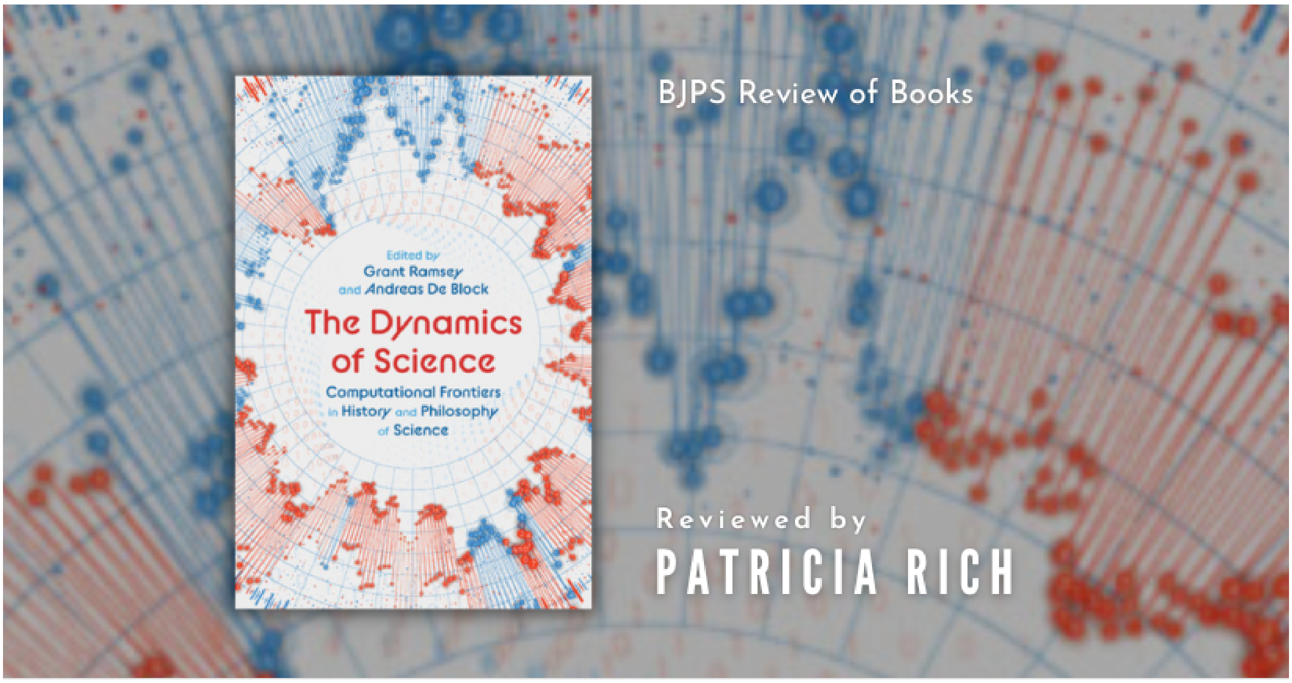

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THE DYNAMICS OF SCIENCE

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Reviewed by Patricia Rich

The Dynamics of Science: Computational Frontiers in History and Philosophy of Science
Grant Ramsey and Andreas De Block (*eds*)
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Very few researchers will have failed to notice that computing technology has been advancing rapidly, so that the landscape of computational tools and resources at our disposal looks completely different than a generation ago. Some researchers from the humanities and social sciences have embraced new ways of doing research, while many others have only a partial or passing awareness of the emerging computational research programmes within their fields. This book provides a fairly gentle and broad introduction to the new possibilities. This is a valuable contribution, since it would be a shame for the significant potential of computers to go untapped simply because people aren't aware of this potential. For some sub-fields (such as social epistemology), computers have already been a game-changer.

The editors see this book as addressing the important question of whether the new computational tools can address some issues in the history and philosophy of science in particular; they answer in the affirmative, arguing that there is great potential here. For example, they note that the proper relationship between history and philosophy in HPS has been a matter of debate, and that the common practice of using specific historical examples to support general philosophical claims is problematic (because, for example, a cherry-picked example may mislead regarding scientific phenomena more generally). Computational tools can help to solve this problem by enabling researchers to encompass much or all of the relevant scientific track record in their inquiries. The sheer output of modern science presents a problem for philosophers and historians, since it is difficult to keep up with the research even on specific topics; again, computational tools provide ways to see the bigger picture and to avoid missing literature on the target topic.

Overall, the editors support the trend towards a naturalistic philosophy of science, and see computational tools as a way to naturalize philosophy of science more thoroughly, by naturalizing the tools that it uses, too. They promote this scientific approach to the study of science, or a computational HPS, not as a replacement for traditional HPS but as a valuable supplement. The goal of the book is therefore to give those interested in such supplementary tools a broad view of what tools are out there—their capabilities, sensible applications, and limitations. They envision interdisciplinary collaboration in which historians and philosophers work together with researchers from other disciplines (such as statistics or computer science). This vision—in which the HPSers provide research questions but do not necessarily engage themselves in the technical part of the work—is reflected in the way the computational tools are explained and presented, namely, with minimal technical detail. I return to this point later.

The book is divided into three parts. Part 1, 'Toward a New Logic of Scientific Discovery, Creativity, and Progress', aims to show how computational tools can enable valuable new insights into traditional questions in philosophy of science. In practice, the focus here is on computer simulations and building models of science, a thriving enterprise. By building a series of Bayesian models, Paul Smaldino (chapter 1) shows how we can better understand the replication crisis and how to address it by looking beyond simple models of empirical hypothesis testing and instead modelling science more comprehensively, including an evolving population of scientists within an institutional structure where they must apply for grants. Justin Bruner and Bennett Holman (chapter 2) use two simulation models to study social learning in scientific networks, specifically whether scientists learn to pay attention to the most reliable of their peers and how often the community reaches correct conclusions. Mike Schneider et al. (chapter 3) use agent-based simulations to investigate diverse collaborations in science, especially possible ways of promoting or improving them. Interestingly, the simulations show that a policy that might be thought, intuitively, to increase collaboration across groups can backfire by increasing actual discrimination. David Chavalarias et al. (chapter 4) point out that the evolution of science can be understood both in terms of its patterns (for example, is change gradual or does it come in spurts?) and its processes (what causes the patterns?); ideally, philosophers of science would reason both from processes to possible patterns and from patterns to possible processes. It shows how a technique called 'phylomemies' can enable this, in particular by facilitating the latter direction of reasoning and using data mining to infer the patterns.

Part 2, 'Frontiers in Tools, Methods, and Models', aims to show the 'cutting edge of computational HPS' and provide an 'instruction manual'. The first two chapters here are about machine learning. Colin Allen and Jaimie Murdock (chapter 5) present a variety of topic modelling known as latent Dirichlet allocation or LDA, which involves using machine learning to infer sets of words that frequently co-occur ('topics') and then assigning these topics (probabilistically) to documents. The authors give an example where they analyse Darwin's book-reading over time and calculate the distance between the books Darwin read and his *The Origin of Species*. Krist Vaesen (chapter 6) defends supervised machine learning, in which the researcher starts with a hypothesis and then tests it. They give the example of testing whether a philosophy journal became more homogeneous over a particular period of time, in particular by publishing more analytic work. The chapter continues on the previous chapter's defence of topic modelling, with discussion of the drawbacks and benefits of each of the presented techniques. I was a bit puzzled as to why these techniques were singled out as the 'cutting edge', especially since the variety of topic modelling emphasized in the book is now around twenty years old. 'Cutting edge' may here be a euphemism for 'controversial', since it seems that the value and proper use of these techniques have been questioned more than those of the other computational techniques (such as simulations). Still, these tools are certainly interesting enough to be worth presenting, and the readers can decide for themselves whether they can see valuable applications for them. Finally, Steve Elliot et al. (chapter 7) offer practical advice on how to manage data. It's not specific to new computational tools, but anyone who plans to work with data (or, more generally, in research teams where work needs to be shared and not lost) would be better off for having read the chapter.

Part 3, 'Case Studies', gives more detailed examples of using computational tools to better answer historical questions of interest to philosophers, emphasizing data-based digital humanities research. As with part 1, I thought that seeing concrete examples of computational tools being used to address interesting research questions was much more convincing regarding the merits of those tools than the relatively abstract discussion in part 2. Charles Pence (chapter 8) models discourse networks among scientists to gain insight into how the 'crises' that prompt Kuhnian paradigm shifts unfold. The technique provides an improved story of what the scientists were doing during one such crisis, for example, because the model captures the larger community of scientists involved, rather than just a few famous figures, as traditional historical perspectives tend to do. Christophe Malaterre et al. (chapter 9) use topic modelling (discussed in part 2) to measure the prevalence of 'socially engaged philosophy of science' over the lifespan of the journal *Philosophy of Science*. As the authors point out, the computational tool uncovers types and examples of such work that had escaped the notice of previous researchers (and, in fact, their list includes some articles that had also escaped my notice despite apparent relevance). The work displayed by each of these chapters could be quite valuable as part of larger research projects, since the digital tools provide evidence that would otherwise be lacking. Annapaola Ginammi et al. (chapter 10) show an especially impressive use of digital tools. The authors use a 'mixed method' of *ideengeschichtlich* modelling, text mining, and close reading to answer an open question about Bolzano's theory of concepts, coming to a better understanding of Bolzano's views and how they relate to Kant's. Essentially, the authors bring a great deal of prior knowledge and understanding, and use the text mining to find revealing passages in Bolzano's large body of writing. Deryc Painter (chapter 11) characterizes the interdisciplinarity of evolutionary medicine by analysing data from all the publications in that area, co-authorship networks, and the expertise of the authors in that network. The authors acknowledge that it will be important to compare the picture that emerges about evolutionary medicine in this way to another interdisciplinary field, but it is still clear that the computational tools allow them to form a detailed picture in the first place, of a kind that would be difficult to achieve just by inspecting individual publications.

This book is tailored to a general HPS audience, especially those who have little prior familiarity with computational tools, or who have encountered some but not all of the tools mentioned in the book—so a very wide audience indeed, since hardly anyone will have come across the full set of computational tools covered here. The chapters are very short and mostly very clear, and while it can take some work to grasp the idea behind unfamiliar techniques, it should be possible for the uninitiated to get a good idea of what kinds of research people have been doing, and what kinds of projects are now possible. While the short and concise chapters definitely lower the cost of getting up to speed, this brevity is also clearly the result of a conscious compromise: there is almost no technical detail, and the level of explanation of the methods used that would be required for a journal article is not present. For the most part, authors provide basic explanations of their existing work or perhaps minor extensions thereof, and refer the interested reader to other sources for more detailed explanations. For those unused to reading about this kind of work, this is likely to be very helpful. For those with more exposure, and especially for those with a specific research interest in the results reported, it can feel that too much detail is left out. For example, I found chapter 1 to be crystal clear and very valuable, but would have really liked to have some more basic information about how the model was implemented—for example, an explicit statement about whether some simulations were run or whether the results were derived purely analytically.

Of course, anyone who cares to is free to follow up on the references within the chapters, and it is also important to note that anyone with a concrete research interest in either the presented results or the highlighted techniques must do so. Although the authors mostly do a good job of pointing out the limitations of the techniques they are using (especially in part 2), given the choice of short and accessible chapters, there will be important caveats attached to all modelling or machine learning results that are not fully expressed in the book. Anyone inspired by the book who wants to undertake some computational research of their own would be well advised to read many examples of their chosen technique being applied in regular research articles, and to pay special attention to discussion of modelling choices and the interpretation of results. It may also be best to team up with someone already experienced in the use of the appropriate computational tools, as the editors seem to envisage.

Regarding the possibility that readers will be inspired to try some computational research, although the editors' efforts to make the book accessible are largely very successful, it would have been helpful to have more of an overview of the different computational tools and how they relate; some kind of chart or tree might have made it easier to keep track, and make sense, of the diverse tools under discussion. Similarly, it would have been helpful to have more of an indication of the time and other resources needed to carry out projects like those described in the book. How easy is it to access and use data bases of all journal articles from a particular journal or on a topic? How long does it take to run a topic modelling algorithm on, say, 100 texts? How much special software is needed? And is the software free and easy to use? Reading the book gave me lots of ideas for how this or that technique could be useful, perhaps especially for finding overlooked literature or passages, or for verifying beliefs that I currently support with intuition and anecdotes. It did not give me a clear idea of whether something useful could be accomplished quickly as a rainy-day project, or whether much more of an investment would be needed. It would be wonderful if the book inspired more people to try out computational research, but for those people, such practical questions are very important.

So, is there an impending computational revolution in HPS? It's clear from reading the book that a computational approach provides a powerful new way of trying to get a grip on science, both its past and present. This can help us to correct biases (for example, by identifying more of the relevant literature or scholars; see chapters 9, 10) and to find evidence efficiently (chapter 10). It can help us to better understand how science works (chapters 2, 4, 8, 11) as well as to evaluate ways of improving it (chapters 1, 3). We should make use of these abilities, whether this means that basic computational tools become as standard as internet searches or we outsource much of their use to specialists. Importantly, though, we should use computational tools not because it's trendy or fancy, but because they can help us to answer well thought out research questions that are independently motivated and independently interesting. The most compelling case in the book for computational tools comes from examples of their integration into solid research programmes (as with the chapter on Bolzano). Exploratory research has its place, but I think that any significant and lasting impact on HPS will be based primarily on good ideas by researchers, with computers in a supporting role. In that sense, the authors and editors are good role models, emphasizing the variety of tools for solving the sort of problems faced by HPS researchers rather than simply hyping the abilities of computers.

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