on any other square inch of your room except in the proper drawer results in increasing the state of the mess.

Now, let us imagine, we start moving things in a room at random, without conscious effort to place them where they belong. Assuming the frequency definition of probability (as the ratio of the number of states to the number of all possible states), the probability that we will arrive at the exceptional state (a tidy room) is the ratio of the states in which everything is in its proper place to the number of all

[3] The notion of causality has a much more complex meaning in contemporary philosophy of science than in common perception inherited from Descartes, who said that a perfect science is about inferring the consequences from causes. A presentation of the contemporary concept of causality can be found in Bunge (1959).

possible arrangements of things, which is very small. This means that the probability for uncoordinated (random) moves, such as dropping books and socks, to result in a messy room, rather than in a tidy one, is much, much greater, regardless of the initial state of the room. This shows that the Law of Messy Rooms does not describe any fundamental aspect of human nature but rather the lack of human propensity to keep things tidy, coupled with the limitations of the physical space in rooms.

Similarly, the Second Law of Thermodynamics does not describe any fundamental property of nature, any "force" (propensity) determining the behaviour of thermodynamical systems, such as gases, but that it results from the special characteristics of the environment of the system. The behaviour described by the Second Law, implying for instance that the particles of oxygen in the rooms we live in do not gather suddenly in a given cubic inch of the room under the ceiling, causing us to suffocate—is, to a large extent, the result of pure statistics. It reflects the ratio of the number of states in which these particles are all in the same given cubic inch, to the number of all possible positions of oxygen particles in the room. Consequently, after Boltzmann's proof, the concept of "law" stopped being exclusively a term for a deterministic relation of "cause" and "effect" allowing no exceptions, but it also started to include non-nomothetic laws—the descriptions of some complex totality in terms of probability[4, 5].

Non-nomothetic laws are employed in scientific contexts in situations when we lack sufficient information about the system, even when every its elements are governed by strict rules. In many such cases, especially in complex non-linear systems, we may not have complete information about all the elements and interactions in a system, or sufficient computational power required to model the

[4] The part of Myth One down to this point restates arguments presented in Grzybek (2006).

[5] Half a century after Bolzman's work, in 1922, Schrödinger raised the question motivated by quantum mechanical considerations that possibly all natural laws were statistical in nature. John Wheeler, based on his research in general relativity and quantum gravity, again came to a similar conclusion in 1994 stating that "every law of physics pushed to its extreme, will be found to be statistical and approximate, not mathematically perfect and precise." Wheeler (1994:293).

system step by step. At the same time, because of their non-linear character[6], it is not possible to calculate an approximate solution.

A class of phenomena governed by strict rules, yet without deterministic solutions, meaning their overall outcomes can only be learned by carrying out all procedures step by step, are games such as chess, go, or certain card games. Coping with such evolving systems requires powerful tools based on statistics. In his memoir (Ulam 1991) describes how he invented one of such methods of gaining information, the Monte Carlo method, while playing solitaires during his stay at Los Alamos. Since then, this statistical method has become a standard tool in many disciplines.

> I noticed that to assess the probability of laying a solitaire (such one as Canfield, in which the skills of a player are of little importance), it is much more practical to “expound cards”, to experiment with that process and put down the percent of wins than to try to calculate all combinatorial possibilities, whose number grows exponentially and is so big that, except for the most basic situations, it is impossible to estimate. This is surprising from the intellectual point of view and although not quite humiliating, it forces one to be modest and shows the limitations of rational thinking.

In scientific contexts, statistical laws are also necessary for estimating the parameters of individual components based on the global characteristics of complex liner systems. For example, to calculate the parameters of a given gas particle at some point in time, we would need to know the initial parameters of every gas particle in the container. However, measuring the initial parameters of each element of such a big system is impossible. Instead, we estimate the speed of an individual particle in a gas based on the global characteristics of that gas, such as volume, temperature, and pressure. This way, however, since the values of these parameters are related

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[6] Systems whose behaviour cannot be approximated linearly are characterized by a lack of proportionality between the magnitude of an input and the resulting output. In other words, the relationship between the input and output is not simply a matter of scaling, and doubling the input does not necessarily result in doubling the output. This makes it difficult to predict the behaviour of the system, even if we have a good understanding of its individual elements. In these cases, non-nomothetic laws are often used in scientific enquiry, as they allow for a more flexible and probabilistic understanding of the system's behaviour.

to the average speed of all particles, we can only make a statistical guess as to the speed of the particle being considered.

To sum up, the need for statistical laws in physics is abundant. Therefore, today it is no longer accurate to say that what distinguishes sciences from other fields is the absence of non-nomothetic laws.

2.2] Myth Two[7]: History plays an important part in linguistics, but not in physics.

There is a common misconception that history plays a crucial role in linguistics but not in physics. Some argue that understanding the origin and development of language is essential for understanding language itself, whereas physicists study a world consisting of eternal, unchangeable, identical particles that have no historical context that would be relevant to their present-day characteristics.

However, the belief that the history of physical objects has no relevance to physics is misguided. While individual types of particles, such as an electron, may be eternal, individual electrons are not. Individual electrons may be generated and absorbed in various reactions, which phenomena are the subject matter of elementary particle physics. Similarly, the evolution of atoms, chemical elements, molecules, and materials is studied by chemistry, molecular paleontology, and historical geology, respectively, while the evolution of stars, galaxies, and other astronomical systems is studied by cosmologists. Therefore, the history of the development of objects is also a subject of study in empirical sciences. However, what matters in these studies is not only the description of successive stages of evolution, but also the discovery of relevant laws concerning the evolutionary mechanisms and the conditions under which those laws operate to explain the cause behind the evolution. (This is, by the way, exactly what the Neogrammarians unsuccessfully attempted to do when describing sound changes.)

An extreme way of employing history to learn about physical reality has been offered by the Weak and Strong Anthropic Principles. These Principles propose to explore the consequences of the very fact of the presence of different objects—galaxies, stars, planets with life on at least one of them—to place constrains on how the

[7] The discussion of the myths 2-6 has been inspired by Bunge's reply to biologists arguing against the empirical method in biology.

Universe has been developing. In 1987, using Anthropic Principles, Weinberg demonstrated that the limits on the amount of vacuum energy in the Universe must be at least 118 orders of magnitude smaller—that is, a factor of 10^{118}—than the value obtained from quantum field theory calculations. When dark energy was empirically discovered in 1998, its measurement turned out to be 120 orders of magnitude (a factor of 10^{120}) smaller than that calculated from quantum field theory, and remarkably close to the naïve prediction following from the Weak Anthropic Principle; the difference being only two orders of magnitude[8].

Moreover, the mechanisms driving the evolution of physical objects and language systems have much in common. As Bunge (2003) explains, the evolutionary mechanisms in physics have been self-assembly, spontaneous mutation and the selection by the environment. It may come as a surprise to some, but these three classes of phenomena also manifest in language. Self-assembly in language is evidenced by grammar and by power laws that describe many statistical characteristics of language. Spontaneous mutations in language include *ad hoc* “ungrammatical” constructions, novel lexemes created “inadvertently”, so-called slips of the tongue, or even novel items created purposefully (such as *iv3rm3ctin* used to mean *ivermectin* on social media). These mutations are unpredictable, but if they are useful enough to be repeated by a sufficient number of members of a given linguistic community, they will become engraved in the memories of the interlocutors and thus indirectly in the system. If not useful, such novel forms will disappear from language due to not being repeated frequently enough, thus forgotten. In other words, new words and patterns will become retained in language if selected by the environment.

In summary, both physical phenomena and language are subject to historical processes, which are driven by similar evolutionary mechanisms such as self-assembly, spontaneous mutation, and selection by environment. Therefore, history is just as important when searching for the essence of physical phenomena, as it is when learning about language.

[8] This observation was made by Ethan Siegel (2022).

2.3] Myth Three: Linguistics can explain at most the facts which have occurred, while physics both accounts for past observations and makes predictions of future events.

Many humanists believe that while physics can make predictions about future events based on past observations, linguistics can only explain facts that have already occurred. Etymologists look back in search of the origins of words, and no branch of linguistics can predict the specific forms and meanings of future words, which was illustrated in the introduction with a brief discussion of the meaning of the lexeme *overlook*, as composed of the lexemes *over* and *look*.

2.3.1] Predictability in Different Disciplines

However, as Bunge (1973:56) notes, predictability is not inherent in things, but in our knowledge of them: “It depends both on the sophistication of existing theories and on the available precision of the data’s description”. The sophistication of existing theories refers both to the quality of theories *per se* and to that of models to which theories are applied. The precision of data description reflects the degree to which something can be characterized objectively (independently of the person undertaking the description), for instance, how objectively and precisely someone’s height can be measured, or the meaning of some linguistic item described. If a discipline has theories which are too general, or data that cannot be described precisely enough for a specific theory to be applicable, then no specific predictions, or retrodictions can be made.

For instance, Darwin’s theory—like general quantum theory, by the way, is very general, and thus, it can predict only general trends, rather than specific events. However, if we included a more specific description of the data in line with a more specific model of the species in question and of their environment, the resultant predictions would be much more precise. As Bunge (1973: 57) notices : “the predictive poverty of the theory of evolution is a mark of its generality, rather than the evidence for the lawlessness of organisms”.

Nonetheless, in some circumstances, Darwin’s theory is still capable of providing specific answers, too. For example, it can identify missing links in an evolutionary sequence by determining **which** of the exemplars found meets the criteria for being a missing link, even when those criteria are only specified in general terms. In this sense, Darwin's theory can be predictive and a valuable tool in paleontology research.

Based on the information presented in the introduction of this paper, there is no reason why linguists cannot adopt an approach similar to that taken in socio-natural sciences. Specifically, it should be possible for linguists to propose an empirical theory of language, viewed as an aspect of the psychosocial-natural phenomenon of verbal communication, and postulate and test hypotheses implied by the theory on some linguistic corpora collected in the future or in psychological experiments. However, as with Darwin's theory, due to the complex, non-linear nature of language formation within this approach, linguists should expect to discover theories that enable the postulation and testing only of probabilistic laws that model **trends** in the occurrences of specific utterances.

2.3.2] Examples of Probabilistic Language Laws

An example of research testing probabilistic language laws is Zielińska (2019) study. Zielińska postulated and tested hypotheses concerning linguistic trends implied by the Field Theory of Language (FTL)[9], which was coined within Bunge's (2003) systemism *cum emergentism* framework. The first hypothesis tested was that "counterfactual *before* time clauses" tend to precede main clauses in sentences, and the second was that "counterfactual *before* time clauses"[10] are more likely to be the first clause in a sentence than "non-counterfactual *before* time clauses".

2.3.3] The Field Theory of Language (FTL)

Before explaining, why Zielińska postulated her hypotheses, and how she tested them, it is important to understand the underlying framework of Field Theory of Language (FTL). Coined within the empirical paradigm of socio-natural sciences as explicated by Mario

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[9] The field theory of language is an extension of the communicative field theory of language presented in Zielińska (1999, 2003, 2007a,b, 2014) and recently further elaborated on in the chapters "*How Does Language Work*?" in Zielińska (2020a) and "*Testing the Advocated Theory of Language. The Studies of the Order of Polish Adjectives in Noun Clauses and the Order of Unfulfilled Before Clauses"* in Zielińska (2020b).

[10] To clarify the terminology, let us consider at the sentence *She died* ***before she graduated***. In this sentence, the clause *she died*, which can stand on its own, is the main clause, while the clause *before she graduated* is a subordinate time clause, more precisely, a subordinate, counterfactual *before* time clause.

Bunge (2003), FTL aims to capture the material causes of "languaging", by which I mean language use and formation, correlated with the brain activity reflecting socio-cognitive behaviour of the interlocutor.

2.3.4] The Mechanism of Self-Organisation and Self-Regulation in the Field Theory of Language

The first major assumption of the Field Model of Language (FTL) is that the material causes driving language formation and self-regulation are grounded in the characteristics of human bodies functioning in societies. More exactly, the process of "languaging" (language use and its self-regulation) is constrained by the assumption that a language system arising in a society develops through its members' reacting to the properties and requirements of their environment via some sort of adaptation mechanisms, as explicated by Koehler and Altmann (2005). For example, the way human memory and cognitive apparatus function suggests that certain phonetic/graphical representations of words or language constructions and their meanings that co-occur on a given occasion are more likely to become permanently correlated in the brain if certain conditions are met. These conditions influencing the formation and retention of language items and their meanings include

- high frequency of occurrence motivated by frequent need;
- relating to basic level items (e.g. "dog" as opposed to "dachshund" and "animal", which are functionally more distinct);
- being shorter or less complex than close functional alternatives;
- not being too short, thus, putting too much burden on the addressee when decoding (to avoid misunderstanding);
- communicating content with adequate precision;
- fitting the dominant language grammar and semantic structures appropriately, which makes it easier to understand and recall forms used;
- enhancing communication;
- and such.

Based on the above, the pairs of {words and their meanings in use}_events that become engrained in memory best (by forming new neuronal connections or readjusting the strengths of the synapses that already existed, modifying neuronal activation paths) form the basis for individual "languages" in the brain, which consists of items that are most easily remembered and most useful for communication. The items that are retained in memory allow for efficient communication, while balancing the needs of both listeners and speakers. Therefore, for language to self-regulate, interlocutors do not need to consciously strive to choose language solutions that are optimal for the language system, as postulated by Zipf's Principle of Minimal Effort nearly a century ago. Instead, self-regulation of language is mainly the result of unconscious[11] processes, such as remembering more frequently repeated items best.

2.3.5] The Categorization Mechanism in the Field Theory of Language

The second founding assumption of the Field Theory of Language (FTL) concerns the mechanism of semantic categorization, which generates specific language events (specific form-meaning pairs in use, aka instances of *situated parole*). It is postulated that listeners generate *situated parole* by using words either encodingly or selectively.

People arrive at the interpretation of words and sentences (assign meaning to forms or the other way round) **selectively**, similar to how two points define and identify a line, **assuming you know** we are talking about lines, not circles. In the same way, the encoded content of words serves to identify one of the expectations generated in the minds of the interlocutors. The fact that people generate expectations about what the world around them will look like in a moment, including what can **likely, and with what likelihood,** be said and done next during a verbal interaction, has been well established. These expectations are formed primarily due to the interlocutors' awareness of some aspects of the socio-natural environment of the verbal interaction the interlocutors participate in (the situated speech act), what has been said so far, and the relevant experience available to them at that moment, all of which are passed through their attention and intention filter. In FTL, these

[11] Zipf's (1949) alternative assumption that interlocutors consciously optimize language, known as the Principle of the Least Effort, was criticized for its cognitive feasibility, and rightly so. Unfortunately, this criticism led to the dismissal of Zipf's ground-breaking idea of socio-natural source of language formation for almost half a century until it was rediscovered by the Neo-Zipfians, aiming at grounding linguistics firmly in empirical sciences.

expectations, each with assigned probability of occurrence, are referred to as one's "expectation field". Importantly, then the expectation field is only a tiny fraction of what interlocutors know. It is not merely substantially limited by their attention focus and intentions, but also depends heavily on the associations such limited information accessible to them recently generate.

A visual analogy that helps to emphasize the constraining and guiding function of the expectation field postulated in FTL, which is crucial for interpreting language, has been offered by the picture below. When prompted with the same utterance, *I need a mouse*, interlocutors with different backgrounds and attention foci, generate different expectation fields leading them to select different, idiosyncratic interpretations of the same verbal clue.

Selected meaning arrived at in the specific language events establishes, for the first time or by adjusting, **the current encoded meanings** of the lower-lever units that comprise the just-interpreted construction. The adjusted form-meaning pairings that emerge from this process are subsequently stored in long-term memory, with factors such as repetition frequency, brevity, similarity to common items in language, and such, influencing the likelihood of their retention. A similar retention process guides establishing word patterns within sentences, sentence patterns within texts, and correlations between specific words and word class patterns in which they tend to occur. Each subsequent unit of organisation is organised in the way that reflects the most efficient patterns both for speakers and listeners that the interlocutors have encountered in the past and remembered. This process of remembering certain co-occurring patterns or form-meaning correlations ultimately contributes to the passive self-regulation of language.

2.3.6] Selected Meaning

When the listeners use encoded content of the words they have just heard to selectively identify some percept in their **expectation field**, top-down[12], these words need not fully encode the content of the item identified in the expectation field. The selected meaning is typically much broader than, and may even differ significantly from, the sum of the encoded meanings of the constituent words[13] used during the selection (interpreting) process.

To illustrate the categorization mechanism just postulated, let's consider the interpretation of the phrase *a red rose*. The selected meaning of this phrase is richer than the sum of the encoded meanings of its constituent parts—the meanings of the words *red* and

[12] Note that the mechanism of categorization introduced in FTL deals with the meanings of novel linguistic forms, somewhat similar to the way paleontologists use Darwin's theory to classify missing links. While paleontologists cannot predict exactly what a missing link will look like beforehand, they recognize it once they have discovered it. Similarly, linguists could not have foreseen what the lexeme *a computer game* would mean when computers were first invented, but the term became a perfect name for computer games once they were invented. People who knew of the existence of computer games were able to understand the term, even when hearing it for the first time, in the appropriate context that generated in the listeners' minds an expectation field of options likely to be discussed in the given situation (situated speech act). Such human capability of choosing the best fitting option has been acknowledged by psychologists in relation to language acquisition by toddlers, who are constantly faced with the need to identify referents of novel vocabulary items in pragmatic contexts. In psychology, this phenomenon is called fast mapping.

[13] The most recent models of vision work in a similar way. They propose that what we perceive at a given moment is what we calculated within the past half-a-second, while making the predictions as to what we would see (interpret to see) in half-a-second, based on the data available to us half a second ago. In other words, our perception at a given moment is the result of continuous process of prediction and selection/interpretation. Our brain is constantly making predictions about the future, based on the data available to us in the past, and our perception is a continuous process of updating and refining these predictions in real time.

rose. A *red rose* is not entirely red, instead, it is mostly green, with only a small portion of it being red—its petals. In addition to the meanings of the lexemes *red* and *rose, which* influence phrase's meaning bottom-up, the shade and distribution of redness involved in the interpretation of the phrase "red rose" come from our experience with flowers, and roses in particular—thus, top-down from our expectation field. When interpreting this phrase, the interlocutor first generates a specific field of expectations about what flowers, in particular roses, look like, based on their prior experience. Second, they use the encoded meanings of the lexemes *red* and *rose* to find a rose that is redder than some other roses (white, yellow, pink) and "rosier" than other items.

Note that a typical dictionary (encoded) meanings of *red* and *rose* should be considered rather as proto-meanings. These proto-meanings assume their actual, selected (pragmatic) meanings, only when used in specific phrases uttered on particular occasions (situated speech acts) similar to how Bunge (2003) discusses proto-entities in self-organising systems. (On second thought, it becomes apparent that we almost never use words solely to convey their encoded content, as exemplified by phrases such as *dust furniture* vs. *dust a cake with sugar, a hot day in Stockholm in winter* vs. *a hot day in Miami in summer, a big child* vs. *a big whale, a red bike* vs. *a red pen, a horse is running* vs. *a baby is running*). The encoded content of words primarily serves to indicate **which** item in the field of expectations we are referring to, and only indirectly, **what** that item is like.

It may also be helpful to note that selective categorization, as postulated by FTL, is similar to how pronouns (*he, she, …*) are commonly believed to operate. Pronouns typically point out most of their content from a set of options that are viable on a given occasion, instead of fully encoding their contextualized referents. For example, the meaning of *you* in the phrase *you are right* when spoken by John to Mary, primarily derives from interlocutors' knowledge of the addressee's identity and the knowledge that *you* singles out the addressee. According to the FTL view, this mechanism is not limited to pronouns, but can apply to all lexemes, linguistic constructions, even texts, to indicate "which one it is", akin to how pronouns function, and only indirectly convey specific characteristics of the referents.

2.3.7] Selecting Illocutionary Force and Strong Pragmatic Meaning

The mechanism of categorization by selection in the expectation field is often also used to identify the purpose behind the sentence uttered, known as the illocutionary force, as well as its strong pragmatic meaning. Due to the mechanism of categorization postulated, the purpose of an utterance and its strong pragmatic meaning don't even need to be semantically related to the meanings of the words used to convey them. For example, in response to the suggestion "Let's go for a walk" the sentence *it's raining* will likely be interpreted as rejecting the proposal. This is because the interlocutor's expectation field contains two options for the purpose of that response: "accepting the invitation" and "rejecting the invitation" and the sentence *it is raining* serves to distinguish between the two options. Since people typically do not enjoy walking in the rain, the sentence *it is raining* selects the option of "rejecting the invitation", essentially conveying the strong pragmatic meaning of "Let's not go for a walk, because it is raining"[14].

2.3.8] The Characteristics of Language Organisation Levels in the Field Model of Language

The Field Theory of Language posits that language is a system of successive levels of meaningful language units (except for the lowest-level building blocks—letters). Letters group into morphemes, morphemes group into words, words into phrases and sentences, and sentences may group into larger functional unites, such as reports, letters of recommendation, or poems. Each successive level of organisation is characterized by qualitatively new properties and these levels interact with each other both bottom-up and top-down.

At the lowest level, letters have form. At the next level morphemes and words acquire the novel quality of having a representation and thus being able to be used to refer to something[15]. Several

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[14] Similarly, the FTL categorization mechanism is also of great value in establishing the information structure of utterances, stating which part of the information is already known, has been talked about and which is new. In the FTL view that division need not adhere to the divisions imposed by the grammatical structure of the sentence, which allows one to describe the information conveyed by sentences much more precisely than possible in traditional approaches.

[15] Actually, the form of a word has emergent quality, too. The 1D graphical form of letters becomes additionally 2D when they are put together into a word, and its

emergent qualities arise at the level of forming phrases and sentences. The first novelty at that level is the emergent representational meaning reflecting the fact that *a black car* does not mean simply that it is all black. (Linguists refer to this as enriched meaning or weak pragmatic meaning.) Secondly, the enriched meaning of phrases and sentences can convey information by attributing quality A to B, which is another novelty at that level of organisation[16]. The sentence *The Porsche can go fast* may be used to inform about the Porsch's ability to go fast or convey the message that a thing that can go fast **is a Porsche**. (Dividing the sentence explicitly into the part conveying what is being assessed, the 'Given', and what is the 'New', i.e., stated about the 'Given', is called explicating the information structure of that sentence.) Thirdly, such a message can be evaluated as true or false, which is yet another emergent quality[17] of language at the sentence level.

Note, that the same sentence may express both a true and a false proposition, depending on the assigned information structure. For instance, the sentence 'English is spoken in Burma' is true when it is a reply to the question 'which language is spoken in Burma?' with English being the "New' information. However, if we consider the sentence 'English is spoken in Burma' with the words in Burma as the 'New' information, it does not provide the expected, true answer to the question: 'where (in which countries) is English spoken?' The correct answer to the latter question could be: 'English is spoken primarily in England, Canada, USA, Ireland, Australia, RPA, but also in such countries as Burma.' The difference in truth values between the utterances discussed arises from the changed interpretation of words in the sentence discussed when different elements are assigned the status of 'Given' and 'New' respectively. Such a difference in information structure of a sentence can generate different expectation fields during its interpretation process, resulting in

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phonetical form is not a simple phonetic realization of the string of the constituent phonemes pronounced in isolation.

[16] In fact, after adopting Shannon's definition of information, we might even ask how informative a given message is.

[17] Note that depending again on which options the message serves to eliminate when informing (cf. Shannon's definition of information), the given sentence may be true when answering one question and false answering another one. For instance, the sentence *ships unload at night* is true when answering the question *when do ships unload?,* but false in response to *what do ships do at night?* Both these examples come from Barbara Partee.

different outcomes. Different interpretations open the possibility that one messages is true, while the other may not be true.

The difference in the interpretation of the same sentence due to different information structures assigned, however, need not merely parallel the difference between conditional probabilities P(A | B) and P(B | A), as was the case with the sentence discussed above. For instance, when seeking information about [how many people read few books?], the sentence 'Many people read few books', with many being assigned the 'New' status, will be interpreted as meaning that every person reads a different set of books. However, when answering the question 'Are there many books that many people read?' (or 'Are there many books read by many people?'), the same sentence with the word 'few' having the 'New' status refers to one set of commonly read books, such as The Bible, The Torah and The Quran.

By analogy, consider the possible messages conveyed by the sentence 'The university did not accept many candidates' when the status of 'New' is assigned to the words 'did not' and 'many' respectively. For example, it could be used as a response to the question 'Are there many students in the incoming class?', or to the question 'How many applicants were rejected by the university?', respectively. As illustrated again, a structurally and lexically unambiguous sentence does not necessarily have a single representation prior to being interpreted in a communicative situation. Interpreting a sentence may require knowledge of its information structure. In other words, the resulting explication is not related to the well-known issue of lexico-grammatical disambiguation, as is the case of the sentence 'Fruit flies like bananas'. Instead, it arises from the ways expectation fields evolve during the interpretation process of a sentence with different information structures imposed by their respective communicative contexts.

Fourthly, sentences treated as aspects of verbal interaction in communicative contexts acquire the emergent quality of having illocutionary force and strong pragmatic meaning. On one hand, they serve to perform various social actions, achieving various goals, such as that of scaring, instructing, asking, baptizing, and such, which are called the illocutionary forces of a sentence. On the other hand, sentences convey strong pragmatic meaning, which includes information about its illocutionary force, explicating what has been said and why. Strong pragmatic meaning when selected may differ from the message the sentence in question conveys "literally" (i.e., as the weak pragmatic message), as was illustrated by the phrase *it is raining* used to say "no, let's not go for a walk because it is raining" that was discussed earlier. Strong pragmatic meaning can be revealed by reporting on what someone said using reported speech as in "John: 'Let's go for a walk'." can be reported as "He rejected the suggestion to go for a walk because of the rain".

Finally, at the highest level of language organisation, certain groups of sentences together, such as paragraphs, whole texts, or speeches may acquire a joined illocutionary force, and joined pragmatic meaning, which is not a simple sum of the illocutionary forces and of strong pragmatic meanings of the sentences, respectively. Identifying the joined illocutionary force is necessary to understand the purpose of a given text and what it has accomplished, which may include misleading, manipulating, or constituting a letter of recommendation, among others. For example, when reading a description of a person, such as "He has a beautiful handwriting", to understand what that text conveys, one must know whether it constitutes a letter of recommendation for a graduate school of engineering, or a school essay. Explicating what the speaker meant to convey with his text, what that text accomplishes, such as that they wrote a very strong letter of reference truly recommending the candidate for the job, is called the strong pragmatic meaning of that text.

2.3.9] Selecting the Information Structure

As mentioned earlier when discussing the emergent qualities of language, the Field Theory of Language provides a more comprehensive and effective approach to identifying the information structure of sentences. When traditional grammarians aim to distinguish between the NEW information (what has been said) and GIVEN information (about what the NEW was said) by a sentence, they typically focus only on identifying which structural subpart of the sentence identifies the GIVEN information, serving as the topic of the message, and which indicates the NEW information, serving as the comment on the topic identified. For example, in the sentence *The Porsche is fast*, grammarians might identify two separate pieces of information (messages) conveyed by the sentence; the message [**about** the Porsche] {that it is fast}, and the message [**about** being fast] {that it is a feature of the Porsche}.

According to FTL, the messages expressed with sentences can be more subtle. Firstly, FTL argues that when words are allowed to select meaning from expectation fields, the same word, or phrase, may serve to select both the NEW and the GIVEN information. For example, consider, the sentence *The chess master teaches chess to beginners,* which appeared in a book catalogue. In this context, the phrase *chess master* selects the author of the book as GIVEN and simultaneously assesses the GIVEN, conveying the information that the author is a chess master. In other words, the sentence conveys both the information that the author is a chess master and that he authored the book in which he teaches chess to beginners.

Secondly, individual words themselves, can also be assigned an information structure, which is referred to by the pair of concepts profile (corresponding to NEW) and base (corresponding to GIVEN). In traditional grammars, which do not allow meanings to be selected from the expectation field, each word is associated with one profile and one base. For example, the word *Porsche* conveys the information [a car make] {produced by Porsche} where a [car make] can be considered the GIVEN (or base), and {produced by Porsche} the NEW, or profile.

However, once selective use of words (as well as phrases and sentences) in the expectation field is allowed, words can select not only what is Given and what is New, based on the expectation field, but also allow for multiple divisions of information within a word into the Given and the New. Noting these possibilities allows for a more nuanced understanding of the information structure conveyed by words (as well as phrases and sentences) and of the information conveyed by language.

For example, in the sentence *Jane did not sprain her ankle, she broke it*, the verb *broke* is used to assess the type of injury Jane suffered rather than to inform what event Jane was involved in, what Jane did. To ever need to use this sentence, the speaker must assume that the listener already knows that an accident had happened to Jane and this sentence is providing further details about the type of injury. In contrast, during a phone call, where a mother is enquiring about her children on a summer camp and asks *How are you doing, guys?*, the verb *broke* in the sentence *Jane broke her* *ankle* serves to identify a specific event among the events that happened during camp time: the accident involving a broken ankle.

Similarly, the information structure of the meaning of the word *boys* is different, depending on the expectation field generated by different contexts of its use. For example, in the sentence *This competition is for men, not for boys* the word *boy* stands for {young}[male], while in *this school is for boys, not for girls,* it stands for {male}[child].

Finally, by assigning expectation field dependent information structure to demonstrative pronouns, we can resolve the following paradox pointed out by Chierchia (1990): the truth of the sentences *This is big* and *This is a whale* does not necessarily imply the truth of the sentence *This is a big whale.* The sentence *This is big* can also refer to a baby whale. However, if we consider the information structure expressed by this pronoun in different contexts and assign a field-dependent structure to them, we can clarify the selected meanings of *this* used in each sentence in the following way. The meaning of the demonstrative pronoun *this* used in *this is big* can be explicated as {this [object]}, the whole sentence effectively stating that "this object is big". In contrast, *this* in *This whale is big* can be represented as {This [whale]}, the sentence *This whale is big* effectively saying that "this whale is big". From this perspective, it is clear that the demonstrative *this* in *This is big* and in *This is a whale*, respectively, has not been used to assess the same referent, thus we cannot conclude the truth of the sentence *This is a big whale* from the truth of *This is big* and *This is a whale.*

2.3.10] Motivating Language Laws Concerning Counterfactual Time Clauses

After outlining the general characteristics of FTL, we can now motivate the hypothesis that counterfactual time clauses tend to be positioned at the end of a sentence. We can illustrate this trend with the sentence *Mary died before she graduated*, considering the optimal position of the counterfactual clause *before she graduated.* To understand this sentence, we must interpret the main clause *Mary died* literally and infer from the other clause that Mary died **before completing the process leading to graduation**. If we were to place a counterfactual clause *before she graduated* at the beginning of the sentence and thus, first interpret it literally, which would need to include the information that "Mary has graduated", we would need to reinterpret its initial literal meaning after establishing that Mary died without ever graduating. This is obviously less efficient than starting the interpretation of the sentence with interpreting the factual clause and in that case interpreting the counterfactual time clause only once.

Furthermore it is reasonable to argue that there is no similar reason that would account for a tendency to position factual time clauses last. In other words, counterfactual clauses should be positioned last in sentences relatively more often than factual time clauses. These two hypotheses were confirmed quantitatively using both the British National Corpus and the Polish National Corpus (Zielińska, 2019) and similar investigations can be easily repeated in relation to some future data, by examining corpora yet to be collected.

In summary, both physics and linguistics are equipped to make predictions, and retrodictions, with their respective theories able to offer precise or trend based predictions. The latter is often employed when exploring uncharted domains, when quantitative theories have not yet been formulated, are of stochastic nature, or when collecting data with sufficient precision is not feasible.

Nonetheless, while it is true that quantitative theories are often considered the hallmark of advanced sciences, it is important to acknowledge the value of qualitative research in advancing our understanding of the world. Firstly, qualitative research, often guided by intuition, lays the foundations for any further quantitative investigations by helping to identify the right qualitative assumptions, which are prerequisite for the success of any study. Secondly, significant knowledge about the world can be gained from observations without resorting to the language of mathematics. For example, in the 3rd century Aristotle determined that the Earth is round by observing the shape of its shadow during a lunar eclipse.

It is worth noting, however, that Aristotle's hypothesis about the shape of the Earth was preceded by purely intuitive, qualitative ideas put forward by Pythagoras a century earlier that the Earth is spherical. This purely abstract hypothesis informed further observations and measurements. The next step in our understanding of the shape of the Earth after Aristotle was taken by Eratosthenes, who calculated the circumference of the Earth using measurements of shadows cast by the Sun at distant locations. Thus, the purely conceptual hypothesis of Pythagoras guided others in what could be observed, which eventually resulted in devising the measurements that could lead to characterizing numerically the qualitative solution found.

2.4] Myth Four: Physics studies classes of identical objects, while humanities are concerned with idiosyncratic ones (such as the speaker's meaning, specific pieces of literary works). Since mathematics can be of value only when describing classes of identical objects—but not of idiosyncratic objects, it can be used only in physics.

Are all objects studied by physics identical and eternal? While physical theories do not distinguish among different electrons, except for their velocity and position, physicists are also concerned with more complex objects such as pieces of rock, hurricanes, and planets, which are so different one from the other that they often get individual names. Furthermore, these objects cannot always be treated as instances of the same category. For example, the models of Mercury or Mars cannot be derived from one general model of a planet as its exemplifications, as they are not simply different members of the same category. Although the models of both are applications of a single theory, they are not contained within it. The description of each of these models involves additionally some peculiar hypothesis concerning shape, density, distribution, orbital motion, and so on.

Moreover, the assumption that all electrons and other elementary particles are identical except for their movement in space is just an assumption. It is an assumption based on our inability to detect any differences, or intentional disregard of them to address the problem at hand with our current tools. This is similar to how linguists postulate the existence of lexemes with their meaning of each of them being specified in dictionaries. Thus, in both physics and linguistics, categories are formed by disregarding individual features of category members in order to explain anything. Without such approximations, if we only focused on individual idiosyncratic instances, we would be unable to make any general statements or apply mathematical description.

Furthermore, the progress of physics began with the fundamental assumption that only some characteristics of a given idiosyncratic object influence its selected feature or a particular aspect of its behaviour. Newton for instance proposed to model the movement of a given object by neglecting all its other characteristics except for its mass. Entities as diverse as a man, a piece of rock, a star, the Moon, a bee, and a virus, all are subject to Newton's laws because all of them possess "mass" as one of the parameters in their description.

To describe the movements of bodies more precisely, new laws must be introduced that depend on some other characteristics of an object considered, such as its shape. To account for the impact of air resistance, a law of air resistance must be additionally taken into account. If we wanted to consider other differences between the Moon and an apple, apart from their movement, we would need a new law from a different category, which, we will assume to be independent from the law of gravity. To account for more of the individual characteristics of each object, we would be introducing more and more laws, resulting in a progressively more accurate description of their behaviour and characteristics.

In summary, when building models, first we simplify the reality by disregarding many individual characteristics, and start with a very basic representation. Being able to conjecture the essential similarities and disregard incidental differences within a class of objects is a hallmark of scientific enquiry, rather than art. After empirically confirming the validity of the initial assumption, we refine the model, by incorporating more detailed and nuanced aspects of the phenomenon under investigation, dependent on the purpose of the investigation. This way we will acquire successively more accurate and comprehensive understanding of the objects or processes investigated. Therefore, there is no fundamental reason why one cannot eventually construct a model of an individual exemplar within an empirical paradigm.

The reason why mathematics is more commonly applied in physics than in linguistics is simply a matter of practicality. Physics has a long tradition of approximating aspects of physical phenomena using measurable concepts and quantitative theories, which have proven useful in guiding new applications. In contrast, linguists are still in the process of identifying which parameters can be operationalized, developing methods for doing so, proposing and testing relevant quantitative hypotheses.

2.5] Myth Five: Linguists rely on discrete parameters of description, binary classification, while physicists need continuous ones, inherent in advanced mathematics.

In physics, many parameters of description are not binary, but rather continuous. Bunge (1973: 59) pointed out that the progress of the 17th century physics was driven by the realization that differences between individual systems and changes in them cannot be sufficiently described by merely classifying them into binary categories. Instead, continuous variables are needed to capture the nuances of physical phenomena. For instance, in the case of Newton's theory, all parameters except the one identifying the object considered, are continuous. Thus mathematics became essential for handling the resultant variety and complexity. This *novum* allowed for a revolutionary change in the very goal of research, shifting from striving to provide an exact description of perceptible details to discovering universal patterns and creating models that can account for the characteristics and behaviour of the systems modelled.

The empirical sciences took the next revolutionary step in the 19th century, when statistics came into play, building on the use of continuous variables for modelling. (This was already adumbrated when discussing Myth One.) Physics has since continued to advance its theories and models using successively ever more sophisticated tools of mathematical apparatus, which let physicists develop new concepts and eventually lend them to other disciplines. Quantum mechanical formalism, for instance, first developed for physics, has increasingly been applied within a wide range of fields, including economics, artificial intelligence, complex systems science, organisational decision-making, models of the brain and cognition. Even linguistics has been influenced by these developments as researchers such as Peter Bruza, Kirsty Kitto, Douglas Nelson, and Cathy McEvoy (2009), following an early claim by Nelson and McEvoy (2007) suggesting that word associations can display spooky action at a distance behaviour, have shown that quantum mechanical mechanism can model word entanglement in human mental lexicon. The reference to the concept of quantum entanglement has enabled these researchers to reconcile two earlier somewhat contradictory models of word association, the Spreading Activation hypothesis and the spooky-activation-at-a-distance hypothesis, which were capable of modelling only different subsets of data each, arriving at a more complete model. Interestingly, Bruza et al. (2009)

concluded that QM formalism may reflect the entangled nature of the phenomena modelled, rather than merely the characteristics of physical objects of a quantum scale.

In addition to QM, some researchers of the science of language have even adopted partial differential equations to study language. Peter Grzybek (2006) used this formalism to model certain aspects of texts. While the use of QM or partial differential equations to describe linguistic phenomena is rare, the need for another mathematical formalism, statistical analysis of linguistic data, has been widely accepted in psycholinguistic research. In language acquisition studies, statistical analysis is used to predict, for instance, tendencies in the population, such as the decrease in irregular usage of the form "goed" in children with age. (cf. Skousen, 1989).

Finally, it should be noted that the first statistical investigation of linguistic phenomena was carried out by George Zipf in his works from 1832, 1935 and 1949. Zipf's laws are well known, particularly the one that states that the frequency of any word in a text (of a sufficient length, or in a collection of texts) is, roughly, inversely proportional to its rank in the frequency table for that text. For example, in the Brown Corpus, the most frequently occurring word is *the*, which accounts for nearly 7% of all the word tokens there. (69,971 out of slightly over 1 million). The second-place word in the Brown Corpus, *of*, accounts for slightly over 3.5% of words (36,411 occurrences), followed by *and* (28,852). It turns out that only 135 vocabulary items are needed to account for half the Brown Corpus. Since Zipf, many other statistical regularities of the similar type have been discovered (cf. *Journal of Quantitative Linguistics*, Koehler 2012). It is interesting to notice that such power law dependence, as illustrated here by the relationship between the frequencies and the ranks of words in corpora, characterize self-organising systems at large, which we have postulated language to be.

To conclude, it is not accurate to distinguish between sciences and non-sciences based on the use of complex mathematics versus classification. The choice of tools appropriate for a given discipline depends not on its subject matter *per se*, but on the quality and depth of our knowledge of it.

2.6] Myth Six: While the physicist uses objectively measured empirical data to create his theories, the linguist must rely on his intuition to interpret a text.

Another way to express the misconception that linguists rely on intuition, and scientists on objective data is by stating that while sciences deal with quantities, thus with mathematics, humanities focus on qualitative aspects of the phenomena they study. However, such an argument stems from a lack of understanding of the role of mathematics in sciences, which serves as a tool in constructing a theory. Bunge (1973) reminds us that facts are neither mathematical, no anti-mathematical: only ideas can be open to mathematization if they have sufficient clarity and precision. Alternatively, as Altmann (1985) puts it, neither quality nor quantity are inherent characteristics of objects and phenomena, rather, they are parts of concepts that we use to interpret nature.

In other words, when discussing the quantitative aspects of language, the meaningfulness or meaninglessness of quantitative data is not absolute for a given discipline considered, rather it depends on the discipline's models. Therefore, if language is viewed merely as a set of language patterns, as proposed by structuralists, or as algorithms for generating such patterns, which are part of the organism's genetic endowment, as seen by generativists, than quantitative descriptions are of no use. However if language is considered as a self-organising process of language creation that responds to current communicative needs and changing environments, while taking into account previously noted correlations, then the frequency of occurrence of specific patterns realized in the past becomes crucial for deriving "grammar rules".

Thus, the core issue at hand is determining the degree of precision with which we can articulate our intuition about the concepts involved, that is, the extent to which we can reach a consensus when classifying or measuring entities. Traditional sciences are dominated by concepts that are highly measurable, with many derived from intuitive concepts. In linguistics, such precise, measurable concepts are gaining grounds. More and more often, theories are proposed that operationalize intuitive concepts by establishing corresponding measurable equivalents. Two examples of such concepts are introduced below. Further on, they will be used to formulate a linguistic law that can be objectively tested in quantitative terms.

The first concept to be defined is the **sensitivity of the adjective to the noun it modifies**, which reflects our intuition about the range of variability of the meanings of a given adjective depending on the nouns it accompanies. For example, intuitively we agree that a "big" virus differs in size significantly more from a "big" planet than the shade of "blue" of a forget-me-not differs from the shade of "blue" of a blue sky. In other words, the noun sensitivity of the adjective *big* is intuitively higher than that of the adjective *blue*.

A measurable operationalization of the concept of the **sensitivity of the adjective to the noun it modifies** to be introduced stems from the observation that adjectives whose meanings vary significantly when modifying different nouns are more frequently used in comparative and superlative forms than the remaining adjectives. For instance, in linguistic corpora, "*this … is bigger than …,"* is a more frequent comparison than "*this … is redder than…"*. Using this observation, we can operationalize noun sensitivity of an adjective by considering its gradability, which is the ratio of the number of occurrences of a given adjective in its superlative (e.g., *biggest*) or comparative (e.g., *bigger*) forms to its total occurrences (e.g., either *big*, or *bigger*, or *biggest*) in a given linguistic corpus:

$$\text{gradability (big)} = \frac{\#\,\text{bigger} + \#\,\text{biggest}}{\#\,\text{big} + \#\,\text{bigger} + \#\,\text{biggest}}$$

The other linguistic concept, whose operationalization I shall refer to further on when formulating another linguistic law, is **the degree of the adjective's tendency to form situated subcategories**, or for short: adjectives' subcategory forming tendency. A situated subcategory refers to the intuition that certain adjectives used in Adj+Noun phrases affect the referents of the head noun in more ways than simply by stipulating the value of the parameter of the referent of the head noun expressed directly by the given adjective. A good example of a highly subcategory forming adjective is *wooden*. This can be illustrated by the differences between the situated subcategory of *wooden bridges* vs. *steel bridges*, and between *wooden tables* vs. *steel tables*. A wooden bridge and a wooden table differ from steel bridges and steal tables, respectively, not only in the material used to make them (wood vs. steel), but also in their construction types, likely sizes, and additional materials needed. For example, steel tables often have glass or ceramic tops, while wooden tables are usually all made entirely of wood, except for steel nails. Steel bridges, in turn, tend to be much longer than wooden bridges.

In Polish, we can operationalize the intuition of an adjective's "degree of situated subcategory forming tendency" by examining the semantic impact of the position of adjectives in noun phrases. When placed after nouns, Polish adjectives often indicate a situated subcategory forming property of that adjective. For example, *barszcz czerwony* (*red borscht*) refers to a specific type of soup made primarily of beetroots, which has a somewhat reddish colour, while *barszcz biały* (white borscht) not only has an off-white colour, but most importantly, is made of a different set of ingredients—fermented wheat. So *barszcz czerwony* and *barszcz biały* refer to functionally distinct, situated subcategories of soups, not merely soups of different colours. On the other hand, *czerwony balon* (*a red balloon*) refers to a balloon that differs from a *blue balloon* in colour only, indicating that the adjectives *red* and *blue*, respectively, while prepositioning the noun *balon*, do not single out functionally different subcategories. Therefore, we can quantify the degree of an adjective's tendency to form functionally distinct subcategories (situated subcategories) in Polish by calculating the ratio of the number of its occurrences after nouns in (N+Adj.) phrases, to the number of its total occurrences in noun phrases (N+Adj or Adj+N) in language corpora:

$$\text{subcategory forming tendency (red)} = \frac{\#\,(\text{Noun} + \text{red})}{\#\,(\text{Noun} + \text{red}) + \#\,(\text{red} + \text{Noun})}$$

Based on the two operationalized concepts defined above, we can formulate a quantitative hypothesis about the ordering of adjectives in (Adj_1+Adj_2+Noun) phrases within the Field Model of Language (FTL). As we remember, according to FTL, language self-regulates by interlocutors passively retaining language solutions that optimize cognitive effort involved in communication, because they are easier to remember, recall, more frequently repeated and such.

Therefore, we postulate that the ordering of adjectives in A_1A_2Noun phrases is optimized for cognitive efficiency. Assuming that adjectives in a noun phrase are interpreted starting with the adjective closest to the noun, cognitive efficiency will be increased if we position highly subcategory-forming adjective closest to the noun. The same will be true if we place the most noun sensitive ones the farthest from the noun. This is because, before assessing the parameters of the referent, such as size, colour, value, or opinion, it is good to know the specific characteristics of the situated subcategory the given noun represents. For instance, we can better interpret the size of a *huge building*, if we already know whether this is a *family building* or a *commercial building*.

Therefore, in A_1A_2Noun phrases, where one of the adjectives is subcategory forming and the other is noun sensitive, we should expect to see the trend for noun sensitive adjectives to precede the subcategory-forming ones. This way the listener avoids reinterpreting these noun sensitive adjectives again after interpreting the noun modified by the other subcategory forming adjective. Hence, we typically end up with phrases like *a long wooden bridge* rather than *a wooden long bridge, a huge commercial building* rather than *a commercial huge building, a cute chubby puppy* rather than *a chubby cute puppy, a strong little boy,* and not *a little strong boy, a beautiful French garden* and not *a French beautiful garden.*

Zielińska (2007) used an early version of FTL to demonstrate quantitatively that the postulated tendencies described above hold true for Polish, despite this hypothesis being counter-intuitive for a language with a rich flection and relatively free word order, like Polish, as opposed to English. Unlike English, where the hypothesis of a dominant order of adjectives in A_1A_2N phrases is well known to grammarians and the trend is almost a rule, the Polish version of the hypothesis had not been noticed by Polish grammar books, because this trend is much weaker. Therefore, a quantitative statistical analysis was required to show it[18,19]. Clearly, measurable data

[18] A purely numerical hypothesis of this kind, one considering even more measurable parameters, was confirmed numerically even earlier by Wulff (2003) based on the English National Corpus. Stephanie Wulff, however, was interested only in numerical analysis of her data and did not look for any explanatory theory that could imply the data patterns she found.

[19] Zielińska (2007b) analysed her data statistically by comparing the distribution of semantic categories corresponding to categories of various noun sensitivity and

concerning *situated parole* is needed to note some of the characteristics of *langue*, which are not always binary, but rather of statistical character. And

> Once you begin to look at language from a quantitative point of view, you will detect features and interrelations that can be expressed only by numbers or ranking whatever detail you peer at. There are dependencies of length (or complexity) of syntactic constructions on their frequency, and on their ambiguity, of homonymy of grammatical morphemes on their dispersion on their age, the dynamics of the flow of information on its size, the probability of change of sound on its articulatory difficulty … in short, in every field and on every level of linguistic analysis—lexicon, phonology, morphology, syntax, text structure, semantics, pragmatics, dialectology, language change, psycho- and sociolinguistics, in prose and lyric poetry—phenomena of this kind are predominant. … Moreover it can be shown that these properties of linguistic elements and their interrelations abide by universal laws, which can be formulated in a strict mathematical way in analogy to the laws of the well-known natural sciences. (Altmann & Köhler 2007)

And coming back to the law discussed in this section, the observation about the order of the two classes of adjectives discussed can also be stated in more general terms as two separate laws. The first law: the more sensitive the adjective is to the noun it modifies, the more likely it is to come first in the A_1A_2N phrase. The second law: the more subcategory forming tendency the adjective manifests, the more likely it is to come second in such noun phrases.

2.7] Myth Seven: Unlike in physics, linguistic data is never "pure", and no collection of linguistic data can ever be complete. Therefore, empirical data cannot serve to build a model of language.

One of Chomsky's arguments against using authentic language data, such as language corpora, for language modelling (in McEnery 2003), was that observed language data is never pure. For instance, when uttering a sentence that was later collected in a corpus, the subject may have been under the influence of alcohol, suffered from some sort of memory loss, had a slip of the tongue, or spoke ungrammatically. Moreover, some information in corpus data, such as the

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various category forming capacity, but doing it directly with measurable parameters as proposed here would be preferable.

fact that BNC contains more sentences *I live in NY* than *I live in Danton, Ohio*, does not necessarily reflect a linguistic fact. Therefore, our grammatical commentary based on a corpus data rather than intuition may turn out to be a commentary concerning the health condition of a particular speaker, their level of knowledge of the language, or of the reality surrounding them, and not of a language system. As a result, corpus data cannot be relied on when constructing language models.

Yet, in physics there is no "pure" empirical data, either; all data are theory-laden and require interpretation and thus intuition. For instance, to apply Newton's laws to describe the movement of the Moon around the Sun, one must first approximate the Moon as a point in space having mass, next "attach" vectors expressing forces involved and write down relevant mathematical equations. This requires physical intuition that is so distinct from general reasoning that it is quite possible even for mathematicians to lack it. Moreover, when collecting any kind of data, carrying out measurements, we cannot avoid making some errors due to limited precision of instruments used. However, statistical methods can be used to assess the degree of certainty of the answers obtained.

Whether collected data leads to new insights, or simply confirms known knowledge, depends on the nature of the model being tested. For example, if we observe that galaxies are either spiral (clockwise and anticlockwise) or elliptical, additional observations will not enhance our understanding of galaxy types (assuming no new types are discovered). However, if we are studying the model of the universe's creation, which predicts the distributions of clockwise and anticlockwise galaxies, further observations of galaxies can deepen our knowledge.

The situation is analogous in linguistics. For generative grammar models the frequency of a given structure in a corpus is irrelevant. Yet, for models examining the distribution of preferred grammatical structures based on their impact onto optimizing cognitive effort, analysing their statistical distribution, or even discovering that "more of A leads to more (less) of B" can be most significant.

Chomsky's second argument against constructing empirical models of linguistic phenomena using linguistic corpora, as presented in Tony McEnery *et al.* (2006), was based on the impossibility of including all possible sentences in a corpus. In particular, corpora do not include sentences of infinite length, which are theoretically possible according to generative grammar. Furthermore corpora, tend to lack many grammatically correct but false sentences, and contain few sentences stating obvious truths. As a result, Chomsky concluded that the corpora, being an incomplete source of language data, cannot serve as a basis for constructing a comprehensive model of language[20].

It is true that a corpus cannot determine whether a given sentence is grammatical or not. Yet, empirical data used in physics is never complete in the sense of providing outcomes for all possible situations implied by a given model, either. Even when confirming Newton's Laws of motion, physicists have not tested them for every possible value of every parameter of every specific model. For instance, when modelling a free fall in the gravitational field, they did not test the laws for every conceivable mass and every possible height of the tree the apple could be dropped from. Therefore, there are many potentially true and "grammatical sentences" that have not been observed in physical experiments. Nevertheless, that has not prevented physicists from forming hypotheses that have been confirmed with a high degree of certainty.

Finally, as it is with a linguistic corpus, the collection of physical data also contains a fraction of "ungrammatical" as well "grammatical, but untrue" sentences. After all, everybody makes mistakes and occasionally arrives at incorrect solutions or incorrect interpretations of collected data. Sometimes experimental results are reported, which after repetition turn out to have been wrong. Yet, these untrue statements found in journals of physics, do not discredit model creation based on the experimental data. Just as linguists reject some data as inadequate, so do physicists. Just as linguists extrapolate from actual data collected, so do physicists—the latter with the help of statistics, because as Durka (2003: 13) puts it, "statistics is the art of drawing conclusions from incomplete data. [translation DZ]."

2.8] Myth Eight: It is commonly believed that physical theories can be tested broadly and with great precision, i.e., received physical theories and

[20] Tony McEnery and Andrew Wilson (2003) and Geoffrey Sampson (2001) offered somewhat similar arguments. These books, additionally, provide very interesting arguments against the use of introspection in language model creation.

models give predictions in perfect agreement with experimental results, while—to use Sapir's words—"all grammars leak" (1921: 38).

It is a common misconception that models of physical phenomena perfectly mirror reality, and experimental results align with the predictions of these models simply because these models use mathematical language. While mathematical advances have allowed for the exploration of new ideas in physics, the core of modelling in natural sciences is rooted in appropriate simplification rather than replication of reality.

Physicists do not aim at creating exact copies of objects, systems and processes they study through models, but rather at creating their simplifications. Which characteristics of the phenomena will be included depend on the purpose of the given model. A hunter shooting ducks will need a different model of a duck then a biologist studying its migration patterns.

Scientists may need to simplify their models even further to enable them to solve the equations that constitute them. Another limitation on the precision of viable theories and models arises from the fact that when creating models, it makes sense to include only parameters that can be measured. Further restriction comes from the constrains imposed by the uncertainty introduced by measurements. Finally, we always need to approximate reality in order to study classes of objects and processes so as to be able to draw conclusions of any generality. All these limitations require accepting a more modest goal for models, which is to partially account for observed data rather than provide a perfect match to reality.

To illustrate how much the approximations made due to restrictions on what we can solve can diverge from reality, Bunge (1973) cites studies published in the *Journal of One-Dimensional Physics,* which model 3D (three-dimensional) solid-state objects as if they were 1D (one-dimensional). This is done to propose models based on equations that physicists can solve. One example of such simplified 1D model is Volkenshtein's explanation of the elasticity of macromolecules and the uncoiling of proteins, based on a one-dimensional (Ising's) model of a chain of atoms. However, the problem is that the reality observed is not 1D, which means that a discrepancy between experimental results and theory is unavoidable. Nonetheless, such simplified models can often provide useful insights into the nature and behaviour of actual 3D objects. For instance, Volkenshtein's model provides a qualitative explanation of the type and direction of changes taking place.

In some situations, as demonstrated by a recent astronomical discovery reported by Kroupa, the potential value of the results of testing even as simple hypothesis as "there are more As than Bs" in a given system, may result in extremely significant insights. In the paper published in *Monthly Notices of the Royal Astronomical Society,* Kroupa (2022) described the recent observation of several star clusters that appear to violate both the law of gravity proposed by Newton and that by Einstein by dissipating in an asymmetric manner. According to each of these theories star clusters are supposed to dissipate symmetrically into two tails with an equal number of stars each. But recent observations of this cluster show that this is not the case. This simple "more As than Bs" observation has now prompted a search for a new theory of gravity to explain the data, as well as indicated a need to revisit alternative propositions. So summing up, models in physics never constitute copies of reality and therefore the results of testing these hypotheses only approximate some characteristics of the phenomena studied, some more exactly, others more crudely. Nonetheless, even the results of the tests of those crude hypotheses can be of immense importance.

Moving on to Sapir's observation that all grammars leak, it is certainly true. All grammars leak and there is a systemic reason for that failure. On the view that language arises in a society and develops through its members' reacting to the properties and requirements of their environment *via* some sort of adaptation mechanisms, a grammar rule understood as the description of a grammatical language structure, can be viewed only as a probabilistic trend in *situated parol.* Since probabilistic laws concerning trends cannot capture individual cases by definition, all grammars, reflecting merely such trends, not only leak, but they must leak. Counterexamples to such laws (leaks) at the level of a single case (the occurrence of some string of words), not only fail to refute such statistical laws, but are expected and can be quantitatively determined.

In summary, it is essential to note that all grammars, regarded as concise descriptions of grammatical language structures, not only leak, but they must leak. Furthermore, seemingly crude laws resulting from counting tokens and analysing their interrelations, such as "more As than Bs", "the more of As, the more/less of Bs", can yield significant insights when exploring uncharted territories in all empirical sciences, whether that be in empirical linguistics or physics.

3] Conclusions

The opposition of influential academic linguists to researchers adapting the empirical approach in language research may be rooted in the history of mainstream linguists' unsuccessful efforts to identify deterministic, summative laws governing language grammar and meaning in language. Traditional linguists longed for the discovery of language laws akin to Kepler's summary of Tycho Brahe's data on planetary movement around the Sun, not being aware that the grammar of language cannot be condensed into such deterministic rules perfectly because of the nature of its source.

When attempts to find deterministic summation rules in language data fell short of expectations, mainstream linguists wrongly concluded that language cannot be studied within the framework of the empirical paradigm. This belief led to a number of myths that were meant to corroborate this misguided conviction, some of which have been dispelled in this article. However, the existence of a group of linguists, often physicists-turned linguists, who have already been researching language within the empirical paradigm provides perhaps the strongest argument against this misguided conviction. Koehler (2012) presents an overview of over a hundred language laws developed within this paradigm. In this paper, two groups of additional language laws coined within the empirical paradigm were discussed: one concerning the ordering of adjectives in noun phrases (Adj+Adj+Noun), the other concerning the ordering of counterfactual time clauses.

In addition to refuting common misconceptions underlying the belief that language cannot be studied within an empirical paradigm, this paper also outlines the framework enabling such research. To this end, first of all, language must be seen as an aspect of a material system. With our current knowledge of the brain, such as expressed by Jeff Hawkins' model presented in his paper "Computing Like the Brain: The Path to Machine Intelligence" (2013), it is reasonable to assume that language emerges and evolves in a society through the adaptation mechanisms of its members' reacting to the properties and requirements of their environment, as explicated by Altmann[21] and Koehler (2007). In particular, efficient language solutions (such as frequently needed, shorter, resembling other already well-entrenched items), are retained in memory, resulting in self-regulation of the system, without speakers actively searching for optimal solutions[22]. Given that language is clearly a self-organising self-regulating system, the mechanisms forming language can be guided best by the empirical framework systemism *cum emergentism* explicated in Bunge (2003).

Regarding the studies of meaning within this framework, what needs to be postulated is the mechanism that allows the interlocutor to calculate situated meaning perceived in a specific socio-natural situation (in a situated speech act) at a given stage of interpretation process that may potentially serve as the input for further inferring processes. With systemism *cum emergentism* in mind, constructing the Field Theory of Language, Zielińska (2007, 2019) proposed that situated meaning is the result of interlocutors selecting in the field of their expectations the item(s) matching the closest the encoded content of the words being interpreted. The expectation field reflects the ideas and words that, a moment ago, came to one's mind as likely to be expressed next during the interpretation process. The expectation field is established by taking into account such factors as the information about the social situation involved (situated speech act), including its purpose and environmental constrains, information comprehended verbally so far in the given verbal encounter, the encoded contents of the items being interpreted, and associations formed on the way. All this information is filtered by interlocutor's knowledge, experience, biases, interests, current attention focus and similar relevant factors[23]. Each option in the field is assigned a likelihood of being intended. "Efficient situated meanings", as defined above, are stored in memory, building and regulating idiosyncratic languages. Statistical trends in such

[21] This idea was expressed already in Altmann (1978), albeit in a more general manner.

[22] This assumption crucially distinguishes current Neozipfian approaches to describing the mechanism of language self-regulation, from Zipf's Principle of Least effort, which posits that speakers consciously search for optimal language solutions when speaking.

[23] This parallels recent models of visual perception. Perceiving visually is the result of processing the stimuli received half a second earlier to calculate the present moment of perception of the surroundings using our models coined based on our prior experience.

individual languages correspond to *langue*—language of the community seen as an abstract structure. It is also worth noting that the meaning of a word, or of some other stable unit in language, is stored in the brain not only along with its form but also with the contextual information it has been correlated with, both verbal and non-verbal.

The assumptions outlined above provide a foundation for studying both the quantitative and qualitative aspects of language within the empirical paradigm, leading to valuable insights of both kinds. When examining quantitative aspects of language, viewed as a dynamic, non-linear system comprised of situated utterances subject to evolutionary processes, many of its characteristics can only be captured quantitatively as probabilistic trends in the interrelations between tokens under examination.

The quantitative laws of language, first explored by Zipf, encompass dependencies such as the relationship between word length and rank, the complexity of linguistic constructions and their frequency, or the dependence of the dynamics of the flow of information on its size. It has been observed that many of these dependencies follow power-law distributions, a characteristic common to other self-organising systems. Moreover, we can study quantitatively correlations among the sets of words correlated with words, specifically examine correlations between words' verbal contexts, thus gaining relational insight into the meanings of these words. By the way, it is also worth noting that it was over a century ago when Firth made the observation that "you shall know the word by the company it keeps," heralding the relational approach to the study of meaning.

Another approach to studying language in the empirical paradigm that is practiced today involves testing quantitative hypothesis implied by qualitative theories of language understanding and processing. This can be done by analysing language corpora or considering the characteristics of physical responses accompanying verbal interactions, such as data resulting from measuring reaction times, recording eye tracking, or monitoring brain activities. Although such hypotheses are often crude, for instance stating "the more of As, the more of Bs", their test results also help gain valuable insight into understanding language, for instance, validate qualitative assumptions made.

All in all, it is clear that in language studies, as in other empirical disciplines, quantitative research is possible and complements qualitative studies. Quantitative results can be used to fine-tune language characteristics hypothesized qualitatively, to draw new hypothesis suggested by the observations, or to rigorously test qualitative assumptions made, among others. However, making effective qualitative assumptions, such as shifting from viewing language as a self-standing structure to seeing language as a self-organising and self-regulating system, selecting the appropriate operationalization of concepts, or utilizing the quantitative information that can be measured, is critical to the quality and significance of all insights, including those gained quantitatively.

For example, postulating that language is an aspect of a material system that has a self-organizing and self-regulating mechanism provides the source of Zipf laws, elevating them from mere trivia to constituting the central argument for language being a self-organizing and self-regulating system. In turn, proposing additionally the qualitative mechanism of interpreting meaning in the expectation field, which uncouples encoded meaning of words from their selected (situated) meanings, allowed us to gain, among others, the following novel insights into language.

Firstly, it allowed for an explanation of the emergence of novel meaning in language. This is crucial for elucidating the meaning of words used in specific situations, accounting for the compositionality of meaning, the self-regulation of meaning in idiosyncratic languages, and ultimately in a community language. Secondly, it offers a more comprehensive account of the messages that can be conveyed with the same sentence in different situations, going beyond what the traditional division into sentence comment and topic (the NEW and the GIVEN) can do. According to the view advocated, any part of a sentence may contribute to identifying in the expectation field of the interlocutor the non-encoded topic and/or the comment (or both), resulting in the possibility of the sentence selecting a much larger number of messages than what the traditional division of a sentence into the GIVEN and the NEW allows one to account for. It also provides the explanation for the observations that the same structurally and lexically unambiguous sentence used with a different purpose, (with different information structure) may have different representations and therefore, even different truth values. The reason is that since the expectation field postulated by FTL categorization mechanism evolves during the interpretation process, therefore when the parts of the given sentence are interpreted in different order (which is the case when different elements are treated as the GIVEN), the final interpretations of that sentence may differ from each other. Last but not least, it was demonstrated that FTL can serve as a source of semantically motivated quantitative language laws.

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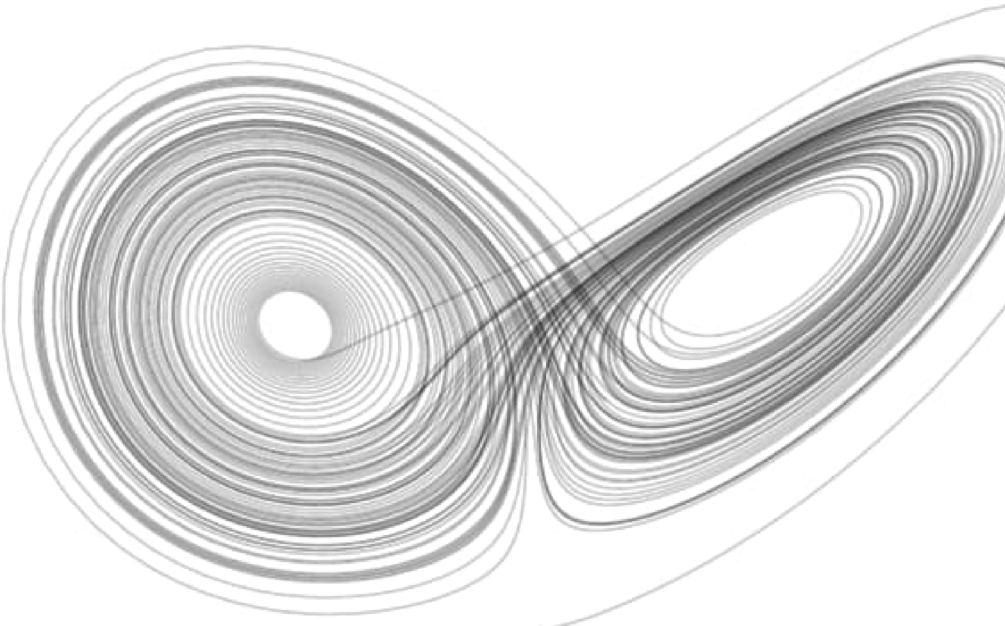

On Philosophical Heuristics

Andrés Pereyra Rabanal[1]

Abstract—Philosophy can be regarded as a type of conceptual research subjected to the usual standards of rationality. However, there seems to be no objective and accepted criteria for evaluating and comparing philosophical theories. From a heuristic- and erotetic-based approach, philosophy is here considered a set of second-order reflections that are presupposed by more specific theories; and evaluated by their informativeness, adequateness, cogency, generality, novelty, and presuppositional nature. As a practice, one can proceed upwards (from problems to presuppositions) or downwards (from presuppositions as meaning conditions for assertions under question). But as a product, a philosophical theory is to be assessed as how it helps foster knowledge and assists in learning, posing, and solving new queries.

Résumé — La philosophie peut être considérée comme un type de recherche conceptuelle soumis aux normes habituelles de rationalité. Cependant, il ne semble pas y avoir un ensemble de critères qui fait consensus pour évaluer et comparer les théories philosophiques. D'un point de vu heuristique et érotétique, la philosophie est ici considérée comme un ensemble de réflexions de second ordre à propos des présupposées de théories plus spécifiques. Ces présupposés sont évalués en fonction de leur caractère informatif, de leur adéquation, de leur pertinence, de leur généralité et de leur originalité. En tant que pratique, on peut procéder vers le haut (des problèmes aux présupposés) ou vers le bas (des présupposés comme conditions de signification des affirmations en question). Mais en tant que produit, une théorie philosophique doit être évaluée en fonction de la manière dont elle contribue à favoriser la connaissance et qu'elle aide à apprendre, poser et résoudre de nouvelles questions.

Keywords—Philosophical practice, Heuristics, Presupposition, Entailments, General and special concepts.

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No distinctive feature seems to fit the process of philosophical inquiry other than the act of deliberation common to any other rational enterprise. It is also usual to assert that everyone knows what philosophy is except for philosophers who are not sure of being able to give a proper definition of it (Salazar Bondy, 1964). As Sellars (1963) points out, philosophy does not have a special theme on its own that could not be delegated to specialists in other fields. Its agenda is barely defined by the range of problems shared by the same community.

Nonetheless, there are various conceptions of philosophy sharing resemblances:

- [The value of philosophy is to] enlarge our conception of what is possible, enrich our intellectual imagination and diminish the dogmatic assurance which closes the mind against speculation (Russell, 1912).
- The aim of philosophy (…) is to understand how things (…) hang together in the broadest possible sense of the term (Sellars, 1963).
- The discipline that studies the most general concepts (…) and the most general hypotheses (…) (Bunge, 2003.)
- Philosophy is the most global and reflexive part of the continuum [between science and philosophy] (Mosterín, 2013).

In most cases, philosophy is distinguished by an emphasis on logical rigor, conceptual analysis, and critical inquiry at the expense of empirical considerations (Russell, 1912). It can be regarded as a type of *conceptual research subjected to the usual standards of rationality and capable of raising questions considering the best available knowledge with the help of formal tools such as mathematics and logic* (Bunge, 2018; Romero, 2018; Rescher, 2006). To the extent that we pose and debate problems that cross disciplinary divisions, the use of philosophical concepts is inevitable and their difference with the rest of ordinary, empirical, or theoretical concepts is a matter of degree, not of class.

1] Criteria for Philosophical Practice

Philosophy has sometimes been regarded as something entirely distinct from other disciplines. Although this is popular among amateurs, media, and scholarly publications, it is not clear whether it has a subject matter on its own. What ensures us that we are before

Being, the Soul, God, the Absolute, or Possible Worlds? It is knowledge sanctioned by evidence and reflexive judgment that give substance to philosophy, not the other way around.

An "intersection" has been thus proposed to establish communicating vessels between philosophy and science. This path is promising as the philosophy "of" mathematics, physics, biology, or psychology does suppose an intersection between fields. A set operation such as $A \backslash B = \varnothing$ can be made to prevent inflationary concepts. After all, we have no doubts about scientific facts but are less confident about "philosophical entities", whatever they are.

Yet there are no philosophical facts other than worldly facts. Our best theories attempt to represent all kinds of phenomena and lead us to act upon them, so the difference lies in the dependence relation between general and special concepts, so a "deflationary" conception of philosophy fits better in its relation to science:

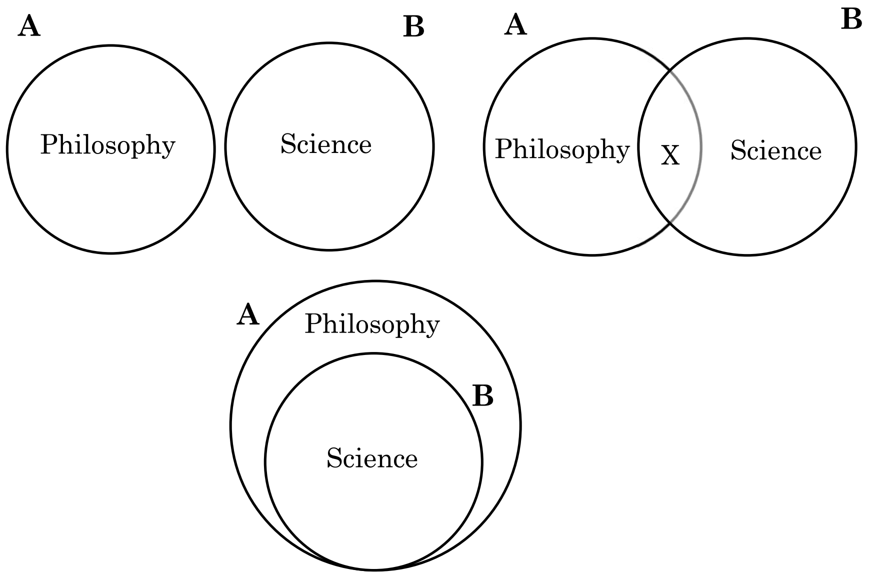

Figure 1: Three kinds of relationship between philosophy (A) and science (B). The first one illustrates an inflationary concept (i.e., two distinct disciplines). The second one exemplifies the intersection between fields while the third one stresses the continuum among a single domain, namely, the system of human knowledge.

To the extent that every intellectual endeavor begins with cognitive dissonance, we look for the most appropriate ways to solve it, not to dissolve it. Although a particular enterprise can be abandoned, its abandonment cannot be advocated through rational argumentation (Rescher, 2014). But doubting everything is unreasonable as well for all argumentation begins with some knowledge that disputants share (Russell, 1912). Neither an "absolute foundation" of scientific rationality is required since reasoning can be seen as a resolutive pursuit in the face of indeterminacy, conceptual inconsistency, or practical immediacy.

But whereas scientific research has evaluation criteria such as clarity, coherence, empirical adequacy, external consistency, or predictive capacity, philosophical hypotheses are not weighed for their conceptual, empirical, or moral merits but are chosen mainly based on intuition, utility, or ideological affinity. As there seems to be no objective and accepted criteria for evaluating philosophical theories, Rescher (2006) underlines the need for methodological maxims to specify a good practices for philosophical inquiry such as the following:

- *Principle of information adequacy*: Demands providing adequate information on a topic; or facilitating a better understanding of it. It points out the relevance of identifying and specifying what is going to be addressed (Px) distinguishing it from another ($Px \neq Qx$). Therefore, it is an informative or clarifying principle.
- *Principle of rational cogency*: The principle of rational cogency is of probative type and demands convincing reasons regarding the evidence, instantiation, or justification for each substantive statement formulated under the principle of sufficient reason $\forall x \exists x (Rxy)$. It states that no contention can be rationally supported except by others, that is, that conclusions are weak enough to be entailed by their premises.
- *Principle of rational economy*: This principle seeks to ensure efficient philosophical practice. It demands interrupting argumentation if it is impossible to solve an issue in the given terms or if the problem is undecidable.

As a corollary, Rescher (2002) mentions that something should not be explained by further obscuring or complicating its subject matter (*non explicari obscurus per obscuriour*) which orders not to increase the terms without an improvement of its probative capacity.

Henceforth two additional maxims can be here proposed:

- *Principle of generality*: To tackle philosophical problems, seek out transdisciplinary concepts, general hypotheses, or underlying issues within intellectual endeavors.
- *Principle of novelty*: Philosophical discussions should provide relevant supplies to pose novel problems or address older ones related to empirical, theoretical, or logical issues[2].

The sole act of questioning does not constitute a philosophical attitude *per se* but insofar as there are contentions to discuss, reasons to provide, or answers for big questions to reject, the above principles will be justified by their procedural competence although others can be considered iff: 1) they are not inconsistent with each other; 2) from their acceptance, the suitability of any philosophical practice is followed.

2] Two Orders of Understanding

Kekes (2014) distinguishes a "practical approach" where one uses available resources to cope, solve, or manage a problem; from a "reflective approach" where one compares, contrasts, and gives reasons for or against that solution. Any mode of understanding is bound to a specific point of view of relevant facts which are unimportant from another perspective, although there may be gray areas between them. But for figuring out conflicting views, one usually adopts a "second-order" reflection[3]. It is one thing to research something and another one to raise foundational questions about method and scientific rationale. One can certainly stay out of such affairs by advocating the utility of science, but this already implies adopting a philosophical perspective, be it utilitarian or pragmatist.

However, not everyone would agree that philosophical theses are to be found among clashing ideas for there would be countless reflections considered philosophical. Popper (1952) held that "pure" philosophical problems do not exist, for they are liable to degenerate

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[2] Similar as the *Principle of Creativity* formulated by Miró-Quesada (2012), which argues that every rational proof of a theorem leads to the establishment of something not evident before (*quod erat demonstrandum*). Certainly, without creativity there is no possibility of forging a new theory and no hypothesis emerges from nowhere.

[3] The expression of philosophy as a second-order reflection is proposed by Bueno (1995) concerning its role in education, politics, and religion.

into empty verbalism. Genuine philosophical problems are rooted in sources outside itself, which can even turn out to have factual components. Mosterín (2013) exemplifies this stance by claiming that philosophical problems may not form part of our standard models of science but are still considered in the long run as sources of speculation and rational criticism.

Therefore, philosophy is a second-order reflection for clarifying and systematizing the basic assumptions of our ideas, although it may be brought to bear *after* conflicting ideas are put forward. Even the pragmatist and skeptical approaches are reflexive in this sense. I will argue from now on for a heuristic- and erotetic-based approach to posing these kinds of reflections.

3] Problems and Philosophical Presuppositions

Scientific queries are concerned with factual matters and are characterized as open problems such as tracing viral origins in their proteome or including framing effects in standard economic models. Improving sustainability without generating considerable losses is not a scientific problem but rather a technical or political problem such as lifting a bridge or improving our health services.

Problems precede a search for a solution in a context where no answer is yet provided and can be listed according to the logical, factual, technical, practical, social, or moral questions they face. According to Bunge (2017), the logical form of any problem is as follows:

$$?xPx \text{ (Problem)} \rightarrow \exists xPx \text{ (Generator)}$$

$$\therefore Pa \text{ (Solution)}$$

Where "?" is not an operator but designates the type of answer under question (i.e. *which*-, *what*-, *how*-, and *why*-questions). The solution is the member x of a class with the property P that satisfies the generator. Since most real-life problems have multiple solutions, given the output of a system, one must find its input, mechanism, or both proceeding from the observable behavior of the system toward its causes or initial conditions.

Empirical and logical questions are closed in principle (i.e., answerable by meeting adequate conditions), whereas philosophical questions are open and remain so even after an answer has been formulated (i.e., they are not empirically or mathematically answerable) (Floridi, 2013). To answer how many "x" are in a finite numerable set one just needs to rely on counting. However, to ask why there is being instead of nothing does not seem to be answerable in the same fashion.

The concept of closure of a set appeals to the idea of some inability to get out of the set by means of an operation (Mosterín and Torreti, 2002). A set is closed under an operation if carrying out that operation on members of the set always produces a member of that set (e.g., natural numbers under addition). Formal arguments are closed under deduction as every member of the set of statements is either an assumption or a logical consequence of an assumption. If philosophical arguments are open (not answerable), they can be considered undecidable at best. Yet scientific queries can also be opened under the operation of *questioning* where they end up outside their original set becoming philosophical in nature (Floridi, 2013). But since philosophical propositions are not subjected to measurement and empirical control, the Vienna Circle considered them as no more than vicarious statements for clarifying the logical and semantic aspects of our ideas.

The generation of philosophical propositions is still viewed with suspicion since these, it is argued, have not a truth-content we can all agree on. But while the aim of science is reaching an objective representation of the world, the task of philosophy seems to be attaining systemic consistency. Philosophical queries can be considered main nodes, cornerstones, or attractors of a set of questions (Floridi, 2013). If philosophical statements F are embedded in a network of concepts presupposed by theories Q, they become devices for a better understanding of these.

Based on Gödel's incompleteness theorem, Celluci (2015) asserts that for any consistent theory $T \in \mathrm{Q}$, there are sentences of T that are true but indemonstrable in T. And as a sentence expressing the consistency of T is not demonstrable by absolutely reliable means (i.e., there cannot be a theory T capable of expressing the concept of being a true sentence of T), then science cannot rely upon mathematical logic alone. Hypotheses are instead obtained by means of non-deductive rules which are not truth-preserving but ampliative (i.e., their consequences possess novelty with respect to their premises) thus relying on abductive reasoning:

$$\Theta, T \to \phi$$

where "Θ" and "ϕ" refer to a scientific field and an unexplained phenomenon respectively. Hence, theory T best explains ϕ in light of Θ (Iranzo, 2007). This has been regarded as an inference to the best explanation (IBE) and has been used to describe not only the inferential steps taken in scientific activity but as the basis of all philosophical argumentation. It is possible to pick a hypothesis based on which provides the best explanation of the data proceeding by searching through our background for guiding our research (Dawes, 2012; Day and Kincaid, 1994). But what sustains Θ? Faced with the conventional challenges to inductivism and apriorism, one can rather say that philosophical hypotheses Φ specify the presuppositions that best account for a specific field Θ.

IBE should be then understood more as a heuristic procedure for potential explanations than as an epistemic rule for favoring either true, partially true, confirmed, or highly probable statements when comparing rival hypotheses (Iranzo, 2007). If no scientific theory *includes* philosophical concepts but *presupposes* them, these are to be characterized by their generality and presuppositional nature. Borrowing the account of Belnap (1966) of interrogative sentences, one can state that a sentence is a presupposition of a statement if the truth of the sentence is a necessary condition of the statement having some true answer, or if every interpretation which makes the question truly answerable is an interpretation which makes the presupposed sentence true.

Entailments and suppositions are common in everyday speech. But philosophical statements are almost always presuppositions as truth conditions for a set of specific assertions. For instance, to state that thermodynamics governs any system that works presupposes (among many other things):

- Properties are bound to things, not otherwise.
- Energy is a universal property of things that work.
- There are laws governing things that work.

The assertion of evolutionary processes as responsible for population speciation presupposes:

- Processes occurring at lower levels are the basis of further complexity.
- Selection leads to novelty changes.
- There are emergent properties.

The various accounts of mental activity in neuroscience, cognitive sciences, and psychology presuppose any of the following:

- There are only organs, no minds (substance monism)
- The mind interacts with the organ (substance dualism)
- The mind is a function of the organ (property pluralism$_1$)
- The mind is a function of the organism (property pluralism$_2$)

One might say that philosophical hypotheses are trivial because asserting that *Px* presupposes that *x* exists is blatantly obvious. But by enhancing our premises we considerably increase their presuppositions. Even the modest theory makes assumptions about the composition of the world, the way it is arranged, and the way we can (or cannot) know and act upon it, which are rendered necessary for scientific knowledge without belonging to a particular science such as:

- Objective patterns (e.g., laws) exist independently.
- Theories represent objective patterns of the world.
- It is possible to know the world through our theories.

And unless we see philosophy as a purely formal enterprise, these assumptions may acquire the status of a theory by going from being aggregate conjectures to well-formed systems shedding light on other fields.

4] The Nature of Philosophical Propositions

One can proceed upwards (from problems to presuppositions) or downwards (from presuppositions as truth or meaning conditions of the assertions under question) in philosophical inquiry. In any case, the difference between a scientific and philosophical statement remains open. Without denying that this is only a conceptual distinction, Bunge (2018) proposes the following classification:

- *Ordinary empirical generalization*: Inductive assertions based mainly on ordinary experience (e.g., All swans are white).
- *Scientific empirical generalization*: Involves no theoretical concepts but is subjected to measurement and empirical control (e.g.: Galileo's law of free fall, cinematic theory, learning theory).
- *Scientific statement*: Involves theoretical concepts that are directly or indirectly subjected to measurement and empirical

control (e.g.: theory of relativity, evolutionary theory, Keynesian theory).

- *Philosophical statement*: Involves theoretical concepts that are not subjected to measurement nor empirical control, but indirectly to specific statements. (e.g., All things are material, or *Ex nihilo nihil fit*).
- *Wild speculation*[4]: Involves theoretical concepts that are not subjected to measurement, empirical control, or specific statements (e.g., creationism, accounts of parallel Worlds, or ramblings about *Dasein*).

Even when theoretical physics contains extremely general statements, philosophical hypotheses are too astray from measurements to be directly testable. They, however, entail other statements, so the main way to test a philosophical theory is through its interactions with more specific theories of science (Romero, 2018). Proceeding upwards the relation is one of a presupposed background; but proceeding downwards, the relation is one of entailment (through a set of auxiliary assumptions). The former leads us to one last maxim of philosophical practice:

- *Principle of presuppositional condition*: Philosophical presuppositions must entail the truth or meaning of empirical, theoretical, logical, or moral issues.

Although philosophical concepts are presupposed, there are factual constraints (except perhaps in the philosophy of mathematics) so no wild speculation is allowed. One can risk entering "empty verbalism" or "vagueness" as Popper (1952) warned if no real problems are tackled. The current proposal stresses the task of the philosopher as a generalist for imparting systemic order into the domain of relevant data.

Without undermining the psychological aspect of awe that originates a philosophical mode of understanding (see *Addenda*), a set-theoretic view of philosophical inquiry asserts that general statements are truth conditions for the specific concepts they entail (i.e., for these to be "meaningful") which remain presupposed until a second-order reflection occurs. These propositions constitute a

[4] "Nonsense speculation" can be included as a pseudoproposition not subjected to anything (nor grammatical rules) but the author's imagination akin to Peirce's tenacity method.

continuum with its subject matter, not a distinct sphere. Moreover, these statements are to be evaluated by their informativeness, adequateness, cogency, generality, novelty, and presuppositional condition.

But even considering these heuristics, there is one problem, namely, theoretical overdetermination. There can be many philosophies that count as presuppositions for an open problem or question. However, not all proposals have the same heuristic scope. One must narrow the search space and see which is the best account while keeping the general and presuppositional aspects of philosophy as much as possible. A comprehensive *synopticon* continues to be the lofty aspiration of philosophers.

5] Addenda

Metaphilosophy addresses general conditions of philosophical practice and knowledge. It is usually divided into descriptive and normative metaphilosophy. The former belongs to the field of historiographic, psychological, or sociological research, whereas the latter discusses topics such as those presented here. As philosophical theories must be supported in some way, they are not arbitrary speculations nor are they all on an equal footing. It would not be possible to deliberate, promote rational debates, or reach agreements as a means of learning, questioning, or clarifying problems without resorting to the aforementioned principles of philosophical inquiry. Philosophy is here defined as a second-order systematization of pervasive concepts on issues regarding knowledge, truth, and value. This position has historical support as various philosophical schools have upheld the need for a comprehensive view of the world (*Weltauffasung*), an interest in lived experience (*Lebenswelt*), and a depiction of mankind in society (*Sozialstruktur*) (Vidal, 2012).

But once a theory is developed, rules for evaluation can also be formulated. The following rules are offered by Bunge: (2012):

- *Fertility Criterion*: Compare philosophical theories by how they help foster knowledge.
- *Deliberation Criterion*: Compare philosophical theories by how they help to learn, pose, and solve problems.

Philosophy as *conceptual research* must adjust to good practices of argumentation. But as a *product* (i.e., a philosophical theory) it wouldn't hurt to consider these additional rules to assert its value.

Plant (2007) further argues that metaphilosophy must also address the social and institutional factors where philosophical practices are performed such as academic communities, psychological factors, cultural heritages, conceptual methods, distinguished authors, or communicative norms. This emphasizes that no human practice occurs in a social or institutional vacuum. In that sense, Rescher (1985) is right to dismiss consensus as a *sine qua non* criterion. The lesson is not to neglect or undermine the external factors of philosophical practices, but to locate them without detriment of the internal factors that illustrate the effort for a rational and systemic foundation of our bulk of knowledge.

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Object-Oriented Ontology and Materialism

Martín Orensanz[1]

Abstract—According to Object-Oriented Ontology, matter does not exist. Here I will challenge that idea, by advancing some arguments that aim to establish that matter can be conceptualized both as a sensual object as well as a real object. I will also argue that matter is not fictional, and that the word "matter" can be understood as a term that is grammatically singular but referentially plural. This being so, matter itself is a plurality of things, each of which has some kind and quantity of energy.

Résumé — Selon l'ontologie orientée objet [*object-oriented ontology*], la matière n'existe pas. Je vais ici contester cette idée, en avançant quelques arguments qui visent à établir que la matière peut être conceptualisée à la fois comme un objet sensuel et comme un objet réel. Je soutiendrai également que la matière n'est pas fictive et que le mot « matière » peut être compris comme un terme grammaticalement singulier mais référentiellement pluriel. Cela étant, la matière elle-même est une pluralité de choses, dont chacune possède un type et une quantité d'énergie.

Keywords—Objects; Matter; Fiction; Energy.

Object-Oriented Ontology is one of the most interesting philosophies of the 21st century. I won't present the main features of that philosophy here, I'll assume that the reader is familiar with them. Instead, what I would like to discuss is OOO's critique of matter. Harman first advanced that critique in *Tool-Being*, where he says:

> What separates this model from all materialism is that I am not pampering one level of reality (that of infinitesimal particles) at the expense of all others. What is real in the cosmos are forms wrapped inside of forms, not durable specks of material that reduce everything else to derivative status. If this is "materialism," *then it is the*

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> *first materialism in history to deny the existence of matter*. (Harman, 2002: 293; emphasis in the original)

He continued to develop this critique throughout his subsequent publications.[2] The most recent of these is his discussion with Javier Pérez-Jara, published as a book chapter in *Contemporary Materialism: Its Ontology and Epistemology*. I believe that the fact that Harman was invited to contribute to this book shows that the editors regard him as one of the most important immaterialist philosophers of our times, if not the most important.[3]

In this article, I will challenge Harman's claim that matter does not exist. But a few preliminary comments are in order. Firstly, I would like to mention that I am in no way hostile to Object-Oriented Ontology. Quite the contrary, it has been, and continues to be, a great source of inspiration for me. So, this article shouldn't be read as an attack piece. Far from aiming to demolish OOO, my intention is to provide some constructive criticism. Nor do I seek to turn Harman into a materialist. If, after reading the present article, he finds flaws in what I have to say, or if he comes up with new objections against materialism, then I will feel that what I have said here has been of some use for the development of OOO.

Secondly, I believe that materialists (and I'm one of them) should interpret Harman's critique of matter as a wake-up call. As materialists, we typically take the concept of matter for granted. But, given the force of Harman's critique, we need to rethink the fundamental concept of our philosophy.[4] Fortunately, it's not necessary to do this from scratch, since Bunge's definition of matter seems to be more or less correct, at least for the time being. However, I will argue that there is a certain problem with Bunge's point of view, since

[2] I won't list all of those publications here, but see especially Harman (2010, 2011, 2014). See also his discussion with Manuel DeLanda, in DeLanda & Harman (2017).

[3] Yet, Harman's philosophy is usually misunderstood in this or that aspect. The editors of the aforementioned book incur in one such mistake when they characterize Harman as an idealist (Romero *et al.*, 2022: xiv). This is a mischaracterization, since Harman is not an idealist, he's a realist.

[4] One should distinguish two different but related critiques in Harman's *oeuvre*. On the one hand, there is the critique of materialism as a philosophy. On the other hand, there is the critique of the concept of matter itself. In this article, I will focus only on the latter.

he defines matter as a mathematical set, and he acknowledges that sets are fictional. I will say more about this later.

At first glance, it would seem that I should begin this article by offering a definition of matter. But I would like to proceed in a different way. What I aim to show in the next section is that, irrespective of how we define matter, it can be conceptualized as a sensual object. In other words, for the purposes of critiquing OOO's rejection of matter, it doesn't matter (pardon the pun) how we define the concept "matter". This is because any definition of that concept is compatible with the claim that matter can be understood as a sensual object, as we shall see in the next section.

1] Matter as a Sensual Object

Recall that OOO distinguishes two basic kinds of objects: real and sensual. Real objects exist by themselves, while sensual objects exist relationally. That is, a sensual object can only exist in relation to a real object. For example, if I imagine a centaur, then I am the real object in this case, while the centaur is the sensual object. In *Guerrilla Metaphysics*, Harman says:

> We saw earlier that any sensual object, a centaur for example, comes to presence by subordinating a number of component objects. We do not encounter a set of colored data-points that are then immediately woven into a total object. Instead, there is a layering effect in which the centaur is not assembled equally from eyeballs, hairs, color-flecks, and atoms, but only from its most proximate parts, whatever those might be for any given viewer. (Harman, 2005: 184)

With this in mind, what I would like to suggest is that if centaurs exist as sensual objects, then matter also exists as a sensual object, since there would seem to be nothing that would warrant a differential treatment here. In other words, I advance the following argument:

> (SO1) There is no ontologically significant difference between a centaur and matter.
> (SO2) If so, then: if centaurs exist as sensual objects, then matter exists as a sensual object.
> (SO3) Centaurs exist as sensual objects.

(SO4) So, matter exists as a sensual object.[5]

This argument is structurally similar to the one that Daniel Z. Korman reconstructs for the case of islands and incars.[6] It's indeed an argument from arbitrariness, also known as a parity argument.[7] Before discussing it, let me say a few words about the formulation of arguments in general. In *Prince of Networks*, Harman criticizes Meillassoux's lecture at Goldsmiths, and he compares his way of thinking to analytic philosophy:

> A similar model of thinking is proclaimed by analytic philosophy, with its assumption that tearing down the faulty logic of unsound arguments is the primary task of philosophy. For the analytics the great enemies of human thought are fuzziness, non sequiturs, lack of clarity, poetic self-indulgence, and insufficiently precise terminology. I disagree with this threat assessment. In my view these are all relatively minor problems in comparison with shallowness, false dichotomies, lack of imagination, robotic chains of reasoning, and the aggressive self-assurance that typifies analytic philosophers at their worst. (Harman, 2009: 167)

I don't disagree with this characterization of analytic philosophy. And it would be an understatement to say that there is a grain of truth to what Harman is saying here, because there is certainly quite a lot more than just a grain of it. That being said, I happen to like arguments. Not only do I find them useful for discussing this or that point of view, I also find arguments to be aesthetically

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[5] In a personal communication, Harman (2022) says: "Yes, matter *can* be a sensual object if someone imagines 'these centaurs are ultimately made of matter', but I doubt that this happens very often." My reply: point taken. Though I don't know if the frequency of such occurrences is relevant here. In my everyday life, I don't usually think about anteaters or the moons of Jupiter, but the fact that I don't usually think about them doesn't mean that I don't encounter them as sensual objects on those rare occasions in which I do think about them.

[6] Here is Korman's original argument:

> (AR1) There is no ontologically significant difference between islands and incars.
> (AR2) If so, then: if there are islands then there are incars.
> (AR3) There are islands.
> (AR4) So, there are incars. (Korman, 2015: 6)

Korman himself rejects AR1, and I agree with him. There is indeed an ontologically significant different between islands and incars: they have different sorts of persistence conditions.

[7] The term "parity argument" was proposed by Fairchild & Hawthorne (2018).

pleasing. Korman's *Objects: Nothing out of the Ordinary* is one of my favorite books, mostly because the way in which he constructs arguments is masterful. In other words, I believe that there is an artistic aspect to the formulation of arguments. It's a craft, comparable in some sense to painting, sculpting and wine making.[8]

Having said this, let's take a more detailed look at the argument that runs from SO1 to SO4. The idea behind the first premise is that there would seem to be nothing that would warrant treating a centaur, but not matter, as a sensual object. So, given that both are sensual objects, there is no ontologically significant difference between them. SO2 follows from this. If it makes sense to say that centaurs exist sensually, then it also makes sense to say that matter exists sensually, as long as they're ontologically on a par. To claim otherwise would be to embrace metaphysical arbitrariness. SO3 simply summarizes what I believe is one of Harman's main points in his discussion of centaurs in *Guerrilla Metaphysics*. Given these three premises, the conclusion follows.[9]

Now, if matter exists at least as a sensual object, then this contradicts the passage in *Tool-Being* quoted before, in which he denies the existence of matter. It can't be the case that matter does not exist at all, or in any sense, because at the very least it exists sensually, just as centaurs do.[10]

[8] In the same personal communication mentioned before, Harman (2022) says, "I don't dislike arguments either. As you probably realize, I just dislike the hyper-aggressive way that analytic philosophers rely on them." Here's my reply: Yes, I dislike that attitude as well, and I consider myself an analytic philosopher. I find it cringy when people use arguments as an excuse for being unnecessarily aggressive. It gives analytic philosophy a bad name.

[9] Harman (2022) tells me: "I'm not saying that matter *cannot* be a sensual object. Anyone who believes in matter is encountering it as a sensual object. I simply deny that it is *usually* there as a sensual object in most situations. Most people will encounter a centaur, but not matter." My reply here is that I've said my piece about this a few footnotes ago. Then Harman says something more about matter: "It *can* exist sensually, just as any false theoretical object can." My reply: this is an interesting objection, I take it that matter understood in this way would be comparable to the aether, which was a staple of pre-Einsteinian physics. I would need more time to come up with a suitable response to this objection, so I'll leave that for another article.

[10] To be fair, Harman had not developed the concept of sensual objects in *Tool-Being*, that would occur in *Guerrilla Metaphysics*. So, perhaps he would change his mind about the passage in his first book where he denies the existence of matter.

As for myself, I reject the argument that runs from SO1 to SO4, even though I'm the one that has formulated it. Why would I formulate such an argument if I reject it? Because, although this argument is not problematic for a materialist like me, it is indeed problematic for Harman's philosophy. It would be metaphysically arbitrary to claim that a centaur is a sensual object but that matter is not. That being said, the premise that I myself reject is SO1. I claim that there is indeed an ontologically significant difference between a centaur and matter, because the former is fictional while the latter is not.[11] I will say more about this later. In the next section, I will argue that from the point of view of OOO, matter also exists as a real object.

2] Matter as a Real Object

In the original workshop on Speculative Realism, Brassier asked Harman what would be the difference between a quark and a hobbit. In asking this question, it seems that he was raising an objection: OOO has no principled way of distinguishing them, even though it seems evident that quarks are real and that hobbits are not. Harman noted this veiled objection, and replied that on this point, he's a Latourian. Contrary to Brassier, Harman argues that there is a sense in which hobbits are real. As he explains:

> Clearly a hobbit has to be a real object in some sense, because I can ask 'What is a hobbit?', 'What does a hobbit do?', 'How does it behave?', and this will never be completely reducible to all the things that Tolkien says in all of his novels, because you can imagine new scenarios. You can ask, 'Could a hobbit fit in a Lovecraft story?', 'Could a hobbit fit in a Proust novel?' I would say no. Now why is that? It's never been tried, so why is it that when I mention these possibilities we immediately reject them? It's because you have a sense of what the hobbit is beyond all of the things that have been said about hobbits in films and novels that we already know. So I'd say a hobbit is real. (Harman, 2007: 325-326)

[11] Harman (2022) says: "But this cannot be determined on the purely sensual level. 'Fiction' cannot arise on the sensual level. Even if I know I am imagining fictional rather than real centaurs, the fictionality only concerns the relation between sensual and real, not the sensual level itself." I honestly don't know what to reply here. But it seems to me that it would be better to leave any such reply for a different article.

But if this is so, then I believe that the same holds for matter. To see this point more clearly, I would like to advance a new parity argument:

(RO1) There is no ontologically significant difference between a hobbit and matter.
(RO2) If so, then: if a hobbit is a real object in some sense, then matter is a real object in some sense.
(RO3) A hobbit is a real object in some sense.
(RO4) So, matter is a real object in some sense.

Here is the idea behind RO1. The questions that can be asked about a hobbit can also be asked about matter. We can ask: What is matter? What does matter do? How does it behave? And this will never be completely reducible to all the things that materialists (and non-materialists) say in all of their writings and conversations, because it's possible to imagine new scenarios. How so? Well, to give at least one example, someone could write a story about matter that has never been written before, like the following one.

Once upon a time, there was a nightclub called Triple O. An array of fictional characters are lined up at the entrance. The first one is a centaur. The bouncer asks: "Name?" The centaur replies "Arkhytas". The bouncer checks his list, which is one long Latour litany. "Yes, you're on the list. Please come in". Next up is Sherlock Holmes. The bouncer checks his list again, and lets him in. This goes on and on, every fictional entity gets admitted into the building. Except for one. The last of these entities is matter. The bouncer checks his papers, and says, "Sorry, you're not on the list, you can't come in". Matter says: "But shouldn't I be on the list? I'm just as much of a sensual object as those other entities. And, if they're also real objects in some sense, then so am I". The bouncer shrugs and says, "Maybe, I don't know. I just work here. You'll have to talk to Graham Harman about that."

This being said, instead of asking if a hobbit could fit in a Lovecraft story or a Proust novel, we could ask if matter would fit in Harman's Object-Oriented Ontology. Intuitively, the answer is no, matter doesn't fit in OOO. Now, why is that? It's never been tried, and yet we immediately reject that possibility. Because—to use Harman's own words against him, making the appropriate replacements—, you have a sense of what matter is beyond all of the things that have been said about matter in the written texts and conversations that we already know. So, we arrive at a perplexing result: that matter doesn't fit in OOO, but this is precisely one of the reasons why it must be the case that matter is a real object, at least in the same sense that a hobbit is a real object.

From here, RO2 follows. If we accept that hobbits and matter are ontologically on a par, then if hobbits are real, matter must be real as well. At least in some sense. Of course, Harman doesn't believe that Bilbo Baggins actually exists as a living, breathing individual somewhere in the world, just as he doesn't believe that the tooth fairy exists as a tiny winged creature flying around somewhere. But he does believe that the tooth fairy, as well as hobbits, have a 'real' dimension qua Latourian actors, as he says in *Prince of Networks*:

> The only small concession Brassier needs to make is that the tooth fairy has a 'real' dimension qua actor in stories and myths, even if not as a genuine winged fairy flying through genuine air. (Harman, 2009: 190)

I believe that this statement applies to matter just as well as it applies to the tooth fairy. In fact, if we make the relevant replacements, then the statement looks like this: the only small concession Harman needs to make is that matter has a 'real' dimension qua actor in some written texts and conversations, even if not as genuine stuff that is located in genuine spacetime.[12]

Given RO1, it would be metaphysically arbitrary to deny RO2. Because, why would it be the case that a hobbit is a real object, but matter isn't? Either both of them are real in some sense, or neither of them is. RO3 is simply taken from the quote where Harman discusses hobbits. Recall that he says, "Clearly a hobbit has to be a real object in some sense." Given these three premises, the conclusion follows.

In the footnotes to this article, I have been quoting and responding to some points raised by Harman (2022) in a personal communication between him and me. His comments on the Goldsmiths workshop are more extensive, which is why I would like to quote them here instead:

[12] As a materialist, I believe that matter is real, not in the sense that the tooth fairy has a 'real' dimension qua actor, but rather in the sense that the table in my living room is real. More on this later.

> [A]s for the Goldsmiths discussion about hobbits, my remarks were insufficiently precise. What I meant to say is that the hobbit has *real qualities* that resist its arbitrary inclusion in a Lovecraft or Proust story. I've never really developed a theory of at what point sensual objects become widely familiar enough that they become real in a sense. So as for matter, I would say that the sensual object "matter" has real qualities. It might become "real" in the sense of being a widely believed-in reality, but again, I haven't done enough to develop that idea so far. (Harman, 2022)

I thank Harman for these observations. All I can say here is that, perhaps this discussion about hobbits and matter can serve as a good starting point for the development of the theory that sensual objects can become real objects in some sense?

Harman can still claim that matter is just as fictional as a hobbit or the tooth fairy. Hobbits don't exist as actual living people, and the tooth fairy does not exist as a small winged creature somewhere in the world. In this sense, he could say that matter doesn't exist as some actual stuff. But what he can't say, unless he's willing to bite the bullet of metaphysical arbitrariness, is that hobbits are real objects in some sense but that matter isn't, or that the tooth fairy has a 'real' dimension qua actor while matter doesn't.[13]

In the next section, I will argue that matter is not fictional, and I will present the definition that I happen to endorse.

3] What is Matter?

Harman might claim that even though I have shown that matter is a sensual object, and that it has a 'real' dimension qua actor, I have not proven that matter exists in the same way that real tables or real comets exist. I will say my piece about this in a moment. But first, let me point out that some scientific materialists, such as Bunge and Romero, would have no qualms about the claim that matter is fictional. For example, here is what Bunge says:

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[13] Harman (2022) says: "Again, I would say that matter as a sensual object can also generate real qualities, without this implying that matter exists as a real object." My response: Well, then hobbits don't exist as real objects either. They can only exist as sensual objects that have real qualities (in addition to having sensual qualities). In other words, you're choosing to deny the premise RO3 from the preceding argument. Which is an entirely legitimate option. I myself prefer to deny RO1 instead.

> DEFINITION 2. *Matter* is (identical with) the set of all material objects.
> In symbols,
> $M =_{df} \{x|\mu x\}$.
> Note that this is a set and thus a concept not an entity: it is the collection of all past, present and future entities. (Or, if preferred, *M* is the extension of the predicate μ, read 'is material'.) Hence if we want to keep within materialism we cannot say that matter exists (except conceptually of course). We shall assume instead that individual material objects, and only they, exist. (Bunge, 1981: 22)

This definition is from his book *Scientific Materialism*, which was published in 1981. Decades later, in 2006, when he published *Chasing Reality*, he reiterated the same idea, though with different symbols:

> That is, we can define "matter" as the set of all material objects present, past, and future:
> Definition 1.1 Matter $= \{x \in \Omega | x \textit{ is material}\}$
> $= \{x \in \Omega | x \textit{ is changeable}\}$
> where Ω denotes the collection of objects of all kinds.
> Being a collection, matter (the concept) is immaterial. So are hydrogen, the collection of all hydrogen molecules, and humankind, the set of all humans. (Bunge, 2006: 11-12)

The reason why Bunge believes that matter is fictional is because he thinks that all mathematical entities are fictional, and he defines matter as a mathematical set. By contrast, the real and material things are the elements of that set. But the set itself is unreal and immaterial. Romero agrees with Bunge on this point. As he explains:

> Matter, then, is not a substance but a concept: an abstraction from concrete material things. What actually exists are material beings, not matter. Matter, in the words of Bunge, is not material. It is conceptual. (Romero, 2022)

This is why Pérez-Jara (2022: 351) says that matter can be defined "in its broadest sense as changeability and plurality". I'll address the issue of changeability later. Matter does not exist as a single, universal stuff that underlies individual objects. That's just a fiction. What really exists is a plurality of material objects. There is no underlying universal stuff. I believe that there is an important parallel between Bunge and Harman here.[14] Harman does not say that the world is a single gigantic object, instead he postulates multiple different objects from the start. Likewise, Bunge does not say that matter exists as a single universal stuff, instead he postulates multiple different material things from the start.[15]

Despite the admiration and respect that I have for Bunge, here I have to disagree with him. Matter is not a mathematical set. Thus I don't join Bunge and Romero in claiming that matter is immaterial.

Here is what I propose. Instead of defining the word "matter" as a mathematical set, it should be defined instead as a disguised plural. Following Korman (2015), I characterize a disguised plural as a term that is grammatically singular but referentially plural. An example is the word "assortment". Consider the following situation:

> There is an assortment of objects scattered across my desk, consisting of a laptop, a mug, some receipts, and a couple of pens. Each of these is part of the assortment. It would seem to follow that there is a single thing—an assortment—that is composed of these objects. (Korman, 2015: 139)

But, says Korman, it's not the case that the assortment is a single object composed of a mug, a laptop, some pens, and everything else that is on his desk. An assortment is not one thing, it's many things.[16] As he explains:

> An assortment of things is not a single object. Nor is it a single *anything*. It is several things. 'The assortment' behaves grammatically like a singular term, but it is referentially plural. Like 'Alice, Bob, and Carol' or 'the students', it refers to some things, not one thing. Which, of course, is not to say that it refers to *each* of them; rather,

[14] Harman (2022) says: "Agreed. I just wouldn't call the underlying objects 'material'."

[15] For other parallels between Bunge and Harman see Orensanz (2021a) where I compare and contrast their respective theories of objects, and Orensanz (2021b) where I discuss their ideas on causation.

[16] Harman (2022) says: "Agreed, though it *can* become a sensual single thing". I believe that Bunge would agree, since he says: "A concatenate need not be a system; that is, no bonds need be involved: an arbitrary assemblage of things counts as an object." (Bunge, 2010: 269). But the question is if the assortment is a single, unified real object. As for myself, I would be inclined to say no, it isn't, if only to avoid the problem posed by the transitivity of parthood. More on this in a moment.

> it refers collectively to all of them. (Korman, 2015: 17; emphasis in the original)

Another example of a disguised plural is "The Supreme Court". This term is grammatically singular, but it's referentially plural. The Supreme Court is not a single object, it's many objects. Specifically, it's nine judges. But why isn't it a single object? Because that claim leads to a problem. It's generally considered that the relation of parthood is transitive. If x is a part of y, and if y is a part of z, then x is a part of z. Now, if this is so, and if the nine judges compose something, then it follows that the Supreme Court is a single fleshy object that has nine tongues and eighteen elbows. As Korman says:

> Is the Supreme Court a single fleshy object with nine tongues and eighteen elbows? Intuitively, no. There is an assortment of things on my desk, which includes a ceramic mug and a metal laptop. Is there a single object on my desk that is partly ceramic and partly metal? Intuitively, no. Some (e.g., permissivists) may insist upon affirmative answers to these questions, but no one (I hope) would deny that *no* is the intuitive answer (Korman, 2015: 145)

Does this mean that the Supreme Court does not exist? No, it doesn't. The Supreme Court does indeed exist, but not as a single object. It exists as many objects. The same is true of the assortment. It exists, but as many different things, not as a single thing.

On this point, Harman asks me why it wouldn't be possible to deny the transitivity of parthood:

> I don't think I agree with this view that parthood is transitive. Why isn't the Supreme Court an emergent object that *does not* have all of the transitive parts? This is the core of DeLanda's argument for emergence: the Supreme Court remains a durable unit even when its members change, because those members are not necessarily relevant to the actions of the Court as a whole. In most cases it only matters, say, that there was a 5-4 decision, not who the 5 Justices were in the ruling. (Harman, 2022)

There are two things that I would like to say here. The first one is that Bunge would agree with Harman as well as DeLanda in claiming that the Supreme Court is indeed an emergent object. He believes that parthood is transitive, but he manages to avoid the paradoxes associated with it by distinguishing levels of composition:

> A social system is a set of socially linked animals. The brains of such individuals are parts of the latter but do not qualify as members or components of a social system because they do not enter independently into social relations: only entire animals can hold social relations. (Bunge, 1979: 5)

He distinguishes five levels of reality: physical, chemical, biological, social, and artificial. Accordingly, there would be five levels of composition. But I believe that there is a problem here. Although his viewpoint sounds plausible when he discusses the example of brains and social systems, it sounds less plausible if we consider other examples, like the following one: a single-celled organism is composed of organelles, which are composed of molecules, which are in turn composed of atoms, and so forth. If trans-level composition is prohibited, then this means that single-celled organisms don't have atoms, since the physical level is different from the biological level. But this is absurd. And, indeed, Bunge (1979) argues that the chemical level emerges from the physical level, and that the biological level emerges from the chemical level. But this contradicts what he says about levels of composition, especially when he discusses the example of brains and social systems. An alternative reading would have him say that we humans are only *interested* in levels of composition, as if trans-level composition were prohibited in reality, when in fact it isn't. For example, he says:

> Thus in the case of an animal society regarded as a whole, we are interested in the set of its components not in the full set of its parts, such as the cells of the animals, even less the atomic components of their cells. That is, we want to know what the "relative" atoms of the whole are. (Bunge, 1977: 47)

But if the animals have an atomic composition, does this mean that brains are indeed parts of social systems after all, contrary to what he says in Bunge (1979: 5)? That's an open question. But it's far from being unproblematic. If the answer is "yes", then it turns out that the Supreme Court is indeed a single fleshy object with nine tongues and eighteen elbows. If the answer is "no", then it would seem arbitrary to say that brains are not among the components of a social system but that atoms are indeed among the components of an animal.

The alternative is to deny the transitivity of parthood. This is a live option, and it's an issue that has led to some interesting discussions.[17] But it's a controversial idea, because it leads to problems of its own, like the following one. Your fingers are parts of your hands, and your hands are parts of your body. If parthood isn't transitive, it follows that your fingers are not parts of your body. So, you don't have fingers. Or this other problem: these bricks are parts of this wall, and this wall is a part of this house. If parthood isn't transitive, then these bricks are not part of this house. So, this house doesn't have bricks.

That being said, Harman might argue that the Supreme Court is indeed a single object, which is not reducible to its nine judges, just as the Dutch East India Company or VOC is a single object that is not reducible to its officers. He might add that to claim otherwise is to agree with Margaret Thatcher when she says that society does not exist, only individuals exist. My reply is that materialists will have to make a tough choice here. The options are: 1) To agree with Margaret Thatcher in claiming that society does not exist, even though it evidently does, 2) To agree with Bunge in distinguishing levels of composition, even though this leads to the problems mentioned before, 3) To agree with Harman in rejecting the transitivity of parthood, even though it leads to the problem of not having fingers, 4) To embrace the highly problematic idea that the East India Company is a single fleshy object that has thousands of tongues and elbows, not entirely unlike the Hecatoncheires, fictional creates from Greek mythology, which are typically depicted as individuals that have fifty heads and a hundred arms, and 5) To conceptualize the term "society" as a disguised plural, as Korman understands this term, and to explain why this viewpoint is not identical to Margaret Thatcher's. Easier said than done! I choose the fifth option. I'll leave the articulation of this idea to a future article, though I can already see that it will be an uphill battle.

Having said this, it's important to note that the Supreme Court is different from the mathematical set that has nine judges as elements. That entity, the mathematical set of nine judges, does not

[17] See for example Johansson (2004), Varzi (2006), and Seibt (2014).

exist.[18] But the Supreme Court, as a plurality, does indeed exist. The mathematical set of things on Korman's desk does not exist. But the plurality of things on his desk—the assortment—, does indeed exist. I claim that matter is comparable to these cases. The word "matter" is referentially plural. It's not one thing, it's many things. And it exists, just as the plurality that we call "The Supreme Court" exists, just as the assortment of things on Korman's desk exists. Matter as a plurality, I suggest, is different from the mathematical set of all material objects. Bunge and Romero are right when they say that the mathematical set of all material objects does not exist. But they are wrong in identifying that mathematical set with matter itself.

The other characteristic of Pérez-Jara's definition of matter is changeability. Following Bunge, we can define changeability as having energy. It's important to note that matter is not identical to energy, nor is a material object identical to the energy that it has. A material object is a thing, while energy is one of its properties. Indeed, Bunge suggests that energy is the most general property, in the sense that every material object has some kind and some quantity of it. This is all that it takes to define a material object.

Contrary to popular opinion (and to some academic opinions), matter and energy are not identical. They're not even equivalent. Energy is equivalent to mass, but not to matter. This confusion seems to stem from incorrect interpretations of Einstein's famous formula, $E = mc^2$. As Bunge explains:

> It has been said that "$E = mc^2$" proves that physics has dematerialized matter. This claim involves two confusions: the identification of "matter" and "mass", and the belief that energy is a thing, while actually it is a property of material things: there is no energy without things, just as there are no areas without surfaces. (Bunge, 2012: 137)

Having this in mind, I think that it's wrong and misleading to use the phrase "matter-energy", as some thinkers do. For example, Manuel DeLanda, who is one of Bunge's greatest readers, and who agrees with Bunge's theory of causality, says this:

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[18] More precisely, since Bunge traces a distinction between conceptual existence and real existence, we can say that the mathematical set in question exists conceptually, but it doesn't exist in reality.

> In a very real sense, reality is a *single matter-energy* undergoing phase transitions of various kinds, with each new layer of accumulated "stuff" simply enriching the reservoir of nonlinear dynamics and nonlinear combinatorics available for the generation of novel structures and processes. Rocks and winds, germs and words, are all different manifestations of this dynamic material reality, or, in other words, they all represent the different ways in which this single matter-energy *expresses itself*. (DeLanda, 1997: 21; emphasis in the original)

I disagree with DeLanda here, for two main reasons. Firstly, I reject the term "matter-energy". Since matter is a thing and energy is a property, to speak of "matter-energy" is like speaking of something that we may call "apple-red". As if an apple, which is a thing, were identical to the reddish color that it has, which is one of its properties. But this is wrong, an apple is not identical to its color.[19] Secondly, I deny that matter is a single universal stuff from which different individual things such as rocks and germs emerge. Matter exists, but it's not a single cosmic thing, it's many different things.[20]

Bennett seems to agree with DeLanda.[21] She says: "I believe in one matter-energy, the maker of things seen and unseen. I believe that this pluriverse is traversed by heterogeneities that are continually *doing things*." (Bennett, 2010: 122; emphasis in the original). Again, I reject the term "matter-energy". I believe that the heterogeneities that Bennett speaks of shouldn't be conceptualized as the products, or the things that are made by, a universal entity called "matter-energy", as if the latter was their maker. Instead, I suggest that these heterogeneities should be conceptualized as different material entities from the very start, without any universal stuff underlying them. Plurally, they *are* matter, instead of emerging from an underlying universal matter, just as the plurality of objects on

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[19] Nor is it identical to all of its properties taken collectively. To claim otherwise is to embrace the empiricist idea that a thing is nothing more than a bundle of qualities, which is a far cry from realism.

[20] Harman (2022) asks: "How is this different from my view that there are only forms?" My reply is that this is different because not all forms, as OOO understands them, have energy. For example, Sherlock Holmes doesn't have energy, but he's still a form according to OOO.

[21] Harman (2022) remarks: "I don't think that Bennett agrees with DeLanda here. Despite their shared root in Deleuze, I don't see DeLanda as retreating to that level of a single matter-energy in his theory." My reply: fair enough, point taken.

Korman's desk *are* an assortment, instead of composing a single object called "an assortment".

This being said, Romero raises an objection against Bunge's identification of energy and changeability:

> I can offer an objection to this second definition provided by Bunge. Although change always requires energy, and then it is correct to say that all material things have energy, it is not true that energy always allows for change. If a complex system is in thermodynamic equilibrium, i.e. if its entropy is at a maximum, then the system will not change. This is because it is not the total energy that matters for change, but the difference of energy between different parts of the system. This difference is quantified by entropy. Bunge's definition, I think, only applies to simple things, substances, and not to systems. In general, energy does not amount to mutability, which is the true trademark of materiality. Hence I will adopt in what follows the first definition of material thing: any substance, system, or aggregate with a non-trivial state space. (Romero, 2022: 83)

If this is so, then I would disagree with Pérez-Jara in defining matter as changeability and plurality. Instead, I believe that matter should be defined as a plurality of material objects, each of which has some kind and some quantity of energy, without implying that energy is identical to changeability. The concept of energy is what allows us to say that rocks and tables are material, while mathematical sets and fictional creatures are not. The former have energy, while the latter do not.[22]

[22] Harman (2022) says: "Interesting, but then it's not clear why you would speak of matter at all, instead of simply saying 'energy.'" Here's my reply: because energy is a property (or quality, if you will) while matter is a plurality of objects, such that each of them has energy. Otherwise, instead of speaking of, for example, lemons, we should simply say "yellow", as if a lemon were identical to its color, which is one of its properties. But, since we're realists instead of empiricists, we wouldn't be inclined to say that. Then Harman asks "Also, is it really true that immaterial objects have no energy?" My reply: I'd say something more cautious: the claim that immaterial objects have no energy has not been proven to be false, at least so far. Next, Harman says: "The Supreme Court may be immaterial, but clearly it has energy, doesn't it?" I think that the Supreme Court is material, since it's nine judges, and each of them is material. So, each of the nine judges has energy, which means that the Supreme Court itself has energy. This, however, is an extremely controversial claim, and it requires an article of its own. There are alternative views, which are certainly live options: the Supreme Court could be just an institution, and perhaps all institutions are immaterial insofar as they're concepts. Or it could be the case that the Supreme Court is immaterial, but instead of being a

4] Concluding Remarks

I have challenged Harman's attempt to eliminate matter, and I have done so by formulating different arguments from arbitrariness, also known as parity arguments. What they aim to establish is that it would be metaphysically arbitrary to countenance centaurs as sensual objects and to repudiate matter as one of those, or to countenance hobbits as real objects and to repudiate matter as one of those. Either centaurs and matter are both sensual objects, or neither is. Either hobbits and matter are both real objects, or neither is. Furthermore, I have rejected those very arguments that I formulated, by identifying a significant ontological difference between matter and fictional entities.[23] This is in contrast to Bunge and Romero, who believe that matter should be understood as a mathematical set. Instead, I suggest that matter should be understood as a plurality of real things, each of which has some kind and some quantity of energy. Mathematical sets and fictional characters don't have energy, so they're not material.

Acknowledgments

I would like to wholeheartedly thank Graham Harman for his invaluable comments on an earlier version of this article, and for giving me permission to quote our personal communication. I wish him good luck in the development of his immaterialist philosophy, and I look forward to reading his future works.

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concept, it's a real, emergent object. This last claim could be articulated in a way similar to how Harman understands the Dutch East India Company.

[23] Harman (2022) says: "Here I would repeat my point that both hobbits and matter have real qualities without necessarily being real objects, even if they are both really pluralities of objects." My reply: duly noted. I've said my piece about this some pages ago.

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Matter and Society
Response to Orensanz

Graham Harman[1]

Abstract—This article is a response to Martin Orensanz's argument that object-oriented ontology ought to accept the existence of matter as both a sensual and a real object. That matter can exist as a sensual object is a point immediately granted, since "sensual object" is such a broad term that nothing could be excluded from this designation. Yet I argue that this is not the case with respect to real objects, which must exist independently of any other entity that might encounter them. This leads to a related debate on whether parthood is transitive, in which Orensanz takes up a recent argument of Daniel Korman while I defend the modified Aristotelian position that only the proximate parts of an object can be said to belong to it in the strict sense.

Résumé—Cet article est une réponse à l'argument de Martin Orensanz selon lequel l'ontologie orientée objet devrait accepter l'existence de la matière en tant qu'objet à la fois sensuel et réel. Que la matière puisse exister en tant qu'objet sensuel est d'emblée admis, puisque « objet sensuel » est un terme si large que rien ne peut être exclu de cette dénomination. Ce n'est pourtant pas le cas, selon moi, des objets réels, qui doivent exister indépendamment de toute autre entité susceptible de les rencontrer. Cela conduit à un débat sur le caractère transitif de la relation partie-à-tout, dans lequel Orensanz reprend un argument récent de Daniel Korman, tandis que je défends une position aristotélicienne amendée selon laquelle seules les parties proximales d'un objet peuvent être considérées comme appartenant à cet objet au sens strict du terme.

Keywords—Materialism; Object-oriented ontology; Speculative realism; Mario Bunge; Daniel Korman.

Speaking as an object-oriented ontologist, it is a pleasure to respond to Martin Orensanz's article "Object-Oriented Ontology and Materialism" (Orensanz 2024). Among other things, it is

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refreshing that the first lines of his abstract get straight to the point: "According to Object-Oriented Ontology, matter does not exist. Here I will challenge that idea, by advancing some arguments that matter can be conceptualized both as a sensual object as well as a real object." (Orensanz 2024: 268). Orensanz is correct that for Object-Oriented Ontology [OOO], matter does not exist; he correctly notes that this was true as early as my first book (Harman 2002). He will attempt to counter this view, proclaiming that matter can be treated on OOO's own terms as *both* a real object and a sensual object. Perhaps I should begin by saying that the sort of "matter" attacked by OOO was initially the formless "prime matter" thought by some to exist prior to any individual objects, but to an increasing degree the target has been the "pre-individual" realm championed by Gilbert Simondon (2020). If something exists, then it is one, and in that case its unity gives it a minimum of one quality. In OOO's terms, this is enough to make it an object, even if it is given such anti-objectual nicknames as "pre-individual," "apeiron," "blob," "*il y a,*" "whatever," or "inconsistent multiple."[2] Yet the question of whether matter can be an object is less central for Orensanz than the rather different one of whether it can exist as both real and sensual. Thus an explanation of these terms is in order, given that some readers of this article may not have previous familiarity with OOO.

1] Sensual and Real

We begin with the term "sensual," which does not refer to the senses as opposed to the intellect, but to whatever is directly accessible as opposed to a reality that is not thus accessible (Harman 2011: 20–34). It would not be wholly inaccurate to link OOO's distinction between real and sensual with Kant's division between thing-in-itself and appearance (Kant 1965). The chief difference is that for Kant appearance always means appearance to some (invariably human) mind, while for OOO the sensual realm pertains to all relations whatsoever, including those involved in inanimate causation. While this is an especially controversial and interesting aspect of OOO, it is not of particular importance to Orensanz at this

[2] These are the terms proposed respectively by Gilbert Simondon (2020), Anaximander (cf. Zeller 1886: 39–41), the architect Greg Lynn (1996), Emmanuel Levinas (2001), Jean-Luc Nancy (1993), and Alain Badiou (2005).

juncture, and thus we leave it aside. More pertinent here is the link between OOO's sensual realm and the concerns of phenomenology. Franz Brentano is widely credited with reviving the medieval term "intentionality" to refer to the property of every mental act that it is directed toward an object (Brentano 1995). Brentano also uses the phrase "immanent objectivity" to refer to this situation, though without clarifying what relation—if any—this immanent object might have to a world outside the mind. One of Brentano's most talented disciples, the Polish thinker Kazimierz Twardowski, proposed a dualism of "objects" outside the mind and "qualities" inside the mind (Twardowski 1977). In opposition to this model, the young Edmund Husserl protested that any inside/outside distinction would render knowledge impossible, since there would be no way to establish a link between a real Berlin-object in the world and the Berlin-qualities I have in my mind (Husserl 1994). Rather than trying to explore how such mediation might occur, Husserl insisted that any notion of a real Berlin different in kind from mental Berlin-qualities is "absurd." In this way, both the power and the limits of phenomenology were permanently established. On the one hand, phenomenology's rejection of anything like a Kantian thing-in-itself was etched in stone. On the other, Twardowski's object/content distinction was ingeniously retained by imploding *both* terms into the intentional sphere. This can be seen in Husserl's crucial distinction between intentional objects and the numerous fleeting adumbrations (*Abschattungen*) through which they become accessible to us (Husserl 1970).

Unlike Husserl, OOO regards the Kantian thing-in-itself not as absurd, but as an essential consequence of the fact that no relation (or sum total of relations) can ever exhaust the reality to which it relates. The Berlin that is accessible to me is in fact *not* equivalent to the real Berlin, as easily seen from the fact that whatever Weimar-era cabaret shows and Nazi rallies might occur in someone's mind, these mental experiences do not have the same causal status as the actual shows and rallies in Berlin itself. There is the additional fact that someone might be confused or outright deluded in their thoughts about Berlin, and while thoughts may be utterly confused or deluded at times, a real thing such as Berlin cannot be deluded in its act of existing, but simply is what it is. Although Martin Heidegger often shares his teacher Husserl's intuition that the inner/outer distinction is a "pseudo-problem," in practice Heidegger is closer to Kant. This is perfectly clear from an explicit but under-recognized passage in his book on his great predecessor, in which he faults German Idealism for its denial of the thing-in-itself (Heidegger 1965: 251–252). More broadly speaking, none of Heidegger's reflections on the forgetting of Being and its various disclosures through the course of history would make any sense if he agreed with Husserl on the transparent accessibility of any object to an intentional act (Heidegger 1962). In any case, the thing-in-itself that exceeds direct contact—and not just for humans—is what OOO calls the real.

In arguing that matter can exist in the form of a sensual object, Orensanz appears to be contesting an explicit passage in *Tool-Being* that runs as follows: "If [OOO] is 'materialism,' *then it is the first materialism in history to deny the existence of matter*." (Harman 2002: 293). Orensanz reads this denial in a maximalist sense, as though it denied the possibility that matter could exist even sensually, though he concedes in a footnote that I "had not developed the concept of sensual objects in *Tool-Being* that would occur [three years later] in *Guerrilla Metaphysics*." (Orensanz 2024: 5n10). But in case I did mean to deny even sensual existence to matter, he lays out a diligent pre-emptive proof of how—on my own terms—matter should at least be permitted to exist in the sensual realm. After all, *Guerrilla Metaphysics* already permits the existence of centaurs as sensual objects (Harman 2005: 184). Given this, Orensanz is easily able to show that matter ought to be treated at least as liberally as the mythical horse-humans of ancient Greek lore. In so doing he refers to a similar argument made for the existence of Eli Hirsch's "incars" (defined as cars positioned entirely inside garages) by Daniel Z. Korman, who proposes to demonstrate that such incars are every bit as real as islands (Hirsch 1982; Korman 2015: 6).

As concerns the permissibility for OOO of matter existing as a *sensual* object, Orensanz is assaulting an open door, though this may be my own fault due to lack of clarity (or foresight) in the aforementioned passage from *Tool-Being* against materialism. On any occasion where I may have said "matter does not exist," or anything along those lines, it would have been meant solely to deny the existence of matter as something *real*. In OOO's sensual realm, anything goes. Not only centaurs and incars circulate freely, but so do "outcars," non-centaurian centaurs, square circles, cartoon characters, and all monsters and demons that one can imagine. The sensual is a kind of Meinongian nature preserve where nothing can be eliminated. Yet it is also a purely harmless preserve, since it does not entail that any of these objects exist independently of thought (Meinong 1983). We can imagine complaints from the likes of Willard van Orman Quine that this sensual realm is aesthetically sloppy: "[this] slum of possibles is a breeding ground for disorderly elements. Take, for instance, the possible fat man in that doorway; and, again, the possible bald man in that doorway. Are they the same possible man, or two possible men?" (Quine 1980: 4). Yet the objections are irrelevant here, since we are not talking about *possible* sensual objects, but fully actual ones, whose number is heavily restricted by the fact that they exist only while someone or something is thinking of them. The sensual object "centaur" only exists for the one who actually confronts this object right now; once this person changes their focus of mental attention, falls asleep, or dies, the sensual centaur vanishes from the universe. And true enough, Orensanz is right that just as we can think of a centaur, a fat man in the doorway, or a possible bald man in the doorway, we can also think of matter. Thus I have no objection to the sensual existence of matter: not because it is matter, but because it is anything at all. The sensual realm is an ontological "safe space" where pretty much anything is welcome as long as we relate ourselves to it. The question is whether matter is also *real*: that is, whether it exists even when no one is positing its existence. While I freely admit that it *could* exist, I also deny that it does.

But before moving on to Orensanz's discussion of the real, I would like to address one recurrent misunderstanding of the real and the sensual in OOO. According to this misreading, the sensual realm consists of all manner of different objects, but then only "some" of these objects turn out to be real. For instance, if I am in a room in which my pet dog is present while I am also imagining a battle of centaurs, then the dog is real but the centaurs merely sensual. Even as careful a reader as Quentin Meillassoux makes this mistake—in connection with qualities rather than objects—in his Preface to the French translation of my book *Dante's Broken Hammer* (Meillassoux 2023: 18)[3]. Here Meillassoux misconstrues the standpoint of OOO as one that is closer to Wilfrid Sellars's

[3] The French translation of the book is Harman (2023), while the original English is Harman (2016).

distinction between the manifest and scientific images: all of which are images, but only some of which adhere tightly enough to reality (Sellars 2007). For OOO, by contrast, there is a radical incommensurability between any image—which can only be sensual in our terms—and the real it aspires to denote.

Since this point touches on a crucial aspect of my rejection of the existence of matter, it is worth a bit more of our time. Let's use the term "intellectual intuition" to refer to the mechanism by which some philosophers hold that reality can be made directly present to the mind via certain mental acts, something wholly forbidden by Heidegger and Jacques Derrida under the title "metaphysics of presence." (Heidegger 2009; Derrida 2016)[4]. Some philosophies, known collectively as "direct realism," go even further and hold that pretty much any experience gives us at least some degree of access to the real. But for most advocates of direct access, there are privileged sorts of mental acts that do this with especial adequacy. In Husserl's case, we are meant to follow the path of eidetic reduction and categorial intuition to gain insight into the essence of a thing. For Meillassoux it is mathematics that enables us to view the primary qualities of things directly (Meillassoux 2008). In both cases, and in all other such cases of intellectual intuition, an overlap is posited between the thing and the mind that knows it. We need only recall Husserl's denial that there is any ontological difference between Berlin itself and the Berlin I intend, despite the fact that real buildings and schools of poetry can exist in Berlin but not in my mind. Precisely here is where the concept of "matter" is usually invoked: as a guarantor of the identity of the two Berlins. The idea, in short, is that Berlin can be known directly because one and the same form is contained in the Berlin of the world and the Berlin of my knowledge; the difference between them is that the real Berlin exists "in matter" while the Berlin of knowledge does not. But given that formless matter has never been seen or even indirectly detected, its existence can only be justified as a fictional prop for the groundless wish that forms might be moved from the world to the mind without translation or energy loss. I would certainly concede that an imaginary table does not hurt my foot in the night, though

[4] Derrida pushes the critique further to cover a non-existent additional enemy dubbed "self-presence," leading him to the needless sacrifice of the principle of identity. See Harman (2022).

a real one often hurts me badly: I simply deny that the difference between them consists in the supposed "material existence" of the real table. Instead, there is a difference *in form* between the table that hurts and the one that does not, a difference usually overlooked because we falsely imagine that the presumed visual congruity between the two is enough to establish an identity of form. A similar assumption haunts Kant's inadequate view of the difference between real and imaginary coins (Kant 1965: 500–507). Namely, he holds that all of the qualities of the two coins are the same except that the real ones have "being," which he then interprets as "not a real predicate," so that being has to become a matter of "position" with respect to us. What Kant fails to see is that the real and imaginary coins do not have the same qualities to begin with, and this prevents him further from addressing the ontological proof for the existence of God in the proper way. But that is a topic for another time; we now return to Orensanz's argument that matter is also a real object.

Orensanz begins by citing a passage from the 2007 Speculative Realism workshop in which I appear to argue for the "reality" of hobbits, after Ray Brassier presses me on the question of whether hobbits are just as real as quarks (Ray Brassier, in Brassier *et al.* 2007: 316–317). My misleading response at the time was that I am a Latourian on this point: that is to say, given that hobbits as literary concepts can have effects on other entities, and given further that despite their fictionality hobbits cannot conceivably fit just anywhere (such as in the novels of Proust), they must be granted a certain reality (Graham Harman, in Brassier *et al.* 2007: 324 ff.). Anyone familiar with my critical appreciation of Latour in *Prince of Networks* and elsewhere will immediately recognize that I do not hold that for something to have effects on the world qualifies it as a real object (Harman 2009). That is Latour's own position, but definitely not mine. Orensanz himself clarifies this by helpfully citing a later email in which I specify that a hobbit should instead be interpreted as a sensual object with real qualities, which is precisely how I read Husserl's intentional object.[5] For OOO, all sensual objects have real qualities, since otherwise they would consist of nothing but swirling accidental features. As a result, (1) intentional objects would be nothing more than a series of adumbrations, and (2)

[5] Personal communication, June 13, 2022.

all intentional objects would be the same. It should also be noted that sensual objects are sometimes able to turn into real ones, in ways that neither I nor anyone else connected with OOO has written much about, but this is not the place to develop that notion. In any case, Orensanz is right that I have to treat matter as liberally as I treat hobbits: even though I do not accept the existence of something called matter, I must at least concede that matter qua sensual object has real qualities. The concept "matter" does exist, after all, and it does lead people to behave and react in specific ways while discussing it, though from the OOO standpoint it is nothing but a fiction.

Of course, Orensanz notes that at least some scientific materialists are equally happy to call "matter" a fiction: he points in particular to Mario Bunge, and more recently Gustavo Romero (Bunge 1981; Romero 2022). What these authors share in common is the notion that matter is merely a concept, while what really exists are individual material beings; Orensanz seems to be in agreement on this score. OOO would certainly agree with all of them that a concept is not quite a real object in the strict sense, and would further agree that individual beings are all that exist, though OOO sees no reason to call these individuals "material." This does not mean that I find the remainder of their argument satisfying. After all, if one believes in a plethora of something called "material beings," it seems clear that one is committed to the existence of something like matter in a way that OOO is not, even if that matter is found nowhere else than in fully-formed individuals.

But the claim that only individual material beings exist leads Orensanz to some additional, mereological claims with which I largely disagree, and which may be of interest to readers. In particular, he borrows from Daniel Korman the idea of a "disguised plural," which Orensanz will use to describe his own conception of matter no less than Bunge's and Romero's (Korman 2015: 139). If we consider an assortment of numerous random things, most of us will not be inclined to treat that assortment as a single individual, even though it is grammatically singular. This is a clear and illuminating case of a disguised plural. Korman also presents a more intriguing case: the Supreme Court. Here again we have an example that is grammatically singular. But is the famed Court really an individual being? Korman (and Orensanz himself) say that it is not. The reason as stated by Orensanz is that "[i]t's generally considered that the relation of parthood is transitive." In layman's terms, if the Supreme Court is a single entity composed of nine Justices, then the parts of the Justices should also be parts of the Court. But this would lead to apparently ridiculous results, as seen in the following rhetorical question from Korman: "Is the Supreme Court a single fleshy object with nine tongues and eighteen elbows?" (Korman 2015: 145). Always committed to a spirit of fair play, Orensanz cites our aforementioned correspondence of 2022, in which I argued that parthood *is not* transitive. The source to which I appealed was Manuel DeLanda's discussion of emergence: in particular, his idiosyncratic but effective use of the term "redundant causation." (DeLanda 2006). In DeLanda's usage, redundant causation refers to the fact that an object can lose many of its components while still remaining the same object: as when a tire loses a multitude of atoms, or Los Angeles bids farewell each year to the many residents who die or move away. The same insight was anticipated by Aristotle in the *Metaphysics* when he said that a thing is only made of its most proximate pieces: we might plausibly refer to semen as a potential human, but to refer to wheat as a potential human would be skipping too far down the line (Aristotle 2016: 149).

Orensanz then plausibly links my view and DeLanda's with Bunge's idea of "levels of composition." For instance, animals have brains as parts, but since it is entire animals rather than brains that engage in social relations, we can easily dismiss the transitive assumption that brains (as parts of animals) would also be directly involved in social relations (Bunge 1979: 5). But here Orensanz worries that such means of avoiding the transitivity of parthood might lead to emergent entities that are somehow disembodied. For instance, in light of the multiple structural layers separating an entire cell from its constituent atoms, we might be led to the dangerous conclusion that cells have no atoms. Here, however, I think Orensanz is equivocating between multiple senses of "have." Los Angeles without any people would in some sense not be Los Angeles anymore, but merely the ghostly remnants of a city. It does not follow, however, that the need for a city to have people means that individual humans need to have direct causal impact on the city as a whole, without intervening emergent layers. In the case of the Supreme Court, it should be equally clear why the Court is not a fleshly entity consisting of nine tongues and eighteen elbows. If one or more of the Justices of the Court were to lose their tongues or one or both arms in some grotesque tragic incident, this would inspire much public sympathy, but would surely not raise doubts as to whether the thereby disabled Justices were still members of the Court. To summarize, when we consider a human being qua judge, arms and tongues take on the aspect of mere accidents. The difference between the essential and the accidental takes on further importance when Orensanz plays with another variant of the supposed paradox: "If parthood isn't transitive, it follows that your fingers are not parts of your body. So, you don't have fingers." But this is a *non sequitur* akin to saying that if people are not the proximate elements of Los Angeles, then Los Angeles has no people. Or better, in Aristotle's terms: if wheat is not a potential human, then humans do not consume wheat.

2] Concluding Remarks

Although Orensanz continues to raise interesting ideas until the final page of the article, our main topic effectively ends on page 14. For it is there that Orensanz outlines five possible ways of dealing with the problems covered so far. The two of interest to us here are my own rejection of the transitivity of parthood (number three on the list), and Orensanz's preferred solution (number five) of the disguised plural. He admits that he faces an uphill battle in his future systematic defense of this position, though in denying that "society" exists as anything more than an assortment of individuals he can count on the assistance of the late Bruno Latour, who was endlessly horrified by Émile Durkheim's unified "Society" with a capital S (Latour 2007). But one need not accept Durkheim's view to support the idea that societies are formed of emergent layers of structure rather than simply of piecemeal individual humans. If I have a worry about Orensanz's own developing social theory, it is a concern that his final picture of society will contain far more elbows and tongues than necessary, to say nothing of atoms.

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What's Left of Philosophy?

François Maurice[1]

Abstract—We continue our examination of the idea that there is a sub-discipline in philosophy of science, philosophy in science, whose researchers use philosophical tools to advance solutions to scientific problems. Rather, we propose that these tools are standard epistemic, cognitive, or intellectual tools at work in all rational activity, and therefore these researchers engage in scientific or metascientific research.

Résumé—Nous poursuivons notre examen de l'idée selon laquelle il existerait une sous-discipline en philosophie des sciences, la philosophie *dans* les sciences, dont les chercheurs utiliseraient des outils philosophiques pour proposer des solutions à des problèmes scientifiques. Nous soutenons plutôt l'idée que ces outils sont des outils épistémiques, cognitifs ou intellectuels standards, à l'œuvre dans toute activité rationnelle et que, par conséquent, ces chercheurs se consacrent à la recherche scientifique ou métascientifique.

In our article "When Philosophy is No Longer Philosophical" (Maurice 2022), we examined an idea defended by Pradeu, Lemoine, Khelfaoui and Gingras, according to which within the philosophy of science there is a philosophy *in* science, a philosophy that uses philosophical tools to tackle scientific problems and put forward scientifically relevant solutions (Pradeu *et al.* 2021). We then argued that these tools are standard epistemic, cognitive or intellectual tools at work in any rational activity and, consequently, that these researchers of philosophy *in* science are dedicated to scientific or metascientific research. While this 2021 article by Pradeu *et al.* served to define philosophy *in* science and identify philosophers who practice it, a new article by Pradeu, Laplane and thirty-six collaborators shows the usefulness of philosophy *in* science using cases

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drawn from cancer research (Pradeu *et al.* 2023). This research project to identify a philosophy *in* science begins with the publication in 2019 of “Why Science Needs Philosophy”, an article by Laplane, Mantovani, Pradeu and six collaborators (Laplane *et al.* 2019).

1] Critique of the Idea of Philosophy *in* Sciences

In our article entitled “When philosophy is no longer philosophical” (Maurice 2022), we examined the idea put forward by Pradeu *et al.* (Pradeu et al. 2021) that there is a sub-discipline in philosophy of science, called philosophy *in* science. Researchers in this sub-discipline would use philosophical tools to put forward solutions to scientific problems. However, I defended the idea that these tools are standard epistemic, cognitive or intellectual tools, used in any rational activity. Consequently, these researchers would be dedicated to scientific or metascientific research.

Of the 160 or so authors identified by Pradeu and colleagues as belonging to philosophy *in* science, we examined five. We have concluded that these thinkers no longer practice philosophy, at least not in the articles examined. The tools used by these authors are part of the standard ways of thinking not only in science, but also in any rational enterprise, such as technology, engineering, medicine, law, management, and so on. Thus, philosophy *in* science cannot exist if “philosophy” is seen as anything other than a synonym for “rational thought”. For this discipline to exist, it would be necessary to find authors who use exclusively philosophical tools or methods, supported by philosophical doctrines, to solve scientific problems and propose solutions that scientists consider useful for the advancement of science. Thinkers of philosophy *in* science practice rather a metascience and in some cases even a science.

A long extract from the introduction to the 2023 article sums up the authors’ conception of philosophy *in* science as set out in the 2019 and 2021 articles:

> [From 2021 article] Conceptual clarification and interdisciplinary integration of methods and knowledge can […] enrich our understanding of cancer and suggest new therapeutic avenues. […] We argue that philosophy can contribute to this aim through its classic tools of conceptual clarification, critical assessment of scientific assumptions, analysis of argumentative consistency, formulation of new concepts, theories or research programs, and connection

> between different disciplines. [New in 2023 article]. Note that (*i*) *philosophy here refers to a set of tools or methods*, rather than content (the idea is not to apply traditional ideas from philosophers to cancer, but to use philosophical methods); (*ii*) *we defend a pragmatic use of philosophy* with the clear intent of improving oncology; (*iii*) *these methods are also used by scientists*, especially conceptually inclined ones. [From 2019 article] So what we are describing here is ultimately a continuum of scientific contributions. Philosophers, because of their strong background in logic and argumentative reasoning, can operate the above tools with higher degrees of thoroughness and freedom. Scientists have better experimental skills and more expert knowledge in their area of specialization. This spectrum of skills makes the cooperation between these two communities particularly fruitful to build a theoretical oncology. (Pradeu et al. 2023, p. 3-4; italics ours)

This is no mean feat. The authors reduce philosophy *in* science to a set of tools or methods. Not only do the authors empty philosophy of its content, but they evacuate all philosophical methods except those that have the merit of being methods also used by scientists. The authors claim to defend a pragmatic use of philosophy. But what else? Why this conception of philosophy rather than another? In fact, Pradeu, Laplane and their collaborators make no pronouncement on the nature of philosophy. They take it for granted that philosophy *in* science is a branch of philosophy of science, which is itself a branch of philosophy. Philosophy *in* science is associated with philosophy of science by a tenuous link, a link the authors describe as pragmatic, since they propose to use "philosophical" approaches and methods common to philosophy and science. Philosophy *in* science therefore has no specific content or object of study. It is merely a set of so-called philosophical methods, although the authors acknowledge that these are also methods used by scientists (Pradeu *et al.* 2021).

Let's return to a thesis supported in the 2021 article. The existence of this philosophy in science demonstrates "the existence of a methodological continuity from science to philosophy *of* science" (Pradeu et al. 2021; italics ours). As formulated, the statement is false. The authors have succeeded in demonstrating a methodological continuity between science and philosophy *in* science, but not between science and philosophy *of* science. In the latter case, if the authors see continuity, it's because they have decreed that philosophy *in* science is a branch of philosophy *of* science. Since there is indeed a methodological continuity between science and philosophy *in* science, and if the latter is conceived as a branch of the philosophy *of* science, then a continuity is established between science and the philosophy *of* science, and since the latter is conceived as a branch of philosophy, then there is also continuity between science and philosophy tout court. But why should philosophy *in* science be a branch of philosophy *of* science? This conception of philosophy *in* science as a branch of philosophy *of* science is based on weak links. Philosophy *in* science has no proper philosophical content, goal or object of study. All it shares with philosophy is a small set of conceptual tools, none of which are unique to philosophy. If we remove the methods, objects and objectives that are properly philosophical, and keep only what is common to all rational activity, what's left of philosophy?

The authors are right to describe this continuity as methodological, since the very practice of philosophy in science "presupposes a distinction between philosophical problems and scientific problems" (Sober 2022), or, in our view, metascientific problems are not the same as scientific problems. And if the problems are different, it's because the objects studied are different. And if the objects are different, the objectives will not be the same. On the other hand, certain methods and tools, especially conceptual ones, may be common to philosophy in science (metascience) and science, hence this methodological continuity, which applies to all rational activities.

However, the aim of philosophy in science as stated by the authors is problematic: to use philosophical tools to produce scientific knowledge rather than knowledge about science (Pradeu et al. 2021). Firstly, the tools in question are not specific to philosophy, but are tools shared by all rational activity, including science. Secondly, isn't the production of scientific knowledge the objective of the sciences? If philosophers in science use tools that are not specific to philosophy, and if they produce authentically scientific knowledge, aren't they ultimately practicing a science?

To claim that philosophy in science is a branch of the philosophy of science is unreasonable, since no philosophical doctrine underlies the research carried out by the thinkers associated with philosophy in science, insofar as a philosophy of science, to be philosophical, must support a philosophical doctrine that orients its questioning of science. What remains of philosophy if we cut out its methods, its objects of study and its distinctive aspirations, and retain only the universal foundation of all rational thought?

2] Sober and the Philosophy *in* Science

Sober is associated with philosophy in science by Pradeu and his colleagues (Pradeu *et al.* 2021)[2]. He is one of those rare philosophers of science to propose scientific solutions to scientific problems using philosophical tools. Sober, in his article "Philosophy in Science: Some Personal Reflections" (Sober 2022), looks back on his experience as a practitioner of philosophy *in* science to offer his thoughts and recommendations, as well as to warn philosophers about the possible adverse consequences on their careers if they choose to practice philosophy *in* science.

In his introductory paragraph, Sober notes that the idea of philosophy *in* science rests on a distinction between philosophical and scientific problems, since after all, if philosophers who practice this form of philosophy attempt to solve scientific problems, it is because these problems are not philosophical. Consequently, Sober also argues that the main objective and the way of evaluating their respective theories are not identical in science and philosophy. However, "the fact that this pattern has exceptions opens the door to PinS [philosophy in science]". Thus, *exceptionally*, "conceptual analysis and attention to arguments (the philosopher's bailiwick) can do good work in science"[3].

There's a problem with this formulation. Sober sees philosophy *in* science as an exception in the philosophical landscape. He admits a difference in nature between philosophy and science, but philosophy *in* science would transgress its philosophical nature to produce scientific results albeit with tools that would be the prerogative of

[2] Note that Sober is also one of the co-authors of the article "Why Science Needs Philosophy" (Laplane *et al.* 2019), with, among others, Laplane and Pradeu, the first article in a series of three (so far) from this research project of a defense of the usefulness of philosophy in science and the identification of philosophers who practice a particular form of philosophy that would produce scientific knowledge using philosophical tools.

[3] Sober also defends a partial naturalization of philosophy: "And scientific observations, along with the scientific theories that those observations justify, can do good work in philosophy, thus giving rise to SinP (= science in philosophy)".

philosophers. It may be exceptional for philosophers, and even philosophers of science, to contribute to the resolution of a scientific problem, but it's not exceptional for scientists to use conceptual analysis and pay attention to arguments, even if in a less sophisticated way than philosophers. These are tools or approaches that can be found in any rational discourse, including scientific discourse. By way of example, we need only mention the debate that has been going on for the past twenty years in connection with the reproducibility crisis. This is a methodological crisis in science, concerning the difficulty of reproducing the results of a large number of scientific studies. Few philosophers are involved in resolving this crisis, and, more importantly, the scientists who are involved do, of course, use "philosophical tools". Sober's conception of philosophy *in* science is therefore incoherent. He cannot argue for a difference in nature between philosophy and science and then make an exception for philosophy in science. The philosophy *in* science practiced by the thinkers discovered by Pradeu and his colleagues, the philosophy *in* science practiced by Sober, and the metascience practiced by the thinkers involved in resolving the reproducibility crisis all make use of tools common to all rational endeavors. The exceptional thing about philosophy *in* science is that thinkers in this discipline are paid by philosophy departments rather than science departments, even though they are working on scientific or metascientific problems. So why treat philosophy *in* science as an exception within philosophy, instead of seeing it as a scientific or metascientific discipline rather than a philosophical one?

Despite this inconsistency in the way philosophy is conceived, Sober, like Bunge, does not hesitate to take the side of science and criticize the way philosophers study and analyze science. Let's look at an example from Sober's article. To illustrate his journey as a philosopher *in* science, Sober presents five scientific controversies in which he has taken part. One of these concerns the unit of selection problem, which is characterized as follows: "The unit of selection problem concerns the question of which biological entities are susceptible to natural selection." (Martens & Merlin 2021).

In 1966, George C. Williams published *Adaptation and Natural Selection: A Critique of Some Current Evolutionary Thought*, in which he puts forward several arguments against the group selection hypothesis, i.e., the possibility that natural selection can be exerted on groups and not just on individuals or genes. Sober reports one of Williams' arguments in the following way: "Only genes can be units of selection (organisms can't, and neither can groups) because a gene can exist through numerous generations whereas an organism or a group usually has a much shorter lifespan." (Sober 2022) Sober then appeals to the type-token distinction to show the weakness of this argument: "the type/token distinction helps shows that the argument is flawed. Gene *tokens* are evanescent, but gene *types* can be exemplified over long stretches of time; the same can be said of organism and group tokens and organism and group types." (Sober 2022; italics by Sober)

In other words, Williams confuses the concrete object with the set to which we assign it, which is fallacious reasoning. Here, just like an organism or a group (e.g., a biopopulation), a particular gene has a lifespan, but the classes into which we place genes, organisms and groups have no "lifespan" because they are constructs that serve, along with many others, to represent the world to us. In general, the clarification exercise will not provide an immediate solution to a problem, but it should enable progress towards its resolution. The scientific debate on selection units will not be closed by a conceptual clarification, but this clarification will enable us to eliminate reasoning deemed to be erroneous, thus clarifying the terms of the debate, and this acquired precision sometimes leads to a reorientation of the debate.

Note that the type-token distinction, or, to put it another way, the class-object distinction, can be applied to any type of discourse. In logic and mathematics, objects are not concrete, but they can be arranged in sets (in type). And in law, laws can be classified. In fact, even in unstructured discourse, such as we use in our daily lives, we make use of this distinction, often clumsily.

In the context of the factual sciences, the distinction, or rather the type-token dichotomy, to which Sober appeals in order to reveal fallacious reasoning in Williams, is one of many ways of expressing the general dichotomy between conceptual representation and concrete reality. In other words, the tokens at issue in the debate on units of selection are concrete objects (gene, organism, biopopulation) that are part of reality, whereas types are classes or sets, hence abstractions, fictions in Bunge's terms. This allows Sober to assert that tokens (concrete objects) are evanescent, while types (classes) are exemplified over long periods of time (as long as we place objects in a class, that class exists for us, even if the objects have ceased to exist). Williams therefore confused the tokens of concrete objects with the classes in which we can place them. He reasoned about genes as a class, while at the same time reasoning about organisms and biopulations as concrete objects.

The distinction between representation and reality is elementary, but not always easy to apply. Reification and ideaefication are widespread phenomena. We reify an idea if we treat it as a thing, i.e., as a concrete object endowed with energy and subject to natural laws, or if we treat it as a real but non-concrete object, and we ideaefy a thing if we treat it as an idea, i.e., as an ideal or formal object no longer subject to the laws that apply to material entities (Bunge 2003)[4]. In any case, this distinction is used by everyone, in every circumstance, albeit often awkwardly, i.e., without realizing that sometimes we are reifying and sometimes we are ideaefying. On the other hand, among philosophers, reification and ideaefication can be intentional, in particular the reification that conceives an idea as having an existence of its own, even if this existence is not concrete. For example, Plato sees types as transcendent autonomous objects, Forms or Ideas, and Aristotle sees them as autonomous but immanent objects, Forms or Essences. Whether found in Plato, Aristotle or any other philosopher, reification and ideaefication are sophisms that Sober does not hesitate to exploit in his criticism of Williams.

Interestingly, Sober illustrates his point using the type/token dichotomy, even though he downplays the scope and power of this conceptual tool. On the other hand, Mario Bunge does not hesitate to elevate the type/token or representation/reality or fictional/real or concept/thing dichotomy to the rank of methodological axiom (Bunge 1977, pp. 117-118). This dichotomy conditions all Bunge's thinking. It implies, among other things, ceasing to accord an ontic value to logic and mathematics, as philosophers do. In themselves, logic and mathematics have no factual or concrete scope, and

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[4] Bunge's characterization of reification is broader than the usual one: "The treatment of a property, relation, process, or idea as if it were a thing". Thus, concrete properties, concrete relations and concrete processes are not to be confused with concrete objects, which are endowed with properties, relate to each other and participate in processes. In other words, just as we must not treat an idea as if it were an object, we must not treat a property, a relation, a fact, an event or a process as if they were objects.

therefore no ontic value in metascience. Philosophers grant them an ontic value because they are said to have a factual scope insofar as concrete objects are made up of logical and mathematical properties. However, we have no reason to believe that the objects of the world possess logical or mathematical properties. A planet is not a mathematical sphere. We use logic and mathematics to help us represent the world, and this representation is a construction, whereas the world is a given. The world is a given for the factual sciences, the set of logical and mathematical objects is a given for logic and mathematics, and the set of constructs of the factual sciences is a given for the metasciences.

Sober is among the philosophers *in* science identified by Pradeu and his colleagues, as he adheres to the dichotomy between representation and reality. In other words, he recognizes the world as an objective reality studied by the factual sciences. This position manifests itself in his advice and recommendations to future practitioners of philosophy *in* science, which in turn constitute critiques of philosophy itself. Let's limit ourselves here to quoting the main piece of advice Sober offers:

> […] there is a broader remark that is as obvious as it is important: you've got to understand the science you are taking as your subject. If the science makes use of probability, you need to understand enough about probability to follow what is going on. Taking a course in pure mathematics is probably not the best thing to do here, *nor are most philosophy of probability course what you need*; it would be better to attend a methods course in the science in question. (Sober 2022, italics ours)

Sober illustrates his point by criticizing David Lewis's idea of the notion of parsimony in phylogenetics:

> And still another philosophical pronouncement falls by the way once you look at science. This is the idea that the principle of parsimony has no justification. What is true is that it has no universal and unconditional justification. However, given assumptions that make sense in a given research context, justifications are often available. (Sober 2022)

Philosophers often seek knowledge that is universal and absolute, not contextual. Philosophers are not interested in the fact that the notion of parsimony varies from one scientific context to another. And this is precisely one of the reasons why philosophy is neither a science nor a metascience. Philosophers are not interested in the scientific approach to knowledge of the world, nor in the metascientific approach to knowledge of science. Philosophers problematize scientific knowledge in such a particular way that the scientific context that justifies Perrin's demonstrations of the existence of the atom cannot serve as a context of justification. Something philosophical is missing. Thus, we witness sterile debates, even among scientific realists, on the existence or not of the atom, living cells, gravitational waves, stars and galaxies, etc., because philosophers are debating the best philosophical justification, a justification that can only be alien to scientific justifications.

At the end of his article, Sober issues the following warning to future philosophers *in* science:

> […] if you publish a paper in a science journal, your colleagues in philosophy who are not philosophers of science may dismiss it, thinking that what you've done is science, not philosophy. This might hurt your career. (Sober 2022)

We agree with the fellow philosophers mentioned in this passage. If a philosopher has succeeded in publishing an article in a scientific journal, there's a good chance that it's an article on methodology, metascience or philosophy *in* science. A discipline without philosophical content cannot present itself as a branch of philosophy. The object of study of a discipline is just as important, if not more important, than the methods used to study it. If the object of study consists of the products of science, such as concepts, statements, classifications, models and theories, not to mention the general postulates that science must uphold, even if only temporarily, then we are dealing with a metascience. And if a thinker tackles a factual scientific problem using primarily conceptual tools, then there may be a back-and-forth between science and metascience. The methodological continuity of which Pradeu and his colleagues are referring is therefore not between philosophy and science, but between metascience and science.

Sober's warning reminds us of an anecdote reported by Martin Mahner:

> Bunge's status as an *enfant terrible* of philosophy was such an open secret that, when in 1992 I applied for a post-doc stipend to work

> with him on the philosophy of biology, a well-known German philosopher considerately asked me during an interview whether I was aware of the problem that working with Bunge could be bad for my career. (Mahner 2021, p. 19)

The passage in question suggests that it is Bunge's reputation as an enfant terrible that could be detrimental to his students' careers. We don't deny that his independence of mind and provocative style may have something to do with it. However, we would argue that Bunge's main failing as a philosopher is that he is not a philosopher, even for the scientific realists who barely mention him. And not only is he not a philosopher, but he has also had the nerve to develop a vast system of metascientific thought that competes with philosophical doctrines, rather than simply being a philosopher of science.

3] Conclusion

The work of Pradeu, Laplane and their collaborators on identifying a group of thinkers who specialize in conceptual research to solve scientific problems is important, since it helps to answer the question "what is the use of philosophy in science?" Philosophy is of no use to science, although certain conceptual approaches associated with philosophy are extremely useful, even necessary, for the advancement of science. But these approaches are not unique to philosophy. All rational activity makes use of conceptual techniques and methods. And when these techniques and rational methods are used to tackle a scientific problem or to study science itself, it is science and metascience that we should be talking about, not philosophy. The criticism we can address to those who defend philosophy *in* science is that they perpetuate the myth that philosophy contributes to scientific knowledge.

The "philosophical" methods identified by the authors represent only a small fraction of the methods used by philosophical schools. The authors have retained only those methods used in all rational activities. Philosophy *in* science is thus an empty philosophical discipline or a non-philosophical discipline. It studies no philosophical object, and uses no method that is properly philosophical. If the objects of study and the methods are not philosophical, what about the objective of philosophy *in* science? The objective is stated explicitly by the authors: to use philosophical tools to produce scientific knowledge rather than knowledge about science (Pradeu et al.

2021). Clearly, this objective is not philosophical. What remains of philosophy within philosophy *in* science?

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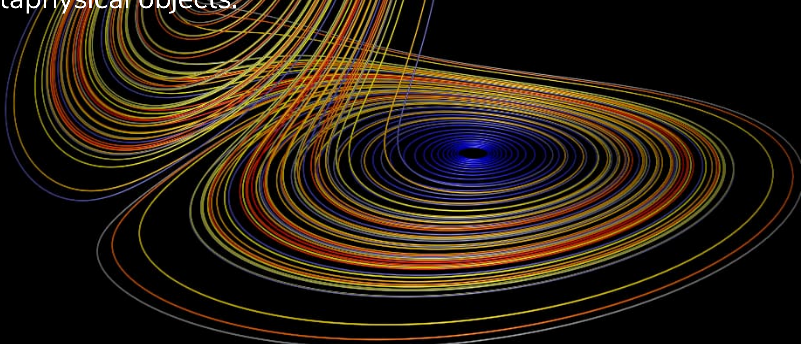
This third issue of the journal ***Mεtascience*** continues the characterization of this new branch of knowledge that is metascience. If it is new, it is not in a radical sense since Mario Bunge practiced it in an exemplary way, since logical positivists were accused of practicing only a mere metascience, since scientists have always practiced it implicitly, and since some philosophers no longer practice philosophy but rather metascience, but without characterizing it or theorizing it, that is, without realizing that they have abandoned one general discourse for another. The novelty therefore lies in this awareness that a general discourse without philosophy is possible: a scientific general discourse.

The ten contributions gathered in this volume illustrate the metascientific approach to knowledge of the world as well as to knowledge of knowledge of the world, that is, science. And like Bunge's project, they are neither part of the analytical movement nor the continental movement in philosophy. We will read here studies about the Bungean system, some applications of Bungean thought, some metascientific contributions, and some reflections around metascience.

Among metascientific disciplines, epistemology occupies a prominent place in this issue of ***Mεtascience***. Metascience differs from philosophy in its rejection of the fundamental philosophical distinction between appearance and reality. Metascientific epistemology therefore does not postulate the existence of any metaphysical reality. But metascientific epistemology, no more than philosophical ontology, is a factual science. The first, because it studies scientific constructs and not concrete objects, the second, because it is interested in transcendent or metaphysical objects.



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