strong shaking at relatively large distances, in turn enhancing the risk from infrequent earthquakes (*11*).

Disaster Deferred tends to vilify government scientists' role in continuing to push for strict building codes in the face of new scientific evidence. Stein's account fails to recognize the breadth of the scientific and engineering consensus surrounding the current approach to hazard analysis, which uses a robust logic-tree approach (*3*, *4*) to acknowledge multiple working hypotheses and allow for contributions from a broad range of the scientific community. For the national seismic hazard maps, for instance, this process allows considerations that incorporate a range of values for the magnitude of the "characteristic" New Madrid earthquake—from 7.3 to 8.0.

Ultimately, the debate about the importance of seismic hazard in the New Madrid region revolves around what is considered to be an acceptable risk. Stein holds that the current criterion, which mitigates against a relatively low, 2% risk in a 50-year time span, is excessive. He argues quite convincingly that Americans' perception of risks is wildly out of proportion to their true magnitude. Perhaps he is correct in suggesting that we should be spending more on everyday risks like heart attacks and automobile accidents. That position, however, might have seemed more reasonable prior to our recent spate of geological catastrophes around the globe—most notably the 2004 Indian Ocean tsunami and the 2010 Haiti earthquake—which demonstrate the social, political, and economic costs that accrue in the absence of adequate disaster planning. Ultimately, we must make the subjective decision on the degree to which we are willing to expose our cities to the risk of a rare but catastrophic event. It may be that a sustainable civilization is not one that applies a strict cost-benefit analysis to each of its decisions but one willing to invest heavily in a future that is girded against devastating natural disasters.

References

1. A. Newman *et al.*, *Science* **284**, 619 (1999).
2. E. Calais, S. Stein, *Science* **323**, 1442 (2009).
3. E. H. Field *et al.*, *Bull. Seismol. Soc. Am.* **99**, 2053 (2009).
4. M. D. Peterson *et al.*, *Documentation for the 2008 Update of the United States National Seismic Hazard Maps* (U.S. Geol. Surv. Open-File Rep. 2008-1128, 2008); http://pubs.usgs.gov/of/2008/1128/.
5. M. P. Tuttle *et al.*, *Bull. Seismol. Soc. Am.* **92**, 2080 (2002).
6. M. P. Tuttle *et al.*, *Seismol. Res. Lett.* **76**, 489 (2005).
7. W. Thatcher, *J. Geophys. Res.* **80**, 4862 (1975).
8. J. W. Savage, W. H. Prescott, *J. Geophys. Res.* **83**, 3369 (1978).
9. W. Thatcher, J. B. Rundle, *J. Geophys. Res.* **89**, 7631 (1984).
10. S. J. Kenner, P. Segall, *Science* **289**, 2329 (2000).
11. A. Frankel, *Seismol. Res. Lett.* **75**, 575 (2004).
12. H. Howe, *Historical Collections of the Great West: Containing Narratives of the Most Important and Interesting Events in Western History ...* (Cincinnati, 1851).

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INFORMATION SCIENCE

Bounds and Vision

Mason A. Porter

Visualization is a crucial but underappreciated part of science. As venues like the American Physical Society's Gallery of Fluid Motion and Gallery of Nonlinear Images illustrate every year, good visuals can make science more beautiful, more artistic, more tangible, and often more discernible. Katy Börner's continuing exhibition *Places & Spaces: Mapping Science* (*1*) and her book *Atlas of Science: Visualizing What We Know* arise from a similar spirit but are much more ambitious.

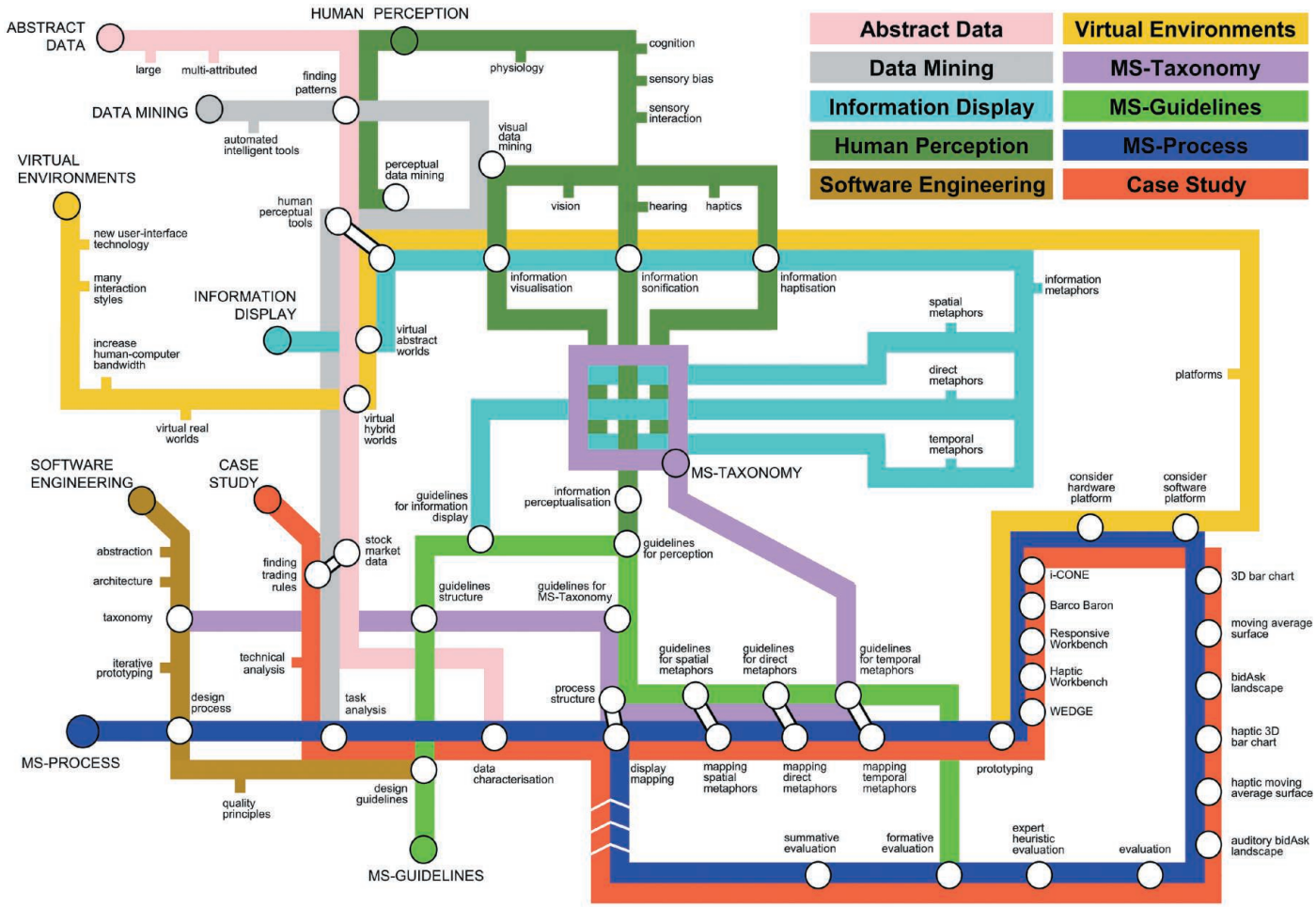
Visualization is one of the most compelling aspects of science. Breathtaking visuals from sources like fractals and Disneyland's long-dead "Adventure Thru Inner Space" ride are what originally inspired me toward my personal scientific path, so I welcome any resource that promises to bring the visual joys of discovery to a wide audience. Importantly, Börner's exhibition and book are not mere artistic manifestations, although they would be impressive accomplishments even if that were her only goal. Some scientists have occasionally had great success in the visual arts; for example, physicist Eric Heller has long exhibited the gorgeous fruits of his research on quantum chaos and other topics (*2*). To fully appreciate Börner's efforts, however, one must be conscious that she is deeply concerned not just with visualization itself but with the science of visualization. Accordingly, her book discusses the history of the science of visualization, where it is now, and where she thinks it can go. *Atlas of Science* both illustrates and educates, and it does so in an enjoyable (though somewhat flawed) manner.

Atlas of Science
Visualizing What We Know
by Katy Börner
MIT Press, Cambridge, MA, 2010. 266 pp. $$29.95, £22.95. ISBN 9780262014458.

Börner (an information scientist at Indiana University) espouses the creation of science maps, which—analogous to their geographic counterparts—are meant to represent complicated, interwoven phenomena in science in beautiful but digestible packages. These are produced using a gamut of different visualization tools and software, many of which were developed by the book's contributors. Most of the entries in *Atlas of Science* take the form of large, lush two- or four-page spreads, though some of the historical and background discussions occasionally depart from this format. The volume is organized into five sections. The introduction considers the growth of science and information as well as the importance of studying and mapping such growth. The book's second part (my favorite) offers a history of science maps—including a timeline and expositions of discoveries and discoverers, visions and visionaries. The next part discusses the path toward building a science of science. The fourth part (occupying half of the book) presents the 30 maps from the first three years of the *Places & Spaces* exhibition along with descriptions of how many of them were constructed. The final part surveys some possibilities for the future of science mapping.

At its best, *Atlas of Science* is excellent. The three years of the exhibition incorporated in the book contain numerous beautiful images, and each year's juxtaposition of "classical" and modern elements is inspiring. For example, the first year compares and contrasts early maps of the world (including their imperfections and inaccuracies) with several scientific maps, such as a "Ph.D. Thesis Map" inspired by the Sydney metro map, that should be rather poignant to anybody who still remembers their own path to a doctorate. I really enjoyed many of the individual maps, but the highlight of the book for me was the exposition of the pioneers and milestones in mapping science. I discovered some important figures, such as Paul Otlet, of whom I was previously embarrassingly unaware. (Otlet, a Belgian lawyer and bibliographer, was using terms such as "web of knowledge" in the 1930s.) I also

The reviewer is at the Oxford Centre for Industrial and Applied Mathematics, Mathematical Institute, University of Oxford, Oxford OX1 3LB, UK, and at the CABDyN Complexity Centre and Somerville College, University of Oxford. E-mail: porterm@maths.ox.ac.uk



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got to read fascinating tidbits about scientific heroes such as Derek John de Solla Price, who studied preferential attachment before it was invented. The extensive timeline was interesting as well, although I was frustrated by its occasional inaccuracies and the short shrift given to mathematics. Börner actually takes pains to explicitly marginalize the contributions of graph theory, on which network science fundamentally relies, even though many of the visualizations in the book depend critically on network representations. Although one might argue that a book like *Atlas of Science*—despite its focus on examples—ought to include a tutorial on creating scientific visualization, that aspect has already been well covered by Edward Tufte in a book (*3*) discussed by Börner. Nevertheless, a bestiary of simple visualization techniques would have made a valuable addition to the book.

Unfortunately, at its worst, the book can be quite painful to read. The text is marred by occasional glitches, with some terms spelled inconsistently and figure locations that sometimes differ from those promised. The author doesn't seem to have maintained a consistent view of her intended audience, as she often fails to explain vocabulary that I only know from my scientific activities yet on occasion takes pains to clarify terms from standard English that ought to be familiar to the book's readers. I think the book fits best on the coffee table, but Börner sometimes runs the risk of alienating her audience with an overabundance of jargon and technobabble. The text accompanying many of the book's spreads is heavy-handed, too often reading more like promotional literature (for people, software, causes, etc.) than explanatory or enjoyable narrative. I found this quite off-putting. This tone is especially prevalent in the book's final section, where it reaches such an extreme that the text comes across as proselytizing. The book would have been much better without the entire section. Lastly, I was continually frustrated by the absence of any consideration of the limits and potentially misleading nature of visualizations in science. I adore visualization, but it is a supplement to rather than a replacement for genuine analysis, and Börner's book gives exactly the wrong impression in this respect. As was supposedly written on maps in days of yore, "Here be dragons."

"Tracks of thought." Keith Nesbitt's mapping of the interconnected themes that run through his computer science Ph.D. thesis, *Designing Multi-Sensory Displays for Abstract Data* (*4*).

Despite its flaws, I enjoyed reading *Atlas of Science*, and I savored its myriad lush visuals. It definitely deserves a choice spot on one's favorite coffee table. I am confident that Börner's book will help both lay and scholarly audiences to appreciate scientific visualization and its history. Nevertheless, my summary judgment is "promise unfulfilled." The book is pretty good, but it could have been great. Too many of the spreads had the flavor of an advertisement for a cause (however noble), such as the *Places & Spaces* exhibition, a person, or a piece of software. Frankly, that left a bad taste in my mouth.

References

1. http://scimaps.org/.
2. www.ericjhellergallery.com/.
3. E. R. Tufte, *The Visual Display of Quantitative Information* (Graphics Press, Cheshire, CT, ed. 2, 2001).
4. K. V. Nesbitt, thesis, University of Sydney, Sydney, Australia (2003).

10.1126/science.1201504