

# Scientific Visual Representations in History

Matteo Valleriani · Giulia Giannini ·  
Enrico Giannetto  
Editors

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 Springer

*Editors*

Matteo Valleriani  
Max Planck Institute for the History  
of Science (MPIWG)  
Berlin, Germany

Giulia Giannini  
Dipartimento di Studi Storici  
Università degli Studi di Milano  
Milan, Italy

Enrico Giannetto  
Dipartimento di Scienze della Persona  
Università degli Studi di Bergamo  
Bergamo, Italy

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# Preface

Any output of scientific activity is an external representation of scientific knowledge. Such representations may take multiple shapes: an object (like a model), a text (like an early modern scientific commentary), an image (like a photograph of a plant), or a video (like a meteorological simulation).

This book explores continuity and ruptures in the historical use of images in science, while also considering more recent developments that attest to the unprecedented importance of scientific visualizations—be they video recordings, animations, simulations, graphs, or enhanced realities. The volume collects historical reflections concerned with the use of visual material, visualization, and vision in science from a historical perspective, from antiquity until now and ranging through multiple cultures and disciplines.

Visual representations are fundamental to the scientific endeavor as they belong to the realm of visual reasoning. The present work represents only the first step in a larger research endeavor concerned with the epistemic function of visual representations. The main goal of such a step is to provide a series of case studies focused on the epistemic functions of visual representations. Contrary to most visual studies in the context of the history of science, we also explore the fields of close disciplines, such as art history and anthropology. Moreover, from the very beginning, we decided to develop an approach that would allow us to achieve a *longue-durée* historical overview and therefore included case studies from antiquity through the twentieth century.

Studies concerned with visual representations in science indeed tend to focus on one specific epoch or even one specific geographic area. Our aim, on the contrary, is to search for the more abstract, universal mechanisms that disclose the function of visual reasoning in the sciences and, perhaps, in the process of knowing. We have therefore avoided a chronological, geographical, or disciplinary focus.

We refer to visual representations such as drawings, prints, tables, mathematical symbols, photos, data visualizations, mapping processes, and (on a meta level) visualizations of data extracted from historical sources in order to support, visually, the historical research itself. Continuity and ruptures between the use of visual material in the past and the present are presented against the backdrop of the epistemic functions

of visual material in science. The function of visual material is defined according to three major epistemic categories: *exploration*, *transformation*, and *transmission* of knowledge.

Visual material is the preferred means for the *transmission* of knowledge due to its highly synthetic character and the ease with which knowledge is perceived and re-worked by its recipients. The visual codification of knowledge can therefore be seen as a historical phenomenon that emerged as a consequence of an increase in knowledge resources, processes of knowledge accumulation, and the demand for scientific knowledge. The use of visual material in science has always had the effect of lowering the threshold of access to knowledge—and therefore remains an indispensable tool in education.

Visualization, moreover, is a means to *transform* and re-shape knowledge. It allows the adaption of knowledge to our methodological, institutional, and cultural expectations and enables the integration of practical and tacit knowledge.

As a means of *exploration*, the process of visualizing is used in the context of scientific discovery. Visualizations allow for the development of new research perspectives and ideas, especially in the framework of modern science and its strong mathematical approach.

Such epistemic functions of visual scientific material are analyzed in their cultural, social, and technological context. The historical actors' opinions and judgments concerning the use of visual material and technological innovations in the media of knowledge transmission—be these clay, paper, or processors—influenced and were influenced by the process of the visual codification of scientific knowledge.

The chapters are organized into three sections that focus on three major conceptual lines, which in turn correspond to the three epistemic functions of visual representations just mentioned: transmission, transformation, and exploration. To be clear, each chapter considers all these epistemic functions and more, but we believe that this order offers an efficient transversal reading of the opinions proffered by the volume's contributors. Within each section, the papers are organized chronologically.

With the term *transmission*, we refer to the capacity of visual representation to transmit scientific knowledge. In this respect, we intend to investigate, first, the act of production of visual representations, as well as the mechanisms of their circulation. Secondly, the chapters focus on the way visual representations transmit knowledge, and therefore on their capacity to work as tools for information management while aggregating, re-appropriating, and actualizing present knowledge and becoming pivots around which the knowledge is fixed and transmitted. In particular, this section discusses the creation and use of visual representations in the educational framework—teaching and learning—as well as in research endeavors.

The epistemic function that we define as *transformation* denotes the capacity of visual representations to transform scientific knowledge. While aware that any form of transmission also implies a form of transformation, we nevertheless distinguished these two functions. In fact, by *transformation* we mean, first, the capacity of visual representations to change the institutional features (authority, identity) of scientific knowledge and, second, the actual scientific meaning of the works that contain such representations. In this respect, therefore, the chapters focus on the evolution of visual

representations and of visual reasoning in general. A particularly well-developed subject in this section is the transformative capacity of visual representation in the context of the text-image relationship. Text and images are often produced together, but they are, simultaneously, ontologically distinguished carriers of knowledge. The image then becomes a means that, in its interaction with the text, fundamentally shapes and informs the scientific meaning, be this by way of description or criticism.

Finally, we consider visual representations as tools of *exploration* for two interconnected reasons. The first concerns their capacity to combine different domains of knowledge or even of processes to acquire knowledge. Perception, imagination, depiction, observation, quantification, and geometrization are only a few of the acts of knowing that are combined among themselves in all possible ways by means of visual representations. The second concerns the role—the function—and the goal of such matching, which correspond to the need to build scientific arguments. Such scientific arguments are therefore heterogenous, though we consider the most relevant among them to be those whose aim is to demonstrate the truth of the scientific content represented. Visual representations in this respect are tools to describe, explain, measure, calculate, and experiment.

As mentioned, the three sections of this volume are simply a way of organizing the material, but all chapters contribute to the understanding of all three epistemic functions.

The volume's general goal is to investigate the process of evolution of knowledge from the particular perspective of visual scientific material. It discusses the production, reproduction, and appropriation of knowledge, while considering different orders of knowledge as well. It investigates how we think about thinking and also operates on a more practical level—for example, how we use vision to investigate how vision evolved.

The book also discloses cases of second-order knowledge: diagrams that display logical rules and mathematical objects, images that celebrate knowledge, objects in books that represent objects in the world, maps built upon mental maps, and many other similar cases.

Through a top-down narrative, the volume examines not only images and visual material used to understand the evolution of our knowledge about nature, but also images used to investigate nature itself and its mechanisms. The historical case studies presented in the book offer a long series of examples in this vein: experiments rendered through the investigation of images and private drawings, methods of reducing a problem to an image, visual methods and images used to create new ideas, and the idea of “visualization as a question-generating machine.”

Images, visualization, and vision explore and therefore create and innovate, for instance when data are turned into visual outputs and “facts” are created. The collection and manipulation of data to create an output always adhere to certain rules of the codification of knowledge. Such rules bridge the knowledge from one kind of external representation to the next, or from one order of knowledge to the next. By means of such rules we explore and therefore transfer, transmit, and translate knowledge, for instance from words to images and vice versa.

Moving from nature to representations of nature, the volume takes into account the relation between reality and the virtual and artificial. Images conceived to display the mechanical plausibility of a cosmological idea—and therefore reality—touch the domain of the ontological value of visualization. Images and vision become a link between abstraction and reality, a way to explain nature’s mechanisms by making them visible. In other terms, visualization connects and resolves the real and the artificial within itself. Images both represent the world and become virtual instruments to explore it.

Attendant to forms of visualization is the role of their material aspects. Poor electronic material (such as scans of digitized books), the necessity to reverse photography into woodblocks for publication, incomplete GPS datasets, and limited computer performance in producing simulations are some of the material limits discussed here. Materiality in turn implies technology and its history of innovation in the service of advantages, such as easier replicability and diffusion. The technology of vision also includes the social aspects of the production of visual material.

By considering the epistemic functions and their interplay with material aspects of visualization, the book finally collects case studies that show the functions of such visual material in science, from antiquity until now, moving from the histories of science and art to consider their material, economic, political, pedagogic, and philosophical aspects.

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Matteo Valleriani  
Giulia Giannini  
Enrico Giannetto

# Acknowledgments

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The framework that enabled this encounter is the institutional cooperation between the University of Bergamo (Rector Stefano Paleari, and then Rector Remo Morzenti Pellegrini) and the Max Planck Institute for the History of Science (Director Jürgen Renn).

We would like to first express our gratitude to all the scholars involved in these four projects and who contributed to the creation of this institutional research agreement. Our profound gratitude goes specifically to Nana Citron and Victoria Beyer, who assisted in the “assemblage” of the present volume at each phase, from the raw contributions to the very final touches in the proofs. The prose was edited by Zachary



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The contributors to the present volume met for the first time at a kick-off workshop over several days in October 2018. We would like to thank the administration of the University of Bergamo for the organization of that meeting.

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Matteo Valleriani

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# Editors and Contributors

## About the Editors

**Matteo Valleriani** is research group leader at the Department I at the Max Planck Institute for the History of Science in Berlin, an Honorary Professor at the Technische Universität of Berlin, and a Professor by Special Appointments at the University of Tel Aviv. He investigates the relation between diffusion processes of scientific, practical, and technological knowledge and their economic and political preconditions. His research focuses on the Hellenistic period, the late Middle Ages, and the early modern period. Among his principal research endeavors, he leads the project “The Sphere: Knowledge System Evolution and the Shared Scientific Identity of Europe” (<https://sphaera.mpiwg-berlin.mpg.de>), which investigates the formation and evolution of a shared scientific identity in Europe between the thirteenth and seventeenth centuries. Among his publications, he has authored the book *Galileo Engineer* (Springer 2010), is editor of *The Structures of Practical Knowledge* (Springer Nature 2017), and published *De sphaera of Johannes de Sacrobosco in the Early Modern Period. The Authors of the Commentaries* (Springer Nature 2020). Together with Andrea Ottone, he also published *Publishing Sacrobosco’s De sphaera in Early Modern Europe. Modes of Material and Scientific Exchange* (Springer Nature 2022).

**Giulia Giannini** is an Associate Professor of History of Science at the University of Milan (Italy). She is the principal investigator of the ERC Consolidator research project TACITROOTS—*The Accademia del Cimento in Florence: tracing the roots of the European scientific enterprise* (2019–2024). She worked at the Centre Koyré in Paris and at the Max Planck Institute for the History of Science in Berlin. Her research interests focus on the history of experimentation and on cultural, political, and social studies of science in Early Modern Europe.

**Enrico Giannetto** graduated from the University of Padova in elementary particle theoretical physics, and then he studied early universe cosmology at the ISAS of

Trieste. He studied the history of science at the *Domus Galilaeana* in Pisa and obtained his doctorate in theoretical physics of condensed matter at the University of Messina. He has been working as a researcher for ten years at the University of Pavia within the History of Science and Science Education Group. There, he taught in particular “General Physics.” Since 2001 he is the Full Professor of History of Physics and History of Science at the University of Bergamo, Italy. In Bergamo, he has been teaching many disciplines from “History of Scientific Thinking” to “Theoretical Philosophy,” “Epistemology of Complexity,” and “Physics.” His research is focused on a perspective of a wide history of cultures where mythology, history of religions, anthropology, philosophy, and human and natural science are entangled. In particular, he worked in the following disciplines: quantum chromodynamics; quantum electrodynamics; early universe quantum cosmology; phase transitions in cosmology and condensed matter; special and general relativity; foundations of quantum mechanics; quantum logic; history of quantum physics, of relativity, of chaos physics, of elementary particle physics, of medieval physics, of romantic natural philosophy, of the scientific revolution, and of theoretical physics; history of psychology versus physics, science education; hermeneutics; philosophy of dialogue; anthropology of scientific thinking; and history of primeval Christianity. He has published more than 200 scientific papers and four major books: *Saggi di Storie del Pensiero Scientifico*, Bergamo University Press, Bergamo 2005; *Il vangelo di Giuda—traduzione dal copto e commento*, Medusa, Milano 2006; *Un fisico delle origini. Heidegger, la scienza e la Natura*, Donzelli, Roma 2010; *Sguardi sul pensiero contemporaneo. Filosofia e scienze per cambiare il mondo*, libreriauniversitaria.it, Limena (PD) 2018.

## Contributors

**Bougleux Elena** Università degli Studi di Bergamo, Bergamo, Italy

**Bushart Magdalena** Technische Universität Berlin, Berlin, Germany

**Casini Silvia** University of Aberdeen, Aberdeen, Scotland

**de Mûelenaere Gwendoline** Ghent University, Ghent, Belgium

**Giannetto Enrico** Università degli Studi di Bergamo, Bergamo, Italy

**Giannini Giulia** Università degli Studi di Milano, Milan, Italy

**Hood Stephanie L.** UZH - Universität Zürich, Zürich, Switzerland

**Kräutli Florian** Max Planck Institute for the History of Science, Berlin, Germany

**Lockhorst Daan** Max Planck Institute for the History of Science, Berlin, Germany

**Pantin Isabelle** École Normale Supérieure (Paris)-PSL, IHMC (UMR 8066), Paris, France

**Ricciardo Salvatore** Università degli Studi di Bergamo, Bergamo, Italy

**Roby Courtney Ann** Cornell University, Ithaca, USA

**Schemmel Matthias** Universität Hamburg, Hamburg, Germany

**Shlomi Noga** Max Planck Institute for the History of Science, Berlin, Germany;  
Tel Aviv University, Tel Aviv, Israel

**Valleriani Matteo** Max Planck Institute for the History of Science, Berlin,  
Germany;  
Technische Universität Berlin, Berlin, Germany;  
Tel Aviv University, Tel Aviv, Israel