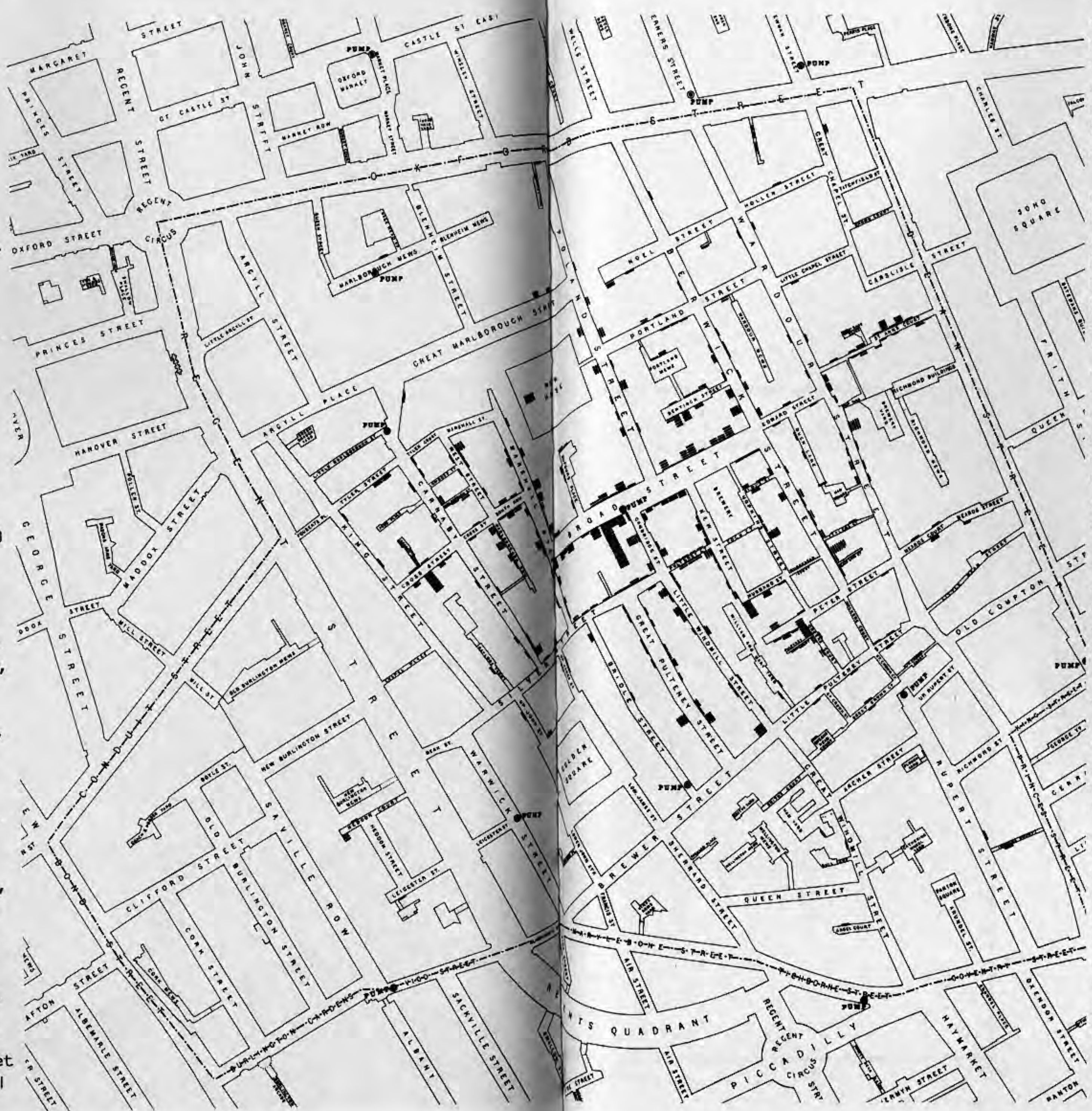
Hall, Peter. "Critical Visualization." In Design and the Elastic Mind, edited by Paola Antonelli. 122-131. New York: Museum of Modern Art, 2008.

previous page:
Barrett Lyon. The Opte Project.
Mapping the Internet. 2003.
Opte software

In an age when information is more prolific and more widely available than ever before, diagrams, maps, and visualization tools offer a means to filter and make sense of it. We live amid a deluge of data—gathered by sensors, arrayed by software, and dispersed via ever-proliferating networks—and to visualize it is to understand it, or so we hope. Colin Ware, a researcher in human perception, notes that we acquire more information through vision than through all of the other senses combined: the twenty billion neurons in the brain that help us analyze visual information provide a pattern-finding mechanism that is a "fundamental component in much of our cognitive activity." Ware makes a five-point case for the advantages of visualization: it helps us comprehend huge amounts of data; it allows us to perceive emergent properties we might not have anticipated; it can reveal problems with the data itself; it facilitates our understanding of large-scale and small-scale features; and it helps us form hypotheses.[1]

Yet, at the same time, the data explosion has brought about an aestheticizing of information, to the point that it has become difficult to sort function from creative expression. Information graphics adorn advertisements, architecture, magazines, textbooks, TV shows, and political campaigns.[2] Cascading veils of information, as famously depicted in the binary code of the 1999 film The Matrix, have become a definitive signifier of our age. As Arthur Robinson's history of early thematic mapping reveals, the line between visualization as a mode of scientific inquiry and as a form of figurative expression has long been blurred. Medieval *mappae mundi* eschewed geographic knowledge in favor of a Christian view of the earth divided into three continents, as repopulated by the descendents of Noah, with a greatly enlarged Holy Land at the center.[3] Even the flurry of scientific disease and morbidity maps of the nineteenth century, which reflected a growing concern with social conditions resulting from the movement of populations into cities, were rife with creative projections, such as E. H. Michaelis's map investigating a relationship between elevation and incidences of cretinism.[4]

By extension, early maps of the Internet seem equally wishful. With the benefit of a few years' hindsight, the graphics that purported to reveal the structure and activity of the Internet are perhaps better understood as *mappae mundi* of the digital age, expressions of a prevailing mythology of an emerging utopia known as cyberspace. In the popular imagination, the Internet was a discrete place we entered through portals, a place detached from the "meatspace" of the physical world; hanging in empty space, the early maps, resembling 3-D baubles or elaborate Tinker Toy constructions, reflected that sense of a discrete utopia.[5] Today we tend to think of the Internet as something that enhances or augments the physical world, something we encounter everywhere we go.



John Snow. **Cholera Map of London.** 1855. Original map: 16 1/2 x 17 1/2" (41.9 x 44.5 cm)

The Value of Visualization: Three Views

How, then, do we gauge the value of a visualization? Some maps, graphics, and diagrams seem to obfuscate or distort information or bewilder readers, while others have a profound effect on society, changing the course of government policy, scientific research, funding, and public opinion. This vast terrain of imagery —of network diagrams, 3-D mappings, charts, graphics, and browsers—presents something of a navigation problem in itself. Is it an art or a science? In an effort to take stock of the current state of the field, Jarke van Wijk, a math and computer science researcher at Eindhoven Technical University, The Netherlands, identifies three prevailing views of visualization: as a technology, as a science, and as an art.

As a technology, information visualization is theoretically aimed at developing new solutions and selecting the best ones, according to the criterion of usefulness. A benchmark of usefulness cited by van Wijk is one of the best-known information graphics in history, physician John Snow's 1854 map charting the location of eighty-three deaths from an outbreak of cholera in central London. Snow revealed that fatalities occurred in a cluster around the water pump at Broad Street, and argued—against prevailing wisdom that cholera was an airborne disease—that the pump was contaminated and should be shut down. Both Robinson and Edward Tufte, the writer and publisher of four well-known books on information design, wax lyrical about this graphic, which arguably changed the course of epidemiology and information design. Its apparent efficiency is stunning.

Visualization as an empirical science can be dated to the 1987 publication of an influential paper, "Visualization in Scientific Computing,"[6] and is perhaps best characterized by Ware's textbook Information Visualization, which uses psychological principles of human perception to build a set of rules governing the effective presentation of information. Ware provides a foundation for this view by first tackling the argument that something so arbitrary as the manipulation of images to represent concepts can ever be systematized, making a case for those conventions that are so entrenched in our brains that they have become hardwired.

As we shall see, both the technological and scientific approaches have some limitations. The third view, visualization as an art form, is given the least credibility by van Wijk, who characterizes its goals as the production of images that have "clear aesthetic value" and the pursuit of simple, elegant solutions that provide "intellectual and aesthetic satisfaction."[7] He quickly counters that this is not a line of defense that can "help us to convince our prospective users and sponsors."[8] Such a diminutive account of art might be expected from the computer sciences, but outside the world of peer-reviewed papers and industry-backed research, the art of visualization can be seen as an important critical counterpoint to the technological and scientific views. As a practice, it might even open up the field.

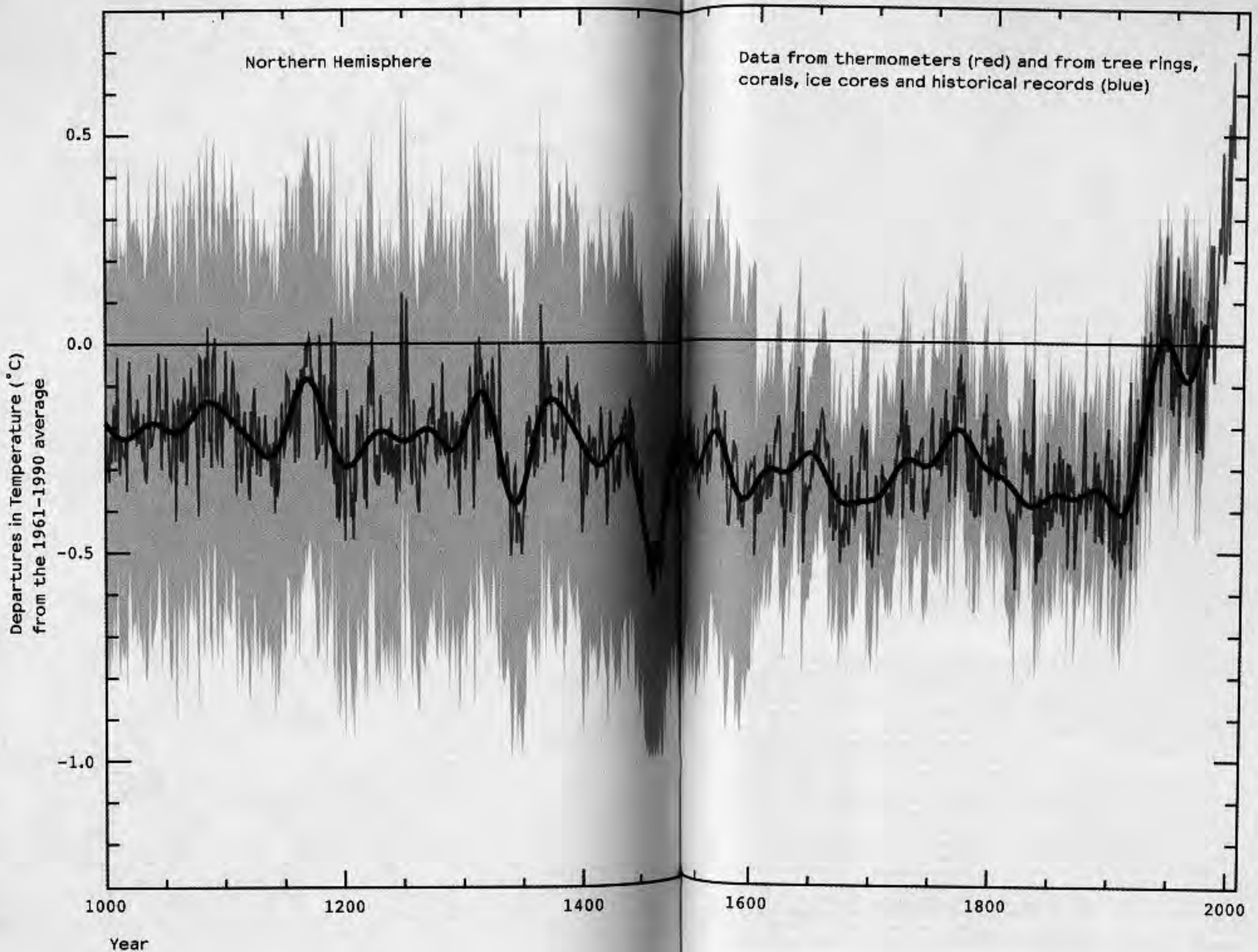
Technological Determinism?

The canonization of Snow's map is a good starting point for examining the technological view, which places a great deal of emphasis on technique and the integrity, efficiency, and effectiveness of visualizations. Tufte focuses on the notion of graphic integrity, frequently redrawing "deceptive" graphics to illustrate how to avoid distorting data in the representation. Revisiting Snow's map in Visual Explanations, he gives an intriguing lesson on how different time-series representations of Snow's data can be used to support a sensationalist version of the tale, which states that immediately following Snow's report the Broad Street pump handle was removed and the cholera outbreak subsided. As Tufte reveals with his chart of the day-to-day chronology of deaths, the decline had begun before the handle was removed, most likely because Londoners were fleeing the area. Simply reorganizing the death rates by weekly intervals shows a sudden dramatic decline in death rates immediately following the handle's removal.

By drawing attention to the possibility that the removal of the water pump was unrelated to the decline in cholera in the area, Tufte seems to point to a problem in the very myth he is weaving around Snow's map. Is the graphic important because it is a technical paradigm of visual clarity and integrity, or because it is inextricably linked in our minds to the progress of epidemiology? Clearly, if Snow had been wrong about cholera and water, the map would not be a benchmark today. It certainly was not a technical innovation. Medical maps were common in the mid-1800s, and plotting deaths with dots was not a Snow invention.[9] The backbone of the case for cholera as waterborne was Snow's detective work, as revealed in his prize-winning essay on the subject, to which the map was simply an accompaniment. To canonize the map through association is to risk invoking a kind of technological determinism, which suggests that Snow's map alone changed the way we view disease. If in the future Snow were proven to be wrong about cholera, one suspects his map would be quietly dropped from the "infoviz" canon.

A more recent example of putting undue emphasis on an information graphic can be found in the brouhaha that greeted the "hockey stick" graph showing temperature change over the last one thousand years. First published in the magazine Nature in 1998, the graph was included in the United Nations Intergovernmental Panel on Climate Change Third Assessment Report, in 2001, and writ large in Al Gore's 2006 film, An Inconvenient Truth. It earned its nickname from its shape, depicting relatively level temperatures for nine hundred years followed by a sharp upturn in the last

Michael E. Mann of Pennsylvania State University. Raymond S. Bradley of University of Massachusetts. Malcolm K. Hughes of University of Arizona. **Patterns of Organized Climatic Variability: Spatio-Temporal Analysis of Globally Distributed Climate Proxy Records and Long-term Model Integrations.** 1998–2000



ninety years.[10] Based on proxy evidence from tree rings, ice cores, coral, historical records, and instrumental data, the graph points the finger squarely at human activity as the cause of global warming. Opponents of this argument contend, however, that the visualization was derived by using a particular statistical convention that favored production of the hockey stick form. By focusing on one decontextualized graphic, and side-stepping the overwhelming body of evidence linking human behavior with climate change, right-wing critics were able to muddy the waters of the argument. (Incidentally, this tactic effectively overshadowed other statistical conventions that achieved the same hockey stick shape. A paper published in Nature in 2005, to cite one example, found—using proxy evidence from stalagmites and lake sediment—the latter part of the twentieth century to be the warmest period in two thousand years.)[11]

Effectiveness, a barometer of the technological view, is also an unreliable test of visualization. Consider a set of graphics produced by the New York Times to accompany a report in April 2002 on the vulnerability of New Orleans's flood-control system (pp. 126–27).[12] A shaded relief map using a twenty-fold vertical exaggeration (albeit a Tufte no-no) effectively shows the changes in terrain around New Orleans, highlighting the critical role of the levees in protecting land (shaded red) at sea level or below. A cross section of the same area reveals the water levels of the Mississippi River and ocean in relation to the land. An aerial view shows the potential path of a "worst-case hurricane." And, finally, three flooding scenarios show the city in various states of submersion. Although the case for preventive measures was clearly and efficiently spelled out, the visualizations, like others published ahead of Hurricane Katrina, had little or no effect on policy. Its value is contingent on hindsight, as a vivid artifact of an institutional failure to heed well-documented warnings.

The Science of Visualization

For Ben Fry, who worked at MIT and Harvard University's Broad Institute developing dynamic visualization tools for genomics researchers, the chief oversight of Tufte's approach is its failure to address situations in which data is complex and undergoing continuous change—a situation that often calls for the user to interact with the data.[13] Fry finds certain advantages in the scientific empirical approach laid out by Ware, specifically as a strategic counter to the current impulse to begin a visualization with the data itself. With vast data sets like the human genome, it becomes crucial for research teams to ask themselves, before the visualization stage, what they are trying to show. "Storytelling winds up being the crux of this stuff," says Fry. "Most often I work with people coming from the engineering or science side, and there's a tendency for them to say 'I have a whole bunch of information and data—what do I do with it?' Their starting point is a pile of stuff that they want to make something interesting and clear out of. But it winds up being the opposite. I'm much more interested in getting people to think about what kind of story they want to tell, or what kind of narrative they're trying to pull out, and working backwards from that, back to the data."[14]

Fry's efforts to simplify and enhance standard genome representations with interactivity played a part in speeding the research behind two scientific papers: one that compared the catalogue of all known human genes with that of closely related species, with a view to eliminating aberrations and reducing the overall gene count (humans are estimated to have between twenty- and twenty-five thousand genes); and another aimed at simplifying how researchers identify across several species the areas around the genes linked to diseases like cystic fibrosis or conditions like lactose intolerance.[15] As Fry sees it, Ware's perception-based approach unpacks techniques that graphic designers might consider intuitive, such as a hierarchy of visual modes for attracting the eye, with motion at the top followed by color, size, and shape. "Knowing things like that is important," says Fry, who observes that the first impulse of someone producing a visualization might be to want to match categories of data with colors. Color, however, is one of the first things the eye picks up. According to Fry, "You have to ask yourself whether the categories are the most interesting thing about this data, because if they're color-coded it's what's going to attract the most attention."

Visualization becomes a more slippery science when we peer closer at Ware's distinction between hardwired and culturally learned conventions. The hardwired, or "sensory," aspects of visualizations, he argues, derive their power from being well designed to stimulate the visual sensory system (such as pattern recognition); "arbitrary" conventions derive their power from how well they are learned. Ware admits, however, that the two aspects are closely intertwined, and the boundary between them is fuzzy: "For any given example we must be careful to determine which aspects of the visual coding belong in each category."[16] This is easier said than done: The use of red to symbolize danger, for example, might seem for some to be hardwired, but in Ware's own example, an Asian student working on a system for visualizing a hard disk chose green for deleted entities and red for new entities, reasoning that in Asian culture green symbolizes death and red equals good luck. Similar discrepancies led information designer W. Bradford Paley to treat with caution the close adherence to general principles of perception. In an equities valuation tool he was creating in 1989 for the global finance firm Lehman Brothers, Paley initially used a standard scientific heat map (black =

William E. McNulty and Bill Marsh.
Graphics produced for "Nothing's Easy for New Orleans Flood Control."
Science Times, New York Times,
April 30, 2002

cool = low, red = hot = high). He quickly realized a crucial cultural difference between the sciences and the trading floor when his client said, "Now let me understand this: Being in the red is good?"

The ease with which data can be visualized, Paley argues, has led to a proliferation of initially impressive but ultimately useless tools. "Ironically, some tools are difficult to use for the very reason their designers think they are good: generality. If datasets as different as a thesaurus, a museum, and a list of popular songs look identical, that means you're only seeing the structural variation they share—not where they differ. And the interesting structure is often in the idiosyncrasies." He adds, "There's no simple, consistent translation from data to visuals because every mature problem domain has its own metaphors, its own interpretation frame—making one tool fit all impoverishes its expressive range, and you lose both resolving power and ease of interpretation."[17]

Such issues seem to stunt the growth of network mapping tools like Thinkmap and Inxight's Vizserver, which, while offering to make sense of complex information—such as the knowledge assets in a corporation—end up revealing little about the relations between the nodes on the networks they render. A simple comparison of Thinkmap's Visual Thesaurus, which arrays synonyms in a dynamic network map, with the rich word-usage history of the Oxford English Dictionary quickly reveals to any writer that the former is a reductive tool that closes down meaning while the latter opens up expressive possibilities within language.

Fry has noted that the quality of visual design is generally neglected in the scientific approach to information visualization, perhaps because in its efforts to quantify the practice the field has come to perceive the business of making things attractive as too subjective. Yet those "cosmetic tweaks" on a simple diagram become extremely important when applied to a complex data set of thousands of elements, as Fry notes: "Minor problems in the diagram of a smaller data set are vastly magnified in a larger one." Singling out by way of example the TreeMap software introduced by Ben Shneiderman's Human Computer Interaction Laboratory at the University of Maryland in 2002, Fry critiques its layout, noting the visual noise caused by frames, borders, labels, and the use of valuable screen real estate for sliders and dead space at the cost of providing more space for the data.[18] Indeed, while Tufte's books are chiefly concerned with quality and technique, Ware's is strikingly devoid of beauty.

Finally, as van Wijk and other scholars within the field have observed, visualization as a scientific discipline has some doubts about its own validity. "There seems to be a growing gap between the research community and its prospective users," writes van Wijk, noting that, after the flourishing of diverse ideas in the 1990s, the field today has become more specialized, with submitted work often consisting of incremental progress. "It is not always clear that these incremental contributions have merit, and reviewers are getting more and more critical."[19]

The Art of "Viz" as Critical Practice

Perhaps fallow ground and incremental progress are indicators that a discipline has argued itself into a corner. An expansive science would surely allow for alternative theoretical approaches, just as a technological approach benefits from a meta-perspective. Here, van Wijk's characterization of art as the production of self-rationalized aesthetic objects that bring intellectual delight merits a little rethinking. If instead we align the art of visualization with the art of urban planning and architecture, we open up a potentially fruitful comparison. Both urban planners and architects aim at the production of spaces with clear aesthetic value, yet this is only part of the reason that their users and sponsors are convinced, to use van Wijk's wording. Their services are enlisted in order to take part in a process, to "reformulate what already exists," as landscape architect James Corner argues in his essay "The Agency of Mapping": "What already exists is more than just the physical attributes of a terrain (topography, rivers, roads, buildings) but includes also the various hidden forces that underlie the workings of a given place."[20] Among these, Corner lists several forces indicated in the exploration of the canonic visualizations above: historical events, local stories, economic and legislative conditions, and political interests.

If we follow Corner's lead and imagine the art of visualization as a creative process concerned with not just the finished artifact but the framing, gathering, connecting, and arraying of data, then we can also imagine it as a critical practice: sizing up and reformulating a terrain of knowledge as well as experimenting with new and alternative forms.[21] Drawing from Gilles Deleuze and Felix Guattari, Corner uses the motifs of the rhizome and the burrow for their nonhierarchical and expansive way of connecting points from the middle rather than the beginning or end. Corner finds a paradigm of such "rhizomatic" mapping in a project also lauded by Tufte: Charles Joseph Minard's narrative diagram of Napoleon's ill-fated march on Russia during the winter of 1812–13. The map elegantly brings together facts such as the diminishing size of the French army, its movement, the terrain, locations and times of battles, weather, and the passage of time in one predigital "datascape," printed in 1885. "More than telling a story," writes Corner, "the map conditions how places on the land have come to exist in new relationships precisely through the vector of an event."[22] But he qualifies his praise by noting that the Minard map is a "closed system" that invites only a linear read. According to Corner, a rhizomatic map would be more multivariate

Terraswarm and Natalie Jeremijenko. **OneTrees Project Map.** 2003. ESRI GIS, USGS Landsat 7 satellite photo, and Rhino 3-D software, 22 x 11" (56 x 28 cm)

and open: "Indeed such a map might not 'represent' any one thing at all; rather it might simply array a complex combination of things that provides a framework for many different uses."[23]

Such rhetoric risks encouraging data-driven rather than story-driven visualizations. But it also provides for radical experimentation of the sort practiced by Natalie Jeremijenko, a design engineer and "techno-artist." Jeremijenko's OneTrees project, for example, reimagines cloned trees as environmental sensors. In 2003 she and two San Francisco–based nonprofit groups planted cloned pairs of Paradox trees around the Bay Area in order to register the different social and environmental conditions in the various locations. A map of OneTrees locations, produced with experimental architecture practice Terraswarm, juxtaposes a U.S. Geological Survey Landsat 7 aerial image of the Bay Area with "lay knowledge," such as the locations of bike trails, common hawk flight paths, and the habitat of the endemic song sparrow. The implicit critique is of culturally entrenched hierarchies of information, which, for example, prioritize satellite views and expert, institutional knowledge over the knowledge of ordinary people.[24]

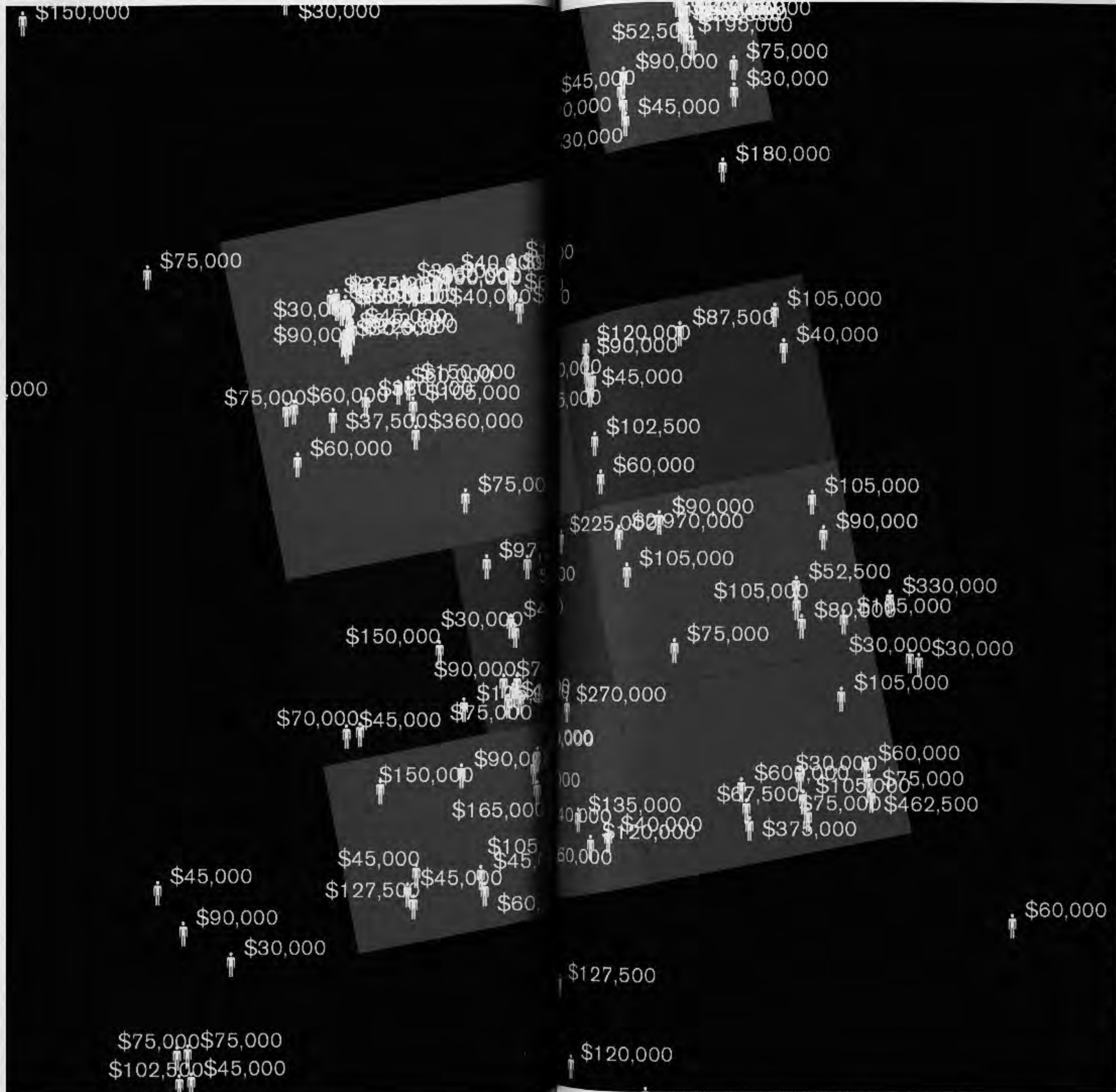
Jeremijenko's provocations attempt to call into question the legitimacy of the entire barrage of scientific procedures, presenting disruptive juxtapositions and very unscientific instruments (such as trees or toy robotic dogs). A more conventional project—though a potentially more disruptive one—was begun by architect and artist Laura Kurgan at the Columbia University Spatial Information Design Lab in 2006. Working with the Justice Mapping Center, Kurgan and Columbia graduate students have been mapping data from the criminal justice system. They have been looking not at where crimes were committed, as is common, but at the home addresses of the people incarcerated as a result of the crimes. Coining the term "million dollar blocks," the research collaborative revealed in their maps how a disproportionate number of prisoners come from a very few neighborhoods in the country's largest cities, to the extent that some states are spending in excess of a million dollars a year to incarcerate the residents of single city blocks. A description of the project, named Architecture and Justice, concludes with a discussion of its implications: "Guided by the maps of Million Dollar Blocks, urban planners, designers, and policy makers can identify those areas in our cities where, without acknowledging it, we have allowed the criminal justice system to replace and displace a whole host of other public institutions and civic infrastructures....What if we sought to undo this shift, to refocus public spending on community infrastructures that are the real foundation of everyday safety, rather than criminal justice institutions of prison migration?"[25]

Potentially, Architecture and Justice does offer a new kind of benchmark for critical visualization.

It utilizes many of the principles espoused by Tufte and Ware, efficiently and effectively conveying a clear, succinct story. As a critical mapping, it challenges current thinking by reformulating what already exists. It uses the master's tools—the aerial view, the crime map, and crime data—to reveal a street-level view of the city: not a crime epidemic but a view of civic infrastructure that necessitates the inclusion of a distant exostructure—prisons and jails.

In his first book, Tufte introduced a guideline with which to judge statistical representations that he called the "lie factor": the ratio of the size of an effect shown in the visualization to the size of the effect in the data.[26] But as the Architecture and Justice project reminds us, the data itself is never neutral; it is collected for a reason, and processed and presented for specific purposes. In other words, "There is no such thing as raw data."[27] Cartography historian Denis Cosgrove once advised attendees at a mapping conference to "always make maps; always question maps."[28] The same should be said of information visualization.

Laura Kurgan, Eric Cadora, David Reinfurt, and Sarah Williams. Spatial Information Design Lab, Graduate School of Architecture, Planning and Preservation, Columbia University. **Architecture and Justice from the Million Dollar Blocks project.** 2006. ESRI ArcGIS (Geographic Information System) software



Notes

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3.
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5.
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6.
"Visualization in Scientific Computing," in Computer Graphics 21, vol. 6, ed. Bruce H. McCormick, Thomas A. DeFanti, and Maxine D. Brown, ACM Siggraph, New York, November 1987.

7.
Jarke J. van Wijk, "The Value of Visualization," in Proceedings of the IEEE Visualization Conference 2005, ed. C. Silva, E. Groeller, H. Rushmeier, p. 85.

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10.
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12.
Jon Nordheimer, "Nothing's Easy for New Orleans Flood Control," New York Times, April 30, 2002. Graphics by William McNulty and Bill Marsh/The New York Times.

13.
Ben Fry, "Computational Information Design" (PhD thesis, MIT Media Laboratory, 2004), p. 39.

14.
Ben Fry, telephone interview, May 29, 2007. Unless otherwise noted, all subsequent quotations from Fry come from this interview.

15.
See Janet Abrams, "Geneography," in Else/Where: Mapping. New Cartographies of Networks and Territories, ed. Abrams and Peter Hall (Minneapolis: University of Minnesota Design Institute, 2006).

16.
Ware, Information Visualization, p. 17.

17.
W. Bradford Paley, e-mail to author, June 14, 2007.

18.
Fry, "Computational Information Design," pp. 40–41.

19.
Van Wijk, "The Value of Visualization," p. 80.

20.
James Corner, "The Agency of Mapping," in Mappings, ed. Denis Cosgrove (London: Routledge, 1999), pp. 213–52.

21.
Ibid., p. 214.

22.
Ibid., p. 245.

23.
Ibid., p. 246

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Alice Twemlow, "Bark to Bytes," in Else/Where: Mapping, pp. 254–56.

25.
Eric Cadora and Laura Kurgan, "Architecture and Justice" (exhibition brochure), The Architectural League of New York, September 15–October 28, 2006. See www.spatialinformationdesignlab.org/publications.php?id=38.

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Edward Tufte, The Visual Display of Quantitative Information, 2nd ed. (Cheshire, Conn.: Graphics Press, 2001), p. 57.

27.
Cadora and Kurgan, "Architecture and Justice."

28.
Denis Cosgrove, "Cartography in the Age of Digital Media" (symposium, Yale University School of Architecture, April 2002). See also Rebecca Ross, "Digital Cartography," The Knowledge Circuit, design.umn.edu/go/knowledge Circuit/smr02.3.Ross.