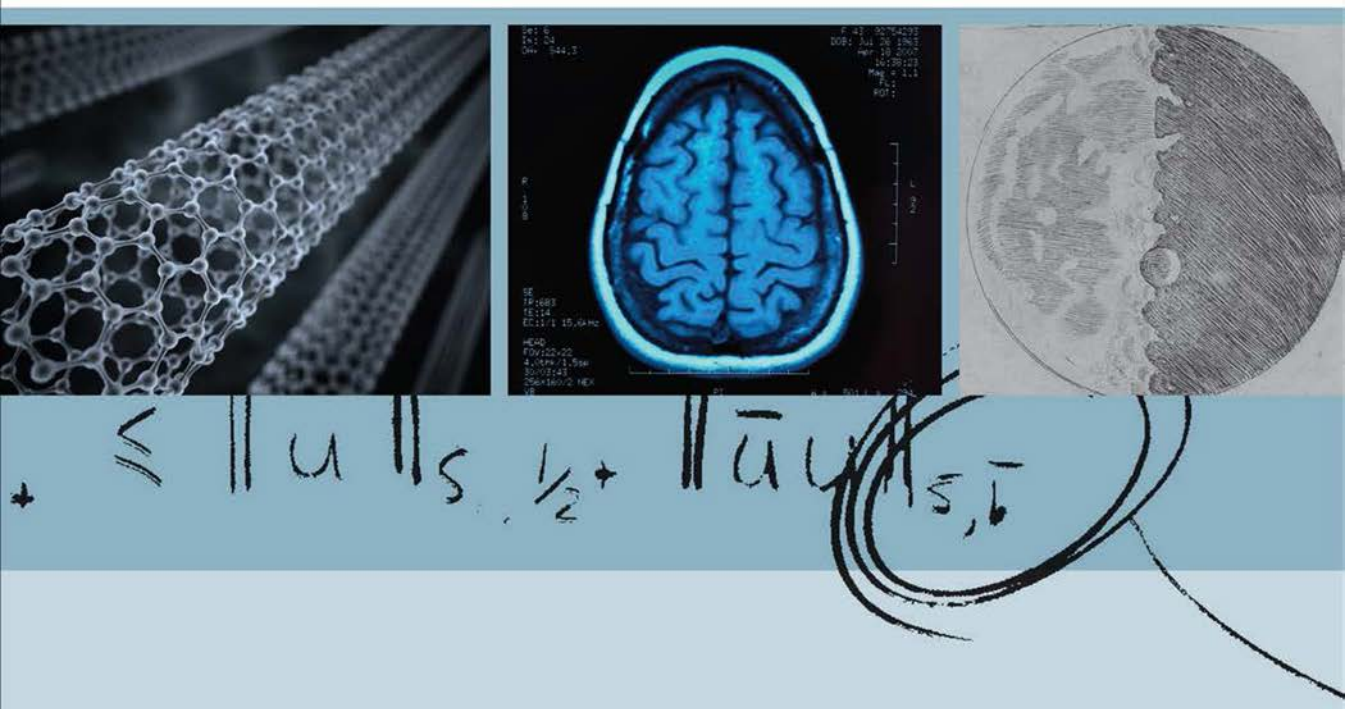
REPRESENTATION IN SCIENTIFIC PRACTICE REVISITED



EDITED BY **CATELIJNE COOPMANS, JANET VERTESI, MICHAEL LYNCH, AND STEVE WOOLGAR**

Representation in Scientific Practice Revisited

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Representation in Scientific Practice Revisited

edited by Catelijne Coopmans, Janet Vertesi, Michael Lynch, and Steve Woolgar

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Preface

Michael Lynch and Steve Woolgar

Thirty years ago, a workshop on "Visualization and Cognition" was held in Paris.[1] It was attended by an eclectic group of scholars including art historians, historians of science and engineering, semioticians, cognitive scientists, and ethnographers of scientific laboratories. The workshop marked a recent and rapidly growing scholarly interest in the production, use, and dissemination of maps, engravings, photographs, micrographs, and other pictorial and graphic displays in science and technology. In the decade prior to the meeting, historians such as Martin Rudwick, Samuel Edgerton, Martin Kemp, and Svetlana Alpers had already begun to establish that artistic and graphic techniques and technologies did not simply produce *images* that were secondary to logical reasoning and mathematical reckoning in the sciences. Instead, their research demonstrated that visual and graphic materials were crucial for enabling discovery and establishing the properties of natural phenomena. By then, sociologists and anthropologists had also been conducting ethnographies of laboratory practices that highlighted the pragmatic shaping of raw materials into polished and publishable exhibits of "facts." One of these ethnographers, Bruno Latour, organized the Paris workshop and presented the keynote address. His address integrated a down-to-earth focus on the work of constructing and inscribing the results of scientific investigations with a more sweeping overview of the importance of "immutable mobiles"—the fixed and transportable literary products of scientific work—in the history of science. Latour argued that, to a large extent, the scientific imagination was a matter of "thinking with eyes and hands." He and others who participated in the workshop preferred the term "visualization" over that of "perception" or "observation," because of the way it connoted practices of *making visible*—fashioning and exhibiting witnessable and accountable material and virtual displays. This emphasis on making visible also downplayed the supposed importance of cognitive and perceptual attributes in doing representation.

Several years later, we were invited to guest-edit a special issue of *Human Studies: A Journal for Philosophy and the Social Sciences*. The editor of the journal at the time, George Psathas, was particularly interested in recent work on science that exemplified an ethnographic and ethnomethodological treatment of scientific practices. After some

discussion, we decided to focus the issue on *representation* in scientific practice. Inspired in part by the growing interest in visualization, we also wanted to bring into play close studies of verbal interaction at the lab bench (or field site), as well as analyses of the literary and pragmatic relations among texts, depictions, and activities. The special double issue (Lynch and Woolgar 1988) included one article that had been presented at the Paris workshop (Lynch 1988) and several other studies of laboratory practices and expository discourse. Authors of the different chapters deployed semiotic, ethnomethodological, conversation-analytic, and discourse-analytic approaches to the practical, interactional, and textual organization of representation in science, and they also drew inspiration from and critically reexamined historical and philosophical conceptions of representation. The MIT Press agreed to publish a volume (Lynch and Woolgar 1990) that included papers from the special issue, supplemented by English translations of Latour's keynote from the 1983 Paris workshop and a paper by the late Françoise Bastide, which had originally been presented there.[2]

Representation in Scientific Practice was not the first book, and certainly not the last, to address representation in the sciences, but it established a distinctive approach to that topic which examined and elucidated the temporal and practical working and reworking of materials that (sometimes) culminate in the presentation and re-presentation of scientific facts, models, and ordered regularities. This approach became a familiar reference point in and beyond science and technology studies. At the same time, scientific visualization and representation became an increasingly established topic in other fields in the social sciences and humanities, including art history and visual studies, literary criticism, feminist and gender studies, anthropology, cognitive science, and the history and sociology of science.

Two decades after its publication, *Representation in Scientific Practice* continued to be read and cited, but by then a new edition seemed long overdue. After discussing plans for the new edition with each other, and with our former students Catelijne Coopmans and Janet Vertesi, we decided to publish an entirely new set of chapters rather than reprinting and revising those that had been published in the earlier volume. A key reason for this decision was that there had been a resurgence of interest in representation in the sciences among younger scholars. Many of them were interested in the uses of novel technologies: fMRI, probe microscopes, and digital visualization and image-processing technologies of all kinds. At the same time, by the second decade of the twenty-first century, the very question of representation in scientific practice had become situated in a different theoretical and conceptual landscape than it had been in the 1980s—a landscape colored by discussions of mediation, ontology, enactment, materiality, and the discursive "performance" of images, among other things. In addition to full-length chapters written mainly by younger scholars, *Representation in Scientific Practice Revisited* also includes commentaries by more established scholars who

were invited to reflect upon changes in the field during the more than twenty years since the publication of the original volume, and thirty years since the Paris workshop.

Notes

1. The workshop on "Visualization and Cognition" was held at the Centre de Sociologie de l'Innovation at the Ecole Nationale Supérieure des Mines de Paris on 12–15 December 1983.

2. See Latour (1990) and Bastide (1990). These and other articles from the 1983 workshop had been published in French, in a special issue of *Culture Technique* (Latour and de Noblet 1985).

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1 Introduction: Representation in Scientific Practice Revisited

Catelijne Coopmans, Janet Vertesi, Michael Lynch, and Steve Woolgar

1 Introduction

Over the past three decades, representation in scientific practice has become an established topic in science and technology studies (STS). From anatomical to astronomical illustrations, from protein gels to atlases, from remote-sensing imagery to brain scans, a rich field of inquiry spanning historical, sociological, and philosophical approaches has produced analyses of scientific efforts to "capture," "render," and otherwise make available aspects of the world. To examine the full richness of these efforts, STS scholars situate historical and contemporary notions of a representation's "truth to nature" within the contingent activity of locally grounded and discipline-specific, yet also mobile and powerful, practices. As the first volume to bear the name *Representation in Scientific Practice* (Lynch and Woolgar 1990; hereafter, *RiSP*) demonstrated, representation involves lengthy struggles with research materials to reconstruct them in a way that facilitates analysis, for example through coding and highlighting key features of interest and aligning them with particular concepts and theories. This treatment of representation in and as *practice* has since spurred a rich body of ethnographic, historical, and discourse-analytic inquiries that demonstrate how the circumstances of knowledge production are folded into epistemological claims and ontological orderings.

Enter a scientific workplace today and representations of all kinds continue to play a dominant role. Now, however, they are not only exchanged on printed pages or visible as protein gels in scientists' hands. Computer screens have pride of place in laboratories and scientific offices, where researchers' attentions are as likely—or more likely—to be focused on colorful digital images, simulations, software suites, databases, or lines of code as on unruly specimens or instruments. Biomedical imaging enrolls fMRI and PET scans alongside X-rays, which themselves are frequently digitally manipulated to produce new modes of vision. Planetary image processing and financial analysis rely on massive datasets (or streams) with their own concomitant visualization tools and skills. As "the laboratory" extends to other spaces and places via collaborative ventures, shared data centers, and information and communication technologies, this expansion

challenges the very distinction between laboratory and field. Still, alongside new computational practices continue to sit older representational forms in scientific work: chalk, marker, and pen scribbles decorating blackboards, whiteboards, and napkins; models of complex phenomena perched atop bookshelves; and glossy, retouched photographs in journal pages.

In part due to the proliferation and, perhaps, intensification of representational technologies and representational forms, STS research on the topic shows no signs of abating. The present volume is a response to a resurgence of such research in recent years, research that grapples with change and continuity in representational practices, and which also bears testimony to the way STS itself has changed. Contributors to the original *RiSP* volume made use of historical, sociological, ethnographic, literary, ethnomethodological, and conversation-analytic investigations, and sought to respecify "representation" as practical action in social and material contexts. They stressed the roles of instruments and textual formats, and the interactional and interpretive work surrounding them. Their emphasis on such public, practical, communicative, and textual work was set off against an established philosophical picture of representation as mental, verbal, or pictorial reference to features of an independent world.[1]

The interest in practice and social interaction remains strong today, but there have been many changes of theoretical emphasis and disciplinary location in the field. STS has become a robust and diverse field, with constituencies in anthropology and cultural studies, communication and information studies, geography, political science, economic sociology, and management and organization studies, in addition to history, philosophy, and sociology of science. Concomitantly, actor-network theory (Callon 1986; Latour 1987), which was just beginning to coalesce when the chapters in *RiSP* were drafted, is now a pervasive approach in STS. Inspired by actor-network theory as well as feminist and cultural studies of science (Haraway 1991), a "turn to ontology" emphasizing material enactments as well as embodied action and social interaction (Mol 2002; Woolgar and Lezaun 2013) has supplemented the "practice turn" (Schatzki et al. 2001) that many of the studies in *RiSP* exemplified.

These and other shifts in analytical interests, expository themes, and research sites are exemplified and elaborated in this new volume on representation in scientific practice. In light of new approaches and thematic interests, the chapters in the volume revisit the question of how we should study and understand (visual) representation, while also building upon prior scholarship on scientific, technical, and clinical practice.

2 The Concept Formerly Known as Representation

When the first volume of *RiSP* was composed more than twenty years ago, most contributors took up one or both of two main analytical objectives. The first, much less prominent today, was to create distance from idealized descriptions of scientific

procedure. At the time, and related to the development of STS as a field, there was a strong emphasis on showing how scientific practice differs from established versions of scientific method in mid-twentieth-century history, philosophy, and social studies of science. Those versions depicted science as a historically unique, logically governed, and socially exceptional method for attaining truth (or eliminating error), which differed from "commonsense" knowledge and everyday practices. The "practice turn" depicted science in its everyday modes as immanently practical, locally organized, and infused with interpersonal trust and tacit knowledge. This reconception of science through its everyday practice has since become so successful that it is now largely taken for granted in STS, if not in philosophy.[2]

The second analytical objective was to extend the analysis and critique of representation from language and logic to nonlinguistic, often visual practices and formats and to instrumental interventions (Hacking 1983). A key move was to reframe representation from an expectation that visual traces and numerical measurements were references to independent objects and properties, to a series of open-ended inquiries into the many different kinds of relations, reference among them, that are accomplished (or dismantled) in the work people do with representational forms. The production and presentation of *scientific* representations served as a particularly revealing source of the dynamics of demonstration and disputation, because of the cultural weight assigned to such representations. In the realm of science, understandings of representations as referential forms were considered particularly tenacious (albeit more among commentators than among practitioners) and thus in need of empirical reframing.

Given the philosophical baggage associated with the term "representation," it may be fair to ask whether it would not be better to abandon rather than to revisit representation in scientific practice. Has not the investment in representation or reference as a key philosophical problem been criticized to death? Even critical antipositivist treatments may have run out of steam by now (Latour 2004). Indeed, we have noted a tendency in STS scholarship to move away from the use of the term "representation." Instead, some authors prefer "mediation" (Pasveer 2006), while others adopt notions associated with the turn to ontology, such as "enactment" (Woolgar and Lezaun 2013). Perhaps most pervasive has been the substitution of "visualization" for "representation" (see, for example, Burri and Dumit 2008; also Wise 2006). It is clear that there is now an abundance of STS research on the effortful accomplishments through which images, graphs, and models are produced, and on how these come to speak for a phenomenon (or a set of relations) and are discursively deployed (Burri and Dumit 2008); but do we need an alternative word to designate *the concept formerly known as representation*?

While we are sympathetic to the argument that "representation" is a problematic term, we have chosen to stick with "representation in scientific practice" as an organizing theme for the present volume.[3] Despite the concern about philosophical baggage,

there is in our view no unproblematic way of designating the practices described and analyzed in this volume. Like "representation," "visualization" is a loaded term, as are closely related concepts such as "observation" and "perception."[4] Perhaps the best way to use such terms, then, is not as purportedly neutral summary descriptions of the scientific, technical, or medical work that is made the subject of analysis, but as unsettled concepts: *Is* it representation we are dealing with? Does what we are dealing with prompt us to extend, or expand, or rethink what we mean by this term? Can we, for instance, following Rheinberger's (1995, 51) provocative suggestion, conceive of "the activity of scientific representation . . . as a process without 'referent' and without 'origins'"?

The new contributions brought together around this organizing theme span a variety of empirical settings, place their emphasis in various ways, and ground themselves in anthropology, sociology, philosophy, history, and permutations of those fields. Some chapters discuss the articulation of particular phenomena, such as adolescence, soil on Mars, or human anatomy. Others concentrate on representational conventions and the work and negotiations associated with them in fields such as nanotechnology and molecular biology. Some chapters are concerned with the tropes that animate the production and presentation of visual representations, while others identify features in the practices they study that call for new analytical repertoires. Several contributions pay attention to the embodied interactions that constitute representational work in science, technology, and medicine. Some contributors to the volume treat representation as a noun, focusing on the "outputs" of scientific endeavor, while others talk of representing as a verb. In some settings, and not exclusively those characterized by interactive digital technologies, this very distinction itself dissolves as screen displays or physical inscriptions are manipulated to expose or enact the reality they make tractable.

3 "New" Studies of Representation in Scientific Practice

The chapters in this volume allow us to ponder the question: How do we understand representational practice today? Rather than provide either an encyclopedic view or a snapshot of a moment when particular visualization technologies (such as various digital systems) are "new," the volume's chief aim is to articulate conceptual issues that promise to outlast any particular example. Consequently, as editors we have not attempted to encompass all forms of scientific representation or all possible analytical approaches to that topic (an impossible task, in any case). Instead, each of the contributions we selected for the volume aims to identify certain key concerns, constituents, mechanisms, or animating features of representation in scientific practice that illuminate and allow reflection upon recent developments in STS. We outline some broad themes here.

The first volume of *RiSP* emphasized interactional elements of practice: many of the chapters examined interactions among researchers, often while working with visual data displays. Such interactions between persons and with things continue to play a key role in our understanding of representation today. However, the notion of practice employed in the present volume must also be understood in the context of current enthusiasms for the notion of *materiality*. Some versions of this notion stress the embodied nature of scientific work, as well as the tools, objects, technologies, and environments in and through which science is practiced. Such concerns have long been a central focus of STS; so, then, what is the importance today of emphasizing "the material"? One way in which some of the chapters in this volume answer this question is by characterizing practices that involve, for example, digital or mathematical phenomena and fields as no less material than, say, a tabletop experiment with vials and burners. In line with current scholarship in STS and media studies, authors move away from commonplace notions of digitality that treat the virtual as ephemeral, and instead attend to the material conditions of digital work expressed in specific entanglements of language, visual evidence, embodied actions, and worldly phenomena. More broadly, the chapters attend to a variety of different material domains: gestures that make sense of visual materials, multimodal interactional environments, and suites of technologies (including extensive databases and software scripts but also blackboards and scrap paper) that constitute an infrastructure for scientific engagement with worldly phenomena.

Many of the representational techniques or technics featured in this volume involve *new* computational systems using digital technology. But rather than establish a discontinuous or a simple skeumorphic relationship between contemporary digital practices and analog forms, the authors focus on continuities, and complicate distinctions between the old and new. Innovation is treated not as a revolutionary break, but as a question of working with, across, and through established representational conventions, technologies, and communities. This applies from the way data are rendered in nanoscience all the way to the low-tech environments in which theoretical mathematicians and economists work toward new approaches and theorems. Another way in which distinctions between the old and new are complicated is entailed in the suggestion in some chapters that insights gained from observing the specificities of digital manipulation also apply to other historical times and places.

Recent STS research has called attention not only to the practices and technological infrastructures of representational production, but also to their entanglement with the *dynamics of reception and circulation* (though see Shapin and Schaffer 1985 for a now-classic treatment of this theme). There is now, for example, an increased sensitivity to shifting notions of objectivity (Daston and Galison 2007) and to the situated production and reception of expert witness accounts (Jasanoff 1998), where issues of trust, expertise, and accountability are very much in play. These issues sometimes

remain internal to a scientific field, but are more often engendered by the circulation of scientific representations beyond the settings in which they were produced, settings in which the audience may be comprised of scientists in different fields, clinicians, or various publics engaged through popular culture or the politico-legal sphere. Several chapters in the volume explore how expertise is produced and contested in and through representational practices that entangle both scientific practitioners and their audiences. In various contexts and with different analytical approaches, they examine how the visual outputs of such practices generate trust (and sometimes mistrust) for particular witnesses in particular contexts.

What is "new" about this volume of *RiSP*, then, is not simply a consequence of focusing on novel technologies, sciences, or institutional arrangements. Instead, it has to do with revisiting and respecifying recurrent themes in light of developments over the past two decades in the sciences studied as well as in our own fields of research. In the process of studying practices and practical entanglements, chapters in this volume trouble many presumed clear-cut boundaries, for example between visual and nonvisual representations, and between epistemic and ontological work. Similarly, the boundary between "science" and "nonscience" is blurred, with discussions related to the domains of surgery and business analytics that raise key questions regarding the nature of technology-mediated seeing (and intervening), and with contributions that trace the circulation of representations across scientific and nonscientific domains.

To be sure, chapters in the present volume invoke some of the classic staples of sociological inquiry, such as trust, value, community norms, and status, as well as some of the now-established concepts of the original volume of *RiSP*, such as inscription devices and the public and discursive production of "perceptual" activity. However, they also extend these conceptual repertoires. Classic questions of visual epistemology are reimagined by reference to contemporary material configurations. Orienting concepts such as "seeing as," modeling, mediation, objectivity, phenomenology, or conceptual hybridity are worked through by reference to particular practices, instruments, and communities. This is the sense in which this volume *revisits* the conceptual themes and analytical perspectives associated with the 1990 volume, presenting a fresh analytical perspective on themes of continuing importance to the contemporary study of scientific representation.

4 The Arc of the Work

The chapters that follow begin with a focus on the detailed practices with screens, data, and visualization algorithms that craft viewing experiences in the digital era. The chapters by Janet Vertesi and Catelijne Coopmans deal with the work of *revealing* that draws digital data into valuable and sensible configurations. Revealing, here, evokes the notion of "making visible" in order to be readily witnessed in a communal perceptual

space. These chapters discuss empirical settings in which participants "make visible" by manipulating large quantities of digital data. **Vertesi's** chapter discusses practices of image construal in NASA's Mars Exploration Rover mission, focusing on how Martian soil is made seeable as a phenomenon of interest. Vertesi stresses that revealing is intense and effortful work: "seeing as" experiences are not limited to an observer's perceptual field but also are crafted with visual materials, and are hence better captured in the notion of *drawing as*. **Coopmans's** chapter interrogates the claim that new data visualization software can help users "see" hitherto hidden insights in datasets. Tracing how this claim is bolstered in and through online software demonstrations that portray visual analysis as a complex interplay between "artfulness" and "revelation," Coopmans argues for analytical attention to the ways in which long-standing epistemological tropes animate and are animated through new practices.

Zooming out from the practices at the screen, the next two chapters by Morana Alač and Rachel Prentice draw our attention to the embodied nature of work with digital visual technologies. These authors insist that the cognitivist notion of "looking at" bodies that are "visually represented" on a screen is wholly inadequate to understand the nature of working with brain scans or doing remotely mediated surgery. Only by fully inhabiting the setting, using gesture and touch alongside visual information, are practitioners able to make present what is salient to their work. **Alač** describes the multimodal coordination work—the screen work, gestures, and talk—through which brain-related objects and features of note are enacted by scientists in a cognitive neuroscience laboratory. Rather than understanding fMRI data patterns as visual "representations" that are being "interpreted" by practitioners, she sees them as *materials for enactment* through dynamic, interactive, and embodied engagement on the part of practitioners. **Prentice** explores "how surgeons and trainees at various levels come to acquire surgical means of perceiving and acting, especially perceiving and acting with technological mediation." She shows how sight and touch merge in the technical and social actions that constitute surgical skill. Prentice argues that the now-widespread use of remotely mediated surgery has brought about an intriguing change in how surgeons inhabit the operating space: they safeguard the coherence of that space by locating their own bodies *inside* the body parts they are operating on.

These discussions of embodied engagement also highlight the technological interfaces and material infrastructures that enable the work of representing (and, for Prentice, intervening): a theme that is taken further in the next two chapters. These focus closely on the constitutive role of materials and technologies in the production of new scientific knowledge. Michael **Barany** and Donald **MacKenzie** discuss the role of chalk, blackboards, and scrap paper in the development of theoretical concepts and approaches in research mathematics. The mundane and modest nature of these materials, according to the authors, is precisely what makes them so important to the "performative unfolding" of mathematical argument. They further contend that, contrary to

the notion that inscription practices in the natural sciences are designed to discipline or tame unruly phenomena, the symbolic objects of mathematics are substantially freed and allowed to morph and change through their rendering in material form. This resonates with Sarah **de Rijcke** and Anne **Beaulieu's** discussion of brain atlases comprised of collections of brain scans that are powered by, and remain linked to, dynamic databases. Brain scans, the authors argue, do not represent a vision of the brain at a static moment in time. Each image viewable on a computer screen stands for a statistical dataset that derives its meaning from its relation to a database that is continually changing. Practitioners thus handle and manipulate these images as *interfaces* to a digital infrastructure, and it is through this configuration that new knowledge and understandings of the brain can be achieved.

Such material infrastructures bring with them conceptual tools and analytical practices that animate ways of thinking and working, and these are discussed in the next three chapters. Natasha **Myers** in her chapter draws on the work of Donna Haraway to show how molecular models *render* protein structures as machines. In her account, machine metaphors are rendered into material form through the development of models that serve as tools for thinking and acting with biological phenomena. This focus on rendering marks a point of continuity between the original *RiSP* and the present volume (see Lynch's [1990] treatment of "renderings" of electron micrographs [also see Lynch 1985, 64n] and Vertesi's focus on "drawing as" in the present volume). Myers argues that machine metaphors are highly productive: they support the enactment of objects of research, bring people together, and even drive entire research programs. Martin **Ruivenkamp** and Arie **Rip** see a similar mobilizing function in the images associated with nanotechnology. They characterize nanoimages as "hybrid monsters" that mix representational conventions. Rip and Ruivenkamp argue that the hybridity of nanoimages is productive for organizing and creating a space for nanotechnology by spurring different imaginations of what the nanoscale might look like, as well as what we might do with it in future (see also de Ridder-Vignone and Lynch 2012). Annamaria **Carusi** and Aud Sissel **Hoel** also discuss hybridity in their chapter on computational biology, here in relation to what they identify as an intertwining of qualitative and quantitative methods in visual practice. Drawing on the later work of Maurice Merleau-Ponty, Carusi and Hoel argue that the new configurations of vision, computational technologies, and objects evident in computational biology necessitate an "ontological reframing" that also has repercussions for how scientific vision is conceived in other domains.

The emphasis then shifts to how the status and significance of scientific imagery are negotiated within communities of practice. Cyrus **Mody** looks historically at the development of a scientific community around a novel instrument that converts haptic apprehension of surface electronics into visual topography. The development of visual styles with the rise of the scanning tunneling microscope and atomic force microscope

in nanotechnology shows tensions in the ways the results of representational work are understood within the relevant communities: as conventional or iconoclastic. Emma **Frow** discusses recent concerns voiced by editors of leading biology journals about the exploitation of programs such as Photoshop to manipulate digital data when preparing images for publication. Frow points out that the editors' efforts to develop rules against illegitimate data manipulation tend to ignore the extent to which, as STS research has shown, data manipulation is a normal feature of expository science. Both Frow and Mody discuss the tensions entailed in stipulating what scientific images are supposed to look like; and both suggest that scientists' perceived trustworthiness or innovativeness is bound up with emerging visual conventions.

The final two full-length chapters in the volume consider the status of particular representations as they become widely disseminated beyond the circumstances of their initial development. Both authors suggest that science is subordinated to popular culture in the deployment of such representations. Yann **Giraud** traces how the Laffer curve—allegedly drawn initially on a restaurant napkin to suggest how government revenues vary with tax rates—became a celebrated (and much criticized) icon for supply-side economics in the 1980s. Giraud shows how a representation that started life as a propaganda tool was subsequently translated into an object of economics research. Curiously, despite extensive modification and criticism, it is the original version that continues to surface in economics textbooks to this day. Joseph **Dumit** provides an account of the role of brain scans in recent disputes about the legal status of adolescence. Dumit shows how brain scan images were configured and juxtaposed to address a legal distinction between degrees of criminal culpability assigned to adults and adolescents. He cautions that "neuroscience has come to have explanatory power far in excess of its confirmatory ability" and that the flexible use of brain images as "scientific" backings for established moral categories should be resisted, despite the temptation they present for lawyers, journalists, and neuroscientists.

The thirteen chapters in the book offer detailed case studies and their elucidation in terms of thematic, theoretical, or methodological implications for studies of representation in scientific practice. These chapters are complemented by short reflections from Lorraine **Daston,** Michael **Lynch,** Steve **Woolgar,** Lucy **Suchman,** John **Law,** Martin **Kemp,** and Bruno **Latour**. Many of these authors were included in the original *RiSP*; others are equally well known for their contributions to research on visual representation in science and other domains. Each of their reflections provides broader commentaries on past, present, and future scholarship on representation in science studies. With topics as diverse—and sometimes as provocative—as the authors themselves, these reflective and reflexive pieces inspire our continued attention to the changing hows and whys of studying representation in scientific practice.

Through these diverse contributions, both chapters and reflections, the volume attempts to raise new questions and revisit old ones, to open up investigative

possibilities, and to reinspire engagement with representational practice—or with the concept formerly known as representation—in and beyond science and technology studies. We do not claim the present volume to be exhaustive or conclusive in its contributions.[5] We simply invite our readers to explore the collection, place its pieces in conversation, and bring new questions, new answers, and new challenges to the fore.

Notes

1. Prevalent at the time, what is sometimes called the "correspondence theory of knowledge" presumed a fundamental distinction between a natural order "out there" and efforts to approximate that order (more or less accurately) with representations in the form of measurements, equations and graphs, verbal descriptions, and visual images. Pervading the diverse contributions to *RiSP* was the insistence that, instead of investing in the correspondence theory, with its established problems and ongoing efforts to overcome them, STS researchers should attend to the "contextually organized and contextually sensitive way" (Lynch and Woolgar 1990, vii) in which particular representational forms are composed and used.

2. See, for example, the recent special issue of *Studies in History and Philosophy of Science* titled "Model-Based Representation in Scientific Practice: New Perspectives," which aims to "explore ways in which close attention to scientific practice . . . can shed light on the philosophical issues raised by scientific representation" (Gelfert 2011).

3. It should be noted that Latour has made a particular effort to reinvigorate the study of "representation" by insisting that its epistemological connotations should be considered in tandem with artistic and religious representational practices, as well as with political meanings of the term. This effort has borne fruit in two exhibitions called "Iconoclash" (Latour and Weibel 2002) and "Making Things Public" (Latour and Weibel 2005), in which a wide range of contributions were brought together "to foster a new respect for mediators" (Latour and Weibel 2005, 29). In contrast to Latour's explicit situating of the question of representation at the intersection of distinct domains of public life, the present volume—in continuity with the earlier one—maintains "representation in scientific practice" as a classic STS concern to be revisited.

4. Lynch (1994) has argued that "representation is overrated," which was a play on Hacking's (1983, 137) earlier statement that "observation is overrated." At the workshop on "Visualization and Cognition" in Paris in 1983, "perception" and "observation" were criticized for being too cognitivist, while "visualization" was considered a less troubled term (see the preface to this volume). Visualization, however, has been associated with its own set of problems, ranging from an uncritical privileging of sight (Garforth 2012) to the "mimetic . . . obsession for an image as a copy" (Latour, this volume) that draws our attention to particular, singular images, graphs, models, and so on, rather than tracing the dynamic way reference is constituted through multiple conversions of form. None of these critiques has been a significant deterrent; recent years have seen the publication of edited collections on *Histories of Observation* (Daston and Lunbeck 2011), *Visual Cultures of Science* (Pauwels 2006), and *Skilled Visions* (Grasseni 2007).

5. Notably absent, for example, are questions of colonialism, non-Western approaches to representation, or cultural modes of representing differences in gender or race (see, for example, Verran 2001; Raj 2007; Anderson 2008).

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