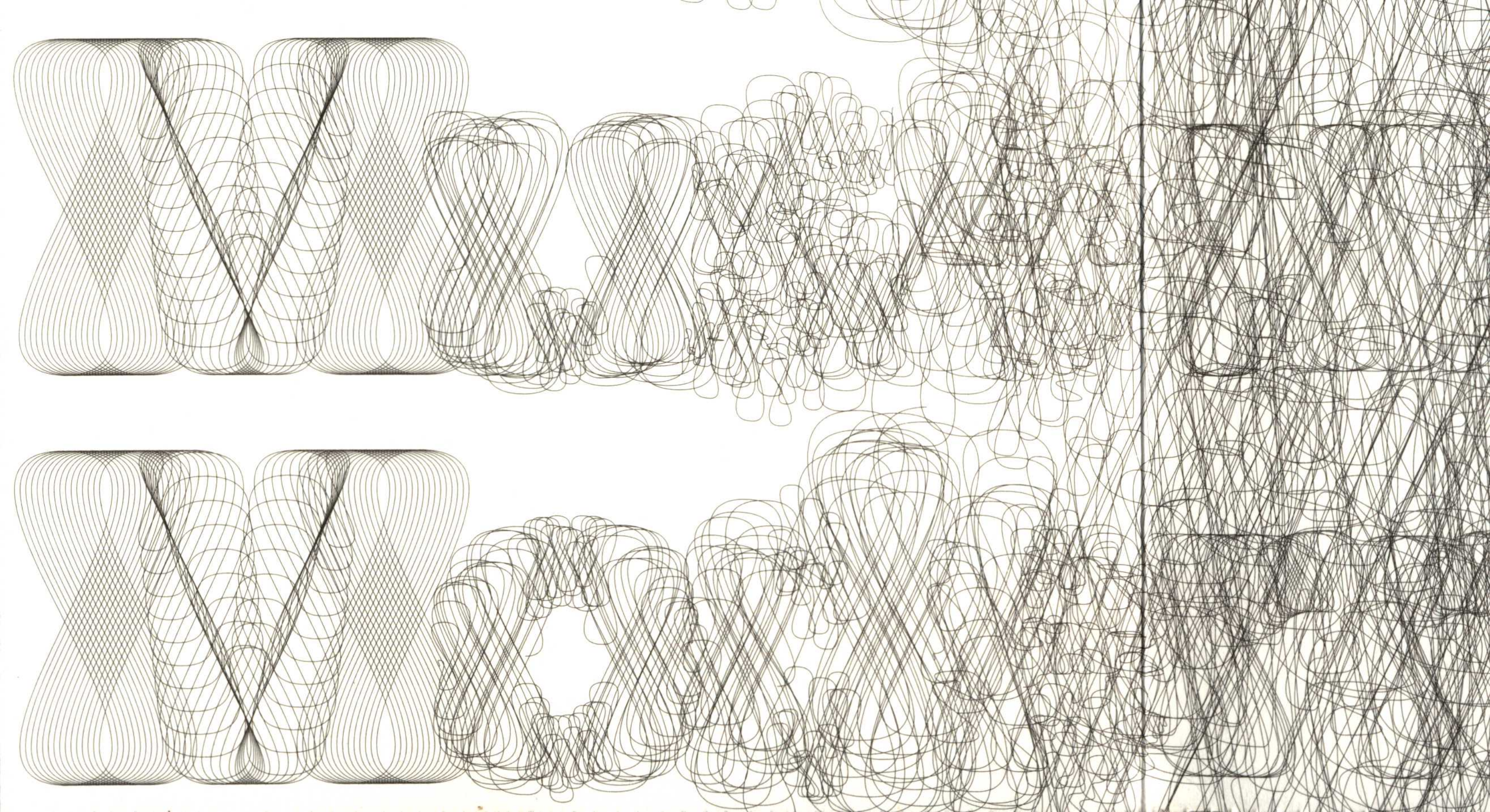
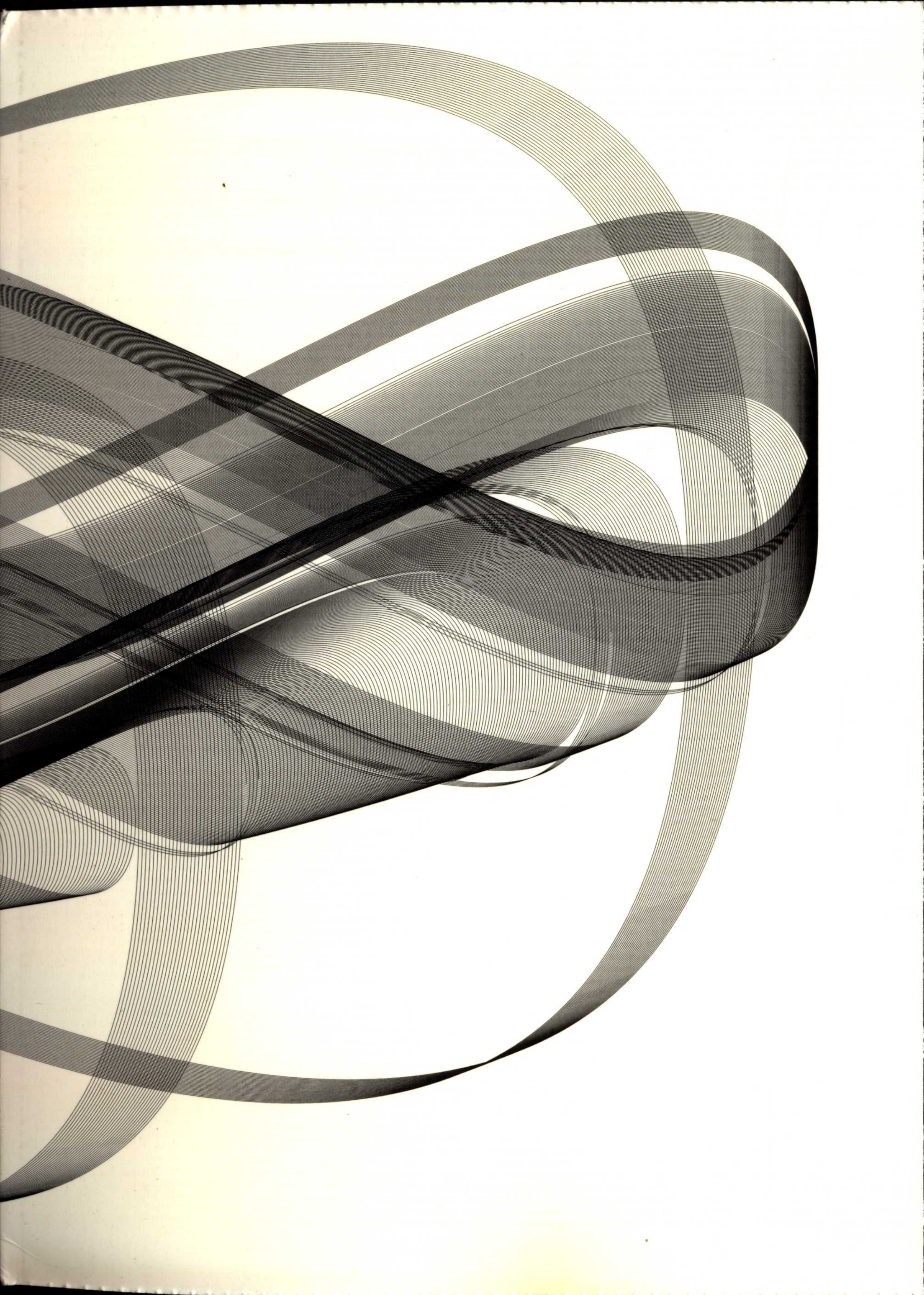
Design and the Elastic Mind





Design and the Elastic Mind

The Museum of Modern Art, New York

Published on the occasion of the exhibition Design and the Elastic Mind, February 24–May 12, 2008, at The Museum of Modern Art, New York, organized by Paola Antonelli, Senior Curator, and Patricia Juncosa Vecchierini, Curatorial Assistant, Department of Architecture and Design

The exhibition is made possible by the Mrs. Hedwig A. Van Ameringen Architecture and Design Exhibition Fund.

Generous funding is provided by NTT DoCoMo, Inc., and Patricia Phelps de Cisneros.

Additional support is provided by The Contemporary Arts Council of The Museum of Modern Art.

Produced by the Department of Publications, The Museum of Modern Art, New York
Edited by Libby Hruska and Rebecca Roberts
Designed by Irma Boom
Production by Elisa Frohlich
Typeset in Courier Sans
Printed and bound by Oceanic Graphic Printing, Inc., China
Printed on 120 gsm Arctic Amber Preprint

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Library of Congress Control Number: 2007939768
ISBN: 978-0-87070-732-2

Published by
The Museum of Modern Art
11 West 53 Street, New York, NY 10019-5497
www.moma.org

Distributed in the United States and Canada by D.A.P./Distributed Art Publishers, Inc., New York

Distributed outside the United States and Canada by Thames & Hudson, Ltd., London

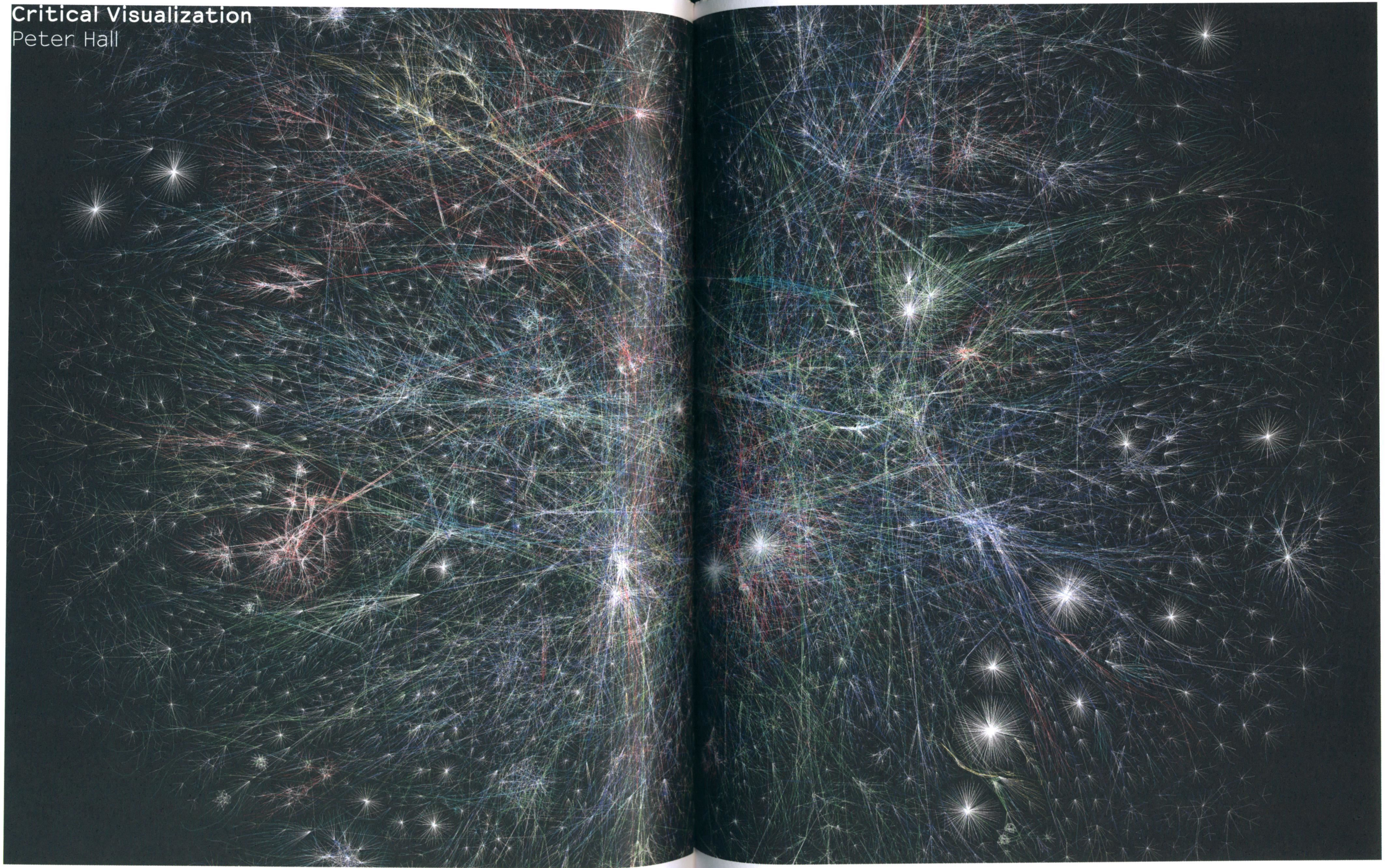
Cover design by Irma Boom
Cover type by Daniël Maarleveld

Printed in China

Contents

Critical Visualization

Peter Hall



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.

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

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.

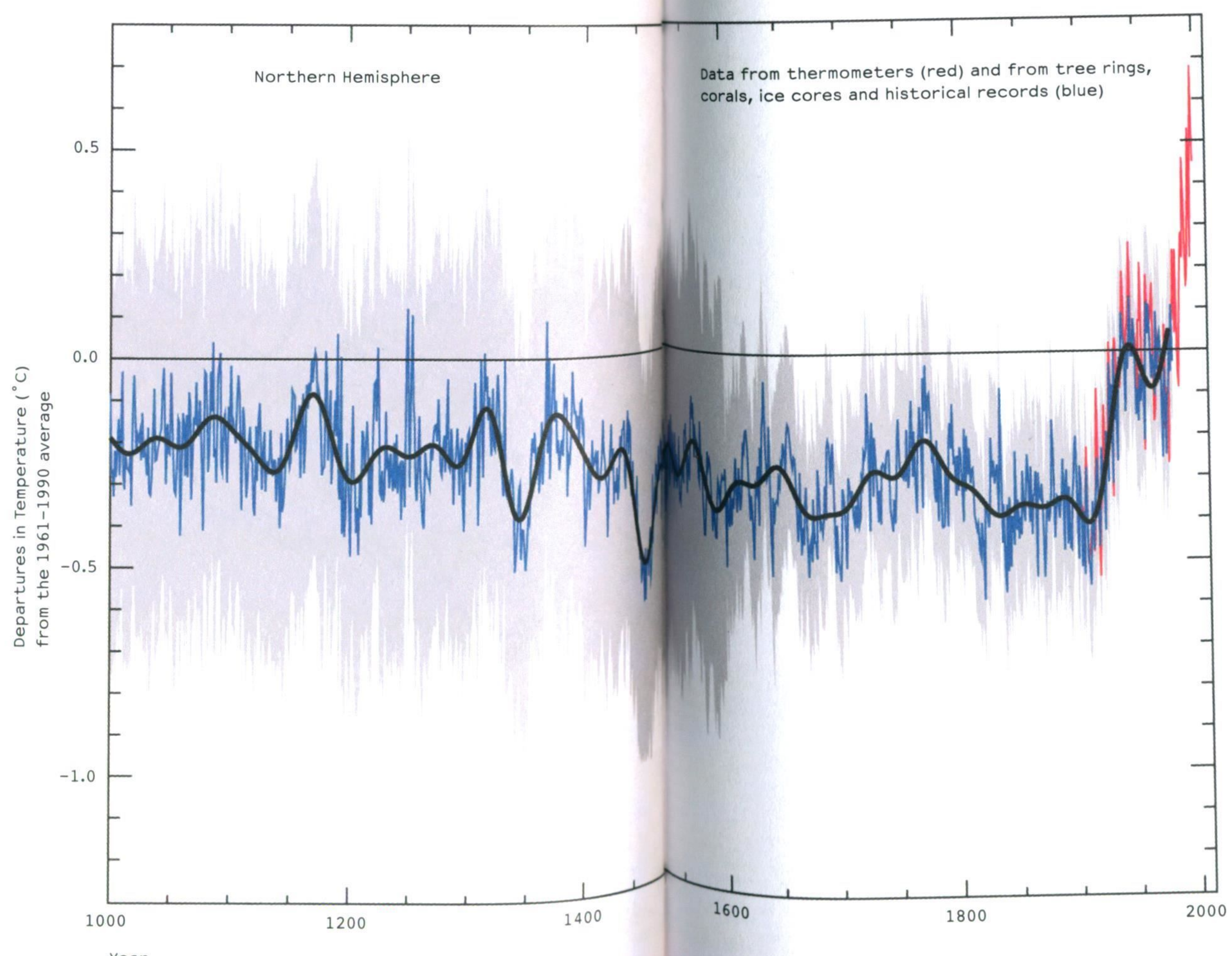
Technological Determinism?

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 = 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?"

By JON NORDHEIMER

NEW ORLEANS — Caught between the Mississippi and the long shoreline of Lake Pontchartrain, this low-lying city has long depended on levees and luck.

Now engineers say those are not enough to protect New Orleans, much of it below sea level, from a devastating flood that could threaten it if a storm surge from a powerful hurricane out of the Gulf of Mexico propelled a wall of water into the lake and the city.

That event could place vast sections under 20 feet or more of water, engineers and scientists say, with worst-case computer predictions showing death tolls in the tens of thousands with many more people trapped by high water that has no natural drainage outlets.

"There's no way to minimize the amount of devastation that could take place under such circumstances," warned Walter S. Maestri, director of emergency management of Jefferson Parish, a suburban region with 455,000 residents on the city's western and southern sides.

Perhaps the surest protection is building up the coastal marshes that lie between New Orleans and the sea and that have been eroding at high rates. But restoration will require time, a huge effort and prohibitive sums of money, perhaps $14 billion, according to a study by a panel from federal and state agencies, universities and business.

Engineers are considering o[illegible] ways to protect the heart of the c[illegible] and provide an island of refuge in [illegible] French Quarter and governme[illegible] centers. Though such approach[illegible] are less expensive, they come w[illegible] their own problems. One plan [illegible] volves walling off an area to keep [illegible] water. But where would the wall b[illegible] built and who would benefit from [illegible]

Many residents give little thoug[illegible] to such matters, counting on th[illegible] knowledge that New Orleans has e[illegible] caped hurricane disaster in the pa[illegible]

The most nervous people are tho[illegible] paid to worry about such things, li[illegible] Dr. Joseph N. Suhayda, director o[illegible] the Louisiana Water Resources R[illegible] search Institute at Louisiana Sta[illegible] University. Like other coastal r[illegible] [illegible]chers, he has been using the [illegible] geological and meteorological [illegible] to refine computer models of [illegible] different storms would damage [illegible] city.

[illegible] a bright spring day with fair [illegible] and no trace of the sultry air [illegible] will dominate the weather in the [illegible] ahead, Dr. Suhayda and a [illegible] colleagues drove city streets [illegible] yards from levees that hold [illegible] Lake Pontchartrain.

[illegible] New York Avenue, near the [illegible] campus of the University [illegible] New Orleans, the car stopped, and [illegible] engineer walked over and unfolded [illegible] wood measuring stick to its 25- [illegible] length. He planted one end on the [illegible] and raised it until it was

Continued on Page 4

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

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 × 11" (56 × 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]

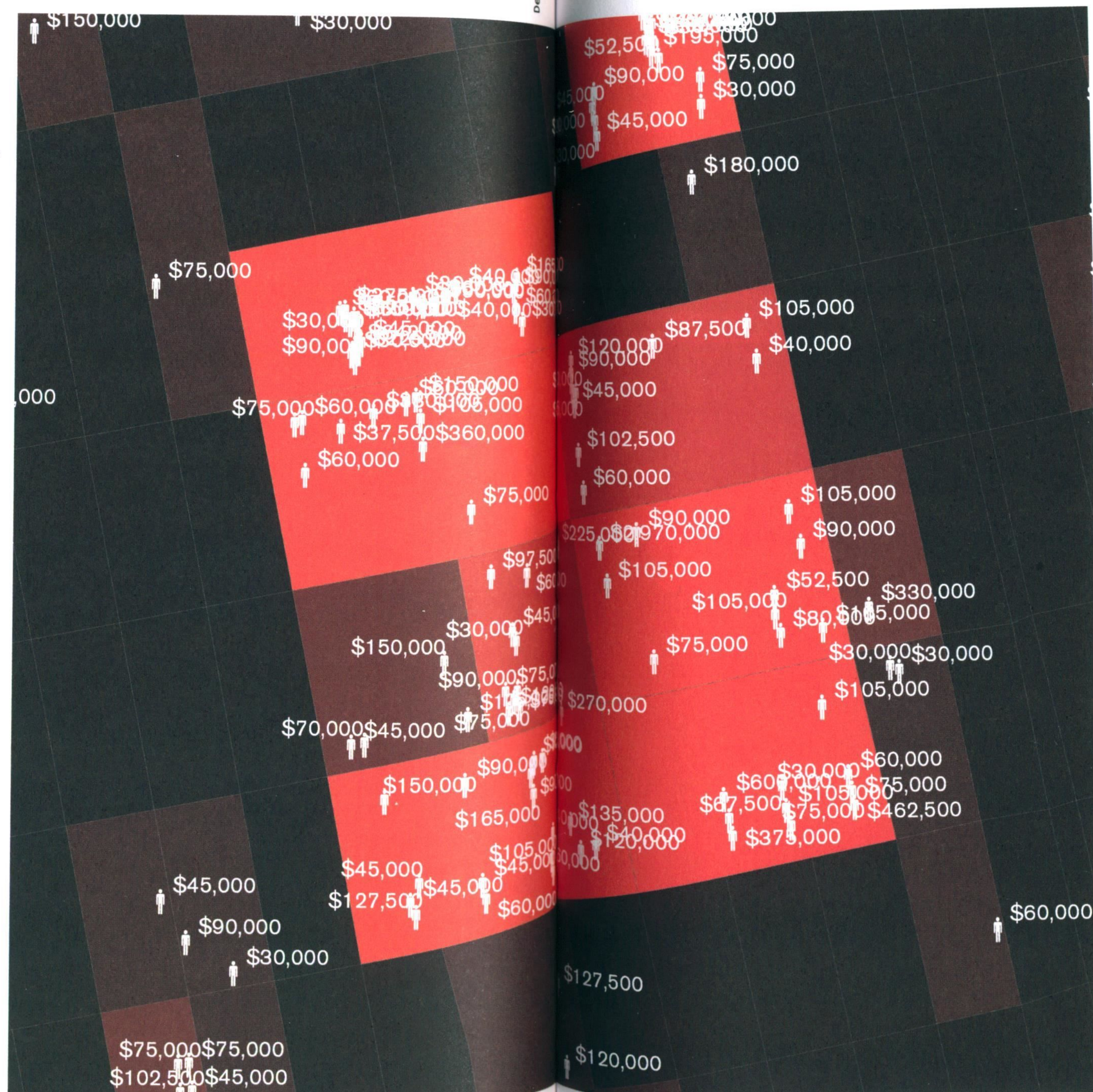
Jeremijenko's provocations attempt to call into question the legitimacy of the entire barrage of scientific procedures, presenting disruptive juxtapositions and very unscientific instruments (such as trees or toy robotic dogs). A more conventional project—though a potentially more disruptive one—was 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



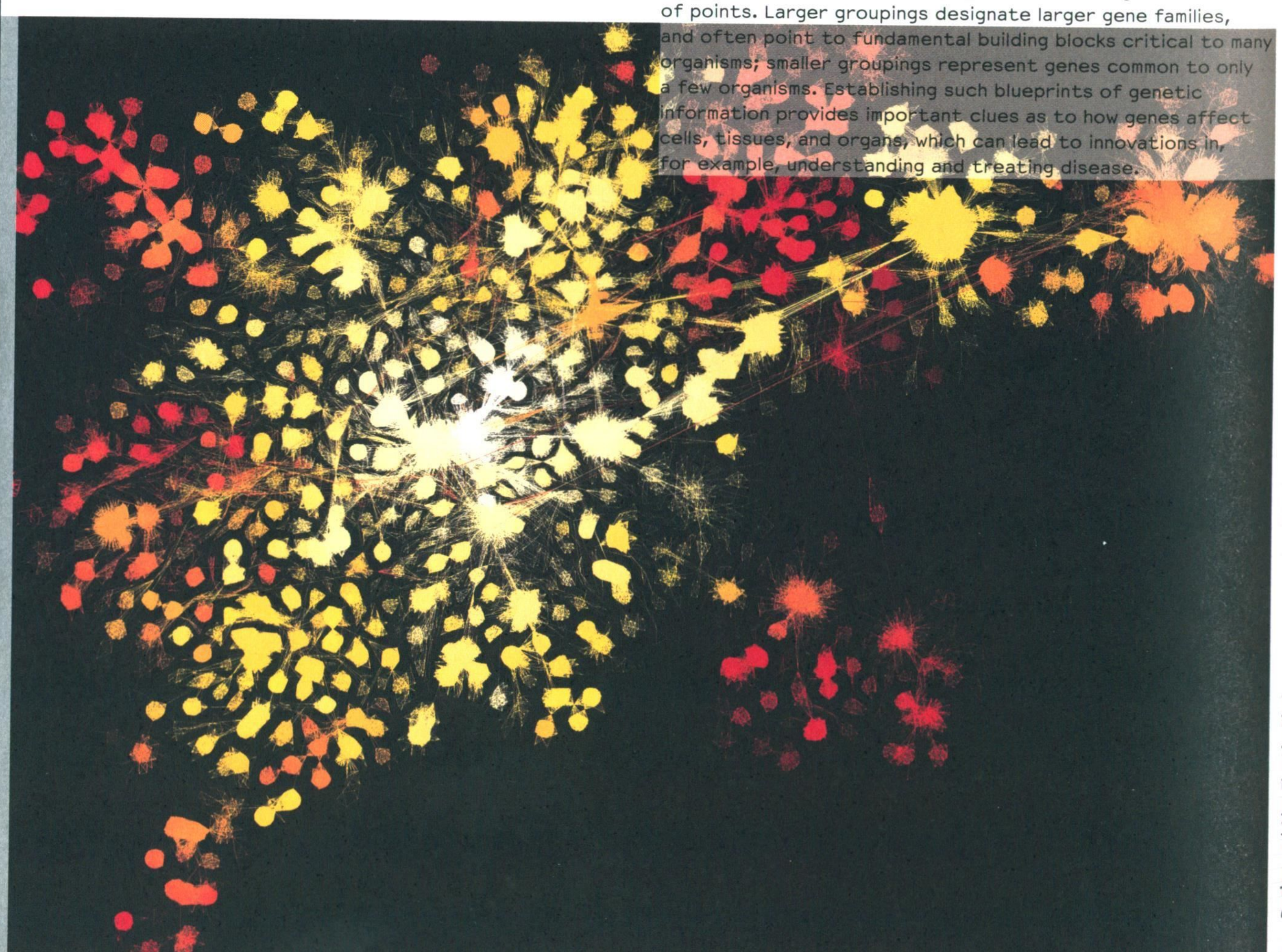
Notes

1.
Colin Ware, Information Visualization: Perception for Design, 2nd ed. (San Francisco: Morgan Kaufmann, 2004), pp. 2–3.
2.
For example, the Move Our Money campaign of 1999–2000, featuring inflatable pie charts and bar charts designed by Stefan Sagmeister. Peter Hall and Stefan Sagmeister, Sagmeister: Made You Look (London: Booth Clibborn, 2001), pp. 169–73.
3.
Arthur Robinson, Early Thematic Mapping in the History of Cartography (Chicago: University of Chicago Press, 1982), pp. 9–11.
4.
Ibid., pp. 174–76.
5.
See, for example, www.cybergeography.org/atlas.
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.
8.
Ibid.
9.
The practice of using spot maps to depict mortality and disease rates can be traced back to the eighteenth century in the United States.
10.
Paul Rincon, "Row Over Climate 'Hockey Stick,'" BBC News, March 16, 2005, news.bbc.co.uk/2/hi/science/nature/4349133.stm.
11.
See David Womack, "Seeing Is Believing: Information Visualization and the Debate Over Global Warming," Think Tank, www.adobe.com/designcenter/thinktank/womack.html.
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
24.
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.
26.
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.

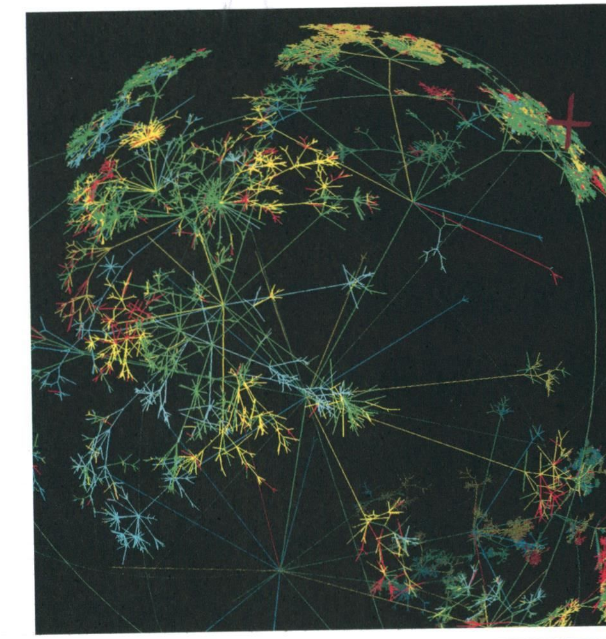
Edward Marcotte (American, born 1967) and
Alex Adai (American, born 1976)
Center for Systems and Synthetic Biology (est. 2003),
The University of Texas at Austin (USA, est. 1883)

Protein Homology Graph 2004
bioinformatics.icmb.utexas.edu/lgl/#gallery
Large Graph Layout (LGL) software

The sequencing of a genome is central to molecular biologists' understanding of the basic makeup of every living organism. The goal is to appreciate how this information comes together to constitute a uniquely characteristic being, whether a human, a plant, an animal, a bacterium, or a virus. The calculus necessary to compile and interpret this enormous quantity of data can be supported only by ever-increasing computer capabilities, which become much more effective when coupled with good visualization design. The Protein Homology Graph is one example of this. To measure homology—the similarities between genes in different organisms that are so strong they point to a common evolutionary ancestor—Edward Marcotte and Alex Adai compared the sequences of 140,000 known genes; after nearly 21 billion comparisons were performed, 1.9 million homologies were established. Marcotte and Adai then used software to present this data as an immense web of relationships in which each point represents a single gene and genes in the same family are connected by lines. Genes that share homologies are placed near each other, creating constellations of points. Larger groupings designate larger gene families, and often point to fundamental building blocks critical to many organisms; smaller groupings represent genes common to only a few organisms. Establishing such blueprints of genetic information provides important clues as to how genes affect cells, tissues, and organs, which can lead to innovations in, for example, understanding and treating disease.



When it comes to visualizing great amounts of data, the Internet is an irresistible subject of study. As it has grown, so has the challenge of accurate measurement and modeling of its topology. Numerous Internet maps exist, some strictly functional and diagnostic (such as the Internet Mapping Project initiated by Bell Labs in 1998), others more "atmospheric," meant as dynamic snapshots of a universe in continuous expansion.

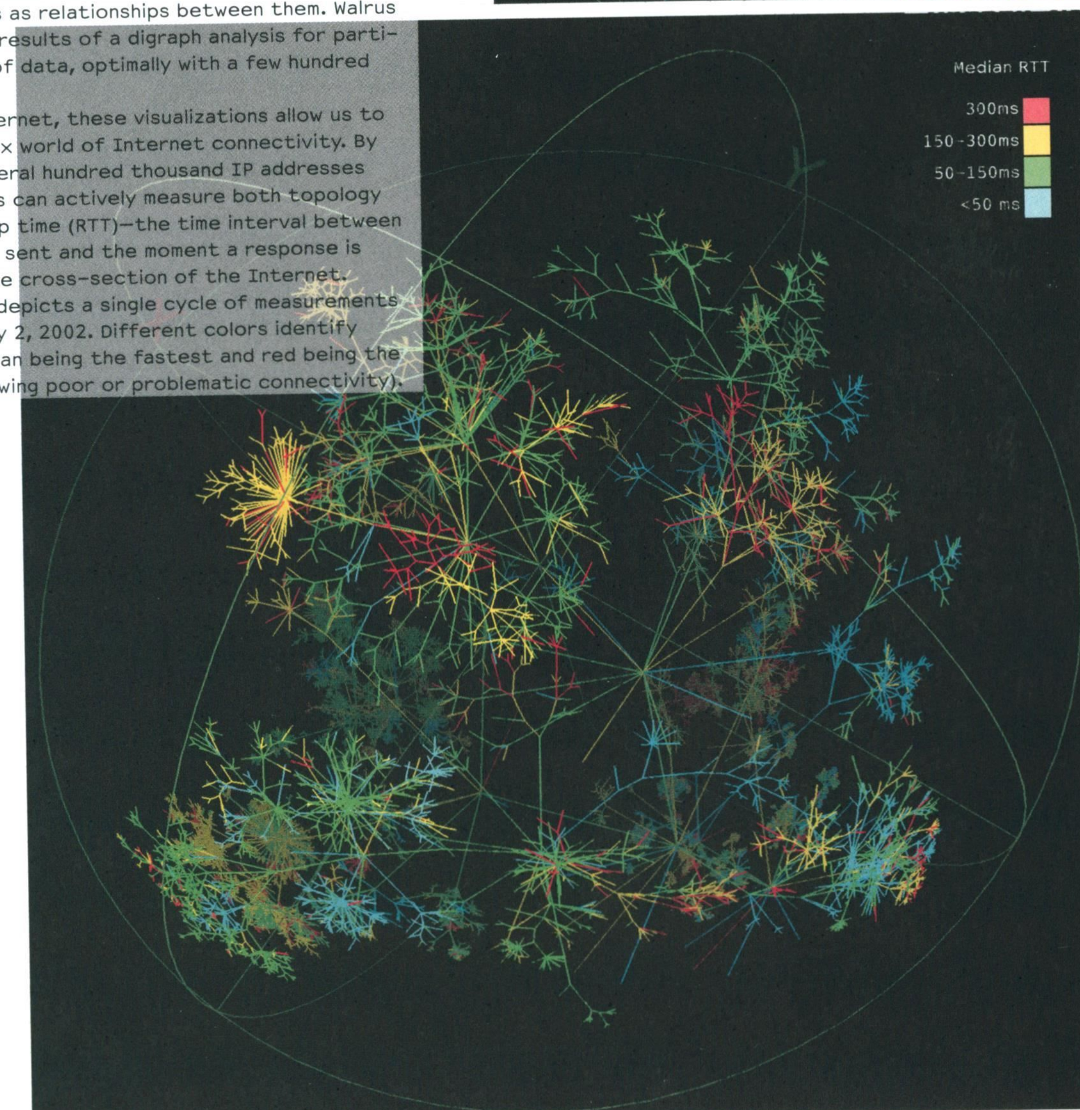


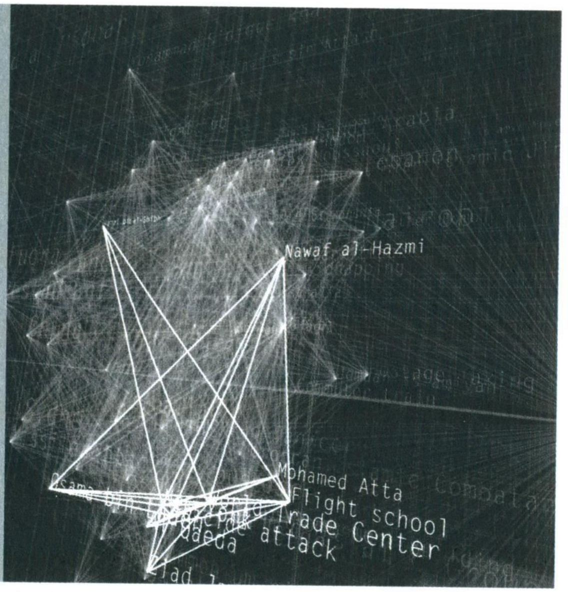
Young Hyun (American, born 1973)
Cooperative Association for Internet Data Analysis, San Diego Supercomputer Center (est. 1997), University of California, San Diego (USA, est. 1960)

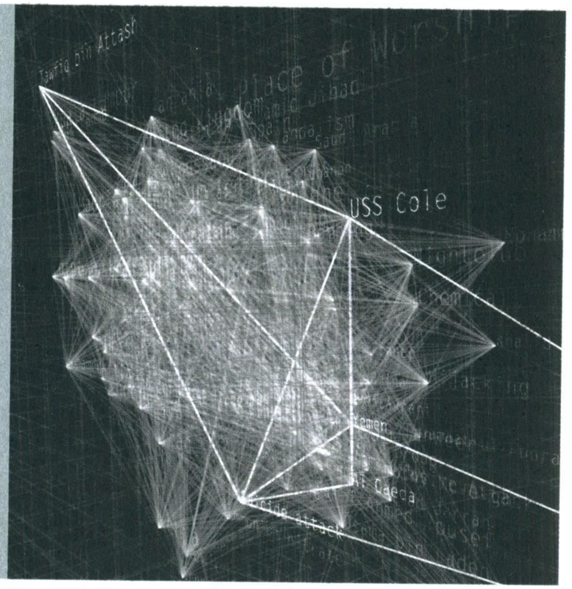
Walrus graph visualization tool 2001–02
Java and Java3D software

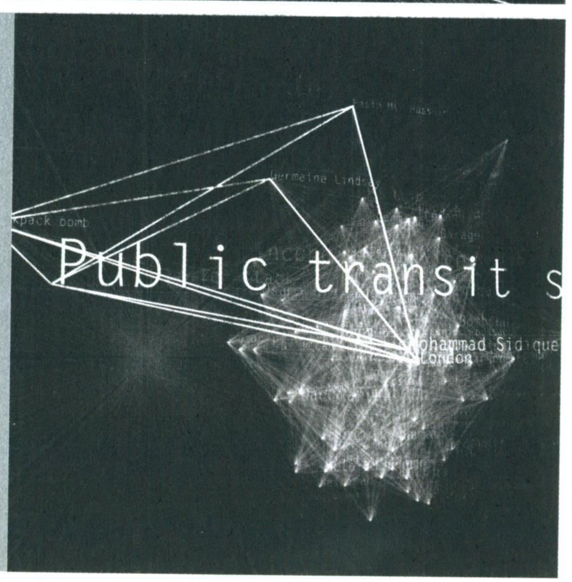
In mathematics and computer science, a graph is a set of points or nodes connected by lines that can be considered equivalent in either direction (from A to B equals from B to A). In a directed graph, or digraph, each direction is instead considered distinct and called a direct arc or link. Digraph analysis has a wide set of applications as a deductive tool, especially in the social sciences, where points often stand for individuals and arcs as relationships between them. Walrus clearly illustrates the results of a digraph analysis for particularly large amounts of data, optimally with a few hundred thousand nodes.

Applied to the Internet, these visualizations allow us to appreciate the complex world of Internet connectivity. By sending probes to several hundred thousand IP addresses every day, researchers can actively measure both topology and average round-trip time (RTT)—the time interval between the moment a probe is sent and the moment a response is received—across a wide cross-section of the Internet. The graph shown here depicts a single cycle of measurements originating on February 2, 2002. Different colors identify each link's RTT, with cyan being the fastest and red being the slowest (and likely showing poor or problematic connectivity).







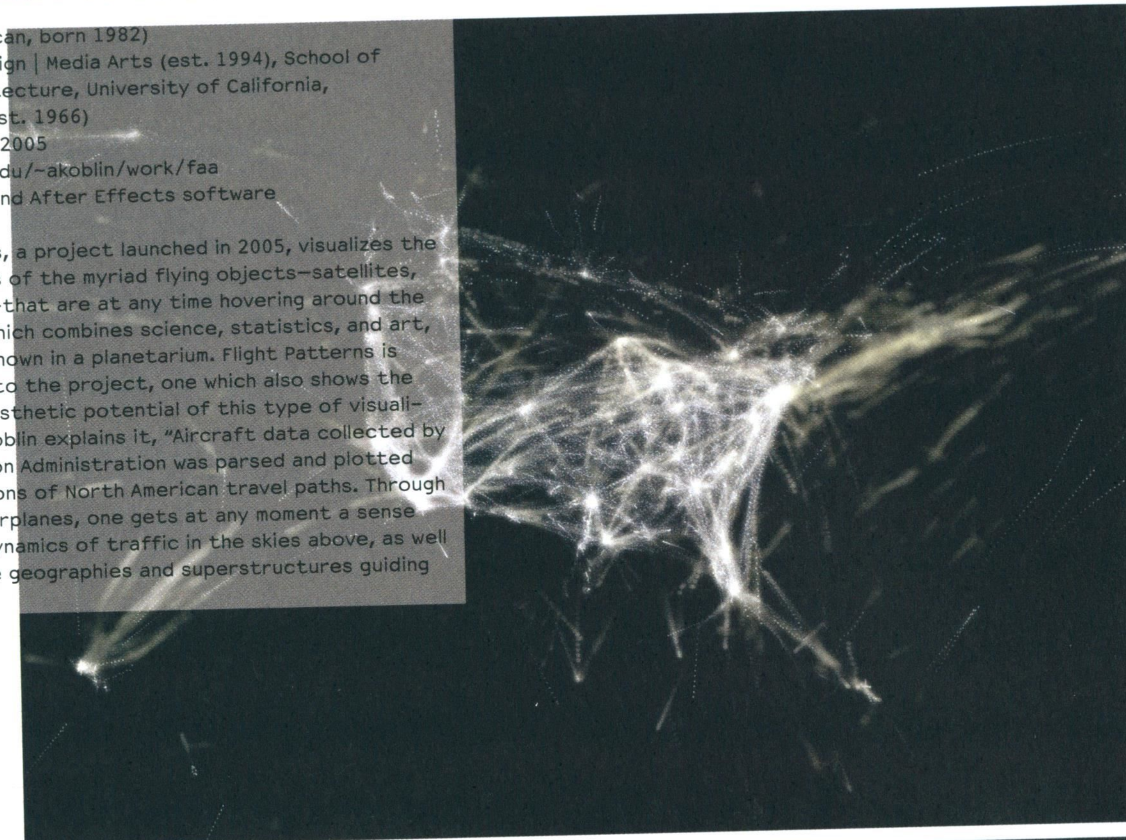


Lisa Strausfeld (American, born 1964) and
James Nick Sears (American, born 1980)
Pentagram (UK and USA, est. 1972)
"Rewiring the Spy" illustrations/applet for the New York Times Magazine December 3, 2006
jamesnsears.com/applets/spies
Illustrator, Acrobat, and Processing software

Understanding connections in the vast landscape of information often requires a new way of looking. On December 3, 2006, the lead story for the New York Times Magazine, penned by Clive Thompson, discussed the challenge of analyzing and interpreting information about terrorism and coordinating its exchange among various intelligence organizations. For the article, information designers Lisa Strausfeld and James Nick Sears programmed an applet in which keywords—in this case names of terrorists or terrorist events—are connected by springlike links, which become stronger and more animated with the frequency of the words' interconnection in a database. The resulting visualizations can be rotated in three dimensions to reveal new viewpoints. While for the purpose of the story the designers used the Internet as the source database, the model could also be adapted by government agencies using their own classified databases.

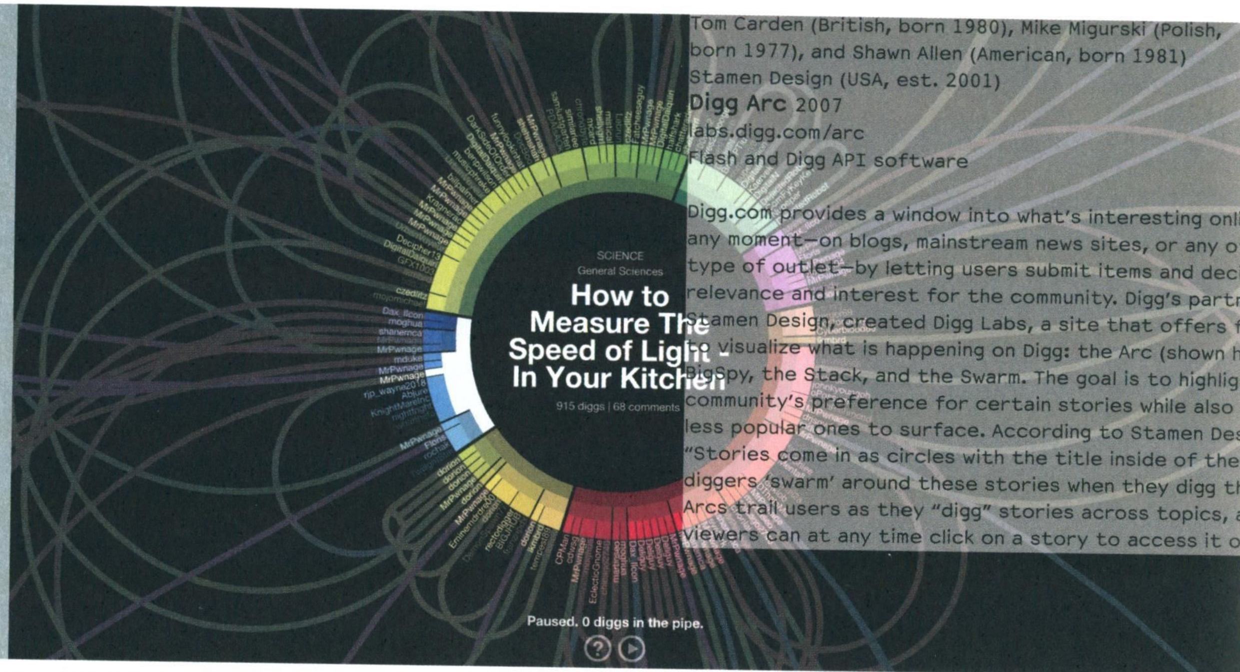
Aaron Koblin (American, born 1982)
Department of Design | Media Arts (est. 1994), School of the Arts and Architecture, University of California, Los Angeles (USA, est. 1966)
Flight Patterns 2005
users.design.ucla.edu/~akoblin/work/faa
Processing, Maya, and After Effects software

Celestial Mechanics, a project launched in 2005, visualizes the arresting patterns of the myriad flying objects—satellites, aircraft, balloons—that are at any time hovering around the earth. The work, which combines science, statistics, and art, was meant to be shown in a planetarium. Flight Patterns is a "flat" corollary to the project, one which also shows the informative and aesthetic potential of this type of visualization. As Aaron Koblin explains it, "Aircraft data collected by the Federal Aviation Administration was parsed and plotted to create animations of North American travel paths. Through visual traces of airplanes, one gets at any moment a sense of the changing dynamics of traffic in the skies above, as well as insight into the geographies and superstructures guiding the network."



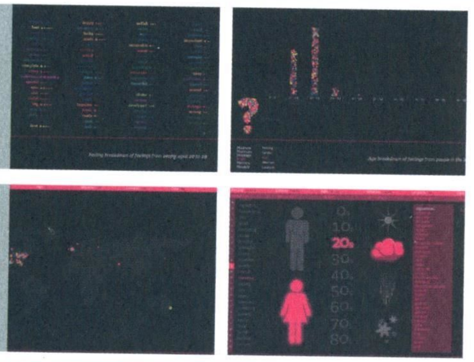
GustavoG (anonymous)
The FlickrVerse: A Graph Depicting the Social Network of the Flickr Community April 2005

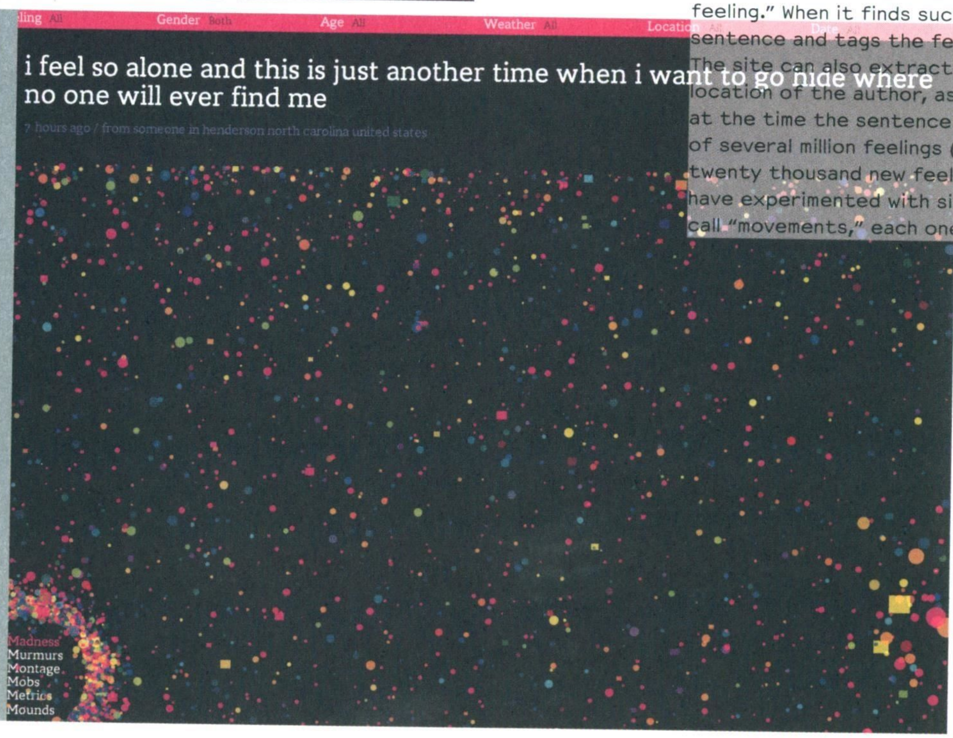
Flickr, the photo-sharing Web site and online community, allows users not only to share personal photos but also to categorize their photos with keywords and to organize them into sets that can easily be searched. Users can add contacts to their profiles, creating a vast network. The "universe" made up of this group and its photos was explored in FlickrVerse, a now inactive blog. One day in 2005, one Flickr user, the elusive GustavoG, designed an image showing the social landscape of FlickrVerse. The graph depicts a network of 2,367 Flickr members, demonstrating the connections and relationships of this unique community at a particular moment.



Tom Carden (British, born 1980), Mike Migurski (Polish, born 1977), and Shawn Allen (American, born 1981)
Stamen Design (USA, est. 2001)
Digg Arc 2007
labs.digg.com/arc
Flash and Digg API software

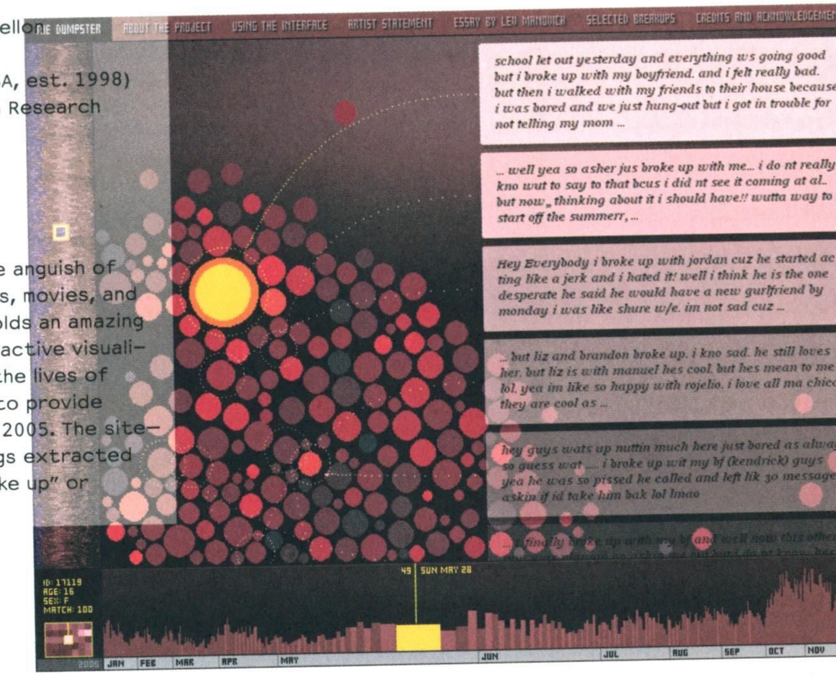
Digg.com provides a window into what's interesting online at any moment—on blogs, mainstream news sites, or any other type of outlet—by letting users submit items and decide their relevance and interest for the community. Digg's partner, Stamen Design, created Digg Labs, a site that offers four ways to visualize what is happening on Digg: the Arc (shown here), the BigSpy, the Stack, and the Swarm. The goal is to highlight the community's preference for certain stories while also allowing less popular ones to surface. According to Stamen Design, "Stories come in as circles with the title inside of them, and diggers 'swarm' around these stories when they digg them." Arcs trail users as they "digg" stories across topics, and viewers can at any time click on a story to access it on Digg.





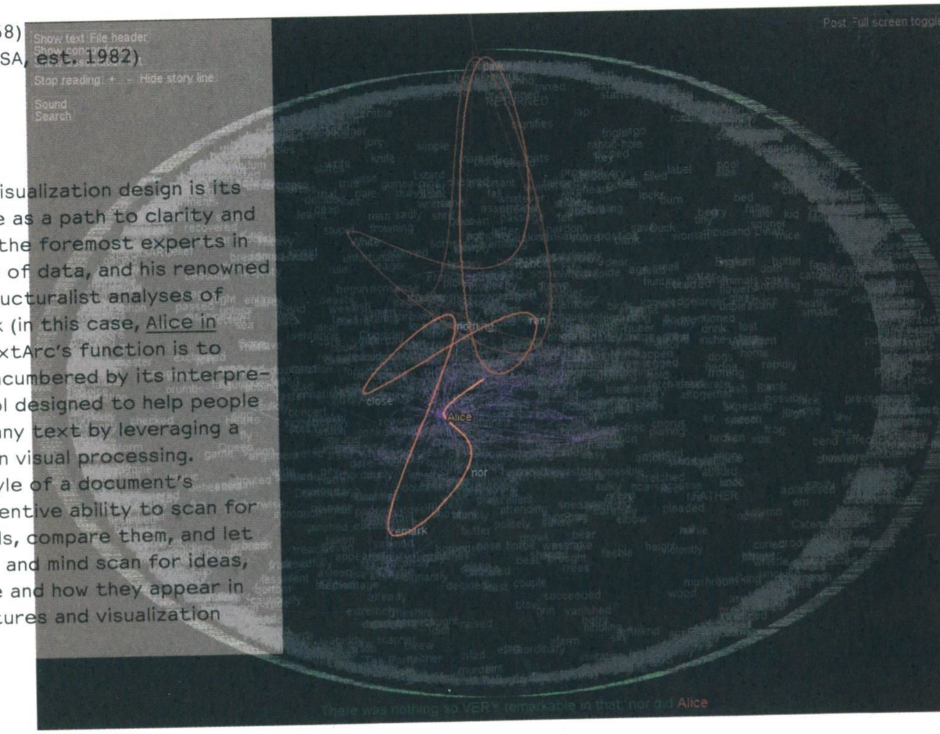
Jonathan Harris (American, born 1979) of Number 27 (USA, est. 2002)
Sep Kamvar (American, born 1977)
We Feel Fine: An Exploration of Human Emotion in Six Movements 2005
wefeelfine.org
Perl, MySQL, Java, PHP, and Processing software

People often use the Internet to express and share emotions and to connect with others. The Web site We Feel Fine has been harvesting human feelings from blogs since 2005. Every few minutes, the system searches the world's newly posted blog entries for occurrences of the phrases "I feel" and "I am feeling." When it finds such a phrase, it records the full sentence and tags the feeling expressed in that sentence. The site can also extract the age, gender, and geographical location of the author, as well as the local weather conditions at the time the sentence was written, resulting in a database of several million feelings (increasing by about fifteen to twenty thousand new feelings each day). The site's designers have experimented with six visualization systems, which they call "movements," each one with its own efficacy and beauty.



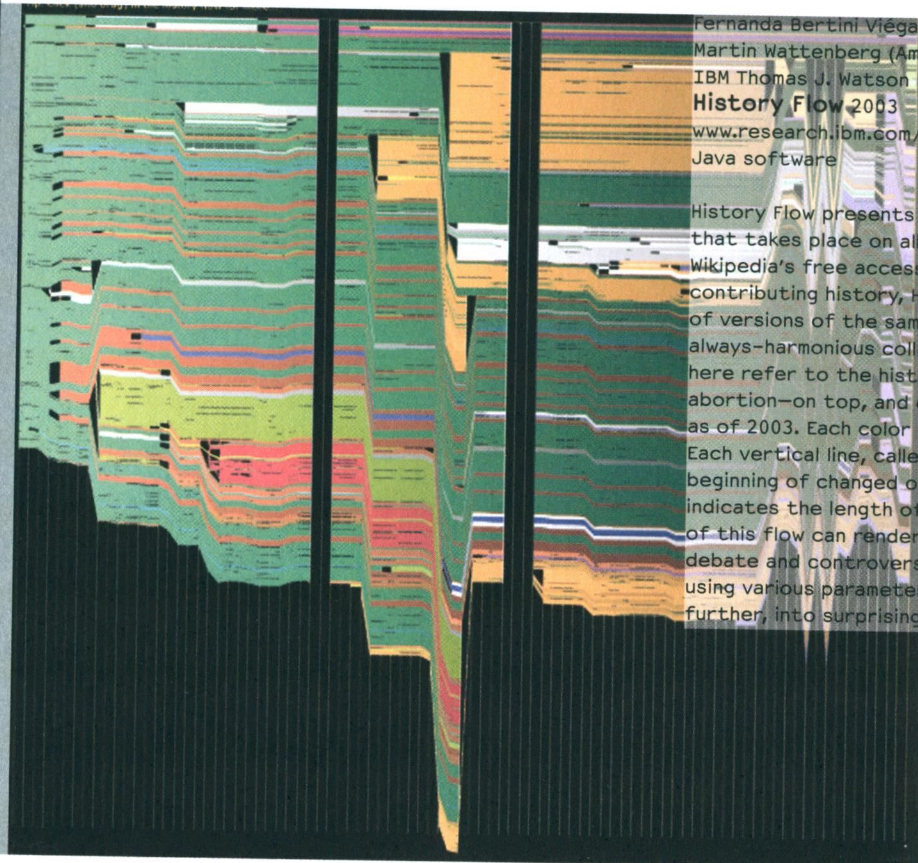
Golan Levin (American, born 1972) of Carnegie Mellon University (USA, est. 1900)
Kamal Nigam (American, born 1972) of Google (USA, est. 1998)
Jonathan Feinberg (American, born 1972) of IBM Research (USA, est. 1914)
The Dumpster (Valentine's Day) 2006
artport.whitney.org/commissions/thedumpster
Java software

The pain of a relationship ending mixed with the anguish of adolescence is requisite material for pop songs, movies, and magazines. Building on the idea that the Web holds an amazing repository of humanity, The Dumpster, an interactive visualization Web site, uses real-life examples from the lives of American teenagers drawn from the Internet to provide a snapshot into the romantic lives of teens in 2005. The site—launched on Valentine's Day, 2006—uses postings extracted from millions of blogs in which the phrases "broke up" or "dumped me" appeared.



W. Bradford Paley (American, born 1958)
Digital Image Design Incorporated (USA, est. 1982)
TextArc 2001
www.textarc.org
Java software

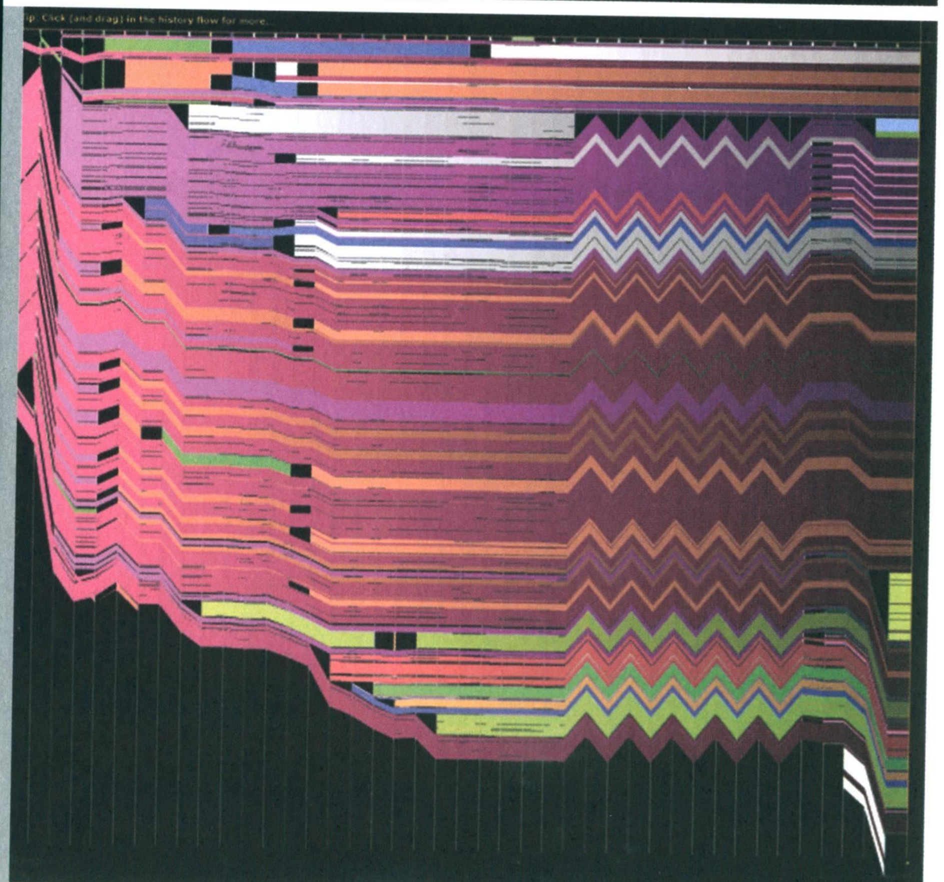
One of the main characteristics of visualization design is its capacity to use beauty and elegance as a path to clarity and analysis. W. Bradford Paley is one of the foremost experts in the communication of great amounts of data, and his renowned tool TextArc is used to conduct structuralist analyses of text. Every line of text from a book (in this case, Alice in Wonderland) is plotted in a circle. TextArc's function is to provide an analysis of the text unencumbered by its interpretation. As Paley explains, it is "a tool designed to help people discover patterns and concepts in any text by leveraging a powerful, underused resource: human visual processing. TextArc exposes the nature and style of a document's content....It taps into our pre-attentive ability to scan for brighter (here, more frequent) words, compare them, and let the eye read those words....The eye and mind scan for ideas, then follow the ideas down to where and how they appear in the text." TextArc has several features and visualization options, one of which is shown here.



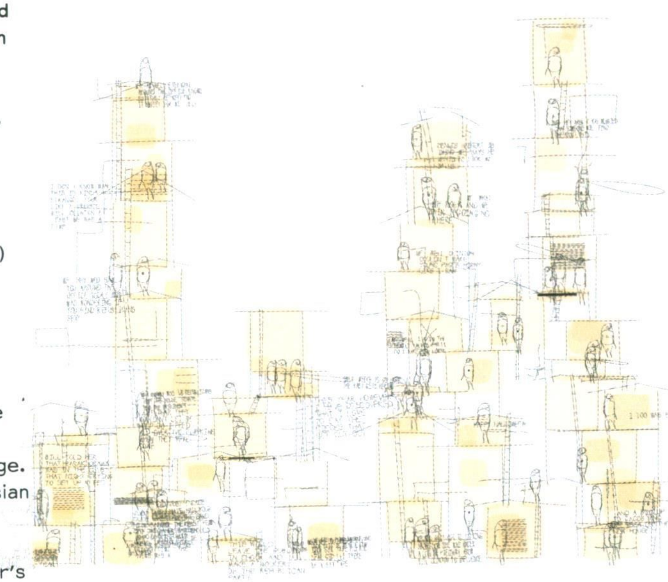
Fernanda Bertini Viégas (Brazilian, born 1971) and
Martin Wattenberg (American, born 1970)
IBM Thomas J. Watson Research Center (USA, est. 1961)

History Flow 2003
www.research.ibm.com/visual/projects/history_flow
Java software

History Flow presents visualizations of the flow of editing that takes place on all Wikipedia entries. Taking advantage of Wikipedia's free access to the complex layers of every entry's contributing history, History Flow maps the entire sequence of versions of the same entry, providing a chronicle of a not-always-harmonious collaborative process. The examples shown here refer to the history of a highly controversial entry—abortion—on top, and of a very popular one—chocolate—below, as of 2003. Each color corresponds to a different contributor. Each vertical line, called a "revision line," corresponds to the beginning of changed or updated text, while a line's length indicates the length of the text. The immediate visual reading of this flow can render with relative precision the level of debate and controversy surrounding a topic. A deeper reading using various parameters, such as time, can push the analysis further, into surprising detail.



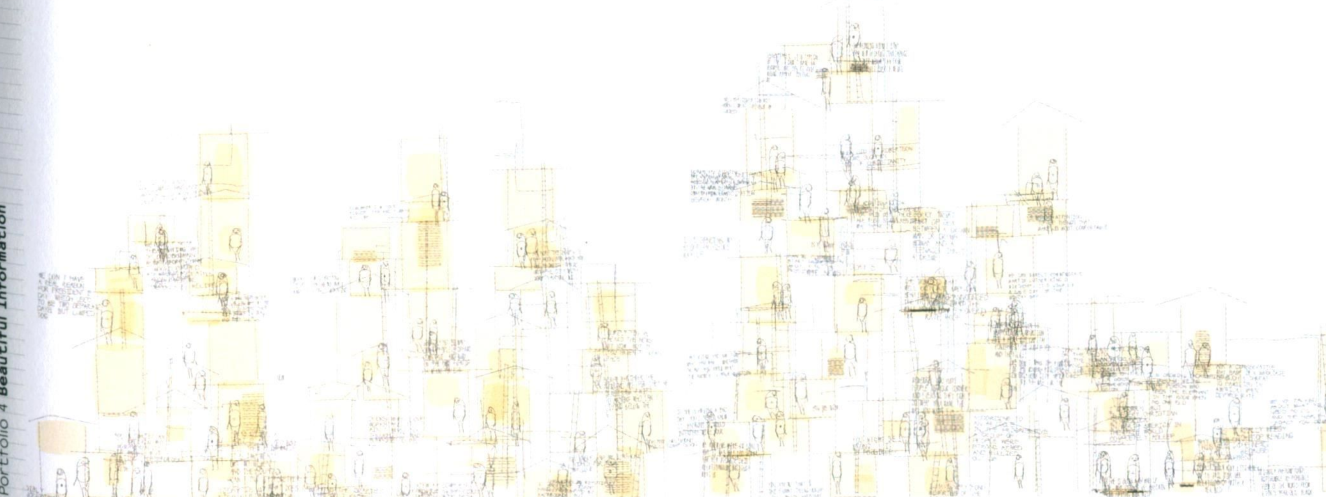
Designed by Casey Reas and Ben Fry, formerly of the Aesthetics + Computation Group at the MIT Media Lab, Processing is an open source "programming language and integrated development environment (IDE) built for the electronic arts and visual design communities" based on Java language. Simple enough to be picked up by nonprogrammers and yet sophisticated enough to be used for high-level design, architecture, visualization, and animation projects, Processing has already had a significant impact as a powerful and inspiring design tool. Presented here are only a few of the many new experiments that Processing has sparked.



Demetrie Tyler (American, born 1973)
Interactive Telecommunications Program (est. 1979),
Tisch School of the Arts, New York University (USA, est. 1965)

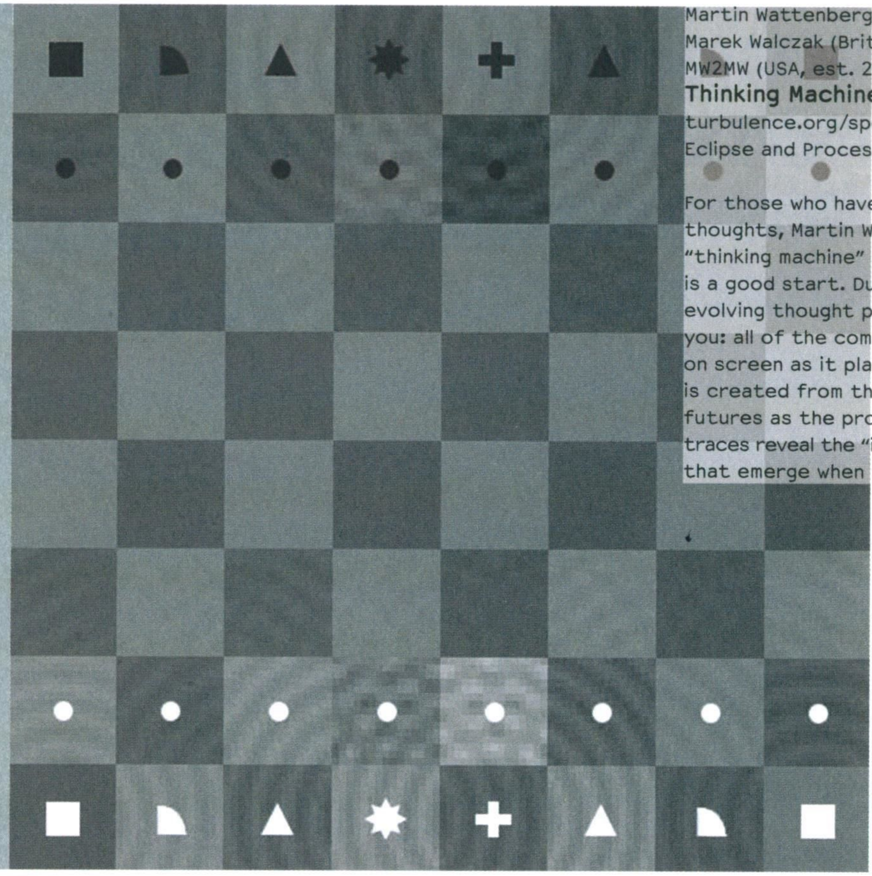
Hypothetical Drawings about the End of the World 2006
www.demetrietyler.com/hypotheticaldrawings
Processing software

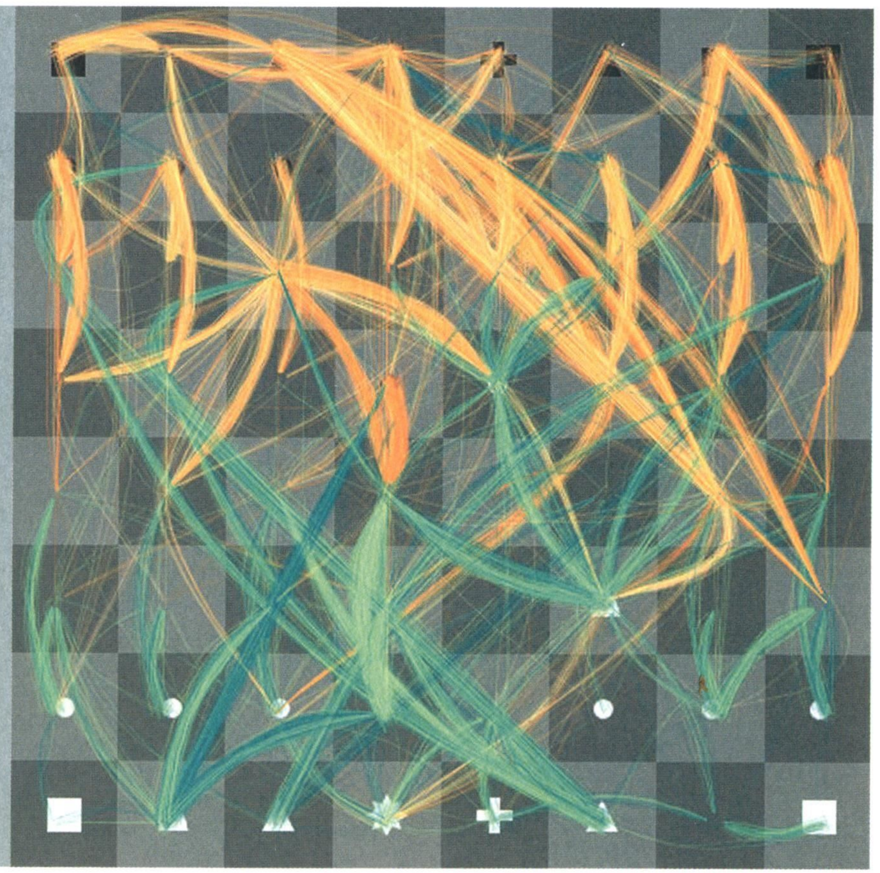
Demetrie Tyler's Hypothetical Drawings about the End of the World are large-format social landscapes inspired by online conversations that contain argumentative and divisive language. These exchanges were found all over the Web by using a Bayesian filter similar to that employed to identify spam e-mail. The images were created using a set of algorithms based on the designer's drawings. The purpose of the work, in the designer's words, is to investigate "the idea that as communities continue to become defined more by common ideologies than common geographies and as ideological contrasts become further exaggerated as a result, we become less able to identify with each other....In other words, the more we choose to spend our time conversing with people who are interested (or worried) about exactly the same things that we are, in relatively tiny but globally dispersed communities, the more we feel like the rest of the world is just plain crazy."



Martin Wattenberg (American, born 1970) and
Marek Walczak (British, born 1957)
MW2MW (USA, est. 2001)
Thinking Machine 4 2003–04
turbulence.org/spotlight/thinking
Eclipse and Processing software

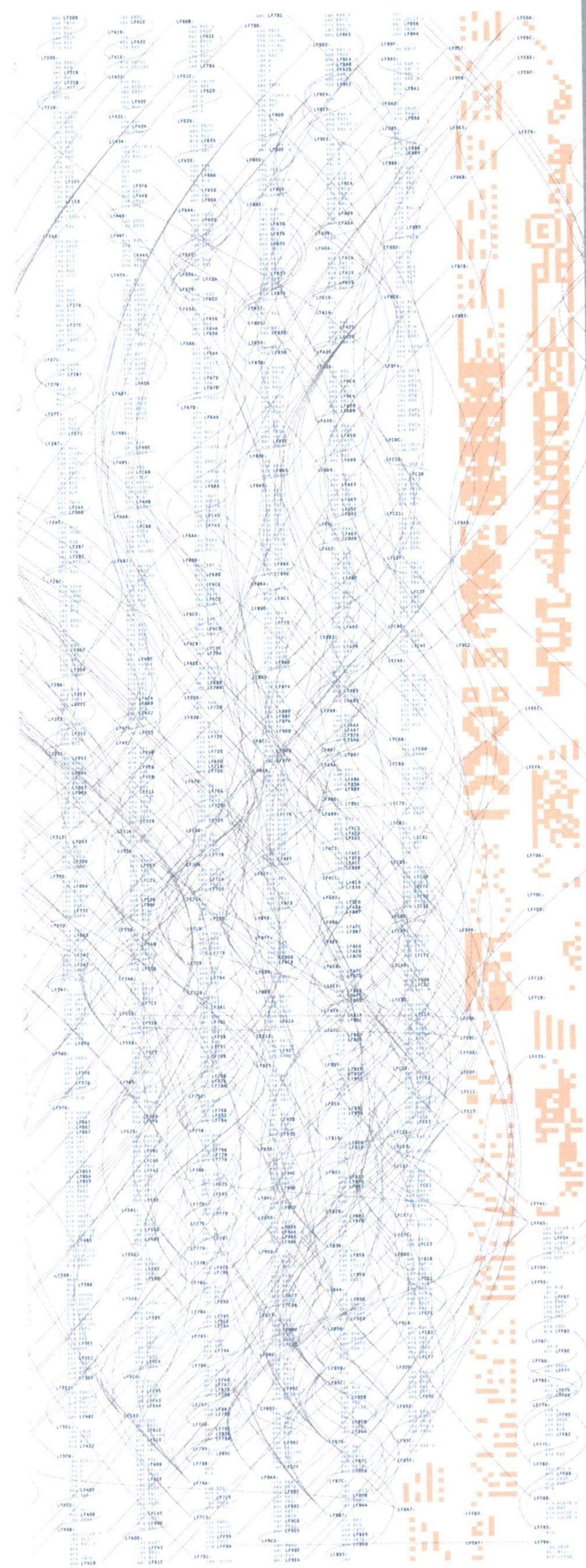
For those who have dreamt of being able to see other people's thoughts, Martin Wattenberg and Marek Walczak's MW2MW—a "thinking machine" against which you can play a game of chess—is a good start. During a game against MW2MW, "the machine's evolving thought process becomes visible on the board before you: all of the computer's possible future moves are sketched on screen as it plays," Wattenberg and Walczak explain. "A map is created from the traces of literally thousands of potential futures as the program tries to decide its best move." These traces reveal the "invisible lines of force"—the power of thought—that emerge when the very act of thinking is made visible.

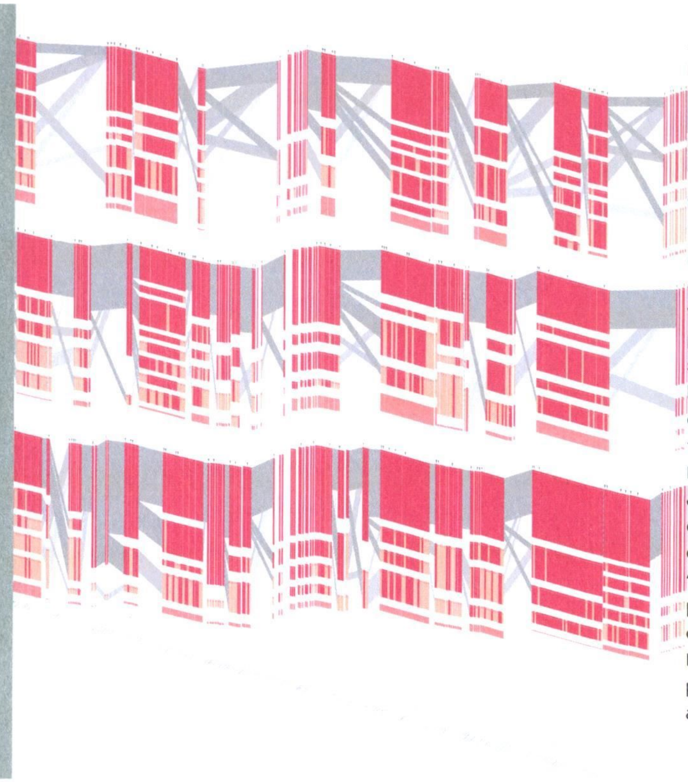




Ben Fry (American, born 1975)
Distellamap (Pac-Man) 2004
benfry.com/distellamap
Processing software

Ben Fry's Distellamap is a visualization of the code and data found in a Pac-Man Atari 2600 cartridge. Fry began "showing" code with his Dismap project of 2003, in which he rendered graphically both the executable code of some early computer games and the data sections that are used to store images or game scenarios, highlighting not only the mathematical instructions, but also the commands that would direct jumps to different locations in the program. In Distellamap, Fry explains, the code is listed as "columns of assembly language, most of it either math or conditional statements (if x is true, go to y). Each time there is a 'go to' instruction, a curve is drawn from that point to its destination. When a byte of data (as opposed to code) is found in the cartridge, it is shown as an orange row: a solid block for a '1' or a dot for a '0.'" With both Dismap and Distellamap, Fry's intent is not to analyze the software but rather to celebrate its elegance with an equally graceful portrait of it.

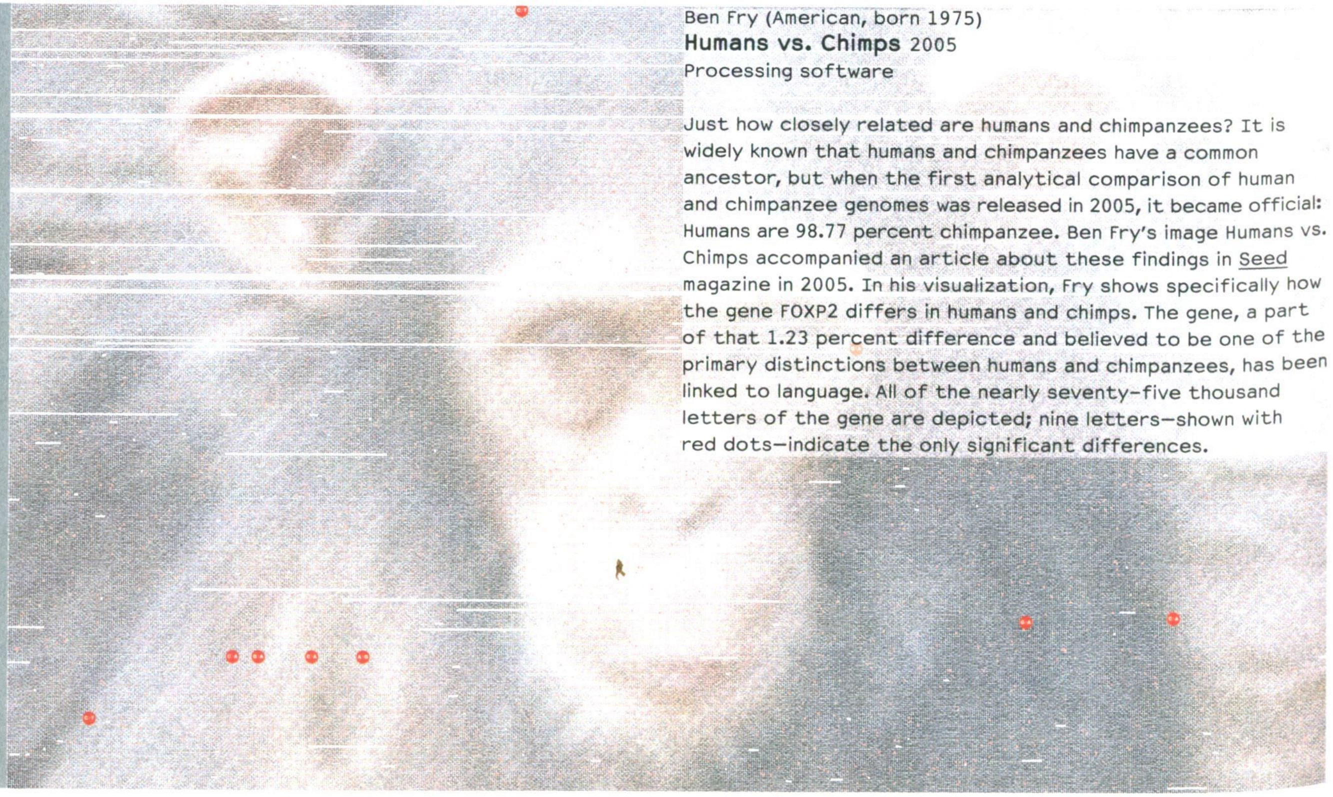




Ben Fry (American, born 1975)
Aesthetics + Computation Group (est. 1996), MIT Media Laboratory (USA, est. 1980)

isometricblocks 2002/2004–05
benfry.com/isometricblocks
Processing software

When comparing the genomes—and thus the exact order of the three billion adenine (A), cytosine (C), guanine (G), and thymine (T) letters—of two different organisms, single letter changes can be found every few thousand letters and are at times very significant. These variations are called single nucleotide polymorphisms, or SNPs, and are often found in consecutive sets that are easily rendered in blocks. Ben Fry's isometricblocks image represents blocks in the genetic profile of three different populations: the top row shows a group of Yorubans from Africa; the middle row depicts groups with Western European ancestry; and the bottom row represents a group of Japanese and Han Chinese individuals. "The vertical height of each column is proportional to the number of people in each group that has one set of changes or another," Fry explains, "and the colors in each row depict one of (only) two variations possible for each single letter change, the most common in dark red and the less common in a paler color." As in many of Fry's other visualization experiments, diagrams are used to provide both an instinctive gauge and a progressive in-depth analysis of a given statistical topic.



Ben Fry (American, born 1975)

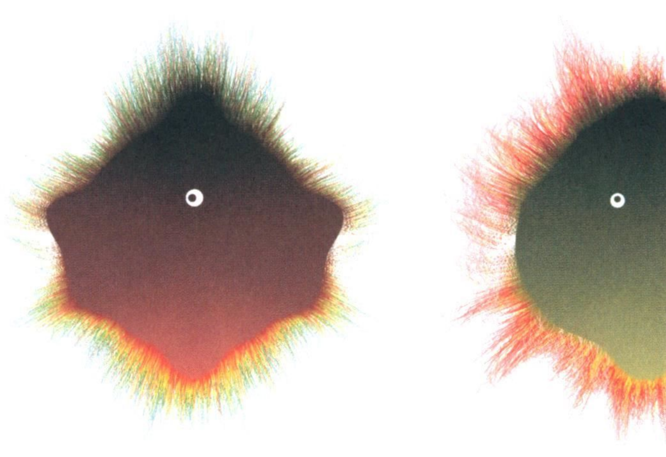
Humans vs. Chimps 2005
Processing software

Just how closely related are humans and chimpanzees? It is widely known that humans and chimpanzees have a common ancestor, but when the first analytical comparison of human and chimpanzee genomes was released in 2005, it became official: Humans are 98.77 percent chimpanzee. Ben Fry's image Humans vs. Chimps accompanied an article about these findings in Seed magazine in 2005. In his visualization, Fry shows specifically how the gene FOXP2 differs in humans and chimps. The gene, a part of that 1.23 percent difference and believed to be one of the primary distinctions between humans and chimpanzees, has been linked to language. All of the nearly seventy-five thousand letters of the gene are depicted; nine letters—shown with red dots—indicate the only significant differences.

Brendan Dawes (British, born 1966)
magneticNorth (UK, est. 2000)

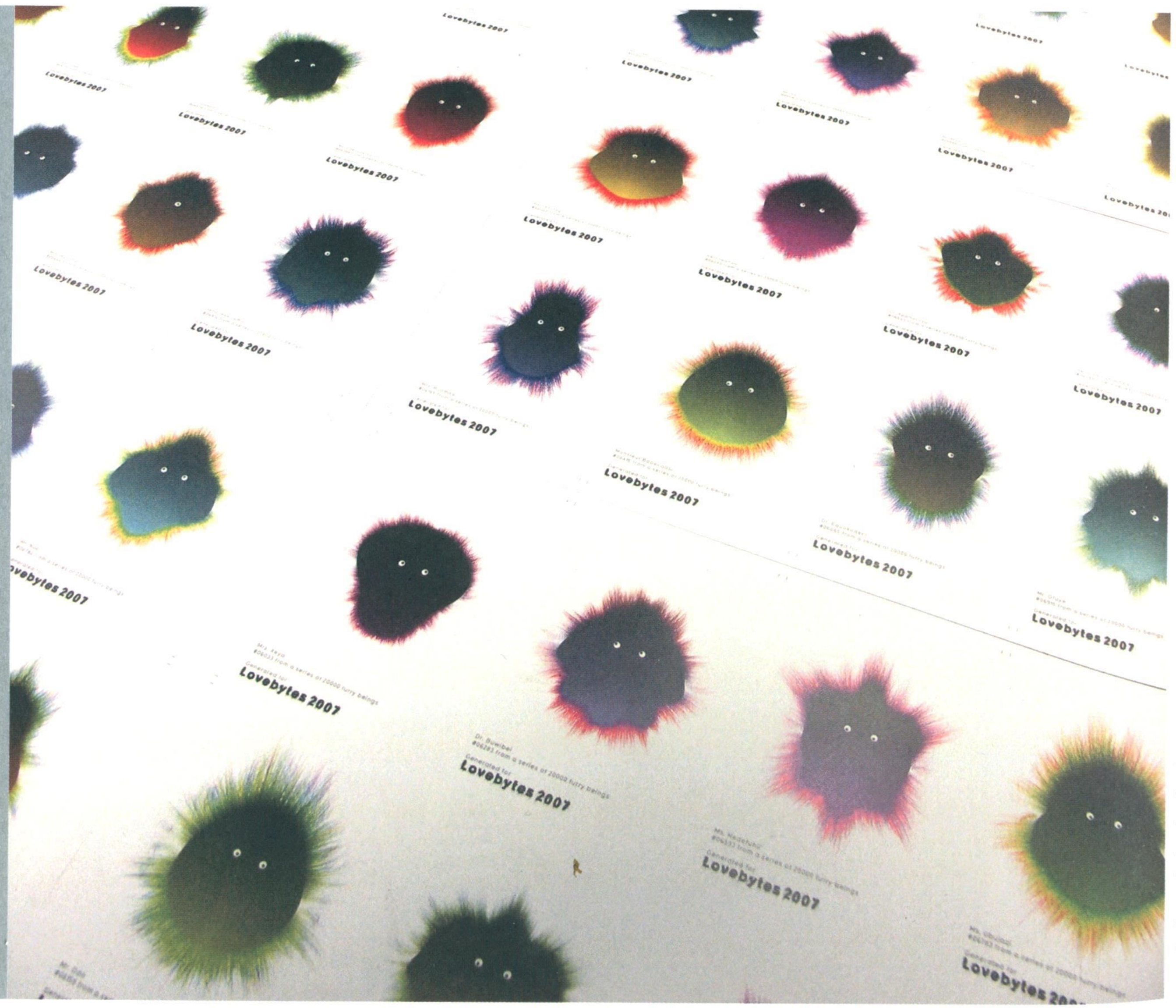
Cinema Redux: Serpico 2004
brendandawes.com/sketches/redux
Processing software

Cinema Redux explores the idea of distilling an entire film down to a single image. Processing software is employed to sample every second of a movie, and generate an eight-by-six-pixel image of the frame at that moment. The process is continued for the whole film, with each row in the visualization representing one minute of film time. The result is a unique fingerprint for that film—a visual DNA showing the film's colors and pacing, as well as the rhythm of the editing process.



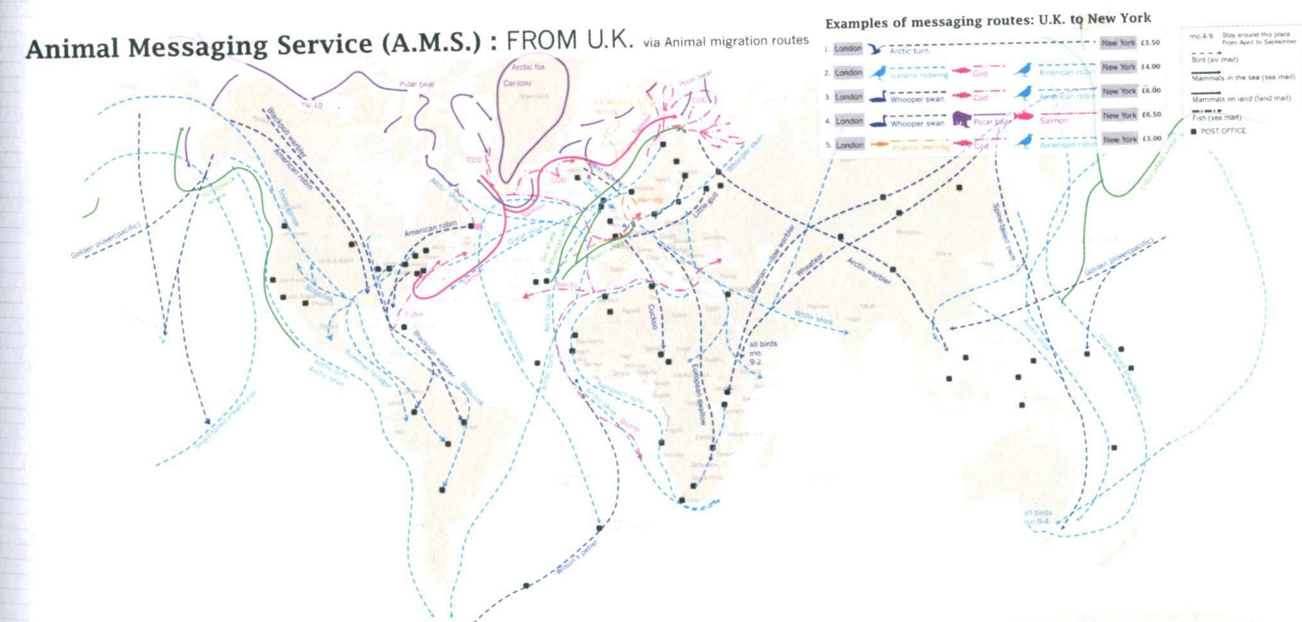
Matt Pyke (British, born 1975) of Universal Everything (UK, est. 2004)
Karsten Schmidt (German, born 1975) of toxi (UK, est. 2000)
Lovebytes 2007 identity generator 2007
festival2007.lovebytes.org.uk/monsters.php
Processing software

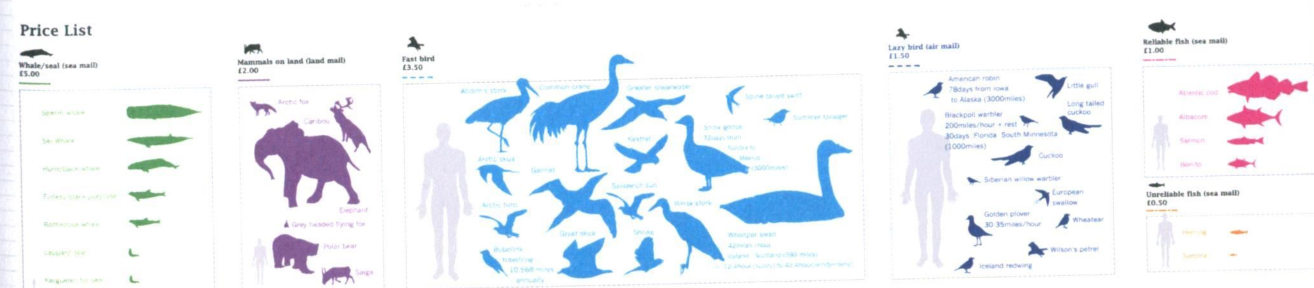
The 2007 edition of Lovebytes, an annual international digital arts festival in Sheffield, England, was devoted to the idea of process. This theme inspired the Lovebytes identity—a population of unique characters, which appeared across all festival literature. Using a rule-based design system, Matt Pyke and Karsten Schmidt created "an automated process with the potential to output an infinite number of designs: A self-contained 'seed' grows into a multitude of design solutions automatically, within an environment defined by ranges of parameters such as hair color, hair length, head shape, eye shape, and name."

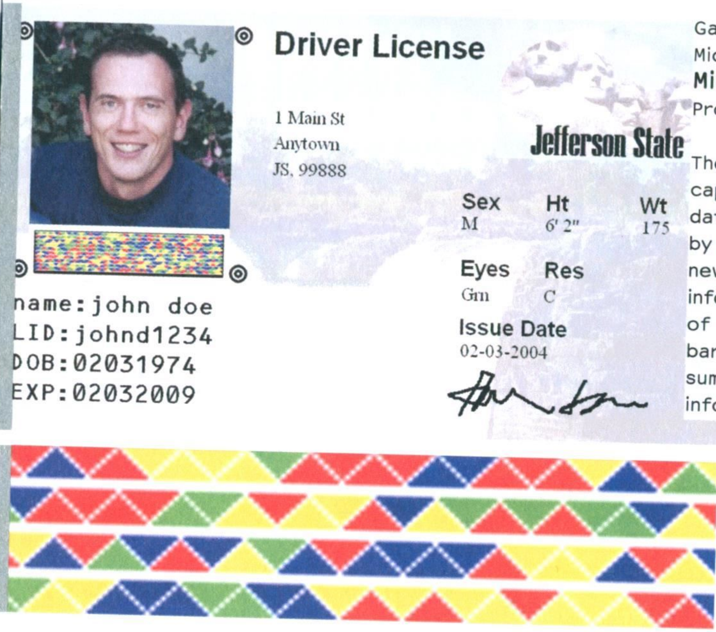


Michiko Nitta (Japanese, born 1978)
Design Interactions Department (est. 1989),
Royal College of Art (UK, est. 1837)
Animal Messaging Service from the **Extreme Green Guerrillas project** Concept. 2006–07
Paper, ink, and acrylic, 27 x 19 5/8" (68.6 x 49.4 cm)

As the environment becomes a worldwide concern, there is a lot of pressure on individuals to initiate change. Extreme Green Guerillas, Michiko Nitta's fictional project, is a community that proposes radical solutions to these preoccupations. It acts against both the Internet and wireless communication—tied as they are to big corporations—and against conventional postal systems, which leave an immense carbon footprint. Instead, Extreme Green Guerrillas proposes to send digital messages by "hacking" into the radio-frequency identification tags placed by environmental protection agencies on migrating animals, and turning them into an animal postal service.

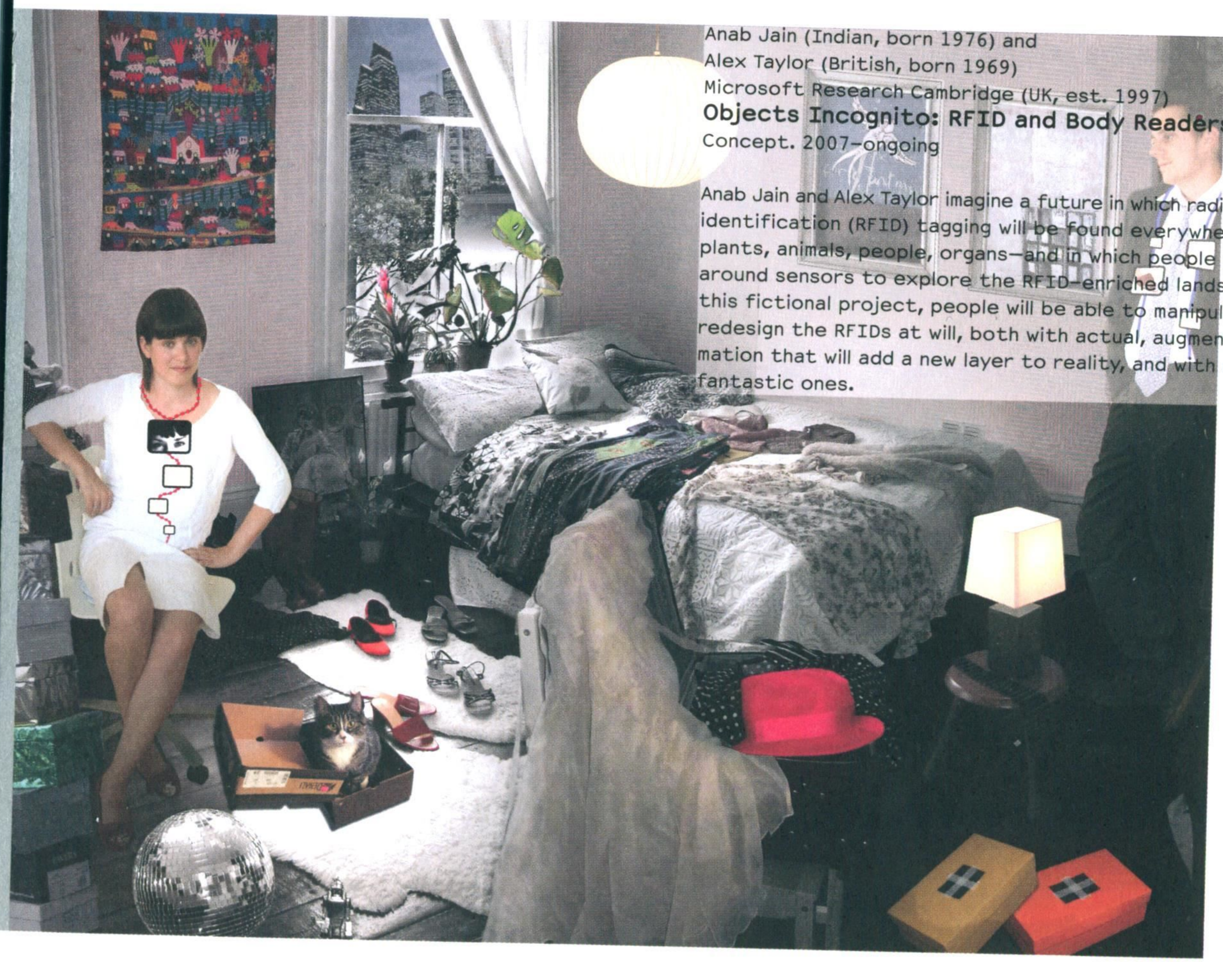






Gavin Jancke (British, born 1970)
Microsoft Research (USA, est. 1991)
Microsoft High Capacity Color Barcode
Prototype. 2004–ongoing

The mapping and tagging of information rely on the increasing capacity and decreasing size of computer chips and other data reservoirs. The High Capacity Color Barcode, developed by Microsoft Research engineering director Gavin Jancke, is a new barcode system capable of holding much more retrievable information than current UPC codes. It is composed of triangles of eight different colors arranged from left to right. The new barcode will be useful not only to vendors but also to consumers, who will be able to scan the barcode and obtain such information as product ratings, promotions, and pricing.



Anab Jain (Indian, born 1976) and
Alex Taylor (British, born 1969)
Microsoft Research Cambridge (UK, est. 1997)
Objects Incognito: RFID and Body Readers
Concept. 2007–ongoing

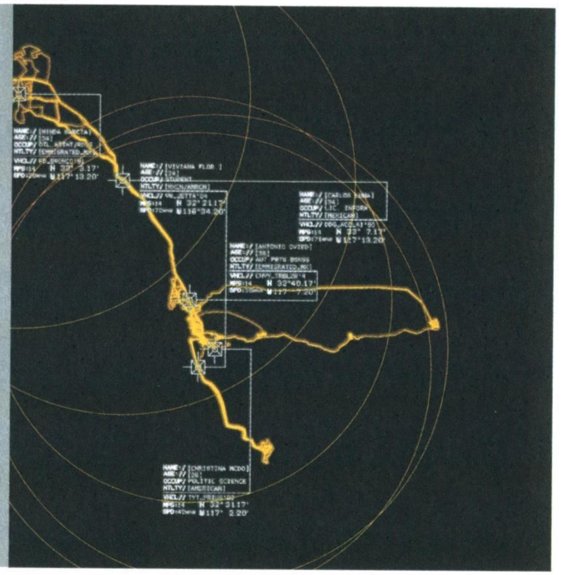
Anab Jain and Alex Taylor imagine a future in which radio-frequency identification (RFID) tagging will be found everywhere—objects, plants, animals, people, organs—and in which people will carry around sensors to explore the RFID-enriched landscape. In this fictional project, people will be able to manipulate and redesign the RFIDs at will, both with actual, augmented information that will add a new layer to reality, and with narrative, fantastic ones.

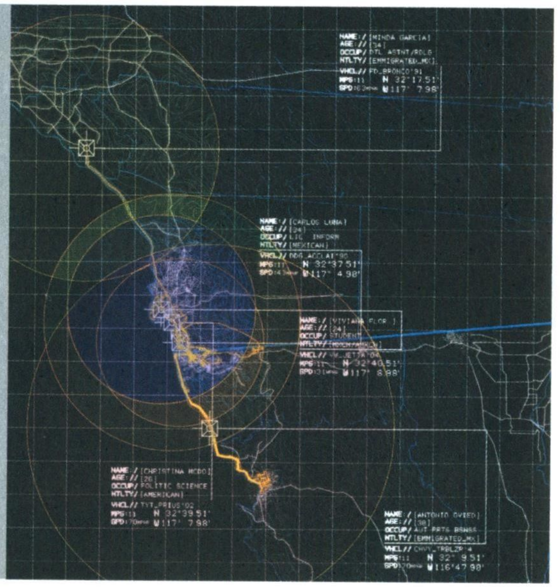
Miquel Mora (Spanish, born 1974)
Design Interactions Department (est. 1989),
Royal College of Art (UK, est. 1837)
Flat Futures: Exploring Digital Paper Models. 2007

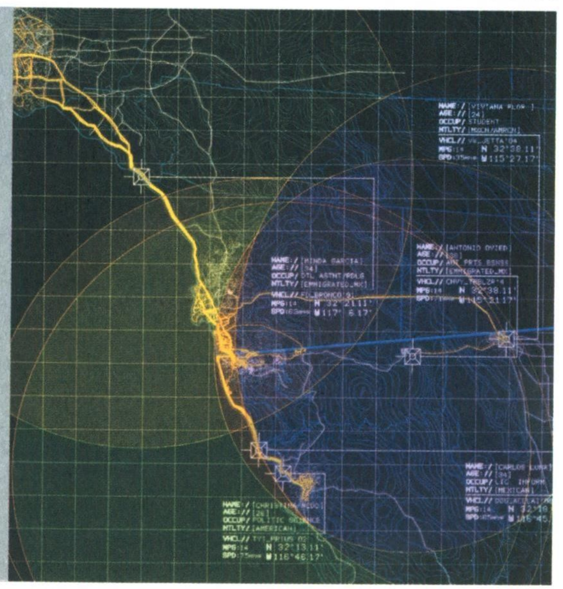
Smart Tapes
Paper and adhesive tape, 2 × 3 7/8" (5 × 10 cm)

Memory Envelope
Paper and adhesive tape, 8 5/8 × 4 3/8" (22 × 11 cm)

Relying on the latest developments in organic electronics—which studies conductive polymers as opposed to the traditional non-carbon-based copper and silicon—and on methods of using nanotechnology to print dynamic electronics, Miquel Mora explores ways to create processors, displays, and batteries on surfaces as flat and flexible as paper. "Objects will wear technology instead of carrying it inside," explains Mora. "The technology will become their skin." In Smart Tapes, a range of electronic components (such as processors, batteries, speakers, and displays) are printed on adhesive tapes, allowing a user to "enhance an existing product, making it smart, or create a new one." Memory Envelopes and Memory Probes are mailing envelopes and add-ons that record and display their journey, offering their own narrative memory.







Raúl Cárdenas-Osuna (Mexican, born 1969)
Torolab (Mexico, est. 1995)

LRPT (La Región de los Pantalones Transfronterizos)

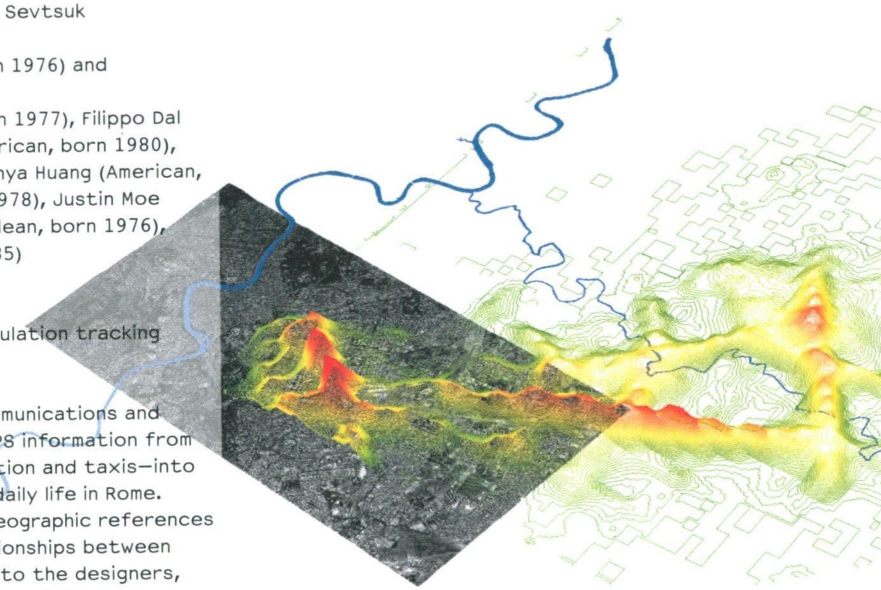
Prototype. 2005–06
Global positioning system, MaxScript, and 3d MAX software

"LRPT is a document of urban ethnography that proposes a new form of cartography for the transborder region between Mexico and the United States," explain the members of Torolab, an architecture and art collective based in Tijuana, Mexico. The designer chose five people settled on either side of the border and developed different "transborder clothes" for each of them. A GPS tracking system was integrated into the garments, which stem from Torolab's Toro Vestimente clothing line that addresses transborder identity and interaction. For five days, as the participants moved through the Tijuana–San Diego region, Torolab tracked their locations, velocities, and fuel consumption. The results from the collected data trace the participants' migration on a topographic urban/natural structure where the geographic and political boundaries are left unmarked.

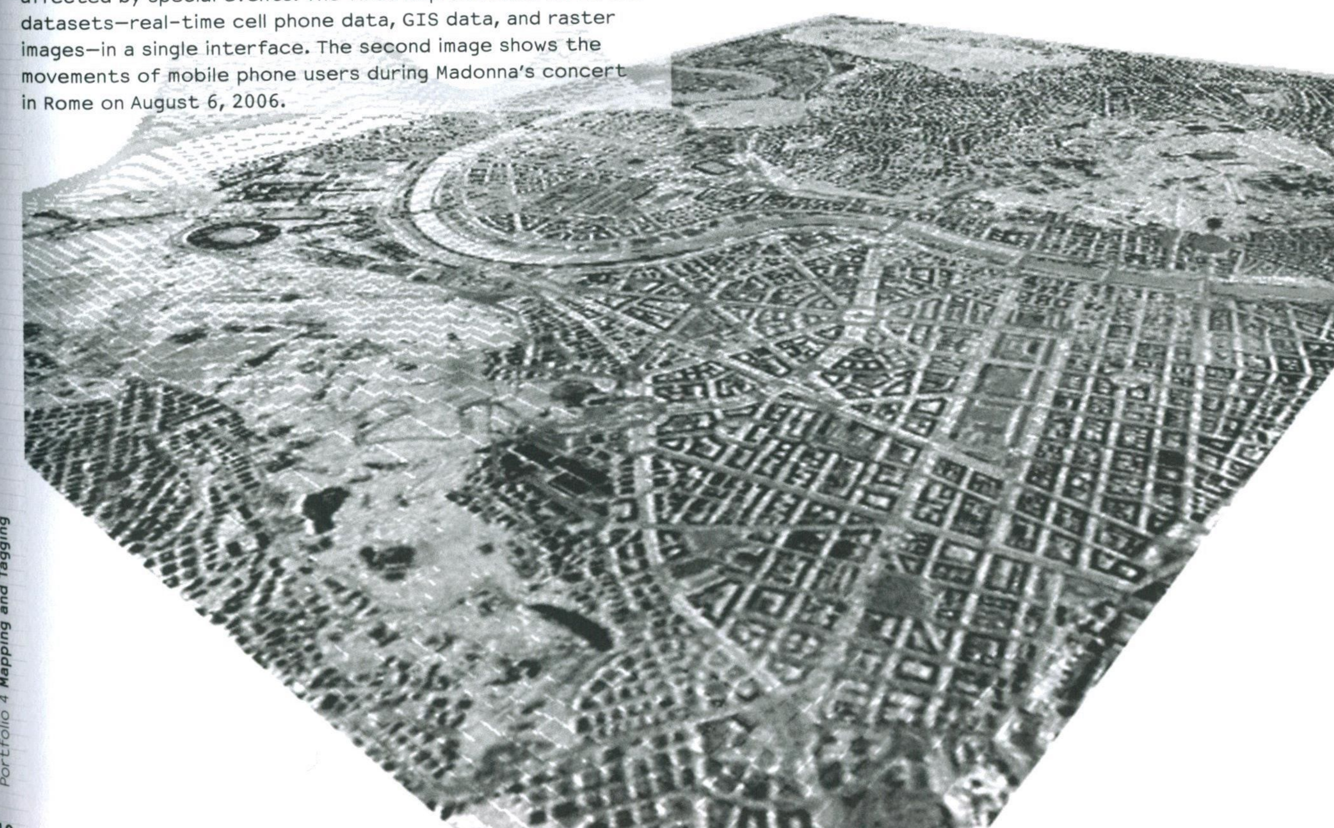
SENSEable City Laboratory (est. 2003), Massachusetts Institute of Technology (USA, est. 1861)
Carlo Ratti (Italian, born 1971) and Andres Sevtsuk (Estonian, born 1981)
Visual software: Burak Arikan (Turkish, born 1976) and Francesco Calabrese (Italian, born 1982)
Project team: Assaf Biderman (Israeli, born 1977), Filippo Dal Fiore (Italian, born 1977), Saba Ghole (American, born 1980), Daniel Gutiérrez (American, born 1986), Sonya Huang (American, born 1982), Sriram Krishnan (Indian, born 1978), Justin Moe (American, born 1986), Francisca Rojas (Chilean, born 1976), and Najeeb Marc Tarazi (American, born 1985)

Real Time Rome 2006

senseable.mit.edu
Processing software and cell phone triangulation tracking system



Real Time Rome synthesizes data from communications and transportation networks—for instance GPS information from mobile phones and from public transportation and taxis—into diagrams that help decipher patterns of daily life in Rome. By overlaying mobility information on the geographic references of a city, Real Time Rome unveils the relationships between fixed and fluid urban elements. According to the designers, "These real-time maps expose the dynamics of the contemporary city as urban systems coalesce: traces of information and communication networks, movement patterns of people and transportation systems, and spatial and social usage of streets and neighborhoods." Such maps also demonstrate how neighborhoods are used in the course of a day, how the distribution of buses and taxis correlates with densities of people, how different social groups, such as tourists and residents, inhabit the city, and how urban dynamics are affected by special events. The first map combines different datasets—real-time cell phone data, GIS data, and raster images—in a single interface. The second image shows the movements of mobile phone users during Madonna's concert in Rome on August 6, 2006.



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Lang, 58, 59, 60 (top); Joseph W. Lauher, SUNY Stony Brook, 52; Jürg Lehni, 62; Henry Leutwyler, 19 (top); Golan Levin, 137 (top); Roma Levin, David Cameron, and Toby Hadden, 30; Tomáš Gabzdil Libertíny, 117; Amir Lipsicas, 101 (bottom); Loop.pH, 119, 180 (top); Barrett Lyon, 120–21; Thomas G. Mason and Carlos J. Hernandez, 101 (top); Materialise, 66; Eriko Matsumura, 38 (bottom); Jacqueline McBride. Credit is given to the University of California, Lawrence Livermore National Laboratory, and the Department of Energy, under whose auspices the work was performed, and editor Arnie Heller, 61; David McNamara, 169 (upper right); Mikael Metthey, 104, 105; Microsoft Corporation, 146 (top); Miquel Mora, 41 (right), 147; NASA and Google, 168 (upper right); NASA, Google, and Ian Spiro, 168 (lower middle right); NASA, JPL, GSFC, and Arizona State University, 169 (lower middle right); William Ngan, 54–55; Nikon Corporation, 22, 22–23; Michiko Nitta, 145; NTT DoCoMo/NEC, 39 (bottom); Opel, 71 (bottom right); Adam Opel GmbH, 71 (bottom left); Neri Oxman, Materialecology, 75; Tapani Pelttari/Opte, 155; Pentagram Design, 134, 163; © Plastic Logic Limited, 41 (bottom left); © Matt Pyke and Karsten Schmidt, 144; realities:united, 179; Stanford Richins, 183 (bottom); Paul W. K. 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Acknowledgments

In the planning of this book and of the exhibition Design and the Elastic Mind, I relied on a wide network of extraordinarily elastic, lively, and generous minds. A diverse team of colleagues, volunteers, friends, and accidental consultants contributed immeasurably to the realization of both undertakings, and I will be forever indebted to them.

On behalf of The Museum of Modern Art, I wish to thank all the designers, engineers, artists, scientists, and manufacturers featured here for their cooperation and enthusiasm. I also wish to thank the sponsors for making this endeavor possible, and the lenders for agreeing to part, temporarily, with their possessions.

We in the field of design are in the concept business, and concepts need endless discussion and reconsideration. Together with my co-organizer, Patricia Juncosa Vecchierini, Curatorial Assistant, Department of Architecure and Design, I would like to thank our closest friends and partners, who so often became sounding boards. Larry Carty, first and foremost, and Lisa Gabor, Jane Nisselson, and Jordi Magrané Fonts were the moving targets for our whole team's lucubrations and doubts. Thank you.

In the research phase, Adam Bly, founder and editor-in-chief of the magazine Seed, was our precious resource and interlocutor. He taught me about science and helped me find unexpected shared interests and objectives between science and design. Along with my colleagues and with Meg Rand from his office, in December 2006 we initiated a monthly salon in which designers and scientists were free to discuss and brainstorm topics that then became pillars of the thesis behind the show. Some of the participants, including Benjamin Aranda and Chris Lasch, Felice Frankel, Ben Fry, and Jonathan Harris, are included here and in the exhibition, but all of them should be considered contributors to our enterprise.

A number of authoritative and imaginative advisors suggested some of the works included in the show. I would like to thank them one by one, but space limitations make it impossible. I would, however, like to mention Janine Benyus and Bryony Schwan from the Biomimicry Institute, Steve Sacks from bitforms gallery, Bruno Giussani, and Twan Verdonck, as well as Shumon Basar, Katy Borner, John Calvelli, Curro Claret, Dalton Conley, Elyssa Da Cruz, Niles Eldredge, Neil Gershenfeld, David Imber, Alan Kay, Sulan Kolatan, Sylvia Lavin, Liane Lefaivre, John Maeda, Alexandra Midal, Louise Neri, Enrique Norten, Alice Rawsthorn, Michael Rock, Stefan Sagmeister, Jukka Savolainen, David Schafer, Arne Sildatke, Cornelia Spillmann-Meier, Paul J. Steinhardt, Matt Taylor, Brian Tempest, Maholo Uchida, Luis Villegas, and Garth Walker.

Many of the designers and artists featured in this book also contributed invaluable suggestions. I would like to thank in particular Jon Ardern, Laurene Leon Boym, Anthony Dunne, Felice Frankel, Peter Frankfurt, Ben Fry and Casey Reas, Chuck Hoberman, Agata Jaworska, James King, Lisa Strausfeld, and Moritz Waldemeyer.

This book comes from the hyperelastic mind of one of the most inventive and perceptive designers in the world, Irma Boom, who was able to straddle space and time to produce an amazing visual synthesis of ideas. In MoMA's Department of Publications I wish to thank Christopher Hudson, Publisher; Kara Kirk, Associate Publisher; David Frankel, Editorial Director; Marc Sapir, Production Director; Elisa Frohlich, Associate Production Manager; Libby Hruska, Editor; and Rebecca Roberts, Senior Assistant Editor, for their efforts in bringing the book to light. Interns Isabel Bohrer, Jamieson Bunn, and Lilit Sadoyan provided vital assistance as well. I also wish to thank Joshua Roebke, Associate Editor, and Laura McNeil, Deputy Editor, at Seed Media Group for their help with editing some of the most scientific bits of the volume. Thanks are due as well to David Lo and Martijn Kicken for their valuable technical advice.

Members of the Museum's Board of Trustees deserve special acknowledgment. In particular, I wish to thank Ronald S. Lauder, Honorary Chairman, and Agnes Gund, President Emerita, knowledgeable and enthusiastic fans of design; David Rockefeller, Honorary Chairman; Robert B. Menschel, Chairman Emeritus; Donald B. Marron, President Emeritus; Jerry I. Speyer, Chairman; and Marie-Josée Kravis, President, for their passionate support of the Museum's curators. Glenn D. Lowry, Director, provided early and unwavering support that was crucial to the realization of the exhibition. Jennifer Russell, Senior Deputy Director for Exhibitions, Collections, and Programs, and Peter Reed, Senior Deputy Director, Curatorial Affairs, were integral in successfully bringing this huge ship to port.

I also wish to thank Maria DeMarco Beardsley, Coordinator of Exhibitions, and Randolph Black, Associate Coordinator of Exhibitions, for working out the complicated administrative details; Ramona Bronkar Bannayan, Director, Collection Management and Exhibition Registration, Susan Palamara, Registrar, Exhibitions, Allison Needle, Assistant Registrar, Exhibitions, and Ellin Burke, Project Registrar, for keeping track of the diverse loan items; and Eliza Sparacino, Manager, Collection and Exhibition Technologies, and Ian Eckert, Assistant, Collection and Exhibition Technologies, for helping us keep all our information in order. I would also like to extend thanks to Linda Zycherman, Conservator, and Roger Griffith, Associate Sculpture Conservator, for caring for all the objects.

The installation was indeed a challenge even for our heroic Department of Exhibition Design and Production. Jerry Neuner, Director, and Lana Hum, Production Manager, designed the installation, and their incomparable crew built it, as usual, to perfection. My gratitude goes to them and to Charlie Kalinowski, Media Services Manager, A/V, and to K Mita, Director, Technology Services, and his whole team, who performed miracles in order to ensure that the technology worked smoothly and effectively. The exhibition also lives on the Web, thanks to the magic touch of Allegra Burnette, Creative Director, Digital Media, and Shannon Darrough, Senior Media Developer, Digital Media.

I also thank Todd Bishop, Director, Exhibition Funding; Mary Hannah, Associate Director, Exhibition Funding; and Lauren Stakias, Senior Associate, Exhibition Funding, in the Department of Development and Membership, for securing the necessary funding, not a negligible feat. I thank Kim Mitchell, Director of Communications, and Daniela Stigh, Manager of Communications, for brilliantly condensing the whole show to get the press irresistibly interested, and Peter Foley, Director of Marketing, for promoting it.

I thank the whole Department of Education for their invaluable suggestions on how to communicate the show to the public, in particular Wendy Woon, Deputy Director for Education; Pablo Helguera, Director, Adult and Academic Programs; and Associate Educators Larissa Bailiff, Laura Beiles, Sara Bodinson, and Lisa Mazzola, and I also thank Jennifer Tobias, Librarian, Reader Services, and David Senior, Acquisitions Coordinator, Library, for their enthusiastic assistance with our research.

In the Department of Architecture and Design, I am deeply grateful to Barry Bergdoll, The Philip Johnson Chief Curator of Architecture and Design, who believed strongly in the exhibition and offered his support throughout the project. The entire department was helpful and encouraging and I thank each of its members, especially Peter Christensen, Curatorial Assistant, who participated in the organization of the show in the beginning. A special mention goes to Linda Roby, Department Coordinator, and Candace Banks, Department Assistant, for their untiring assistance. Several brilliant interns worked on this project; I wish to thank Andrea Lipps, Catharine Rossi, and Nadine Stares. Special thanks also go to Hideki Yamamoto, who helped us secure many loans in Asia and contributed ideas, texts, and invaluable criticism.

Lastly, I would like to thank the person with whom I shared this adventure, Patricia Juncosa Vecchierini. Yet another adventure, I should say, and once more she has proved to be the most valuable partner. I am very lucky to have had so many chances to work with her.

Design and the Elastic Mind celebrates the endless and restless curiosity of human beings and praises design as an expression of creativity and an affirmation of life. For this reason, I would like to dedicate this book and this show to the late Herbert Muschamp, who certainly knew what I am talking about.

Paola Antonelli
Senior Curator, Department of Architecture and Design

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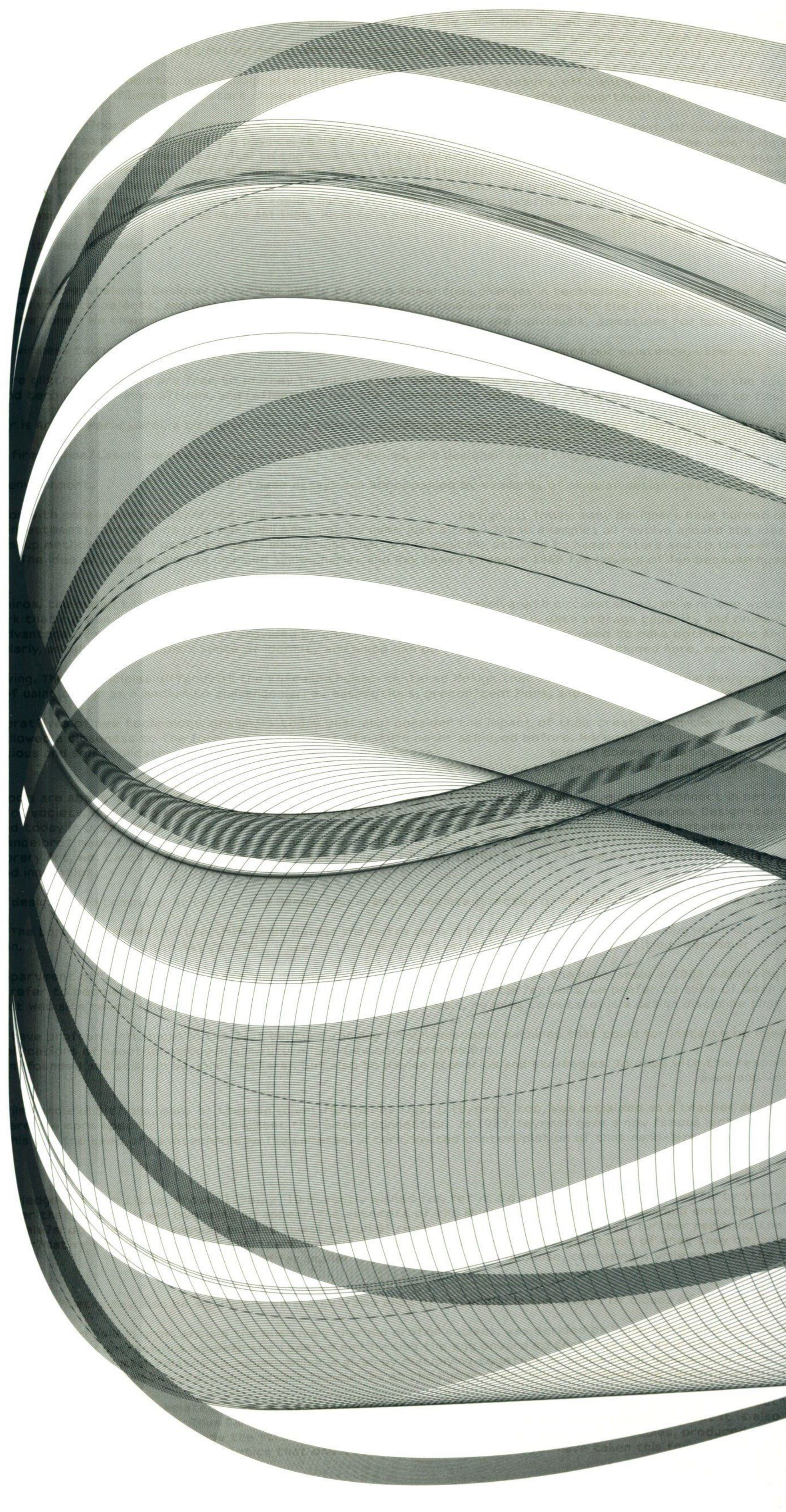

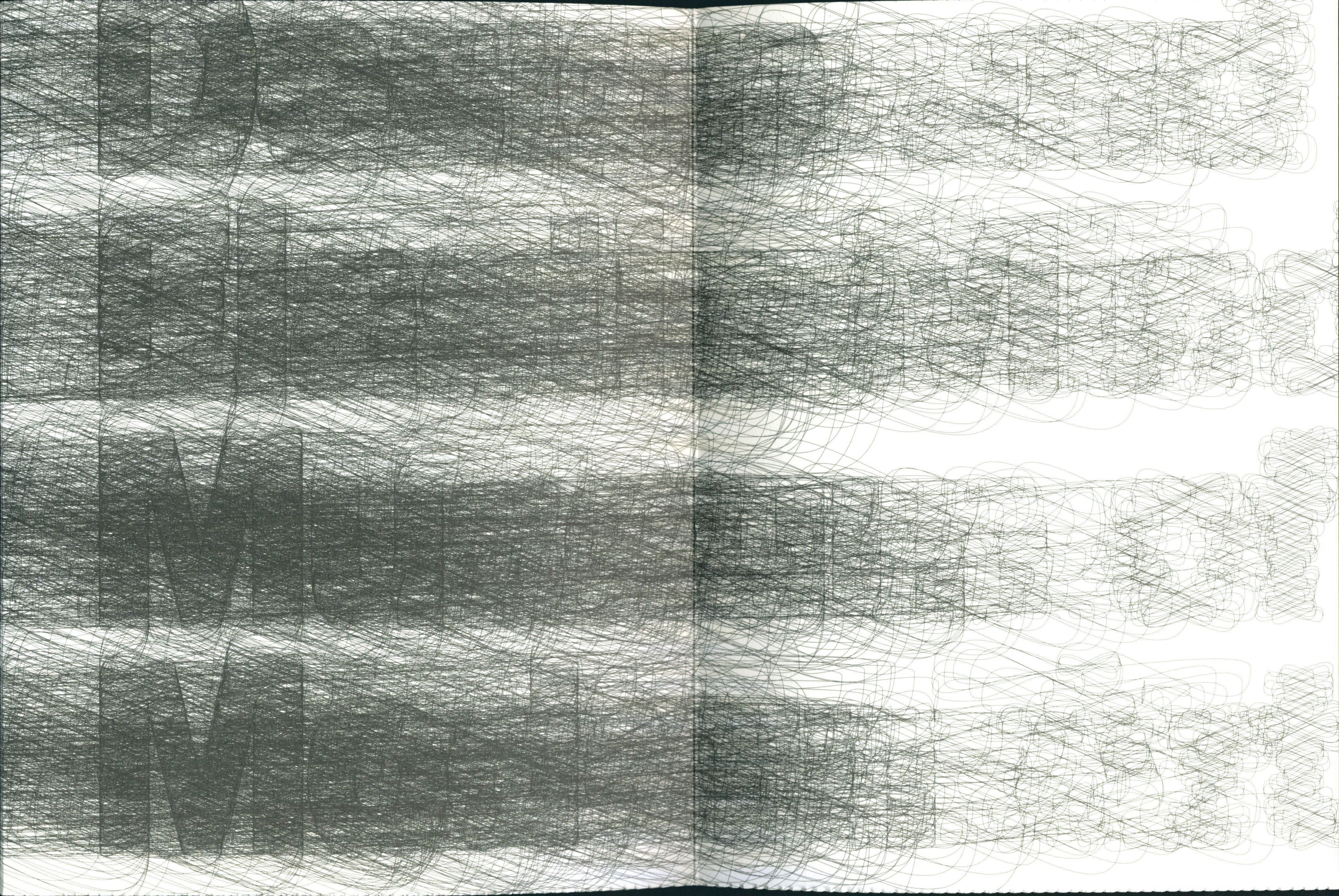

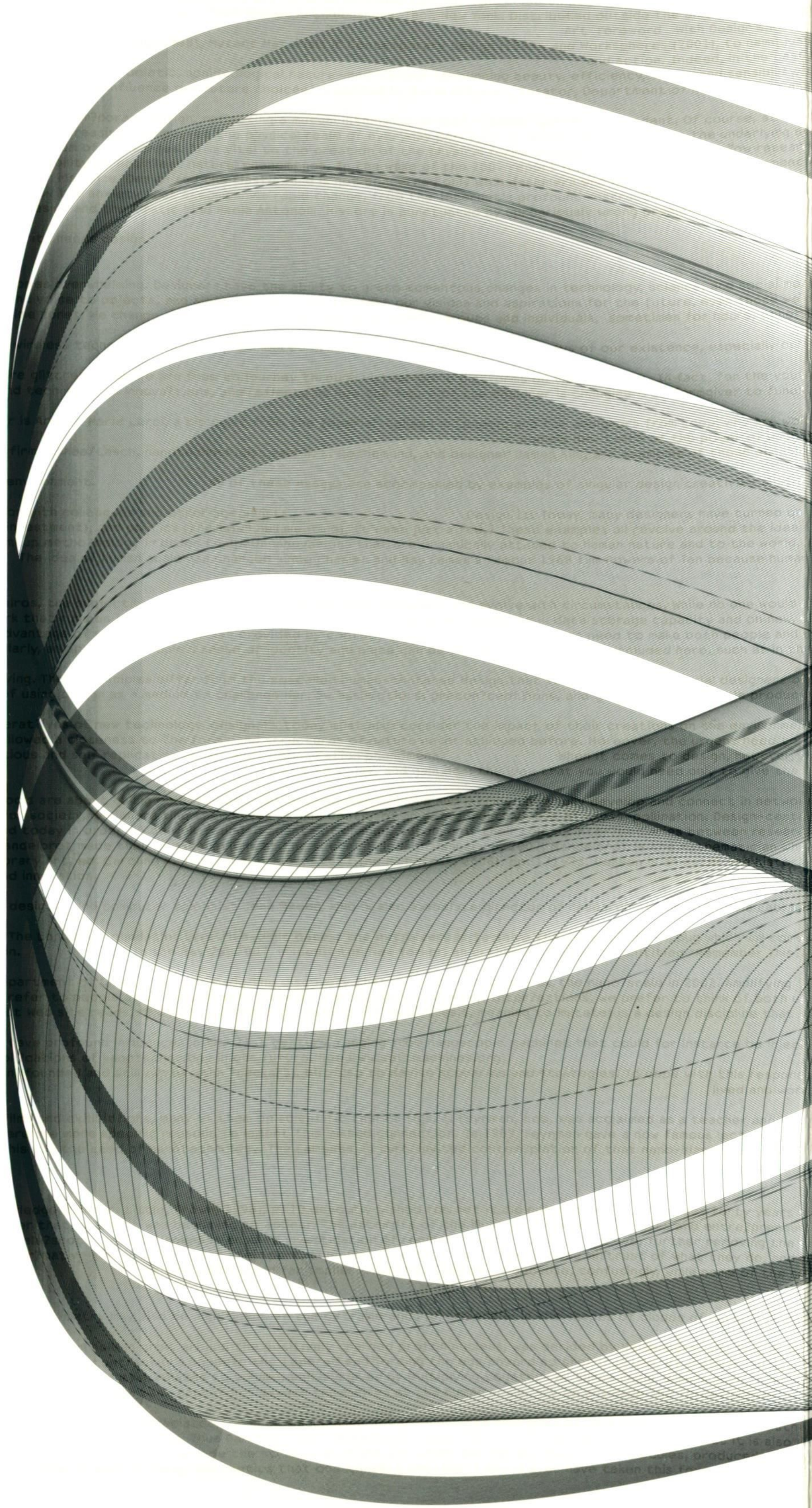

Over the past twenty-five years, in tandem with the introduction of the personal computer, the Internet, and wireless technology, we have experienced dramatic changes in our relationships with time, space, the physical nature of objects, and our own essence as individuals. Design and the Elastic Mind focuses on the responses of designers to the momentous advances in technology, science, and social mores that have characterized the last quarter-century and presents their projects that convert these developments into useful concepts and objects—from nanodevices to full-size vehicles, home appliances to building facades, pragmatic solutions to provocations. Designed by Irma Boom, this book features essays by Paola Antonelli, senior curator of architecture and design at The Museum of Modern Art; design critic and historian Hugh Aldersey-Williams; visualization design expert Peter Hall; and nanophysicist Ted Sargent.

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Antonelli

Design and the Elastic Mind

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