Representation and Explanation in the Sciences

Edited by
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Epistemologia

FrancoAngeli

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Epistemologia, collana diretta da Evandro Agazzi

La collana intende venire incontro a quell'esigenza, ormai generalizzata, di conoscenza epistemologica che si riscontra a livello di cultura medio-alta e che corrisponde, in senso lato, alla diffusa aspirazione a prender coscienza critica della complessa varietà della nostra civiltà scientifico-tecnologica. Aspirazione che si accompagna, altresì, al desiderio di venire in chiaro circa lo statuto epistemologico di molte discipline le quali solo di recente hanno rivendicato l'impegnativa qualificazione di «scienza», pur riguardando ambiti di ricerca non inclusi nell'alveo delle discipline scientifiche tradizionali.
Rispetto ad analoghe collane già esistenti, questa si propone anche di allargare l'ambito delle scuole e tradizioni epistemologiche finora più correntemente conosciute in Italia, e che si ispirano in prevalenza al filone analitico anglosassone, portando l'attenzione su opere e autori afferenti ad altre aree culturali, come ad esempio quelle di lingua francese, tedesca, polacca.
Verranno quindi pubblicati, sia in traduzione che in opere originali, alcuni testi base di carattere istituzionale relativi all'epistemologia generale e alle diverse branche della filosofia della scienza. Per altro verso, verrà dato uno spazio più cospicuo del solito all'epistemologia delle scienze «umane», alla filosofia della logica, alle tematiche etiche che di recente si sono aperte nei riguardi della scienza. Pur senza rinunciare ad opere di carattere tecnico, l'accento generale verrà posto piuttosto su quei tipi di trattazione epistemologica nei quali è più presente un taglio specificamente filosofico.
La collana si propone di essere utilizzabile anche per corsi universitari: a tale scopo, oltre alle opere di carattere istituzionale cui si è fatto cenno, annovererà anche alcuni «readings» antologici, sia a carattere miscellaneo che monografico.

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REPRESENTATION AND EXPLANATION IN THE SCIENCES

(Papers presented at the Conference of the International Academy of Philosophy of Science - Louvain-la-Neuve, 26-28 April 2011)

Edited by
Evandro Agazzi

Evandro Agazzi – Hervé Barreau – Valentin Bazhanov –
Marco Buzzoni – Claudio Calosi – Alberto Cordero –
Giuliano Di Bernardo – Xavier Donato – Itala D'Ottaviano –
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Il volume è stato pubblicato con il contributo dell'Académie Internationale de Philosophie de Sciences.

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Introduction: The Meanings of Representing and Explaining

The relations between representation and explanation have received a particular attention in the recent debates of philosophy of science, especially because explanation has been traditionally linked with theories and it has never been uncontroversial whether the aim of theories was that of "representing" reality, besides their more traditional task of "explaining" phenomena and, in this case, whether they are able to satisfy this aim. Along this debate a kind of inversion of the roles has occurred, namely the question has been put forward whether representations can provide explanations and, in such a way, play somehow the role of theories. This shift has a rather subtle possible meaning: if the original question was whether theories are able indeed to represent reality, this "representing" was understood in a "realist" sense, that is, the sense of telling "how things really are". If now the role of theories is attributed to representations, the uncertainty passes over to representations themselves, that is, they can be questioned as to their ability to tell "how things really are". In short, the "issue of realism" is inherited by representations, since they can be taken "just as representations" like one could take theories "just as theories".

The question is discussed with little results because the very concept of representation has not been univocally and unequivocally defined. For example, it is not clear whether it is synonymous or not with the concept of "description". At first sight it could appear that it is, but from another point of view it seems that description means the record of purely empirical features, without any intrusion of intellectual factors, whereas representation entails the organization of such features into a coherent "image" that implies a certain "interpretation" (things are not simply "seen", but "seen as" something). This "hermeneutic" dimension would already include representations in the theoretical domain, and therefore make them rather similar to theories.

We shall not deepen such questions, but simply note that one finds here a modern articulation that was familiar to Scholastic epistemology, in which

three stages were considered in the effort of knowing a certain reality, stages denominated *quia*, *quomodo*, *propter quid*. The *quia* corresponded to the level of description, to the ascertaining of the state of affairs, be it the result of empirical evidence or something reported to be the case; in short, to the statement that things are so and so. The *quomodo* was the answer to *how-questions*, in the sense of offering a reasonable representation of how the ascertained state of affairs was articulated in itself or functioning in a certain way; it was the result of an interpretation in which certain theoretical connections between data were introduced. Finally the *propter quid* was the most perfect answer to a *why-question* concerning the said reality, the exhibition of *reasons* capable of explaining *why*, through the admitted representation, it was possible to account for the described state of affairs. The transition from the first to the second and the third stage was understood as an increase of the knowledge of a certain reality, a deepening of this knowledge, also addressed to the reinforcement of its certainty. In short, it was inscribed in a realist conception of knowledge itself. Moreover, attaining the highest level, in the answer to the why-question was not considered something possible in all cases; in many cases one should remain content with the "demonstration *quia*", that is, a demonstration that goes from the effects to the causes, and not from the causes to the effects (demonstration *propter quid)*, in particular when the fact to be demonstrated regarded supernatural matters. "*State contenteumanegenti al quia*" ("be satisfied, human beings, with the *quia*") said Dante concerning the pretention of understanding the "how" and the "why" of the trinitarian mystery.

In modern philosophy (that is, the philosophy beginning in the 17th century) representations (usually called "ideas") become the immediate object of our acts of knowledge and, since the intrinsic aim of knowledge cannot help remaining that of attaining reality as it is, the problem arises of finding a kind of "bridge" that could assure us that our representations are representations of reality, that is, that they are not "simply representations".

This gratuitous presupposition (that can be called "epistemological dualism", "representationism", "phenomenalism") produced the sterile efforts for solving the said ill-posed problem within modern philosophy, and is still at the root of anti-realist positions in epistemology. In particular it impregnated the epistemology of science, owing to the fact that it is normal to say that any science studies only its own "phenomena", and these are considered as particular features that are not supposed to express the intimate essence of things in themselves.

Yet a certain intimate connection of the "phenomena" studied by a discipline with the "nature" of the kind of things of which they are manifestations emerged in the course of the 19th century when the socio-historical disciplines vindicated their right to be considered "sciences". As is well known, they advocated this right not because they were able (or could be able) to adopt or at list to imitate the methodological approach of the physical-mathematical sciences, but, on the contrary, by stressing the "specific differences" that distinguished them from the natural sciences.

Among these differences the most salient was the fact that whereas explanation (understood as the logical deduction of phenomena from general laws) is the aim of natural sciences, understanding is the aim of the "human sciences" that study single events or (possibly complex) systems of human actions. This understanding, in turn, consists in an interpretation of such actions as concrete realizations of an *ideal model* whose most elementary sketch can be found in the Weberian theory of the "ideal types", but which, in general consists in the representation of a more or less complex system of "mechanisms" that produce interrelated effects and in such a way make understandable *how* certain events could happen, without really explaining *why* they occurred (though causal explanations are possible within the model adopted, but not as consequences of general laws).

This (very sketchy and approximate) summary of the old debate concerning the *Naturwissenschaften* and the *Geisteswissenschaften* has only the aim of pointing out a new sense of representation, in which interpretation – rather than logical deduction – plays the primary role, the model – rather than the theory – is the tool of investigation, the "how" – rather than the "why" – is the fundamental question. These approaches, however, were not at variance, as it has been shown in a large literature, and is already clear for the fact that causal explanations are looked for and proposed in the framework of a certain model, and (symmetrically) the final result of a theory is some "representation" of the field under investigation.

One must not overlook, however, that certain important novelties are implicit in the methodological strategy of model constructions. They are more sensitive to the "ontological stuff" of the modeled domain of investigation and can easily admit, for instance, goals, finalistic explanations, holistic approaches that used to be removed from the traditional natural sciences and had been considered as forbidden in any scientific enterprise in general. But now the question can be legitimately asked whether these prohibitions were only prejudices and whether their adoption is simply a manifestation of anthropomorphism (and in this case why it should be wrong).

Without going on in this analysis, one sees how many interesting issues are involved in the study of the relations between representation and explanation in the sciences, issues that do not rotate only around the classical debate realism-antirealism, but are much more articulated and regard topics belonging to epistemology, methodology, metaphysics of science in general and of certain particular sciences. The papers contained in the present volume address several such issues; they are distributed in two sections, and are put – within each section – in a certain order of descending generality.

The first section is devoted to *General Epistemological Issues* and opens with a paper by Bas van Fraasen, *Explanation through Representation, and Its Limits*,where the possibility is discussed that representations can equate the role of explanation is envisaged. Why-questions and how-possibly-questions, notes the Author, are two common forms of explanation request. Answers

to the former require factual assertions, but the latter can be answered by displaying a representation of the targeted phenomenon. However, in an extreme case, a representation could come accompanied by the assertion that it displays the only possible way a phenomenon could develop. Using several historical controversies concerning statistical modeling, it is argued that such cases must inevitably involve tacit or explicit empirical assumptions.

The paper by Jan Faye, *Embodied Understanding, Representation and Explanation,* argues that scientific understanding comes in two forms: concrete and abstract understanding. Concrete understanding is embodied as practical skills of the scientists, whereas abstract understanding is what we get by representations in terms of scientific theories and models. Faye's claim is that both forms of understanding contribute to the practice of science and that scientific explanation, being a part of the discursive side of this practice, builds on both of them as well as provides new understanding

Michel Ghins, in his paper *Representation and the Loss of Reality Objection*, addresses the central following question: how can an abstract entity – a model – possibly represent an existing observable entity, which is phenomenally accessible to us, but which is not abstract? This is what Bas van Fraassen calls "the loss of reality objection." Instead of proposing a pragmatic dissolution of this objection as van Fraassen does, Ghins argues that our contact with phenomenal entities is grounded on propositions, dubbed "ontic", that are true in a correspondence sense. Before addressing this issue, a brief presentation of what he believes to be the main features of scientific representing is offered.

Evandro Agazzi notes in his paper *Representation and Scientific Realism* that, when it is spoken of scientific representations, it is often understood that science can offer "only" representations but does not enable us to know reality. This tenet is the inheritance of a gratuitous and inconsistent presupposition that affected modern philosophy during almost two centuries, according to which we know our representations and not things, and we have to find warranties in order to believe that such representations correspond to reality (epistemological dualism). The present paper analyzes this presupposition, shows its inconsistency and, through a discourse regarding the relations between thought and ontology, between sense and reference of the intellectual constructions, between abstract encoding of properties and concrete exemplification of the same by means of operational criteria of reference, justifies the cognitive purport of scientific representations, including the mathematical representations of physical phenomena.

The problem of realism is also the topic of the paper by Alberto Cordero, *Explanatory Elucidation and Scientific Realism.* Explanatory elucidation occurs when a theory T has one or more of its assumptions explained by an independently successful theory T*. Because explanatory elucidation springs from independently supported theories, it improves the credibility of the assumptions it casts light on – hence its relevance for realists. But

cases can be pointed to where explanatory elucidation has badly failed to identify truthful components. One way to address this challenge is by trying to find additional epistemic support for seemingly meritorious theory-parts. A compelling resource in this regard is provided by various streams of vigorous probing that regularly turn up against theories in mature scientific disciplines.

Jesús Zamora and Xavier Dorato, in the paper *Scientific Explanation and Representation: an Inferential Viewpoint* explain that normative inferentialism is the view that cognitive states consist basically in commitments whose dynamics is governed by inferential norms. In this paper it is argued that normative inferentialism provides a natural way of integrating the representational and explanatory capacities of scientific theories and models. Representation will be understood as the capacity of deriving from a theory or model relevant consequences about a target system and explanation as the capacity of enhancing the integrity and coherence of our whole corpus of knowledge. The Authors contend that both capacities can find appropriate accounts in terms of an inferentialism that, similarly to Brandom, participates both of normativism and pragmatism. One of the virtues of this approach is that, by means of it, one can explain the (partial) adequacy of the many models of representation and explanation that have been proposed.

Ruggero Ferro's paper, *Reality, Knowledge of Reality, Representation of the Knowledge of Reality*, starts with the remark that very often reality is equated with our knowledge of it, and in turn our knowledge of reality is equated with the linguistic manner of describing it. It is claimed in this paper that the three moments cannot be seen as identical by pointing out some crucial differences among them obtained through an analysis of the power and limitations of languages and of the manners of acquisition of knowledge.

In the paper *Abstraction and Scientific Knowledge Representation*, Valentin Bazhanov maintains that abstractions play a crucial role in scientific knowledge representation. He then analyzes the nature and mechanisms of functioning of some abstractions in the scientific knowledge representations as well as limitations that they placed upon the result of scientific knowledge acquisition.

The paper by Paul Weingartner, *Is there Teleological Order in Nature? Is there Teleological Explanation in Science?* tries to answer the following two questions: (1) Are there teleological explanations which are logically valid? (2) Are there teleological explanations which are used by scientists? The paper is divided into two parts. In the first part concerning teleological order in nature, different types of order are distinguished: beginning with order as structure and then proceeding to higher and stronger types of order, which include special arithmetical and geometrical relations and eventually also negentropy. It is shown that certain processes of becoming can possess higher order in such a way that they can have teleological order. In the second part a definition of teleological explanation is given and the following two questions are answered: (1) Are there teleological explanations which are

logically valid? (2) Are there teleological explanations which are used by scientists?

The paper by Hans Lenk, *Methodological Remarks on Dynamic Functional Representation*, maintains that representation and causal organization can and should be understood by producing and handling dynamical models, using the theoretical resources of dynamics, and adopting a broadly dynamical perspective including the models of self-organizing systems. Dynamical Systems Theory and dynamical modeling conceive of cognitive structures as laid out temporally and as all the time changing, i.e. as being dynamic. Cognition is understood as a simultaneous, mutually influencing unfolding of complex temporal structures, mostly operating in parallel dynamical processes.

The second section contains contributions regarding **Particular Scientific Contexts**. The first paper by Marco Buzzoni, *The Agency Theory of Causal Explanation and the Problem of Anthropomorphism*, attempts to reply to the objection of anthropomorphism usually raised against the agency theory of causality. This objection comes in two main forms. The first variant claims that the experimentalist theory cannot explain causal connections which are outside our control (such as black holes). The second states that the experimentalist theory denies the existence in re of objective causal ties, because it makes them depend on the psychophysical constitution of human beings. The most common answer to the first objection says that the experimentalist model of causality requires that we construct models which simulate the behaviour of the inaccessible real processes, and on which we can act directly; this enables us to draw conclusions about the real processes by means of analogical arguments. As to the second objection, we need to distinguish between two kinds of anthropomorphism: the first has been rightly rejected by modern science, but the second is inescapable for all theories of causality because it could be eliminated only by assuming the point of view of God's eye, in Putnam's sense. In other words, without reference to human beings, that is, without reference to their reason (or language) and living bodies, there could be no concept of causality. This anthropomorphism can be eliminated neither from the experimentalist nor from any other theory of causality.

Giuliano Di Bernardo's paper, *Explanation in the Social Sciences* treats a classical topic of scientific epistemology from a new point of view. It considers biology to be a science intermediate between physics and sociology, and the transition from physics to biology as proceeding upwards. As a consequence, any type of reductionism will be avoided. The foundation of sociology can now be viewed as an extension of physics and biology. Indeed social reality is built by means of constitutive rules that create those social facts that have been denominated 'institutional' (such as governments and all state institutions, marriage, and money). Having argued for the connection among values and norms (ought-to-be) and actions (is), the problem is that of justifying this connection. Can values and norms be reasons that explain

action? Can reasons be understood as causes? In this paper the thesis is advocated that reasons are not sufficient for causally explaining actions. Taking up the classical analysis of "practical inference", the Author notes that, if from the reasons for action (understood as causes) logically followed the action itself, the reasons would be sufficient causes of the action. This would eliminate free will. For this reason, we must examine the problem of free will. Di Bernardo prefers to adhere to the position of B. Libet, who has demonstrated free will experimentally, and therefore the non-deterministic nature of the practical-inferential model.

The following set of papers is devoted to the physical sciences and is opened by the contribution of Peter Mittelstaedt, *Explanation of Physical Phenomena by Laws of Nature*. For an "explanation" of physical facts by laws of nature, we have to establish a relation between physical facts and laws of nature. It is an open question, whether the laws of nature govern the facts with necessity or whether the laws are related to the facts merely by supervenience. In addition, it is not quite clear, whether the known laws of physics describe only artificially simplified cases, e.g. isolated situations, or whether the laws of physics actually grasp real facts. Known solutions of these problems refer to situations where laws of classical physics are applied to phenomena of classical physics. However, if the same laws were applied to matter of facts of the domain of Modern Physics, then in many cases there would be no "explanations" in the sense mentioned. These new problems can be treated either by additional "interpretations" of the theories in question, or by a radical change of the ontological preconditions of classical physics.

A similar problem is considered from a different point of view in Hervé Barreau's paper, *L'explication par des lois et la représentation par des theories*. In sciences man explains by laws, and represents by theories. First Duhem (however preceded by Poincaré) explicitly opposed explanation by laws and representation by theories, and endowed a physical theory with a classifying power, showing in it a medium to reconcile theoretical conventionalism and relational realism, because, along with Poincaré, relations alone are real. Poincaré and Duhem's distinction between laws and theories perfectly applies to Einstein's relativity theory and to quantum mechanics. But we have difficulties in applying it to the living world, where concepts have more importance than laws; as well as in the human and social sciences, where principles have more importance than laws and where historical and hermeneutical method keep their leading role.

The paper by Claudio Calosi, Vincenzo Fano and Gino Tarozzi, *Holism as an Empirically Meaningful Metaphysical Hypothesis*, considers the thesis according to which quantum mechanics is credited for having clearly shown that the whole is something over and above the sum of its parts. The Authors maintain that there is indeed a sense in which this is true, since even a weak realistic interpretation of quantum mechanics renders a particular metaphysical principle about property instantiation, that they label Property Compositional

Determinateness, untenable. Yet there is another metaphysical principle about composition that is usually maintained to imply that composition of parts exhausts the whole they are part of, namely Mereological Extensionalism. In this case, contrary to widespread agreement, they argue that quantum mechanics does not provide any reason, either direct or indirect, to abandon such principle.

A historical contribution closes this series of papers regarding physical sciences, it is the paper by Fabio Minazzi, *Representation and Explanation in Science in the Opinion of Galileo and Einstein*. According to Galileo, the scientist is a "philosopher of nature". However to study nature the scientist must use mathematical truths and mathematical accuracy in order to attain certainty, and in addition must verify his theory by experiments. So the scientific enterprise is encompassed between two poles: a theoretical constituent and an experimental constituent. Einstein thinks that scientific knowledge flows from the world of life (the *Lebenswelt*) thanks to new ideas through which we can construct a theory by a deductive reasoning. The experiment gives us the possibility to control a theory, but this verification is always questionable. So for Galileo and Einstein science has a conceptual dimension by which we can trace the outline of an objective world.

The last two papers concern the contribution that computer science and logic can bring to the analysis of our problem. Jean-Guy Meunier, in his paper *Cognitive Representation: Computable or non Computale?* remarks that representation is a core concept of classical theories of cognition. Although it is a general concept, it allows to model cognition as a system of representations on which various types of operations can be applied. One main model of the functioning of these operations is proposed here: cognition operates as a computational machine. Many have refused this model on the ground that cognition is not a computational process. Others have rather criticized it on the ground that the classical computational model itself is inadequate for it cannot deal with non-computational tasks omnipresent in cognition. Recent theories of computation offer a new perspective on this debate.

Itala D'Ottaviano, in her paper *Translations as Representations between Theories,* considers logics as representations of inference relations and translations between logics as maps that preserve the inference relations. In this paper a general survey is presented of the main results obtained by the Author. She introduces her general definitions of translation between logics and of conservative translation, and presents some general results on conservative translations. As new dimensions on translations, she discusses her concepts of transfers and contextual translations. Finally she outlines some inter-relations between those kinds of translations and presents some open questions.

The contributions published in this volume correspond to a selection of(revised) invited papers presented at the conference on *Representation and Explanation in the Sciences* that took place in Louvain-la-Neuve

(Belgium) on April 26-28, 2011. This was the annual meeting of the Académie Internationale de Philosophie des Sciences and was organized in collaboration with the Institut Supérieur de Philosophie of the Catholic University of Louvain-la-Neuve, that hosted the meeting in its premises and contributed both financially and organizationally to its realization. Therefore special thanks are expressed to this Institute and in particular to its Director, Prof. Bernard Feltz, as well as to Michel Ghins, Professor of Philosophy of Science at this University, for their active commitment in the scientific planning of this conference. For the careful editorial work spent in the preparation and publication of this volume sincere thanks go to Prof. Paolo Musso, of the University of Insubria at Varese (Italy). The majority of the papers published in this book have also appeared in *Epistemologia*, an Italian Journal for the Philosophy of Science, that is issued by the same Publisher FrancoAngeli that is issuing this volume.

Evandro Agazzi

First Section: General Epistemological Issues

Explanation Through Representation, and Its Limits[*]

Bas van Fraassen

Introduction

The typical request for explanation in science, or posed for a scientist, is a *why-question*, that is to say, a request for a missing bit of factual information – the "missing bit of the puzzle". "Why is the sky blue?" is answered by providing information about atmosphere and optical phenomena.

A representation cannot be an answer to a why-question, so it cannot be an explanation in this typical sense, for it cannot provide new information. Only an assertion can do that. The relevant assertion may well concern a representation. For example, the assertion that the representation is accurate in certain respects may constitute, or be involved in, the explanation of why certain things happen as they do.

But there is, both in daily life and in the sciences, also another form of request for explanation. A *how-possible question*, unlike a why-question is not a request for factual information about the case, but for an (empirically and mathematically informed) act of imagination.

1. The how-possible question and its limits

Such a request comes in the form of "Show me how this *could possibly* come about" rather than "Tell me why it happens". It requires one to show *how* that phenomenon *could* happen or could come about or could develop in the way it does.

Accordingly, presenting a representation can suffice to answer a *how-possible question.* Different, mutually incompatible representations –

* The author wishes to acknowledge support for this research by National Science Foundation grant SES-1026183 and helpful discussion with Isabelle Peschard.