1 Data Visualization

Painting by Numbers

Internet users of a certain age will recall a moment in the latter half of the 1990s when a duo of artists working under the name Komar and Melamid rose to fame online. After emigrating from the Soviet Union to New York in the late 1970s, Alexander Melamid and Vitaly Komar achieved a degree of success in the art world as founders of a movement they called Sots-Art, a blend of conceptual art and playful critiques of Stalin-era Soviet realism. The work was witty and biting, merging irony and politics to the point where it was sometimes difficult to tell which was which. In 1994, Komar and Melamid launched a project with the support of the Nation Institute, for which they hired a professional opinion polling firm to ascertain what features of fine art painting were most and least popular among Americans.

In a telephone survey, more than one thousand respondents were asked approximately one hundred questions designed to elicit preferences in artistic content and style. Respondents were asked about their favorite colors and seasons of the year, as well as their preference between "wild or domestic" animals, "indoor or outdoor" scenes, "religious or non-religious" themes, representations of "reality or imagination," figures that are "historical or contemporary," "men, women, or children," "nude, partially clothed, or fully clothed," and so on. They were also asked to rate formal properties of the paintings, including such factors as "modern or traditional," "sharp angles or soft curves," "expressive brush-strokes or smooth canvas," and whether they preferred paintings that were the approximate size of a dishwasher, refrigerator, TV, magazine, or paperback book. Komar and Melamid then used the aggregated response data to create two paintings, one that possessed as many of the preferred features as possible, and

Figure 1.1
Artists Alexander Melamid and Vitaly Komar translated data gleaned from public opinion polls to create an idealized vision of America's *Most Wanted* artwork. Image courtesy of the artists.

another that exhibited as few as possible. They were titled *Most Wanted* and *Least Wanted*, and both paintings were exhibited at the Alternative Museum in New York in a show titled *People's Choice*.

The March 14, 1994, issue of the *Nation* magazine included an interview with Melamid by editors Peter Meyer, Victor S. Navasky, Katrina vanden Heuvel, and JoAnn Wypijewski.[1] Wypijewski would later go on to edit a book titled *Painting by Numbers: Komar and Melamid's Scientific Guide to Art*,[2] which featured an interview with the artists, a witty DIY paint-by-numbers outline of the *Most Wanted* painting created for the cover of the *Nation*, and an essay by art critic Arthur C. Danto, who sketched an appreciative history of Komar and Melamid's body of work since their immigration to New York. In both the *Nation* issue and Wypijewski's book, the seriousness—if not of intent, then of implications—of Komar and Melamid's work was examined in detail, with an image of the artists emerging as provocateurs digging mercilessly into the soft spot between art and politics in America. Both the critics and the artists themselves took the opportunity to address issues related to instruments of democracy, taste culture, and the relationship between art and commerce. While many dismissed the project as a cynical hoax, Sean Cubitt's 1999 essay in *Millennium Film Journal*, "Cartographic Instruments, Narcissistic Illusions, Regimes of Realism in CGI," sets aside the reading of Komar and Melamid as disingenuous pranksters to focus on interrogating serious dimensions of the work.

> [A] second possibility proposes itself: that the artwork is undertaken quite seriously, and that its object, therefore, is neither public taste nor contemporary painting, but the structure which public taste acquires when viewed through the lens of statistical sampling. This has the virtue of allowing us to accept at face value the artists' statements of the seriousness of their undertaking, and removes the necessity to imagine an elite in-group of ironist snobs.[3]

It is difficult to imagine a similar discussion of Komar and Melamid's project taking place today for several reasons. First, the proliferation of "ironist snobs" winking at each other's cleverness over the internet no longer requires a leap of the imagination. Second, and more important, anxieties about potential undue influence of opinion polls and statistical sampling on shaping everything from product marketing to election outcomes has been justifiably eclipsed by parallel concerns about the power of data analytics. Opinion polls, although still widely conducted and cited, don't begin to compete with the scope or speed of large-scale data systems, which now dominate cultural concerns over the dehumanizing tendency of statistics. Cubitt's essay is primarily directed toward the analysis of the structure of public taste, but he also provides an insight into Komar and Melamid's work that is relevant to our investigation:

> What Komar and Melamid add to this process is the form of their final presentation of data: not tables or diagrams but paintings. In this sense, both the illusionistic and the geometrical paintings are representational. And both are abstract: they represent a statistical result, which in turn represents the stated preferences of a sample, which in turn represents the taste of a population; and those phases of representation indicate a process of abstraction from individual response to statistical aggregate.[4]

In other words, the *Most/Least Wanted* project is significant not because of the data derived from statistical sampling or opinion polling, but because it translates that data into tangible, visual form via the medium of painting. Although the translation passes through several stages of abstraction, Komar and Melamid's work delivers a glimpse of the laborious process, circa the mid-1990s, by which data could become image.

Admittedly, Komar and Melamid's paintings are more of an artistic interpretation than a literal translation of the data gathered by the opinion polls. Though survey respondents expressed a clear preference for natural landscapes that include, for example, a body of water, historical figures (fully clothed), wild animals, and the color blue, Komar and Melamid made a series of specific decisions to include a mountain, blue sky, a lake, male and female deer, and a uniformed George Washington in the frame. Where did this archetypal vision of an ideal artwork originate? Komar and Melamid's survey results were possibly shaped by the broad commercial success of American painter and entrepreneur Thomas Kinkade, whose signature bucolic landscapes had gone into mass production shortly before the survey was undertaken. It is even possible that Komar and Melamid's attempt to "scientifically" capture the taste of American art buyers was motivated by an art world contempt for the unabashed commercialism—and corresponding financial success—of Kinkade. Perhaps to Komar and Melamid, Kinkade's idyllic landscapes, which frequently included rustic dwellings or lighthouses as evidence of the harmonious conquest of nature by man, suggested a distinctly American version of the disingenuous utopianism underlying their old nemesis, socialist realism.

In any case, the notoriety of Komar and Melamid's project, which included a review by Andrew Ross in *Artforum* in January 1995,[5] would certainly have caught the attention of Kinkade, who, in turn, would not have been above incorporating elements of the survey results into his repertoire. Although Kinkade's signature style had been well established by the end of the 1980s, drawing inspiration from nineteenth-century landscapes by Albert Bierstadt and Thomas Cole, the mass-produced images at the heart of Kinkade's success continued to feature many of the exact elements seen in Komar and Melamid's *Most Wanted*. Further linkage between Kinkade and Komar and Melamid's *Most Wanted* might be found in the artist "Favorability Ratings" captured by the opinion poll. The highest favorability rating was received by Norman Rockwell (81%), followed by Rembrandt (79%), Picasso (64%), and Monet (57%), with the lowest ratings going to Jackson Pollock (15%), LeRoy Neiman (25%), Georgia O'Keeffe (30%), Salvador Dali (32%), and Andy Warhol (33%). Kinkade cited Rockwell among his most important influences and famously experimented with a line of paintings inspired by French impressionism, completed under the pseudonym Robert Girrard. Although Kinkade enjoyed more than two decades of steady market growth—albeit marred by charges of fraud, labor issues, bankruptcy, and the artist's own untimely death from alcohol poisoning in 2012—his formally polished work was rarely greeted with the seriousness that attended Komar and Melamid's overt chicanery.[6]

So, did Kinkade's highly visible mall-based galleries (or "malleries") influence public taste in landscapes to the point where it affected the "scientific" data captured by Komar and Melamid? Or might the data resulting from the *Most/Least Wanted* survey have filtered its way into Kinkade's own work? These are chicken-and-egg questions that I am not particularly concerned with resolving. What makes the juxtaposition useful is the parallel evolution of explicitly data-driven artistic production, effectively parodied by Komar and Melamid, and Kinkade's mode of artistic production, which was both responsive to and partially constitutive of market forces. Kinkade, in this sense, was no different from other practitioners of commercial entertainment (film, TV, digital games) who aspire to artistic legitimacy along with financial profit. By this logic, opening weekend box office figures, unit sales, or viewership patterns could reasonably be considered the "data" that drives production in today's entertainment industries.

Based on the success of the Alternative Museum's *People's Choice* exhibit, Komar and Melamid received a commission from the Dia Arts Foundation in 1995, with funding from Chase Manhattan Bank, to hold a series of town meetings in Upstate New York to gather qualitative input and solicit requests for specific painting contents. The commission also supported expansion of the quantitative survey to additional geographic regions, including China, Denmark, Finland, France, Germany, Holland, Iceland, Italy, Kenya, Portugal, Russia, Turkey, and Ukraine. Dia specified that exhibition of the resulting works should take place exclusively on the internet—only the second time the foundation had sponsored an online-specific commission. By expanding the number of countries included in the survey, Dia opened the door for cultural comparison, which indeed dominated much of the project's second round of public discussion and, for Cubitt, provided the key to deriving serious insights from the project.

Except for a few outliers (Italy, Holland, Germany), Komar and Melamid's nation-specific *Most Wanted* landscapes appear strikingly similar, depicting a mountain on the left, with a field of grass in the foreground and a body of water behind. Various wildlife—mostly deer, with the occasional moose (Finland) or hippopotamus (Kenya)—frolic or graze at the edge of the water. Most paintings also feature human figures of some sort: for Turkey, children recline and play; for France, a naked woman watches over naked children; for Belgium, ballet dancers twirl in white tutus. While Americans preferred their painting to be the size of a dishwasher, most of the other countries preferred the size of a TV. Scanning the column of paintings generated on behalf of various countries, one cannot help but narrativize the summary vision they offer: "Of course Icelanders would prefer a verdant landscape." Holland, the only country to favor abstraction, may be read as disavowing the cliché of its own art-historical tradition: "Enough with the landscapes and dramatic skies already!" In contrast with today's data analytics, the deliberate eccentricity of Komar and Melamid's polling instrument, customized for each country, seeds these national narratives.

Just three years after *Most/Least Wanted*, another project would take up the issue of opinion polling as an engine for generating art. Created by Michael Mateas, Steffi Domike, and Paul Vanouse, Terminal Time (1999) was billed as "a history 'engine': a machine which combines historical events, ideological rhetoric, familiar forms of TV documentary, consumer polls and artificial intelligence algorithms to create hybrid cinematic experiences for mass audiences that are different every single time."[7] I have written previously about the historiographical significance of Terminal Time,[8] but here what interests me is the continuation of Komar and Melamid's focus on opinion polling as a vehicle for parodic—yet still serious—critique. In each presentation of Terminal Time, audiences respond via an applause meter to a series of multiple choice questions about the values they hold prior to viewing a historical documentary. Terminal Time was a remarkable apparatus for its day because of its capacity to dynamically assemble a video sequence in real time, using text-to-speech synthesis for narration and drawing on a database of historical audio and visual materials. Unlike Komar and Melamid, Terminal Time's creators wanted to be sure that audiences were in on the joke by running the apparatus at least twice at every performance and encouraging audiences to select varying responses to the opinion poll. The resulting differences in the historical narrative, in turn, showcased the system's ability to rescript its narrative and select and combine media elements to suit audience preferences. Ultimately, Terminal Time was a performance apparatus that focused audience attention on the editing algorithm, as opposed to a method for visualizing serious polling data.

Each of these examples—Komar and Melamid's *Most/Least Wanted*; Thomas Kinkade's malleries; and Mateas, Domike, and Vanouse's Terminal Time—shares a moment in the history of technology that narrowly preceded the emergence of data analytics as the successor to market surveys and opinion polls. More important, the technological literacy of Americans who experienced these projects had not yet been cultivated to understand marketers' ability to trace, aggregate, and analyze data as a means of discerning consumer patterns and preferences. This is partly due to the deliberate obfuscation of systems for capturing consumer data. The media production and distribution company Netflix, for example, harvests data concerning its users' preferences under the guise of improving the company's "recommendation engine." After watching a film, viewers are asked to rate their experience, with the promise of enabling the company to improve its suggestions for future viewing. One marketing solicitation offered, "Let us show you some hidden gems that you may have missed or forgotten about. Remember, the more you rate, the smarter we become at giving you suggestions."[9] Similar strategies are deployed by many other services and social networks, and indeed, the preferences they gather may well benefit consumers through customized recommendations. In fact, the perceived quality of Netflix's recommendation engine is so important to the company's public relations apparatus that it once sponsored a challenge offering $1 million to anyone who could improve the accuracy of its engine by 10 percent.[10] The contest ran for three years, between 2006 and 2009, when a winner was finally declared, but as Wendy Chun points out, the winning algorithm was never incorporated by Netflix.[11] Rather than improving its engine, the campaign primarily served a PR function, publicizing Netflix's commitment to optimizing its subscribers' viewing experience. It also marked a revealing case study for the blurring of boundaries between algorithms and culture.[12]

Netflix has admitted the importance of earning and maintaining the trust of its subscribers in making active use of the recommendation system.

> We want members to be aware of how we are adapting to their tastes. This not only promotes trust in the system, but encourages members to give feedback that will result in better recommendations. A different way of promoting trust with the personalization component is to provide explanations as to why we decide to

recommend a given movie or show. We are not recommending it because it suits our business needs, but because it matches the information we have from you: your explicit taste preferences and ratings, your viewing history, or even your friends' recommendations.[13]

All of this underscores the importance of the human element in otherwise algorithm-driven analysis. In Netflix's case, this extends to the use of professional human taggers to parse the contents of its vast catalog of media, a practice that the company publicly acknowledged in 2012.[14] Although the processing of recommendations is performed by computer, Netflix's data structures, categories, and ratings all originate with humans. This supports Ian Bogost's argument that the algorithms that allegedly dominate our everyday lives are too easily occulted when considered apart from their concrete human and cultural contexts.[15] Ironically, except for a few extreme cases such as Google's Deep Learning project, it is the human labor that is most frequently occulted in discussions of data analytics. I will return to this easily neglected fact when discussing computer vision later in this chapter.

Thus far, I have focused on recommendations resulting from Netflix's user ratings, a process that is of decreasing importance to the company in comparison with its real-time data analytics.[16] Ratings-based recommendations are structurally equivalent to brief opt-in consumer satisfaction surveys and are entirely dependent on capturing good-faith responses from viewers who choose to respond. It is not difficult to imagine the algorithms programmed to identify and respond to patterns associated with particular genres, actors, directors, and so on. Reflective viewers might even deliberately modify their ratings in an attempt to preclude unwanted responses from the recommendation engine. "I may have liked the *Bourne* movies, but *please*, no more Matt Damon!" What Netflix viewers may be less aware of is the company's ability to precisely monitor the real-time viewing patterns of its streaming media subscribers. This enables Netflix to know, for example, which episode in a given season resulted in viewers being sufficiently "hooked" to watch the remainder of that season,[17] or specific narrative events or characters that may have induced a significant percentage of viewers to abandon a particular episode, film, or series. Netflix also captures data related to its users' time spent on the company's website, searching the collection or managing their account, including factors such as "scrolls, mouse-overs, clicks, or the time spent on a given page."[18]

Although the company is notoriously secretive about its viewership numbers[19] and refuses to release data supporting the purported popularity of its offerings, the exposed parts of its recommendation system, which Netflix refers to as "one of its most valued assets,"[20] allows glimpses of the categories it uses to organize its collection. In 2014–15, *Atlantic* writers Ian Bogost and Alexis Madrigal created a data-scraping system that reverse-engineered a list of more than seventy-six thousand potential categories—or microgenres—that could be generated based on the vocabulary used in Netflix descriptors. Bogost and Madrigal then did what any procedurally minded media critics would do and created an online tool for generating sample categories that mimic Hollywood clichés, actual Netflix genres and a third setting dubbed "Gonzo" that creates "ultra-niche" categories highlighting the potential for absurdly granular categories and combinations. These included "Romantic Post-Apocalyptic Small Town Fantasy Movies Based on Real Life Set in Africa About September 11 Starring Jackie Chan," "Talking-Animal War Documentaries Set in Asia Starring Wynton Marsalis," and so on. Although amusing, the Gonzo setting on Bogost and Madrigal's microgenre generator did not aim to produce any real insights into how Netflix uses its data. Nonetheless, the generator might have contributed something to the procedural literacy of *Atlantic* readers, who were invited to denaturalize the demographic categories that drive marketing strategies in different parts of the entertainment industry.[21]

As audiences become more aware of the functioning and limitations of recommendation systems, they also become more critical. Following a proposed dramatic expansion of its presence in international markets in early 2016, Netflix began exposing more parts of its recommendation algorithm. In a February 2016 blog post, Netflix discussed the challenges it faces in refining its algorithms to account for massive variability among viewers and data input from a proposed 130 new international markets. Netflix's blog readers responded with acerbic critiques of the functioning of the recommendation engine, often citing the incongruous or inaccurate selections they already receive from the company.[22] Rather than simply managing their own ratings and recommendations, viewers are showing the ability to critique the functioning of the system as a whole and, by implication, the logic of algorithmic culture broadly.

If the connection is not already apparent, my point is that the original series produced by Netflix may be seen as an interpretive visualization of its viewer data. Like America's *Most/Least Wanted* paintings, this visualization should be understood not as a literal translation, but as an artistic manifestation of the demonstrated preferences of the company's viewership. Yet, there is a potentially disturbing, majoritarian logic to the deployment of viewer data to reverse engineer original content. Successful genres that reach the company's most desired subscriber demographics may favor white middle-class audiences over "niche" profile categories such as "African-American" or "gay and lesbian." Netflix's data analytics are presumably capable of anticipating the audiences for specific identity groups, but judging by the company's selection of original programming thus far, these groups have seemingly not yet crossed the profitability threshold. The secrecy that shrouds Netflix's most valuable asset ensures that this is only speculation, but the continuity between data-informed production and old-school Hollywood suggests the operation of the same kind of circular logic that has long served to maintain the status quo in the entertainment industries.[23]

For a brief period in spring 2016, roadside billboards advertised the Netflix original series *Fuller House*, a decades-later sequel to the white-bread family comedy *Full House*, which aired on ABC from 1988 to 1995. The billboard was free of text except for the title of the series and the Netflix text treatment in its signature red font; nothing else needed to be communicated by means as clumsy as words. The image depicts a large family of creamy-skinned sitcom characters riding in an oversized classic red Cadillac convertible with the Golden Gate Bridge in the background. The surrounding hills are lush and green; skies are blue. The position and expressions of characters in the car suggest a combination of interpersonal dramas and running jokes poised to pick up where the original series left off. Each element of the billboard could be read as an object lesson from Roland Barthes's *Mythologies* (1972), each semiological gesture designed to deliver a piece of a puzzle aimed at inviting viewers to watch, to log in, and ultimately to subscribe to a monthly streaming plan. In the wake of our protracted discussion of Komar and Melamid, it is tempting to read each element of the billboard as a response to a public opinion poll or, in the case of Netflix, a carefully harvested synthesis of user data portending success for the series.

What type of family do you prefer? White? Black? Asian? Hispanic? Other?
Should the family be: Attractive and well off? Scruffy and resourceful? Offbeat and zany? Dark and brooding?
Do you prefer narratives that are funny, dramatic, scary, adventurous, or mysterious?
Do you prefer cities, suburbs, or rural areas?
If cities, East Coast or West Coast?
If West Coast, Los Angeles, San Francisco, or Seattle?
If San Francisco, what is your favorite landmark?
Do you prefer landscapes that are hot and dry, wet and lush, or cold and snowy?
What kind of car do you prefer? Compact, sedan, SUV, convertible?
Do you prefer contemporary cars or classic cars?
And so on.

Of course, Netflix need not ever administer such a crude instrument. These questions—and many others—are answered with far greater nuance by analysis of streaming patterns among viewers of finely parsed demographics. The insights offered by these analytics may then be incorporated into decisions about original programming. In this sense, then, original programming by a company such as Netflix begins to resemble an ouroboros, with data-informed media being used to produce new streams of data to refine future productions, which, in turn, generate new data for analysis. Just as television was once outed for its role in "delivering people," today's media production must be held accountable for its role in delivering data.

When artists Richard Serra and Carlota Fay Schoolman created their classic work of video art *Television Delivers People* in 1973, in which a scrolling text offers a critical analysis of television, it was still possible to speak to TV viewers in the second person as a mostly homogenous group defined by its relationship to mass media. The text includes a series of statements:

There is no such thing as mass media in the United States except for television.
Mass media means that a medium can deliver masses of people.
Commercial television delivers 20 million people a minute.
In commercial broadcasting the viewer pays for the privilege of having himself sold.
It is the consumer who is consumed.
You are the product of t.v.
You are delivered to the advertiser who is the customer.
He consumes you.
The viewer is not responsible for programming------
You are the end product.
You are the end product delivered en masse to the advertiser.
You are the product of t.v.

It is necessary, in light of the conjoined practices of data analytics and data-informed media production, to amend Serra and Schoolman's declarations. Viewers in the 2010s may not be directly responsible for programming, but aggregated data is acknowledged as part of the decision process for Netflix in choosing its in-house productions. Actor and producer Kevin Spacey, in his keynote lecture at the *Guardian's* 2013 Edinburgh International Television Festival, explained the difference between the standard, pilot-oriented model of American television and how the dramatic series *House of Cards* (Netflix 2013–) was received. "Netflix was the only network that said, 'We believe in you. *We've run our data and it tells us that our audience would watch this series*. We don't need you to do a pilot'" (emphasis added).[24] Please don't misunderstand. I do not believe that images—much less entire TV series—are somehow imprisoned in data, waiting to be released. Nor is it my intention to diminish the creativity or sincerity of the producers of *House of Cards* or other Netflix original productions. My point is simple: the television consumer is consumed no longer by advertisers but by data.

The type of analytics available to Netflix represents a difference that is of both scale and kind. Hollywood has long deployed strategies for capturing viewer feedback, ranging from focus groups to Nielsen ratings, to shape its production decisions. In *George Gallup in Hollywood* (2006), historian Susan Ohmer describes the entertainment industry's uneasy adoption of social scientific methods for analyzing and predicting audience taste in the 1940s and 1950s. Founded in 1935, the Gallup organization had quickly earned a reputation as the preeminent opinion polling firm in the realm of American politics and advertising. In 1940, Gallup founded the Audience Research Institute to bring its analytical methods to the film industry. This move was not welcomed by many in the entertainment industry, where studio moguls famously relied on artistic instinct or "hunches," based on years of industry experience, to predict financial success. So long as studio profits remained high, most major studios resisted parsing variations in box office returns. But as film industry profits began to decline later in the 1940s, the "scientific" methods offered by Gallup gained traction. Gallup's methods, like those of Komar and Melamid several decades later, were entirely noncomputational, relying on telephone-based and door-to-door interviewing to derive a combination of quantitative and qualitative data. The use of computers to guide production strategy in the film and television industries evolved steadily and with increasing influence in the decades that followed. Yet, the distance between contemporary computational analytics and the tabulated polling data pioneered by Gallup is as great as that between a viewer's opt-in survey ratings and the data generated by real-time streaming patterns.

The passively generated data resulting from viewers' real-time streaming provides a degree of insight surpassed only by real-time biofeedback, a technology that is starting to make its way into the market, swimming cautiously against the tide of well-justified public suspicion. The closest analog to this type of data might be found in the controlled use of real-time feedback systems that invite test audiences to evaluate material, such as advertisements and TV pilots, by turning a knob to indicate relative levels of attention or amusement. By comparison, the massively scaled data analytics available to streaming media companies such as Netflix, Hulu, and Amazon evaluate both broad patterns and granular specifics, reflecting actual viewer behaviors in their native habitats.

Netflix's commercial success at operationalizing viewer analytics is consistent with the company's alignment with the data-driven sensibility of Silicon Valley in contrast to the box office and ratings orientation of the film and TV industries. Media content, as much as it continues to resemble familiar cinematic and televisual genres, is also a tool for generating an increasing volume and sophistication of viewer data. In the end, what matters is not the existence of a circular relationship between viewing data and media production, but the *absence* of the kind of public discussion around questions of taste, art, and democracy that was occasioned by Komar and Melamid's *Most/Least Wanted*. Consumers who have been sufficiently familiarized with the logic of corporate data mining and procedurality may focus on optimizing their own experience or mocking the obtuseness of recommendation engines rather than engaging in public dialogue or cultural intervention on the subject. On bad days, I view this as approaching precisely the neoliberal cynicism that Cubitt warned against or, indeed, the supplanting of theory by "big data" as celebrated by *Wired*'s Chris Anderson. On better days, the development of even self-serving modes of algorithmic literacy suggests the potential for beginning a much-needed conversation about the role and limits of data mining in everyday life.

Another Parable of Visualization

More conventional histories of data visualization begin with work by nineteenth-century figures such as Charles Joseph Minard, John Snow, and Florence Nightingale, all of whom were valorized by contemporary information visualization guru Edward Tufte. Along with his many disciples, Tufte has passionately advocated for visualization strategies driven by principles of efficiency and clarity, preferably executed by professional designers.[25] Tufte draws a sharp contrast between the hygienic precision of his own economical design style and the excess and imprecision that results from putting digital tools for graphic design in the hands of amateurs.

Tufte's well-publicized diatribes against poorly designed presentations created with Microsoft's PowerPoint software came to a head in 2003 in a public "debate" between Tufte and musician David Byrne, former lead singer of the Talking Heads, who had produced a multimedia artwork using PowerPoint. Their pro-con argument about the platform resulted in concurrent articles in the September 2003 issue of *Wired*, published under the subtlety-challenged titles "Learning to Love PowerPoint" and "PowerPoint Is Evil."

Motivated in part by the public sensation surrounding this debate, Byrne went on to publish a book with a title that parodied Tufte's series of self-published design manifestos. Byrne's book, which was sold with an accompanying DVD containing twenty minutes of animated images and sounds created or assembled in PowerPoint, bore the title *Envisioning Emotional Epistemological Information* (2003). Sometimes shortened to *EEEI*, Byrne's title is at once a parody of Tufte's *Envisioning Information* (1990) and an anagram of the electrical engineering organization IEEE (Institute of Electrical and Electronics Engineers), which counts among its subfields the development of tools for data analysis and visualization.

Like Tufte, Byrne's book sales undoubtedly benefited from the widely publicized difference of opinion over PowerPoint. Both writers, however, share a familiar binary, favoring professional creatives (musicians, designers) over ordinary users of a software program designed for a limited range of business applications. The positive attributes that Byrne finds in PowerPoint's automated animation and presentation features actually do little to address Tufte's attack on algorithmic information visualization. Byrne writes, "I began to see PowerPoint as a metaprogram, one that organizes and presents stuff created in other applications. … What's more, the application can be made to run by itself—no one even needs to be at the podium. How fantastic!"[26] In fact, Byrne's admission that PowerPoint is most effectively used not as an authoring tool but as an aggregator for externally generated content undermines the ostensible premise that he was defending PowerPoint against the charges leveled by Tufte.

Byrne's DVD consists of five short videos, with animations created using text, graphics, and occasionally the background-generator features native to PowerPoint, along with retro transition effects such as pixelated dissolves, gradients, and wipes. The audio track is lush with instrumentation, alternately melancholic, lyrical, and discordant, providing nonverbal accompaniment to the cascade of visuals that is in every way antithetical to the business aesthetics of PowerPoint's intended consumer base. But like many of the graphical elements that Byrne simply animates with the software, the music has been entirely composed outside the presentation software, which serves only to synchronize sound and image for playback.

Byrne's animations mostly use PowerPoint to critique the presumptions and aesthetics of business software and marketing, with one notable exception. The final composition of the five videos, titled "Physiognomies," deals with the then nascent technology of facial recognition, which Byrne positions on a continuum with physiognomy, a nineteenth-century pseudoscience. Physiognomy was devoted to deriving a scientific basis for racist and eugenicist ideology, proposing linkages of bodily features, especially cranial size and shape, with degrees of intelligence or moral character. In the book's introduction to this piece, Byrne notes the reappearance in the digital realm of long-ago discredited methods associated with physiognomy. "Digital Physiognomy uses a sophisticated neural network to identify correlations between facial features and psychological characteristics using photo-identification techniques recognized by law-enforcement officials."[27] Although Byrne's critique is only obliquely implied in the video, his linkage between biometric technologies of the nineteenth and twenty-first centuries is apt. (I return to linkages between the translational strategies of nineteenth-century biometrics and more recent technologies of facial recognition in chapter 2.)

Focusing on more conventional uses of PowerPoint, Tufte compares the software to a drug with unacknowledged side effects that "induced stupidity, turned everyone into bores, wasted time, and degraded the quality and credibility of communication."[28] Although he offered no evidence to support his implication that it was widely or uncritically used, Tufte's diatribe inveighed most bitterly against the tyranny of automated design, PowerPoint's admittedly dubious feature that automatically generates information visualizations from spreadsheet data.

> Applying the PowerPoint templates to this nice, straightforward table yields an analytical disaster. The data explodes into six separate chaotic slides, consuming 2.9 times the area of the table. Everything is wrong with these smarmy, incoherent graphs: the encoded legends, the meaningless color, the logo-type branding. They are uncomparative, indifferent to content and evidence, and so data-starved as to be almost pointless. Chartjunk is a clear sign of statistical stupidity.[29]

In his article, Tufte presents unsightly examples of graphs generated using this tool, but his charges ring hollow in the absence of evidence that PowerPoint users were broadly duped into mistaking them for good design. At the heart of Tufte's denunciations is a conventional reassertion of the amateur-professional hierarchy, occasioned by the spread of desktop publishing and presentation software that promised to erode this distinction in favor of nonprofessionals.

The real problem, in the historical context of the early 2000s, was the general lack of awareness about the functioning of algorithms within digital culture. Even enthusiastic, early adopters of digital authoring software may not have recognized multiplicity as one of the key affordances of algorithmic transformation. However, Tufte's categorical privileging of visual economy should be regarded, like all reductive epistemological models, with a degree of skepticism. Tufte's influential but single-minded desire for direct, minimalist translation of data into visual form represents only one possible response to the spread of algorithmic culture. In fact, what I have dubbed the "translational mode" of converting between images and data is sufficient to describe only a narrow—and far from the most interesting—slice of the overall field of data visualization. Of particular interest, following the discussion of Komar and Melamid above, are those instances where algorithm-based processes of translation are negotiated by humans and/or alloyed with alternative parallax relations.

Data Epistemologies

The stage-managed controversy between Tufte and Byrne marks a transition in the discussion of data visualization from the purposes of art and entertainment to the realm of epistemology. First, we should remember that images were once similarly vilified as simplifiers of complexity, agents of consumerism, and manipulators of democracy. Writing in 1962, historian Daniel Boorstin referred to his century's "graphic revolution" as a symptom of the debasement of mass media. For Boorstin, commercial media, especially television, marked a point of no return for visual culture's addiction to banality.[30] Though Boorstin's critique has long been superseded by more generous and nuanced analyses of popular culture, the sentiment that images pose a threat to traditional text literacy has proved surprisingly tenacious.[31] In an age of data visualization, however, images have come to serve the opposite function. Compared with the abstract realm of data, images are now seen as consummate and efficient conveyors of meaning.

Computational research has a long and controversial history in the humanities, where literary scholar Franco Moretti's advocacy of "distant reading" marks only the most recent example. Moretti's position is deliberately provocative, advocating departure from the humanities' most tried-and-true strategies of close reading. "We know how to read texts," Moretti famously prodded his peers across the academy. "[N]ow let's learn how not to read them."[32] A nondefensive reading of Moretti reveals many more nuanced points that have found their way into mainstream literary studies. In the computational analysis of literature, text encoding can be viewed practically, not as an end in itself but as a means to sort through unimaginably vast quantities of text—more than could be read by many humans in many lifetimes—to refine an area of investigation or test a research hypothesis before undertaking closer analysis.

The introduction of large-scale data analytics within literary studies does not imply a necessary either/or; the two may readily sit side by side, and indeed the logical relationship between them is one of reciprocity. Building on Moretti, Matthew Jockers adopts the term "macroanalysis" to suggest a parallel with the acknowledged benefits of coexistence between the complementary fields of microeconomics and macroeconomics. Macroanalysis, in this context, is a complement to microanalysis, with close and distant reading simply yielding different insights and avenues of investigation.[33] For Lisa Gitelman, among the benefits of introducing a "distant" perspective on humanities research is a reminder that "when we put our own critical perspectives into historical perspective, we quickly find that there is no stance detached from history, which is to say that there is no persistently objective view."[34] In other words, Moretti's methods afford not just a widened critical corpus but a reconception of literary analysis itself as a set of identifiably embedded and delimited historical practices.

Gitelman further argues that we should treat data "as a matter of disciplines—rather than of computers."[35] Here, Gitelman distinguishes between computational humanities work that deploys computers for analysis of large-scale cultural corpora and the need for computationally literate analysis of the ways in which data has functioned in cultural contexts as diverse as astronomy and slavery. In framing her *Raw Data* anthology, Gitelman consistently foregrounds cultural and disciplinary contexts as crucial to the meaningful use of data. This supports my contention that digital culture studies should remain in dialogue with visual and cultural studies; but that dialogue continues to unfold unevenly, depending on disciplinary contexts. As Gitelman further notes, "Few literary critics want to think of the poems or novels they read as 'data,' and for good reason."[36] She continues, "The skepticism within literary studies about Franco Moretti's 'distant reading' approach, which in part reduces literary objects to graphs, maps, and other data visualizations, testifies to the resistance the notion of literature as data might provoke."[37] At its best, the disruption sparked by Moretti should provoke reflection on unspoken or infrequently challenged disciplinary conventions. The defensive posture that frequently results seeks to reassure those in academia that human interpretation is "still necessary." Carried to its logical conclusion, however, the real message is not "we are still relevant" but the opposite—with the way things are going, one day we surely won't be.

Visualization is just one among many strategies that has fueled digitally enhanced scholarship. In fact, efforts at large-scale quantitative research in fields such as linguistics long predates "humanities computing" as it was conceived in the 1950s. American linguist George Kingsley Zipf conducted research on language frequency as early as the 1930s.[38] Although Zipf's work did not involve computation, it did require a corpus of linguistic data to be divided into tabulated components that could be tracked across geographic regions. Decades later, the use of computer algorithms to analyze artistic styles closely followed the model established by text analytics, prompting similar results, headlines, and anxieties within the fields of art history and visual culture.[39]

It is possible to trace multiple historical trajectories for what is now termed the digital humanities, not all of which involve computational analysis, encoded text, or large-scale data sets. Tara McPherson has asserted a historical origin for digital humanities that privileges expressive, affective, and embodied forms of communicating humanities research, looking back on work by Charles and Ray Eames in the late 1950s. McPherson also cites the art-science collaborations of the Experiments in Art and Technology (EAT) collective beginning in the late 1960s as evidence of a vibrant historical collaboration between artists and engineers.[40] Large-scale, complex multimedia installations and performances offer an alternative historical lineage for the digital humanities. This history is quite different from the canonical history of humanities computing that is most often traced back to Roberto Busa's *Index Thomisticus* (1946–1974), an electronic concordance to the written works of St. Thomas Aquinas, which was undertaken with the support of IBM.[41] Within the digital humanities, the legacy of Busa's work can be found in the computational analysis of large-scale digital archives, but this is as likely to result in conventional, text-based publication as in electronically enhanced or richly mediated scholarship.

Within the expansive field of digital humanities, scholars find continuing evidence of a bifurcation that may be grossly described in terms of differing approaches to the study and use of data and images. Dramatic differences in the scholarship resulting from text encoding or data analytics compared with that of, say, videographic scholarship prompted Holly Willis to propose an alternative category she dubs the "cinematic humanities." For Willis, what sets the cinematic humanities apart is its simultaneous investment in "humanistic inquiry enhanced through the practices and modes of cinema, even as cinema continues to expand into what has been dubbed 'the post-cinematic.'" Envisioning a "post-cinematic" future, Willis sees the potential "to imagine critical practices that are immersive, embodied, gestural and virtual, and to engage in acts that integrate thinking, writing, coding and designing."[42] Critical work modeled on the cinematic arts may be uniquely attuned to issues such as space, affect, movement, dimensionality, and the subjectivity of viewers and interactors, all factors that are more readily conveyed by established paradigms of images as opposed to data.

Let's Build a Smarter Planet

For more than six decades, the art and design patronage of International Business Machines (IBM) Corporation has resulted in a striking combination of corporate image building and visionary experiments with computational and protocomputational media. From artist residencies by John Whitney and Charles and Ray Eames in the 1950s to IBM's sponsorship of grandmaster chess (Deep Blue) and *Jeopardy!* (Watson) challenges, IBM has worked for many decades to bring computational literacy to the public. IBM has also been among the most active corporate players in engaging the cultural effects of computerization in the workplace (Walter Lang's *Desk Set*, 1957), in museums (the Eames's *Mathematica* exhibit, 1961), and in daily life (Ogilvy & Mather's Let's Build a Smarter Planet advertising campaign, 2010). The historical trajectory of IBM's ongoing public relations efforts maps a revealing shift in parallax, from the hermetic separation of data and images in the Eames's work to a series of infuriating equivocations in the visually stunning design fictions for Let's Build a Smarter Planet. Although each of the art and design works resulting from IBM's patronage is deserving of analysis on its own, in the context of a discussion of data visualization, I focus on the series of four short videos that launched the company's Let's Build a Smarter Planet advertising campaign.

Let's Build a Smarter Planet included a variety of print and online materials that combined to create a rich visual vocabulary for the idealized synthesis of data and images. Along with it, IBM announced that "smart" technologies could solve a vast array of the world's problems, from health care to transportation and energy use. IBM's advertising agency, Ogilvy & Mather, won numerous awards for the campaign, and IBM has continued to expand its connection to smart technologies and responsible global citizenship as an integral part of the company's brand.

Three of the four short videos that contributed to the campaign—"Data Baby," "Data Energy," and "Data Transportation"—were produced by the Los Angeles–based design firm Motion Theory, while the first video, "Data Anthem," was produced by James Frost of Zoo Films, in partnership with The Mill. The videos themselves, described as a form of "data-driven design,"[43] do not present a visualization of any actual data. This distinction is intended not to privilege "real" over "fake" visualization, only to recognize the difference between visualizations based on literal translations of data, compared with computer-generated motion graphics that are strictly expressive. As examples of the latter, these videos are free of any mathematical connection to measurable phenomena in the world. The politics of these videos therefore lie not in the realm of data acquisition or processing but in visual rhetoric. If authenticity had been the goal, it would certainly have been possible to include "real" visualizations of data pertaining to electricity usage, urban transportation, or a baby's vital signs. Instead, these ads invite us to reconceptualize the visible world as data space, frequently deploying the visual vocabulary of 3D modeling software, including point clouds that seamlessly morph from one shape into another.

The first of the series, "Data Anthem," begins with a colorful radial burst resembling an exploding star, which spins to form a glowing cluster of downtown high-rises. Meanwhile, a disembodied camera performs a rapid fly-through into the heart of a city and tracks around a vehicle composed of glowing bits; the virtual camera completes a semicircular arc before pivoting to an overhead position from which we witness the car transforming into a human figure on a hospital gurney. The camera then pushes through the hospital scene to follow high-voltage electrical wires, zooming down to the scale of an excited electron, then back out—an apparent homage to the Eames's *Powers of Ten* (1977)—to reveal a planet glowing and pulsing with spikes indicating worldwide electricity usage or possibly data production. Finally, the earth explodes into a glowing, pulsing Let's Build a Smarter Planet logo, which in turn shatters and reconstitutes as an oozing, neon version of Paul Rand's venerable IBM logo. This dense thirty-second spot contains not a single cut, which might suggest a threat to the continuity and seamlessness of IBM's synthetic vision of the world.

The accompanying voiceover offers IBM's vision of the central role of data in reshaping every aspect of technology, health care, and urban planning.

Our planet is alive with data.
It's generated by cars on a freeway,
patients in a hospital,
electricity in the grid.
The more we understand data, the more answers we find.
Patterns are easing traffic in over 400 cities,
detecting disease faster,
reducing energy costs by ten percent.

On a smarter planet, we can analyze all the data we now see,
to make the world work better.
Let's build a smarter planet.

Although the narrator's key assertion, "On a smarter planet, we can analyze all the data we see to make the world work better," is predicated on identifying patterns within data that has been translated into the visual register, the video's depictions of "data" shows no trace of the prosaic mechanisms by which real data is captured or processed. Ignoring the need for material apparatuses such as sensors, electrodes, and transducers, the video instead presents colorful, translucent waves that emerge organically from the landscape, from bodies, and from objects in space. The result is a misleading naturalization of data's existence in the visible register, coupled with an ironic suppression of precisely the type of computing hardware that IBM is best known for manufacturing.

In aggregate, the videos that launched the Let's Build a Smarter Planet campaign were an influential model for the vocabulary of data visualization that was rapidly infusing visual culture in the early 2010s. The grammar of visualization seen in these videos reveals the desires we now invest in data as a key component of contemporary knowledge production. Framed by IBM's declaration that 2010 marked the opening of a "decade of smart," variations on the vocabulary of data visualization seen in these spots has filtered into many other contexts, from feature films and television, to newspaper graphics and advertising. Most important, simulated visualizations like this have shaped cultural expectations for what data visualization can or should look like, setting expectations that are often misleadingly high.

The ability to see and interact with waves of data has subsequently become a common cinematic and televisual trope via fictional characters who develop enhanced mental abilities that allow them to directly access information from the electromagnetic spectrum. We may regard these as Hollywood design fictions for an idealized, hardware-free interface by which humans interact with digital information. Like the IBM ads, rainbow-colored sine waves naturalize the encoding and decoding of data as if it were not governed by digital protocols or accessed through physical technologies that require human labor, industrial capital, and a calculable amount of environmental damage simply to appear on screen. In erasing the underlying technology of both software and hardware, these visions of an evolved bodily interface flatten distinctions among the diversity of electromagnetic signals, which are already widely misunderstood, even without imagining that they can be directly accessed by the human senses of sight or touch.

Two recent examples include Scarlett Johansson's eponymous character in the Luc Besson film *Lucy* (2014), whose cognitive abilities have been chemically expanded. Another is the autistic character Gary Bell (Ryan Cartwright) on the Syfy TV series *Alphas* (2011–12). Both Lucy and Bell are able to reach out and touch the streams of data emitted from unseen towers and transmitters, using gestures familiar from screen- or motion-based controls, such as swiping, pinching, and tapping. Not only do the IBM ads and these Hollywood design fictions erase the infrastructures that make them possible, they represent a convenient fiction for Hollywood in the midst of its ongoing rivalry with Silicon Valley. If only human cognitive and perceptual abilities could be amplified to the point of obviating the need for computers and game consoles, then Hollywood's victory over the consumer technology industries would finally be complete. Industrial rivalries aside, it is worth taking seriously the question of whether data visualization creates pseudoknowledge about the world or offers the key to understanding the deluge of cultural data in which we currently reside.

Translational Visualization

The volume and complexity of data generated by machines in the twenty-first century exceed human comprehension. This is nothing new within the discourse of computation or, indeed, that of analog information storage and retrieval. Encyclopedias and physical archives hold more information than the human brain can reliably manage; Bertillon's filing system handled more suspected criminals than any squad of detectives could track. Most contemporary data processing has no visual component, literally no point of entry for the unaided human sensorium to meaningfully engage it. Self-driving vehicles, for example, need not generate real-time models of their environment from the sensor data used for navigation. The most important interactions in such a system take place between machines and other machines, or software and other software. Only when the goal of a data system is to aid human understanding does the translation of data into visual form become necessary. Fields ranging from journalism to the sciences have made a conscious effort to codify the terms under which data is rendered legible to nonmachines and nonspecialist humans. Like any other field of visual expression, data visualization should therefore be understood in terms of cultural rhetoric and not merely as the result of technical processes.[44]

The availability of data, the tools for visualizing it, and the cultural sensibility required to understand it have all dramatically increased in the past decade. In 2012, the *Harvard Business Review* named data visualizer the "sexiest" profession of the year.[45] Data visualization has also proliferated in mainstream journalism. The *New York Times*, to enhance visualization efforts begun in 2008, enlisted the talents of data visualizer Jer Thorpe, who served as data artist in residence at the *Times* R&D Lab from 2010 to 2012, helping to develop the graphical vocabulary of the paper's visualizations in static and dynamic contexts. For journalistic and scholarly purposes, visualization emphasizes reliable translation from the abstract to the evocative or evidentiary, posing logistical and creative challenges. As the *Times* was developing its own expressive style for print and electronic visualization, the paper also opened its data API, allowing anyone with the technical skills and access to create their own visualizations. This led to evocative external projects such as Tim Schwartz's NYT Data Grapher, Command Center, and Geohistoriography, among many others. The *Times* thus became a central conduit in the two-way flow between data and visualization, simultaneously making the paper's contents available for use by others and elevating visualization as a key strategy in the beleaguered evolution of news journalism.

In addition to its utilitarian applications, data visualization has found its way into various artistic forms, ranging from studio art to music video. Among the most prolific and accomplished data artists is Aaron Koblin, who has been a key collaborator on numerous groundbreaking projects, including Chris Milk's "The Wilderness Downtown" (2010) music video for Arcade Fire, and the crowd-sourced music video "The Johnny Cash Project" (2010). Koblin's creative experimentation dates back to his time as a graduate student in the Design Media Arts program at the University of California, Los Angeles (UCLA), where he studied with Casey Reas, cocreator of the programming language Processing. Koblin's MFA thesis *Flight Patterns* (2005) used Processing to translate publicly available flight data from the Federal Aviation Administration (FAA) into colorful traces showing the paths of airplanes over North America during a single twenty-four-hour

Figure 1.2
Visualized flight-tracking data creates an aestheticized portrait of North American air travel in Aaron Koblin's *Flight Patterns* (2005). Image courtesy of Aaron Koblin.

period. Although Processing performs an automated—or algorithmic—translation of abstract FAA data into aesthetic forms, there is nothing natural or automatic about the way the visuals are produced. Koblin made a series of formal decisions, which were encoded into a Processing sketch that converted FAA data into lines, colors, and durations.

If keyed to their original data—the colors on Koblin's map signify different kinds of airplanes, for example—the resulting image could be thought of in terms of the straightforward translation of information into an arbitrarily codified visual system. The aesthetic pleasure of *Flight Patterns*, however, does not lie in its conversion of abstract air traffic data into "understandable" forms. In its time-based version,[46] *Flight Patterns* tells the story of a day-in-the-life of North American aviation. A video running less than a minute traces flight paths during slightly more than twenty-four hours. Only two items of information are provided, the time of day and the number of planes, ranging from about four thousand to nearly twenty thousand being tracked at any given moment. With repeated viewing, several patterns emerge, confirming viewer expectations about the ebb and flow of national and international passenger flights. Likewise, geographic contours of the continent and its cities emerge from the darkness, with hub cities erupting like fireworks across the Midwest as the day begins. International flights arc across the sky like comets with slowly dissipating tails, then disappear abruptly at their destinations. Close inspection reveals that the rendered flight paths are remarkably noisy, quivering and zigzagging along their route, suggesting the limits of the system's ability to translate physical space to digital trace.

Another prototypical visualization project is Jer Thorpe's GoodMorning! (2009). Created during his tenure in the *New York Times* R&D Lab, Thorpe mined the Twitter API for instances of the phrase "good morning" in various languages around the globe. The messages were then aggregated and visualized by language, time of transmission, and the number of users saying "good morning" in any given place. The resulting dynamic 3D model shows waves of colored pistons erupting around the globe, roughly following the sun, and shifting hues to reflect linguistic differences. Although it is possible to derive some meaning about global time zones, and the densities of Twitter users or multiple languages in various geographic regions, GoodMorning! is less about information transmission than a kind of naïve assertion of global sameness. Despite all our differences, the project suggests, the shared ritual of a banal morning greeting unites worldwide Twitter users in rainbow-hued, graphical harmony.

Even before the beginning of IBM's "decade of smart" had officially begun, an array of DIY tools for converting abstract data sets into evocative forms had been widely integrated into knowledge production and dissemination. Among the most prominent and influential was Martin Wattenberg and Fernanda Viégas's Many Eyes (2007), a tool created as part of their work in the IBM Visual Communication Lab from 2005 to 2010. With the stated goal to "'democratize' visualization, and experiment with new collaborative techniques,"[47] Many Eyes was among the first genuinely robust, publicly available online systems for data visualization. Until the project was shuttered by IBM in 2015, Many Eyes allowed users to upload data sets to create multiple formats of visualization. "Data visualization," Wattenberg noted in 2008, "has historically been accessible only to the elite in academia, business, and government. But in recent years web-based visualizations … have reached audiences of millions. Unfortunately, while lay users can view many sophisticated visualizations, they have few ways to create them."[48] Offering fewer graphical presets than the open visual architecture of Processing favored by many artists, Many Eyes nonetheless brought sophisticated tools for visualization to a broad, nonspecialist user base.

Although their mandate from IBM was to facilitate practical, utilitarian strategies of visual communication, Viégas and Wattenberg indulged parallel, creative aspirations for their work. Writing outside their role as IBM researchers, the two were prone to wax artistic when describing the insights that data makes possible, framing their goals in markedly intimate, somatic terms: “Our work explores the joy of revelation: the special electricity of seeing a city from the air, of hearing a secret, of watching a lover undress.” Describing themselves as “proponents of expressive visualization,” Wattenberg and Viégas continue:

> [W]e believe visualization to be an expressive medium that invites emotion. We aim our tools at “data sets” that range from hip hop songs to Walt Whitman’s poetry, from arguments on Wikipedia to expressions of carnal desire. We strive to expand the practical craft of visualization beyond function to create objects of social engagement, pleasure and revelation.[49]

I quote this at length out of respect to Viégas and Wattenberg, whose genuinely pioneering work offers much to be admired. On a personal level, the pair seems determined to follow in the footsteps of Charles and Ray Eames in confounding the domains of art and science, joyfulness and technology. But what specifically are we to make of the romanticist underpinnings of their statement as it careens from sentimental to sexual, technical to sublime? The statement was composed during Wattenberg and Viégas’s early days at IBM—also once home to the Eames—and has followed them to their position since 2010 as codirectors of the Big Picture Group data visualization lab at Google. Perhaps part of the statement’s tenacity lies in its shock value, the unexpected conflation of decidedly human carnal pleasures as a foil for the cold impersonality of computation. Is this a virtuosic turning inside-out of technocratic discourse or a giddy foray into naïve poeticizing?

In Viégas and Wattenberg’s own binary, the scientific and computational realms are placed in stark opposition to the human, poetic, sexual, and artistic. Likening the tools of computation to those of science—microscopes, telescopes—Wattenberg and Viégas revisit the nineteenth-century fascination with phenomena that elude perception by the unaided eye. Scientists and nonscientists alike have long recognized the aesthetic pleasures of their objects of study—the formal beauty of astronomical or microscopic phenomena, for example—as an ancillary feature of their primary pursuit of knowledge, or perhaps as a vehicle for promoting their work to nonspecialists.

There is no doubt of the aesthetic pleasures offered by much of Wattenberg and Viégas's work, some of which alludes gracefully to abstract art, as in Wind Map (2012), while other works brush against the erotic, such as Fleshmap Touch (2008). For Wind Map, Viégas and Wattenberg scraped data indicating wind speed and direction across the United States once an hour from the National Weather Service's National Digital Forecast Database. Using Javascript and HTML, they generated animated lines and swirls that play as a loop until the next data update occurs. The scale of the project necessarily reduces a massively complex and variable weather system to a limited number of homogenous visualizations, ensuring that the project can present only the grossest patterns of actual wind data, pleasingly rendered like the swirled brush strokes of a cloud formation by Van Gogh. As with Koblin's *Flight Patterns*, broad patterns become discernible in relation to known geographic features, such as mountains and bodies of water, or weather events, such as hurricanes, but overall the point of the project is formal pleasure rather than meteorological or epistemological clarity.

Described as "an inquiry into human desire,"[50] Viégas and Wattenberg's Fleshmap Touch attempts to visualize erogenous zones of the human body. To create the project, Wattenberg and Viégas selected images of idealized, white, naked male and female bodies from 3D.SK,[51] then created an online survey via Amazon's Mechanical Turk (a low-cost online system that matches low-wage laborers with projects requiring short-term attention) and invited paid respondents to answer two questions: "How good would it feel to touch this area?" and "How good would it feel to be touched in this area?" Frontal and rear images of the male and female bodies were encoded with 707 potential points of contact, and an interface invited survey respondents to express their preferences for touching and being touched. Wattenberg and Viégas then performed statistical analysis on the responses—including demographic data for respondents, such as gender, sexual orientation, and age—and mapped this data back onto the relevant male and female figures, generating a heat map of desire for sexual touching. In aggregate, the results of the survey largely conform to cultural norms for bodily eroticism.

In an essay titled "Beauty and Danger: The Aestheticization of Information in Contemporary Art," Melissa Ragona articulates a withering critique of Fleshmap that is typical of objections to the knowledge-producing capacity of aggregated data.[52] Visualizations that favor the "signal" of consensus over the "noise" of variation, Ragona argues, may confirm broad trends at the expense of minority opinions. Visualizations that are dominated by the logic of averages and majority opinions are particularly detrimental to projects like Fleshmap that seek to mine individual desire, which is surely more interesting in its capacity for variability and idiosyncrasy than its tendency toward consensus. Ragona mercilessly denounces Fleshmap's failure to do anything but confirm obvious generalizations, noting, "Surprise, surprise: men's favorite zone to be touched is the penis."[53] The results of Fleshmap Touch, for Ragona, remain "enigmatic at best, and obfuscating at worst."[54] Data visualization's ability to express complex phenomena is precisely what confers its power as well as its potential for oversimplification. It is not enough simply to embrace the inevitability that anything that *can* be visualized *will* be visualized. What is needed is an orchestrated retraining of expectations related to the visualization of cultural data, resulting in technically sophisticated and methodologically aware systems of meaning making.

Analyzing Cultural Analytics

Cultural analytics has thrived over the past decade as the central initiative within Lev Manovich's Software Studies Initiative research lab. The cause taken up by Manovich and his team is a laudable one, to bring computational analytics to a wide variety of cultural artifacts as data sets: old and new, high and low, commercial and experimental. The lab's signature inversion of traditional scientific hierarchies privileging quantitative over qualitative data allows humanities researchers to engage directly in computational analysis—and has also opened the door to funding from entities such as the National Science Foundation—bringing issues of visual culture into the realm of digitally enhanced cultural theory.

Broadly, cultural analytics aspires to make a seat at the table of big data available to artists and humanists. Manovich defines cultural analytics as "the analysis of massive cultural data sets and flows using computational and visualization techniques."[55] Projects undertaken in the name of cultural analytics have worked to bring this logic to bear on a diversity of cultural phenomena using an innovative set of software tools and methods.

At the time of the lab's inception, Manovich was a faculty member in the Department of Visual Arts at the University of California, San Diego, and many of the group's projects continue to be exhibited in fine arts contexts, especially gallery spaces and hybrid art-science spaces, such as the Highly Interactive Parallelized Display Space (HIPerSpace) display system at the California Institute for Telecommunications and Information Technology (Calit2). The Software Studies Initiative has subsequently expanded operations to the Graduate Center of the City University of New York (CUNY), where Manovich made the transition from a department of visual arts to one of computer science. The work continues to have relevance across domains of art, design, technology, social science, and cultural criticism. In 2016, Manovich co-organized a months-long institute at UCLA's Institute for Pure and Applied Mathematics, where professional contexts ranged from artificial intelligence to advertising. In addition to establishing best practices for analytics and visualization, one of the benefits of the lab's eclectic range of activities is to catalyze collaborations across unexpected fields of expertise and practice.

In 2013, Manovich distilled many of the research questions of cultural analytics pertaining to the issue of "software epistemology" in his book *Software Takes Command* (2013). He argued for the permanent extendibility of the computer as a "metamedium" that gives rise to an evolutionary system supporting the emergence of multiple new "media species."[56] These are intelligible for Manovich through the lens of software studies, which analyzes in detail the technological affordances of software in specific stages and contexts of deployment. Software studies fills a gap in the literature of media and technology studies, where the affordances, precepts, and limitations of basic tools of cultural production too easily lose their specificity. Software studies takes pains to situate software—both in development and in use—within a historical context that accounts for commercial, technical, and cultural influences.

Cultural analytics likewise promises new ways of viewing and analyzing cultural data. Hence, it is appropriate that frames drawn from Dziga Vertov's documentaries *Man with a Movie Camera* (1929) and *The Eleventh Year* (1928) provided early data sets for analysis. Vertov's human-machine Kino-Eye sought precisely the kind of hybrid vision and ubiquitous capture that would come to drive a whole spectrum of the consumer electronics industry nearly a century later—an intelligent, mobile, mechanical agent for re-visioning the world. When Vertov grafts his brother's camera onto the human body and brings it to life, he endows the apparatus of cinema with both agency and autonomy—a prescient glimpse of contemporary machine vision and mobile media. It is easy to forget, however, that Vertov's intervention in the emerging languages and technologies of cinema was deeply enmeshed in a politics of seeing that was inseparable from the utopian pretensions of the pre-Stalin-era Soviet Union. The significance of this moment in cinematic (and indeed revolutionary Soviet) history is irreducible to the kind of formal properties (close-ups of faces, tonal ranges, shot transitions, etc.) that computers are currently able to recognize. Such analysis might well result in insights related to the formal properties of the film in terms of cinematography, visual effects, or editing, but is less suited to engage issues of politics and history.

In his essay "Visualizing Vertov," Manovich is clear on the complementary methodologies at work in cultural analytics:

> In some cases, we use digital image processing software to measure visual properties of every film frame such as average gray scale value, contrast, number of shapes, number of edges, the relative proportions of different colors, texture properties, and so on. … In other cases, we don't measure or count anything. Instead, we arrange the sampled frames from a film in … single high-resolution visualizations in particular layouts. This use of *visualization without measurements, counting, or adding annotations* is the crucial aspect of my lab's approach for working with media data sets, and I hope that it can add to other approaches already used in quantitative film studies and digital humanities. (emphasis in original)[57]

The Vertov study represented an attempt to put the tools of cultural analytics to the test with a full-scale interpretation of Vertov's work based on image analysis, providing an especially revealing comparison with films made by Sergei Eisenstein during roughly the same period. The resulting insights confirmed, but also challenged, certain aspects of the conventional wisdom about Soviet montage practices and Vertov's own assertions about Kino-Eye. These computational analyses, as Manovich notes, are powerful and fast, saving time for researchers and providing glimpses of potentially fruitful areas for future research. They are also, he reminds us, not intended to supplant the conventions of human-based analysis. They are simply another tool available to media and cultural scholars, a way to augment one's existing expertise.

Manovich aptly compares computational analysis of Vertov's film with the Eames's *Powers of Ten*. Where the Eames created a series of analytical

Figure 1.3
Machine vision software for cultural analytics extracts closeup faces from Dziga Vertov's *The Eleventh Year* (1928). From Lev Manovich, "Visualizing Vertov," *Russian Journal of Communication* 5, no. 1 (2013): 44–55. Image courtesy of Lev Manovich.

zooms through space, from the farthest reaches of the galaxy down to the level of individual atoms, the Vertov project performs a kind of temporal zoom, ranging from the whole of cinema history to the level of individual shots and frames. This massively variable perspective enables a single researcher to bring a shared analytical framework to bear on the entire corpus of early Soviet film, then to zoom in on Vertov's body of work, followed by the entirety of *Man with a Movie Camera* or *The Eleventh Year*, which are further dissected into individual sequences, shots, and ultimately, individual frames. Manovich describes the overall project of cultural analytics as a combination of "browsing" and "exploring," a process by which one discovers questions to ask within an otherwise impenetrable data set.[58]

A persistent problem with computer-vision-based analysis lies in the limitations of its analytical paradigms. If we accept the form-based constraints of machine vision, we may gain some insights into patterns within the text being studied. Manovich maps these onto a meaningful analysis of the films, contrasting or supporting conventional wisdom about montage editing. Presumably, part of the justification for selecting Vertov's work derives from the formal interests of the early Soviet filmmakers themselves. But formalism was not the only—or even the most important—concern for Vertov and his successors. Whereas machine vision is entirely capable of recognizing cuts or close-ups of faces, providing insight into editing or shooting strategies, other types of cultural signification—such as class status or embodiment of revolutionary ideals—which were also central to Vertov's visual rhetoric, remain elusive.

Computer models offer seductive mechanisms for analysis, and carefully selected data sets may yield useful insights. In a historical context, it is important to remember that computational analysis arose at the very moment when minority discourse began to assert a viable mainstream presence within the academy. As feminist histories, postcolonial histories, and a range of alternative, often racial or ethnic, microhistories were achieving credibility, computers enabled the smoothing over of such differences in favor of more readily quantifiable parameters. We need not challenge the veracity of insights yielded by this process, but it is legitimate to question which issues on the vast landscape of cultural analysis are most vital to address at any given time. Even more important, we should ask what our analytical models and technological affordances lead us to do next. For such research to have significance, it is—or should be—a precursor to tangible social action.

Manovich's cultural analytics lab has adopted an open source ethos, allowing free access to a range of custom software tools and analytical paradigms. These include Image Montage, a plug-in for the software ImageJ, which was originally developed by the National Institutes of Health (NIH) for medical imaging and analysis.[59] Adapted by researchers in the cultural analytics lab, Image Montage facilitates the analysis and visualization of formal elements of cinema, such as shot lengths, cuts, close-ups, and transitions, as well as the tonal qualities of individual film frames. As the project has progressed, the range of objects and parameters under consideration in the name of cultural analytics has expanded far beyond cinema, proving especially useful for examining the overwhelming profusion of user-generated content circulated via digital networks.

Among these, the Selfiecity (2014) project has taken an integrated approach that makes use of both human labor and computational image analysis. Selfiecity drew on images posted to the online photo-sharing service Instagram, each geotagged from one of five cities around the world. The images were then processed through Amazon's Mechanical Turk to identify images that were consensually regarded as "selfies." Those images were also rated in terms of perceived age and gender, based on a male/female binary. Researchers then subjected the images to mood analysis based on facial expression and degree of head tilt, enabling them to look for answers to questions such as, "Which city's residents smile the most and who has more reserved looks? Which apparent ages and genders take the most selfies? Do angry people tilt their heads more strongly? What is a characteristic mood for people in Moscow? Do Sao Paulo women actually tilt their heads more? Do New Yorkers or Berliners look older?"[60] The Selfiecity website features an animated frontispiece that cycles through a sequence of dozens of selfies positioned in precise registration based on the eyes of the photographer-subject. The images dissolve from one to the next to the next—too quickly to recognize the specific visual characteristics of any individual. The result is a kind of dynamic Galtonian composite that favors general facial and compositional patterns distilled from the broader data set. The relative uniformity of the self-portraits analyzed in Selfiecity facilitates their dual function as carriers of visual and computable information, though we might still challenge the association of quantifiable factors like head tilt with subjective interpretations, such as expressiveness or anger.

Cultural critic Elizabeth Losh insightfully describes the data set subtending Selfiecity as evidence of a shift from seeing to sensing, noting, "[W]e can observe how the human-computer interaction modeled in Selfiecity depicts users wielding their smart phones as collections of semi-autonomous sensors rather than as neutral instruments that extend their own vision or tools that gives them mastery in subject-object relationships."[61] In Losh's framing, humans serve as extensions of the computers' sensory-input system, simultaneously complicating presumptions about authorship and transferring the resulting photographs to the realm of computable data. Losh also positions selfies in relation to the art-historical discourse of portraiture and feminist discourses of self-representation. Such insights precisely exemplify the sort of contextual and historical critiques that elude strictly machine-vision-based analytics.

Historically, it is important to note the parallel proliferation of selfies and technological systems devoted to facial recognition and data mining.

As discussed at greater length in the next chapter, faces are among the most exhaustively studied phenomena in machine vision. Technologies for facial recognition are the subject of ongoing research for multiple purposes, including government surveillance and identity tracking, as well as seemingly benign uses, such as improving the tagging and locatability of individuals in image archives and on social networks. The selfie obliges a unique conjunction of data and metadata—automatically linking one's name and face with foundational metadata, such as computer IP addresses and geolocation coordinates. Whatever else selfies may be, they are all neatly packaged gifts to facial recognition algorithms and data-tracking systems.

Like Selfiecity, the Phototrails project, led by Nadav Hochman and Manovich, sought to extrapolate broad insights about cities by analyzing specific features of photographs uploaded by their inhabitants. Launched in 2013, Instagram Cities attempts to visualize shared aspects of selected cities worldwide, based on fifty thousand uploads for each city sampled from more than 2.3 million Instagram images. Computational analysis was used to produce a series of visualizations of each city, with contours shaped by factors such as how late people stay up, what kinds of filters they apply to their photographs, and how light, dark, or colorful it is in various parts of the city at different times of the day or night. The result is a series of striking composite images variously described as "visual signatures," "visual rhythms," and "cultural patterns."[62]

The tools used for Instagram Cities also allow mapping time and date as well as the upload activities associated with individuals and locations. Among other things, this allows distinct patterns to emerge in response to cultural events and natural disasters, as well as observations about usage patterns over time—whether a city's "signature" results from many users uploading individual photos from a single location or a few individuals uploading many photos from multiple locations, and so on. In the end, the insights offered by this type of analysis work best when they either overtly contradict expectations or strengthen an anticipated hypothesis. The project website situates Phototrails midway between close analysis and distant reading. "As opposed to privileging 'close reading' (analysis of singular texts) or 'distant reading' (analysis of large scale patterns), we use interactive visualizations to perform a multi-scale reading—moving between the global-scale cultural and social patterns and the close-ups revealing patterns of individual users."[63] Each resulting "signature" is suggestive of the realms of both data and image, resembling nothing so much as a point cloud, which would ordinarily be used to describe 3D spaces. In this case, each "point" is signified by an iconic representation of a single image. The composites also offer a radically distilled visualization of the formal qualities of each image, mapped radially in terms of hue and luminance around a central axis.

In combination, Instagram Cities images offer synoptic hypotheses about the behaviors of each city's residents—at least those who upload images to Instagram. At a glance, one may conclude that Instagram users in Tokyo and San Francisco share images with similar patterns of hue and brightness; while the uploads in Bangkok are more deeply saturated compared with those in New York. The problem is that—in mobilizing our desire for, and belief in, the translational and synthetic potentials of data and image—these images lay claim to a more totalizing meaning than their method actually supports. And here I want to tread carefully. The project documentation profusely anticipates and accounts for such objections. Hochman and Manovich acknowledge that, "as a reflection of social reality or, more precisely, as a giant photograph of social reality, Instagram only captures the curated lives of some members of society and not others."[64] The project website also acknowledges additional limitations of the source data, especially regarding Instagram's own demographic and geolocation tagging.[65] These qualifications are not present in the visual rhetoric of the images, however, and uninformed viewers might reasonably perceive the composites as claiming insight into essential characteristics of the cities themselves. Manovich more convincingly disarms charges of homogeneity and stereotyping when he notes, "[B]y rendering the same set of images in multiple ways, we remind viewers that no single visualization offers a transparent interpretation."[66] Indeed, strategies of multiplicity, coupled with the lab's commitment to open data sets and tools, demonstrate a commitment to inquiry that does not foreclose on alternative readings, hypotheses, or analytical vectors.

In any case, challenging the integrity, limits, and origins of source data misses the point of cultural analytics, which consciously straddles the line between art and social science. Methodologically, I would question a different aspect of these projects. The research agenda for each cultural analytics project derives from a pregiven combination of available source data and technological affordances. In a design context, this is known as "technology push." Ordinarily it originates with a client who funds designers or researchers to develop compelling applications for a new or existing technology in the hopes of expanding its marketability or redirecting future development efforts. This relationship introduces certain obvious constraints that predetermine the nature of the experiments or the applications that follow. This, in turn, represents an inversion of the ideal workflow for design research, in which researchers begin not with the need to make use of a specific technology, but with a question motivated by issues of social consequence. Researchers then look for—or create—an optimal combination of tools and data to address the issue.

Like many archive-driven projects, the research questions available to projects like Instagram Cities and Selfiecity emerge from the available objects of study and tools for analysis. Instead of looking at the world and asking what problems need to be solved, researchers begin by looking at a given data set and the mechanisms they have available to analyze it. Together, these structure the questions that may be productively addressed through data analytics. The metadata captured by Instagram, like any commercially motivated media source, will inevitably support certain kinds of inquiries—*in which cities do women tilt their heads more when photographing themselves?*—at the expense of others. What is gained in terms of scale and access in such projects may be lost in the constraints of questions that are possible to ask. The great potential offered by cultural analytics and related efforts is not to provide the answers to complex cultural questions but rather to use strategies of data analytics and visualization to identify the most productive avenues of inquiry; in other words, making sure we are *asking* the right questions, rather than necessarily relying on existing data systems to *answer* them.

While cultural analytics remains the most prolific and widely recognized project operating at the intersection of research in the arts, humanities, and data analytics, strategies of data analysis and visualization have also infused numerous other realms of cultural practice. Chicago artist Jason Salavon, for example, is part of a generation of artists expanding the horizons of data visualization into an area that might be termed "computational aesthetics." At first glance, the work is seductive. Salavon's series *Homes for Sale* (1999/2001/2002) and *100 Special Moments* (2004) offer a wry critique of the sameness of American (apparently mostly white) middle-class culture. Working from large collections of publicly available online images, Salavon generates multiple superimpositions in which no single image is clearly visible, but which, in aggregate, suggest the repetitive contours of cultural rituals. These composite images draw out broad formal resonances across large data sets of iconic images, such as “curb shots” from real estate advertisements and wedding photos (with bride on the left).

While the images retain their aesthetic appeal, the *critique* implied by Salavon’s work quickly wears thin. Salavon’s technique, which he terms “averaging,” aims to address individual uniqueness and large social patterns simultaneously, but it’s hard not to feel that the resulting images cynically mock conventions of photographic remembrance at the expense of those who participate in them. The irony implicit in Salavon’s title *100 Special Moments* takes an easy shot at the misplaced sense of uniqueness and self-importance evinced by photographic tropes: weddings, Santa Claus shots, graduations, little league photos. Salavon’s point is an obvious one, and he makes it repeatedly. The literal insights yielded by these composites fall somewhere between trivial and obvious: skies are sunnier in Southern California than in the Pacific Northwest; lawns are larger and greener in Dallas than in Chicago, and so on.

The point of Salavon’s work is not knowledge production, and the artist does not pretend otherwise. For a more generous and nuanced anthropological reading of the “home mode” in photography, one should look not to Salavon but to Richard Chalfen’s *Snapshot Versions of Life* (2008). In articulating the parameters of the home mode, Chalfen focuses on the “deep structures” that underlie the production and circulation of codified “home mode” images within an insular economy of prescripted (and, indeed, prescriptive) family narratives. But these interests are nowhere to be found in Salavon’s composites, which do not even attend to potentially revealing historical dimensions, such as race and class, instead choosing to focus on normative data sets without interrogating the presuppositions and “sameness” inscribed in his process.

Salavon describes his interests in “pattern in general and individuality and uniqueness; in the antithesis of that—group dynamics; the large social group—thinking in terms of large entities and thinking in terms of individuals as entities.” In this context, Salavon states, “‘Averaging’ is one way to speak to those things simultaneously.”[67] The question then emerges whether the dialectical relation between individuals and large social groups is adequately mobilized through the process of “averaging.” Salavon’s work, in fact, demonstrates the insufficiency of this aesthetic strategy to reveal actual cultural insight.

A more complex interrelationship between data and images can be found in Salavon's projects *The Loop* (2007) and *City* (2008), both of which are composed from digitally generated images of Chicago. Unlike Salavon's other series, these composites were created not from photographs taken and shared by real people but from digitally generated images simulating the view from the city's trains as they circumnavigate downtown Chicago. Although they are computer generated, Salavon's composites privilege common sites for tourist photographs, presenting digital simulations that are idealized and lacking any of the defects or detritus of lived urban spaces. These abstract but distinctly urban—perhaps even distinctly Chicagoan—images evoke the general category of city*ness*, while insisting on the *constructed*ness of both the physical city and its simulation in digital space.

Technologized Vision

This chapter pairs data visualization with machine vision because they are reciprocal, technical phenomena, each serving, in its own way, as an intermediary between the visual and computational registers.[68] Structurally, however, this model offers no insight into the politics of vision played out across the array of technologies discussed here. It would be entirely possible to focus on affordance and process at the expense of social consequence. Technology too easily distracts from the questions of power, privilege, and ideology that rightly dominated visual culture during the previous century; to ignore them now mendaciously suggests that today's technologies of vision are somehow absolved of responsibility for the very phenomena most imperative for them to reveal. Practicality prevents us from carrying forward all the theoretical models that might be productively adapted from twentieth-century visual culture. For now I will mention just two—Jean-Louis Comolli's apparatus theory of cinema and Donna Haraway's technofeminist critique of scientific imaging—both of which resonate productively with what we now call "machine vision."

Although Comolli's influential 1971 essay "Machines of the Visible" focuses on cinema, its framing of the interdetermination of human and technological apparatuses of seeing offers useful insights into machine vision. Building on Martin Heidegger's answer to the "Question Concerning

Technology," Comolli positions the importance of cinema's apparatus not in the realm of the technological but in that of the social. Technological components, he argued, came and went; they thrived not on inventions or breakthroughs but on their ability to be integrated into social practices and needs. A "new" invention such as the cinema had its roots in a half-century or more of image culture that prepared viewers for the cinema's commercial implementation.

So it is with digital technology, the basic components of which existed long before they became a part of most people's everyday lives. The transition from technological possibility to social integration requires decades of infiltration and acculturation. A "digital logic" had first to be infused in the consciousness of the culture that would eventually embrace it, even if, like its end users, it did not fully digest the terms of service for what it was agreeing to. For Comolli, the iconic visibility of the film camera stood as a metonym for "the whole of the technics"[69] underlying the medium. But what would such an icon look like for digital culture? A supercomputer with banks of flashing lights from a Hollywood prop house? A server farm with cooling towers and backup generators? A microprocessor? Perhaps the mobile devices that many of us are connected to stand in for the sum of all digital technologies. When dozens of individuals on YouTube upload videos of smashing, burning, microwaving, or blending their old cell phones, it's hard not to suspect that the conjoined industrial cabal of hardware and telecommunications is being assaulted in effigy. The absence of any single metonym for "the digital" may be part of the reason digital apparatus theory remains splintered and ineffectual as a vector for social critique.

Writing in the context of the early 1970s and influenced by theories of postcolonialism, Comolli drew a straight line between looking and capturing, with the result that "the visible" is implicated in social apparatuses of colonization and control. Knowledge, according to this model, correlates not only with power but with possession. Comolli assumed that a fundamental characteristic of the visible is that it may be appropriated and owned by one in possession of the photographic apparatus. But the rights of individuals operate differently in the realms of image acquisition and data tracking. Private citizens are generally entitled to a degree of control over how their photographic image may be captured and used. But when those same individuals traverse data space, their movements, choices, and other trace data (time, location, duration, connection, etc.) are captured by default, often after a compulsory licensing agreement relinquishing all right to know, limit, or control how that data might be aggregated, interpreted, or sold.

When thinking about the relationship between seemingly organic, biological vision and the technologized processes by which visual information is transformed into computable data, we should not ignore Donna Haraway's two-decade-old warning about the perils of disembodied vision and the troubling imbrication of scientific technologies of vision that are inextricably tied, in her critique, to "militarism, colonialism, capitalism and male supremacy."[70] These were forcefully articulated in her 1997 article "The Persistence of Vision."

> The "eyes" made available in modern technological sciences shatter any idea of passive vision; these prosthetic devices show us that all eyes, including our own organic ones, are active perceptual systems, building in translations and specific *ways* of seeing, that is, ways of life. There is no unmediated photograph or passive camera obscura in scientific accounts of bodies and machines; there are only highly specific visual possibilities, each with a wonderfully detailed, active, partial way of organizing the worlds. All of these pictures of the world should not be allegories of infinite mobility and interchangeability, but of elaborate specificity and difference and the loving care people might take to learn how to see faithfully from another's point of view, even when the other is our own machine.[71]

Haraway privileges subjugated viewpoints but she does not do so naïvely. Visions "from below" are preferable because they allow for disruptions of the fundaments of power inscribed from above. But this perspective is not easily come by—it requires a highly skilled and self-critical stance that is as complicated as the "highest" stratum of technoscientific visualizations.[72] Haraway goes on to describe a litany of seemingly unlimited "visualizing technologies" capable of enhancing and extending primate vision. The twentieth century's enhancements to the eye created the possibility of "seeing"—by means of visualized sensor data—the vast reaches of the solar system and the inner workings of biological organisms. Today's fusion of data and images promises to reveal a different order of invisible phenomena, namely the conceptual rendering of information flows and patterns. Such data has no logical or immanent visual form; viewing information as colorful or animated graphics has begun to seem natural only by convention. Rather than be seduced into epistephilic complacency, and out of respect for these models of politicized vision, let us always ask, at what cost and in whose interests are these visions of the world constructed? As Haraway asks pointedly, “With whose blood were my eyes crafted?”[73] The answer may be as relevant to what we see with our biological eyes as it is to the visual apparatus of our computers.

Machine Vision/Human Vision

YouTube is not about video; Facebook is not about social networking; and Snapchat is not about sharing images. These companies capture and store collections of media on a massive scale as a basis for refining algorithms for machine vision, marketing analytics, and artificial intelligence. The surface operations of these online platforms provide services of sufficient utility to draw participation from as large and diverse a population as possible. The social network Facebook, for example, is also by far the largest image archive in the world, storing and possessing unlimited usage rights to hundreds of billions of images, with hundreds of millions more being added every day. YouTube reported in 2014 that it was receiving three hundred hours of video uploads every minute, with a total running time in excess of sixty thousand *years*. As collections of images requiring the attention of human beings, such archives are useless. Although humans continue to play a crucial role in training computers to recognize the visual content of images and video, these massive collections only become valuable to their keepers in proportion to the speed and precision with which they may be translated into computable data.

In certain important respects, of course, “machine vision” is an oxymoron. Calling it “at best, allegorical,” Benjamin Bratton notes that “most machine seeing does not involve the production of mimetic ‘images’ as would be recognizable in a human context.”[74] Computers receive images as sensor data in the form of pixels, which are transformed into computable form. This challenge may be computationally demanding, but it is conceptually straightforward. Google’s explanation of pattern recognition puts it in disarmingly simple terms. “Computers don’t ‘see’ photos and videos in the same way that people do. When you look at a photo, you might see your best friend standing in front of her house. From a computer’s perspective, that same image is simply a bunch of data that it may interpret as shapes and information about color values.”[75] A more complex challenge faces researchers who attempt to use computers to recognize subtle, emotional, or connotative meanings within images. The basic process, however, follows a logical progression. Working with a large “pixel-data” set, such as that found on Instagram, researchers identify a desired group of essential qualities, perhaps describing abstract concepts such as happiness, creativity, or beauty. Because these features are highly subjective, Amazon’s Mechanical Turk is commonly used to achieve consensus regarding the presence or absence of these qualities in any given image. To do this, researchers establish a formula based on a series of small-scale trials to determine how many total ratings and what percentage of agreement are required to yield a reliable consensus opinion.

For example, in exchange for a few cents, workers logged in to Mechanical Turk might be asked to classify images based on whether they are beautiful or display signs of creativity or innovation. If a given threshold is reached—say, four out of five viewers agree that a given image possesses a particular attribute—then that image is considered to be consensually so. Once we obtain a large collection of consensual images, those images form a training set for the machine vision system, just as we’d need a large training set if we wanted the machine to recognize parts of an automobile. With a large enough data set and a sufficient number of formal attributes and combinations to identify, the computer can reliably recognize even the most abstract and seemingly elusive concepts. Each stage of this process is open to critique, and the most rigorous machine vision research does its best to account for factors such as cultural specificity, linguistic variations, and varying metrics of taste and value. Smaller-scale variables and anomalies are presumed to be rendered irrelevant by the sheer volume of data analyzed, producing a distinct separation between noise and signal.[76]

While machine vision empowers computers to make sense of the roiling, chaotic sea of images humans create in their daily lives, programmers, designers, and artists use the serial processes of data visualization to make the profuse output of sensor data and information systems understandable to humans. Nothing in the evolution of this research suggests that computers will not eventually be as good as humans at recognizing and interpreting the meaning of images. In fact, this is not such a high bar to set. Humans are notoriously limited in their ability to recognize the meaning of images, for various reasons, ranging from ignorance of cultural context to simple misapprehension. The field of visual studies might not exist if a multiplicity of interpretations were not possible for any given image.

In a similar sense, effectively translating the meaning of data is not a simple process. Like image recognition algorithms that struggle to recognize distinct but computationally opaque behaviors, such as throwing a Frisbee, humans must learn to adapt their perceptive and cognitive abilities to correctly interpret data that has been translated into the visible register. For humans, data visualization is embedded in a complex cultural matrix that includes connotative meanings associated with graphical characteristics, such as shape, color, proximity, and so on. Therefore, data visualization is already cultural visualization, a process of ideological articulation as much as of mathematical conversion.

Data visualization and machine vision occupy opposing ends of an axis defined in terms of computability and mimesis. A different conceptual axis would place machine vision in opposition to human vision. This concept derives from various media works of art, described below, that *seem* to be computational but aren't; that is, these works adopt the logic of computation as a model for human labor. I also find it useful to insist that humans' previously unmarked domain over vision now requires qualification as "human vision." This extends the logic of visual culture theory's insistence that easily naturalized activities such as "looking," "seeing," or "observing" must be analyzed as discrete and culturally situated "practices," "ways" or "techniques,"[77] and as such may be decoded, retrained, or interrogated. When arrayed in opposition to technologies devoted to machine vision, my aim is not to reinscribe the organic nature of human seeing; on the contrary, I wish to reflect on the ways in which it has been reconstituted in dialogue with the computational. In the examples that follow, human vision offers a thought-provoking glimpse of what happens when humans begin not only to *see* like computers but to *act* like them.

A popular form that exemplifies this framing of human vision is the genre of remix video known as supercuts. Many creators of supercuts are satisfied with dramatically or humorously illustrating a single visual trope or cinematic cliché: the mirror scare or loss of cell phone service in horror films, for example, or three-point landings and "kill lines" in action movies. Another genre identifies repeated lines of dialogue or tropes, such as "every ____ in ____": every cocktail in *Mad Men*; every "dude" in *Lost*; and so on. Supercuts, in their earliest manifestations, were primarily understood as labors of love by obsessive fans, activating both the familiarity of an original work of popular culture and the algorithmic pleasures of repetition and distillation.

Among the earliest and most virtuosic progenitors of algorithmic remix are media artists Jennifer and Kevin McCoy. During the early 2000s, the McCoys created a series of recombinant media databases drawn from popular television programs. Included were projects based on the original *Kung Fu* (1972–75), *Starsky & Hutch* (1975–79), Looney Tunes cartoons, and the original *Star Trek* (1966–69) series. For each source, the McCoys began by breaking the show down into granular elements based on formal properties or content categories. Resorted subsets of media were then combined, tagged, burned to CD-ROM, and installed in gallery contexts as a physical database of hard media, combined with a user-controlled player and screen that allowed gallery visitors to select and display media sets of their own choosing.

The insistent physicality of the McCoys' presentation is significant on multiple levels. Conceived during the early days of the internet, the project's use of physical media constituted a refusal of the economy and scale of online distribution. Their controlled circumstances of display for low-resolution CD-ROM-based video files also distanced these works from the moral panic that resulted in passage of the Digital Millennium Copyright Act in 1998. More important, the physical process of selection and combination highlights the human and subjective dimensions of the project. Although the McCoys' work is clearly indebted to database culture broadly, their selection of media suggests the idiosyncrasy of pop culture fans. Likewise, their categorization schemes are highly subjective, offering curatorial categories such as "Every sexy outfit" and "Every thug," while other categories are strictly formal, such as "Every extreme close-up," "Every background music," "Every diegetic noise," and so on. The McCoys' work thus revels in the pleasures of genre while gently mocking the specific forms and styles by which they manifest in popular culture.

In 2009, Natalie Bookchin's *Mass Ornament* quietly elevated the remix genre of the supercut to the status of art. *Mass Ornament* is a single-channel video installation composed entirely of excerpted YouTube videos, mostly of young women dancing in domestic spaces, accompanied by music from Busby Berkeley's *Gold Diggers* (1935) and Leni Riefenstahl's *Triumph of the Will* (1935). Bookchin's video is further broken down into multiple split screens, fragmenting the image into lines and matrices of smaller frames that phase in and out of synchronization with the music and bodily movements of the dancers. Brief solos by individual performers give way to resonant movements as additional frames pop up across the screen or erupt in crescendos of sameness. These moments of synchronization explain Bookchin's project title, which alludes to Siegfried Kracauer's book celebrating Weimar-era mass culture, *The Mass Ornament*, originally published in 1927.

For Kracauer the "mass ornament" represented a cultural response to the regimentation and mechanization of industrial capitalism, exemplified by the synchronized dance troupe the Tiller Girls. Kracauer describes them as "products of American distraction factories [who] are no longer individual girls, but indissoluble girl clusters whose movements are demonstrations of mathematics"—bodies become data.[78] In Thomas Levin's introduction to the English-language edition of *The Mass Ornament*, he describes Kracauer's reading of synchronized performance in more generous terms of "progressive potential as the representation of a new type of collectivity organized not according to the natural bonds of community but as a social mass of functionally linked individuals."[79] To this progressive potential Bookchin's project also turns, but the underlying technology to which it responds is not merely that of industrial capitalism but the digital networks and social practices that are now crucial to its functioning.

Like the McCoys' installations with their dozens of CD-ROMs, *Mass Ornament* was crafted through an extraordinarily labor-intensive process. To amass her original media collection, Bookchin viewed and downloaded hundreds of videos and then manually synchronized them into a kind of collectively unconscious choreography, following musical genre conventions, including scene setting, solos, and synchronized spectacles. *Mass Ornament* also marks a return to Bookchin's early interest in collecting

Figure 1.4
Human vision transforms narrative subsets of internet video into rituals of collectivity in Natalie Bookchin's *Mass Ornament.* (2009). Image courtesy of the artist.

quotidian media artifacts, first seen in her CD-ROM *Databank of the Everyday* (1996), a curated archive of video loops from the artist's life, organized into categories collectively described as a "stockhouse of gestures, routines and habits."[80] But where *Databank of the Everyday* looks inward, *Mass Ornament* radiates outward, turning every webcam on the internet into a massively distributed sensor array.

Bookchin's interest in both the form and the substance of vernacular media persists throughout her work with remix and documentary video. The pleasures of this work derive not from image-based aesthetics of form but from the organizational structures—synchrony, multiplicity, symmetry—of the database. Viewed in conjunction with subsequent projects such as *Testament* (2009/2016) and *Long Story Short* (2016), *Mass Ornament* eloquently attests to the rhetorical power of collection and collectivity—not the condescending critique of sameness seen in Salavon's averages, but a videographic construction of a social body. Whereas *Mass Ornament* presents a lighthearted vision of performance laced with nascent sexuality, *Testament* portrays structurally similar but more emotionally somber topics such as being laid off, coming out, and taking prescription medications. Instead of choreographed bodily movements across multiple frames or screens as in *Mass Ornament, Testament* emphasizes the choreographic potentials of voice, highlighting uncanny resonances across a handful of deeply personal subjects. The stark tonal contrast between *Mass Ornament* and *Testament* illustrates the dexterity of Bookchin's method, which combines technological process with analytical paradigm.

In Wendy Chun's discussion of *Mass Ornament*, she focuses on the project's blurring of internal and external spaces as well as the performance of online identities that are both public and private. These issues resonate with the overall argument of Chun's book, which interrogates the multiple processes by which some of the network age's most troubling social technologies have become habituated. For Chun, Bookchin's work exemplifies some of these contradictions, celebrating connections among individuals as a "hopeful revelation of an unconscious community"[81] that nonetheless takes place within a historical framing bracketed by the visual spectacles of Nazi propaganda and Hollywood musicals. In *Testament*, Chun also finds dissonance among the voices, preserving the "complexities of individuality in collectivity."[82] As artworks that derive from emergent and unforeseen online social practices, both *Testament* and *Mass Ornament* are symptomatic of the paradoxes of network culture—control and freedom, visible and invisible, known and unknown—to which Chun's work has been perceptively devoted for the past decade.

A somewhat different dynamic is at work in Bookchin's subsequent project, *Long Story Short* (2016). In *Mass Ornament* and *Testament*, she defined a method for constructing meaning from the otherwise overwhelming and undifferentiated practices of individual video blogging. To make *Long Story Short*, Bookchin shifted her practice from extracting preexisting content from video-sharing sites to a model in which the artist herself initiated a series of original documentary videos. The result, in *Long Story Short,* is a powerful, polyphonic synthesis of voices testifying to the firsthand experience of poverty in America. In the piece, Bookchin preserved the webcam vernacular of low-res direct address seen in *Testament*. Edited together and composited onto a single screen, more than one hundred individual videos form a matrix of talking heads expressing shared experiences of struggle and indignity in the face of poverty.

Bookchin's database aesthetic proves remarkably effective for accentuating the power of these voices, which are too infrequently listened to in contemporary culture. Where conventional wisdom about media for social change presumes the need for deep personalization and empathy toward those presented as victims of social ills, in *Long Story Short*, the inherent dignity of self-presentation is combined with a literalization of the power of collective voice and action. Although the individuals included in the video have no means of knowing or interacting with each other, the system designed by Bookchin succeeds in amplifying individual voices into a powerful, collective articulation of otherwise socially stigmatizing experiences.

As instances of "human vision," these projects by Bookchin find resonances and distinctions with related projects by Casey Reas and Benjamin Grosser. In very different ways, each of these artists represents an interpretation of what happens when computers encounter popular media. Each approaches a different medium—broadcast television for Reas (*Signal to Noise*); Hollywood feature films for Grosser (*Computers Watching Movies*); and internet video for Bookchin—with correspondingly varying responses. As I discuss in the final section of this chapter, Reas's projects generate audiovisual assaults, as if the apparatus were attempting to digest signal as well as noise to produce a cacophony of pixels, sounds, and rhythms. For Grosser, the computer behaves like an obsessive fan; its viewing is precise and monomaniacal, scanning and focusing on the minutest details and patterns within the frame. In contrast, Bookchin uses a database structure to bring order to the chaos and overproliferation of media online. What makes Bookchin's work especially interesting in this context is its shift from being a strictly reproductive technology—that is, one that samples and recombines existing media—to being a productive one. In *Long Story Short*, Bookchin deliberately assembles a database of content as if the organizing principles of the previous two projects were reverse engineered to imagine the third.

The year after Bookchin released *Mass Ornament*, media artist Christian Marclay completed *The Clock* (2010), a twenty-four-hour film loop composed entirely of cinematic images of clocks, projected in synchronization with the actual time of day. Like Bookchin, who personally invested countless hours watching and downloading YouTube videos, Marclay worked with a group of researchers to comb painstakingly through hundreds of DVDs to find and excerpt images of clocks. Both works share a computational, encyclopedic sensibility, and both attack overwhelming data sets (all of YouTube and all of cinema history, respectively) through the brute force of human labor rather than automated computer vision analysis.

Marclay's signal achievement in *The Clock* is allowing viewers to indulge simultaneously in the pleasures of cinema and in those of computation on more or less equal footing. *The Clock* invites viewers to occupy a dual subject position, both producing and being produced by the complementary regimes of data and image.[83] *The Clock* further transforms audience viewing habits by attuning viewers to the presence of clocks outside the obscure diegesis of Marclay's film. Previously banal or unnoticed images of clocks may begin to burst out of their narrative context for viewers whose perceptions have been recalibrated to notice the presence of clocks anywhere within the cinematic frame.

In principle, both *The Clock* and *Mass Ornament* could have been produced—perhaps even improved on in scope and precision—if they had been created not by humans but by image recognition software. This raises the question, Are projects like *Mass Ornament* and *The Clock* evidence of artistic capitulation to the logic of computation, or are they gestures of defiance—reassertions of essential humanity—against it? In David Golumbia's book *The Cultural Logic of Computation*, he writes with gloomy insight:

Figure 1.5
In Christian Marclay's *The Clock* (2010), viewers indulge simultaneously in the pleasures of cinema and computation. Christian Marclay, still frame from *The Clock* (2010). Single-channel video with sound. 24 hours, looped. © Christian Marclay. Courtesy Paula Cooper Gallery, New York, and White Cube, London. Photo: Todd White Photography.

> [T]here is little doubt that the more we imagine ourselves to be like computers, the more computer-like we will become; conversely, the more we imagine computers can take over sociopolitical functions, the more we will give up our own influence over those phenomena—and the more they will pass into the domain of exactly the powerful agents (states, transnational corporations, and capital itself) that already dominate so much of social life.[84]

I do not aspire to the broad theorization of computation mapped by Golumbia—nor to his inclusive denunciation of "computationalism"—but his critique offers a provocative caveat about the potential excesses of digital culture theory, especially regarding proclamations of epistemic shifts or fundamental changes in what it means to be human. Given the state of things, such proclamations may well be warranted, but they should not be issued lightly, nor accepted uncritically. We have reason to embrace posthumanism not because humans have been or will be surpassed by computers, but because the short-sighted arrogance of humanity has consistently made a mess of the global resources we have pressed into our service. Humans, simply put, do not deserve the place we have claimed at the center of the universe. Rather than supplying evidence of further decline, as Golumbia implies, perhaps the emulation of computational intelligence seen in Bookchin's and Marclay's work represents a transition in the evolution of humanity to a more humble state of being.

Following a variation on this logic, artist Benjamin Grosser has created a series of software-based projects attempting to visualize aspects of computational intelligence as if computers were on the brink of transition rather than humans. Where the concept of "human vision" describes the infusion of a computational sensibility into human artistic production, Grosser's work goes a step further, attempting to visualize what it's like for computers to perform such distinctly human activities as watching movies or applying paint to canvas.[85] For *Computers Watching Movies* (2013), Grosser programmed an artificial intelligence algorithm with the ability to selectively view scenes from motion pictures and respond to prominent visual stimuli—objects, movements, colors, patterns—within the frame.[86] Grosser's software then performs the machinic equivalent of eye tracking. As the algorithm decides which areas of the frame to "watch," it traces lines on the screen that correspond to those areas of greatest interest. For Grosser, this process invites reconsideration of how human media viewing has been culturally shaped. He writes, "Viewers are provoked to ask how computer vision differs from their own human vision, and what that difference reveals about our culturally-developed ways of looking. Why do we watch what we watch when we watch it? Will a system without our sense of narrative or historical patterns of vision watch the same things?"[87]

Grosser's work stands in contrast to platforms for quantitative analysis of cinema such as *Cinemetrics*, Yuri Tsivian's crowd-sourced database of cinematic shot lengths, or the cultural analytics lab's tools for "exploratory image analysis,"[88] discussed previously. Whereas these tools allow for quantitative analysis of cinematic form, *Computers Watching Movies* skips directly to the stage of visualizing the computer's apparent areas of interest as if diagnosing underlying obsessions. As each scene plays out, lines are traced in real time across the frame, sometimes remaining tightly focused, other times exploding into a translucent cloud as the algorithm attempts to take in all pieces of a complex visual effect at once. The project's comparison with human viewing patterns is highlighted by limiting the source material to iconic scenes from some of Hollywood's most popular films. Grosser's installation does not include any original cinematic imagery; however, the computer traces are accompanied by real-time audio

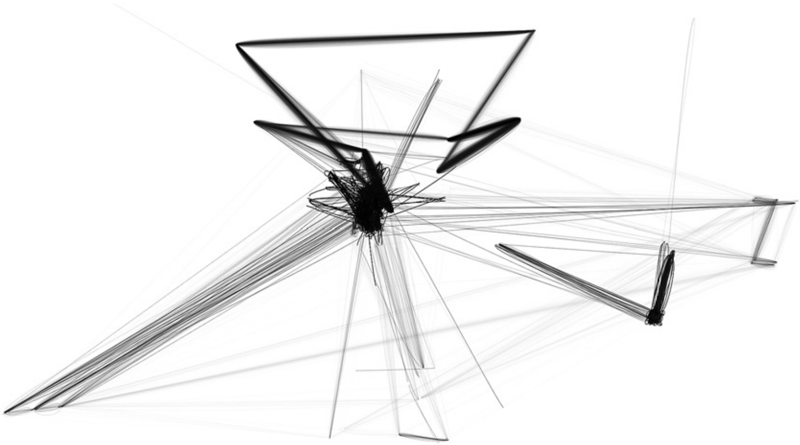

Figure 1.6
Exposed to scenes from classical Hollywood cinema (*2001: A Space Odyssey* seen here), computer vision software reveals its tastes and obsessions in Benjamin Grosser's *Computers Watching Movies* (2013). Still frame from *Computers Watching Movies* (*2001: A Space Odyssey*).

that invites viewers to conjure visual memories of the original clips. Like *Cinemetrics*, Grosser's project confirms certain expectations about shifts in cinematic form over the past few decades. The static minimalism and languorous pacing of Stanley Kubrick's *2001: A Space Odyssey* (1968), for example, generates radically different patterns of interest by the computer compared with the frenetic pace and visual density of Christopher Nolan's *Inception* (2010). In broad terms, Grosser's work does not yet aim to revise our understanding of what it means to be human but proposes an ambitious reconsideration of the two-way relationship between humans and computers.

Google's Brain

Over the course of the past decade, some of the most provocative experiments in machine vision have emerged from Google Lab's Unsupervised Learning project, which was revealed to the public in 2012 by the more evocatively named Google Brain Team. Google engineers frame the project in terms of the need to transform data that is primarily received by the

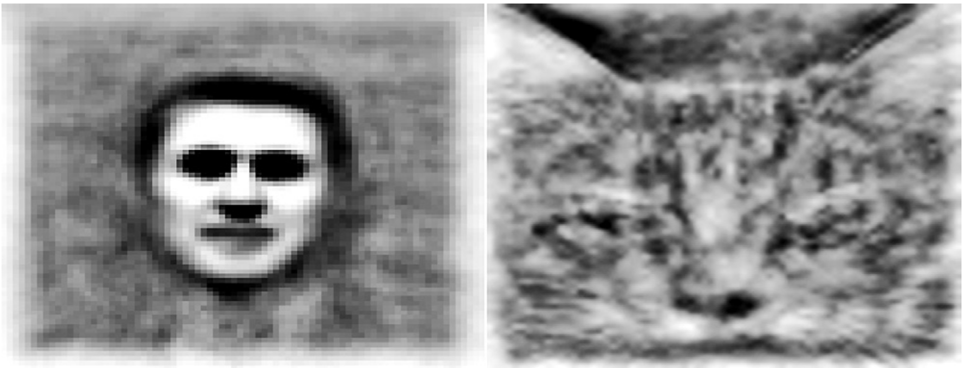

Figure 1.7
Cat faces and human faces emerged as the dominant image phenotypes in 10 million internet videos viewed by Google's Unsupervised Learning project (2012).

human sensorium as media (sounds or images) into a computable form that may be more readily processed by computers.

> Most of the world's data is in the form of media (images, sounds/music, and videos)—media that work directly with the human perceptual senses of vision and hearing. To organize and index these media, we give our machines corresponding perception capabilities: we let our computers look at the images and video, and listen to the soundtracks and music, and build descriptions of their perceptions.[89]

Images related to this project were presented at the 29th International Conference on Machine Learning in Edinburgh, Scotland, in 2012 and circulated widely online thereafter. The presentation by Stanford professor of computer science Quoc V. Le included several images generated by Google's Unsupervised Learning system, which distinctly resembled a cat face, a human face, and rather less distinctly, a human torso. Online, the cat and human faces were most often distributed as a diptych, depicting pixelated, desaturated, humanoid and feline features emerging against a blurry, gray void.

Google Fellow Jeff Dean and visiting faculty member Andrew Ng describe the images as examples of the "perceptions" generated by the Unsupervised Learning system running sixteen thousand processing cores for three days, directed at a collection of unlabeled frames sampled from 10 million YouTube videos. The system's learning was dubbed "unsupervised" because the computers were not told what to look for within each 200 × 200 pixel image. This is what set Google's Unsupervised Learning project apart from other machine vision algorithms, which trained computers to "look for" images matching a particular combination of graphical features. According to Google, the experiment demonstrated a "70 percent relative improvement in accuracy"[90] over other machine learning systems. These findings suggest that large-scale neural networks, when provided with no information or guidance, will, all on their own, identify human faces and cats as the most prominent image phenotypes emerging from YouTube videos and, by extension, the internet at large.

This research was announced a little more than a year after Google software engineer James Zern revealed that only about 30 percent of the billions of hours of videos on YouTube accounted for approximately 99 percent of views on the site.[91] In other words, the vast majority of videos uploaded to YouTube are seen by almost no one, meaning that the company's revenue model of targeted advertising generates no significant value for more than two-thirds of its content. Nonetheless, 70 percent of the vast architecture of YouTube remains devoted to media that is seen by almost no one. The only way to monetize a media collection at this scale is through large-scale automated translation of images into data. With this goal in mind, the billions of hours of video available on YouTube represents not an unmonetized public utility but an invaluable resource for the rapidly expanding fields of machine vision and artificial intelligence.

The human and cat images released by Google were widely received as objects of novelty and amusement, consistent with cultural narratives that trivialize the internet as a conduit for narcissistic self-portraiture and cute kitten videos. A headline in the UK's *Daily Mail* newspaper, for example, read, "Google Creates 'Computer Brain'—and It Immediately Starts Watching Cat Videos on YouTube."[92] Likewise, the UK edition of *Wired* published an article under the headline, "Google's Artificial Brain Learns to Find Cat Videos."[93] One might speculate that these images were meant to serve a palliative function, reassuring the public that Google's hosting of billions of hours of valueless video is, in fact, a harmless or even playful endeavor that contributes to the company's stated goal to "make everyday tasks much easier."[94] This analysis is consistent with the argument put forward by Mercedes Bunz that the visual culture of the technology industries—exemplified by company logos favoring primary colors, cartoonlike graphics, and flattened surfaces—has been long engaged in infantilizing and patronizing users, even as it is cloaked in ideologies of empowerment.[95]

Google's interest in training computers to make sense of vast undifferentiated image collections aims to enhance the company's ability to use data analytics to understand, shape, and predict human behavior. In June 2015, Google Research publicized a process it had developed, which appeared to reverse the logic of image recognition. Google researchers had begun prompting its "neural net" of image recognition processors to *create* images rather than recognize them. This internal reappropriation of one of Google's closely guarded technologies caused an internet sensation, and the company released a collection of provocative images with a distinctive visual style along with an open source version of the software used to create them.

The overwhelming majority of public discourse surrounding these images aligned with one of two discursive paradigms: chemical-induced psychedelia and visualization of the subconscious through dreams. Google itself encouraged the latter model by initially dubbing the system "Inceptionism," a reference that returns once again to Christopher Nolan's *Inception*, in which the traversal of states of consciousness occurs through chemically induced lucid dreaming. Perhaps it was after realizing that the narrative of Nolan's *Inception* begins with a high-tech corporation exploiting its access to the subconscious minds of its clients to steal personal information that Google decided to change the name to the more innocuous Deep Dream. Officially described as a "deep neural network architecture for computer vision,"[96] the Deep Dream visual aesthetic combined elements of the natural world—especially animalistic features of dogs, birds, and reptiles—with geometric, scientific, or architectural shapes.

Soon a proliferation of online Deep Dream conversion engines invited human viewers to experiment with various enigmatic parameters (e.g., spirit, neuron, Valyrian) that shape the resulting images. While early online services offered to perform deep dream conversions for a few dollars per image, it took only a few months for websites such as the Deep Dream Generator to appear, allowing free, unlimited, user-customizable conversions. Several Deep Dream auteurs also emerged, such as Swedish designer Johan Nordberg, whose work painstakingly converted multiply processed images into animated sequences, creating the illusion of real-time transformations from formless static images into nightmarish apparitions.

Comparisons with psychoanalysis-inspired surrealist art and drug-induced literature abounded, overwhelming alternate readings that might challenge the uncritical conjunction of human and artificial intelligence. Rather than project attributes of human consciousness or subconsciousness onto the algorithm, a more productive strategy might derive from consideration of the structures of the neural net itself.

All of this raises the question of what would happen if the deep dream algorithm were used to "interpret" an image generated by the software that was used to develop it? One conceivable outcome of this reversal might be to reveal evidence of the "perception" process by which Google Brain's human and cat images were originally derived—similar to how language translation systems are tested by converting a sentence from one language to another and then reversing the process to see how closely the original sentence is reproduced.

By going deeper into the dream you will discover amazing new dimensions and visual artifacts from the AI's consciousness.
—Deep Dream Generator

Figure 1.8
Johan Nordberg's *Inside an Artificial Brain* (2015) uses Deep Dream software to enhance visual patterns from an original field of random pixel data. Image courtesy of Johan Nordberg, https://johan-nordberg.com.

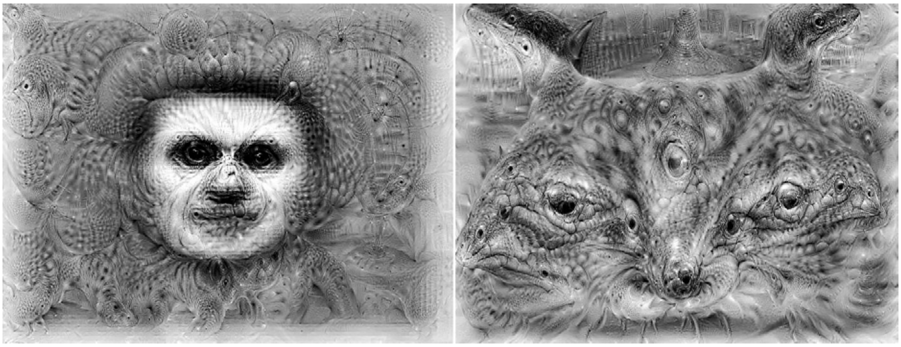

Figure 1.9
A facetious attempt at algorithmic recursion, subjecting computer-extracted image phenotypes to an inverse process of refining visual patterns. Image by the author (2017).

As with the reversal of language translators, which rarely produce a perfect translation, this process did not succeed in reverse engineering anything resembling the original images.[97] The custom recognition parameters of the Deep Dream software alone are sufficient to preclude a one-to-one conversion, but I find this experiment nonetheless revealing. Both human and animal visages became more animalistic; except for the eyes, the primate face in particular became more simian than human, while the fuzzy, undifferentiated halo surrounding both heads acquired a reptilian aura. In the end, this experiment in algorithmic recursion offers little more than amusement or distraction, which may well be the point of Google's gesture in making the software freely available. While these images invite comparisons with the recesses of the unconscious mind, one might also wonder about the real-world systems and values that are thereby shielded from critique. Both the visual rhetoric of the images and the cultural discourse surrounding them suggest yet another narrative that is at once trivializing and reassuring: if algorithms dream, they dream of electric dogs.

Negotiated Visualization

More so than any other creator discussed in this book, Casey Reas's work exemplifies the tortured relationship between abstraction and representation. Though he is not the only artist to fall within what I have termed the "negotiated mode" of relating data to images, Reas has created a series of uniquely varied attempts to work productively across the two domains. In a prolific body of work created over the past two decades, Reas has explored the creative potentials of software art by articulating multiple relationships between data and images, as well as, on occasion, human bodies and physical structures. Nearly all his work is created using the programming environment Processing, which he codeveloped with Ben Fry in the early 2000s while they were graduate students in John Maeda's Aesthetics and Computation Group at the MIT Media Lab. In work by Reas and others, Processing is often deployed to create systems that emulate patterns from the natural world (cellular division, flocking behaviors) via algorithmically specified shapes, textures, and movements. As we will see, the evolution of Reas's own creative work with Processing maps an unexpected trajectory from purely abstract, code-generated art to increasingly image-based and physically situated or embodied artworks.

In Processing, Reas and Fry created a free, open source software platform that is meant to be versatile and accessible to artists. We might compare what Processing brings to contemporary digital art making with what audio synthesizers brought to analog videographics in the 1980s and 1990s, providing a customizable library of signal processing that enables media artists to conceive and generate entirely new types of visual experiences. Processing also readily facilitates the translation of quantitative values drawn from databases into the visual register, making it a versatile tool for visualizing complex or dynamic data sets. In addition, Processing was designed to accept media- and camera-based sources, for both visual information input and interface control, situating it at the threshold between data and image on multiple levels. Although located here within a chapter devoted to data visualization, Reas's work is instructive for how it does *not* conform to translational conventions associated with data visualization. Instead, I focus on two discrete areas of interest within his work—exemplified by multiple image series created using the *Process* library and a later group of works that deploy variations on the *Signal to Noise* software engine—to illuminate how these works uniquely blur the lines between image and data.

Among Reas's foundational inspirations was the work of Valentino Braitenberg, a twentieth-century neuroscientist whose work continues to be influential in the fields of robotics and artificial intelligence. Through a series of thought experiments, Braitenberg described the design of autonomous agents capable of exhibiting behaviors that appear intentional and adaptive through the integration of relatively simple combinations of sensors and actuators. These agents, called Braitenberg vehicles, were imagined to exhibit behaviors that were recognizably organic, even value driven. Braitenberg sought to expose the interpretive systems by which we attribute behavioral characteristics even to objects that we know to be without consciousness. We may perceive in a set of behaviors, for example, signs of aggression, cowardice, or even love toward other agents, along with affinity or aversion to environmental factors such as temperature, light, or oxygen levels.[98]

The emergent behaviors of Braitenberg vehicles inspired early works by Reas including *Path* (2001), *Tissue Prints* (2002), and *Microimage* (2002/2014). The images generated for the *Microimage* series are Reas's most corporeal, resembling bodily tissue, hair follicles, neural connectors, orifices. The color palette of these works is intentionally evocative of mammalian flesh and hair, with occasional blazes of blue or gray. The works are aggressively abstract but also deeply allusive, resembling a cross between abstract expressionist painting and forensic microscopy.[99] Viewers are invited to see bodily textures, shapes, and patterns, which are infinitely, albeit variably, reproducible. The code, in turn, can generate an unlimited number of image states. Reas describes the resulting numbered fine art prints as "documents" of the Microimage software, which itself forms the core of the artwork.[100]

Process is Reas's longest running series, evolving over more than a decade, with all works deriving from a shared library of elements. Specific combinations of predefined elements are called forth and executed in the creation of a *Process* work, causing traces to appear on-screen, resulting in continually emerging images of increasing density. Reas describes *Process* as a "choreographic system" in which he plays the role of "implementor."[101] For each work, Reas selects elements from the *Process* library and combines them into a set of instructions resembling a musical score. An example score describing *Process 15* reads:

> A rectangular surface filled with instances of Element 3, each with a different size and gray value. Draw a small, transparent circle at the midpoint of each Element. Increase the circle's opacity while its Element is touching another Element and decrease while it is not.[102]

Despite its seemingly prescriptive format, this score leaves a great deal of interpretive creativity in the hands of the programmer, who establishes the parameters and variables by which it will be executed. Each of Reas's predefined elements consists of a combination of forms and behaviors. For example, Element 3, used in *Process 15*, is defined as a combination of Form 2 (a line), with Behaviors 1 (move in a straight line), 3 (change direction while touching another Element), and 5 (enter from the opposite edge after moving off the surface). The instructions for how the element will be used are intentionally vague, refusing to specify, for example, the initial sizes of the objects, the number of instances, or their size, color, or opacity; nor is the rate of increase or decrease of size or opacity specified. All these factors are left up to the programmer's interpretations and improvisations, the way a musician or conductor might elaborate during a musical performance.

When presented electronically, the result is a visual experience in a perpetual state of becoming. When committed to static media, Reas selects one or more exemplary moments from each process to create a fixed C-print image, which can be displayed apart from the computational apparatus. To what extent should these arrested moments be regarded as "images" at all? They are primarily surface manifestations of the execution of Processing code. Their relationship to forms in the physical world is one of resemblance or allusion, rather than representation or mimesis. The lines, shapes, and volumes described by the computer's execution of the code may be thought of quite literally as "traces," but not the type of indexical photochemical trace realized in photography or cinema.

Reas states that the original text descriptions constitute the most important element of the work. In this, Reas's "scores" relate to the Fluxus movement and other practices in conceptual art of the sixties and seventies. Reas's method also resembles a computational version of Sol LeWitt's *Wall Drawings*, but with results that are closer to a partially ordered exercise in abstract expressionism. Like a LeWitt drawing based on a set of drafting instructions to be executed by others, Reas's *Process* works are interpreted first by the programmer, then by the software, with each actor afforded a degree of creative or stochastic variation. This, in part, is what makes the works feel organic rather than geometric or mechanical, distinguishing them from most of LeWitt's work.[103]

So rich and variable are the combinations of elements and behaviors afforded by the library subtending the *Process* series that it has supported experiments by Reas for well over a decade, comprising dozens of final images and installations. Throughout this time, Reas also created numerous related works that elaborate on the basic premise of the series. These include *Image Phase* (2004), a seventeen-minute animation created to accompany Steve Reich's 1967 musical composition "Piano Phase."[104] Reas's contribution to the project features abstract smoky shapes that morph in concert with a series of hypnotic, looping note sequences by Reich that phase in and out of synch. The images appear out of focus—an anomaly in Reas's body of work—transforming the images from their ontological status as code to images that appear distinctly videographic.

Although anomalous, this piece bears consideration because it highlights a central tension in Reas's work of this period. The code image is pristine and resolute—infinitely scalable and reproducible without distortion—the visual artifact of a lossless and infinitely executable algorithm. In contrast, the physical objects generated by the code cross the threshold to become images only when they are rendered for consumption. With *Process* works, this occurs at the moment of display or printing—or in the case of *Image Phase,* when rendered as video and thrown out of focus. The images are rasterized, ontologically transformed into a fixed medium, whereupon they commence being subject to decay. Only then do they become mortal, no longer safe in their regenerative capacity for infinite becoming.

To highlight the relationship between final images and the process used to create them, works in the *Process* series are typically presented in diptych form, consisting of two primary components: an operation screen, showing a graphical visualization of the computer's operations at runtime, and a final presentation screen or printed image.[105] The two screens are typically supplemented by wall text, which presents the original score as natural language text description. The temporal structure of Reas' work is thus threefold, referencing early moments of conception when the description and its translation into code were authored, followed by a real-time visualization of that code being executed, usually in a gallery context, and sometimes a different postprocessual moment when a single image is extracted and committed to a fixed object form.

In 2012, Reas launched a series of works titled *Signal to Noise*. Similar to how the *Process* series shared a library of elements, works in the series that followed were created with variations on this original software engine. Rather than taking pure elements of code as its basic building blocks, *Signal to Noise* was designed to sample and transform preexisting media sources such as broadcast television.[106] These works also represented Reas's transition away from the diptych format, resulting in elimination of the operation screen that reminded viewers about the rule-driven processes underlying the work.[107] The nature of the works' generativity also morphed significantly in this series. Whereas the *Process* works were driven first by rules encoded into an expressive software system, works included in *Signal to Noise* derive from preexisting imagery that remains unrecognizable yet generically familiar.[108] Viewers are not invited to experience the pleasure of decoding the algorithms driving their visual experience. Instead, they are asked to step back and experience the display on its own terms, as a visual experience presented without the need to emphasize either apparatus or process.[109]

Arguably, Reas's broadcast series simply shifts attention to different stages in the work's creation. In a series of works using found images intercepted from television broadcast towers around Los Angeles, Reas created loops of televisual imagery as source material to be processed by the *Signal to Noise* engine. Each piece was titled based on the station and month during which the original images had been captured, even going so far as to locate the towers by latitude/longitude coordinates and in terms of their broadcast frequency on the electromagnetic spectrum. Reas describes *KNBC (November 2015)* as "an audio and visual distortion of television signals broadcast during December 2015 over the 602–608 MHz spread of the electromagnetic spectrum from a tower located at 34°13′32″N, 118°3′52″W." Coupled with abstract bursts of sound composed by Philip Rugo, these works create a cascade of visual information—one hesitates to call them simply images—that is evanescent and ever changing, much like the station's own tireless stream of broadcast signal. In these works, however, the hypnotic flow sought by network programmers is replaced by an equally endless but more chaotic visual barrage. There is something unmistakably televisual about these projects, but Reas's work confounds its reception, stripping away the conventional pleasures of popular culture to make way for new ones.

Reas describes the *Signal to Noise* software as "a collage engine that uses terrestrial television signals as the raw material. Like early twentieth-century collages built from the media of that time and mid-century video collage, *Signal to Noise* fractures and distorts contemporary information into new data structures."[110] This is what separates Reas's media appropriation from collage work by artists such as Robert Rauschenberg or Kurt Schwitters. It is ultimately not the images or artifacts of culture that are of interest—nor

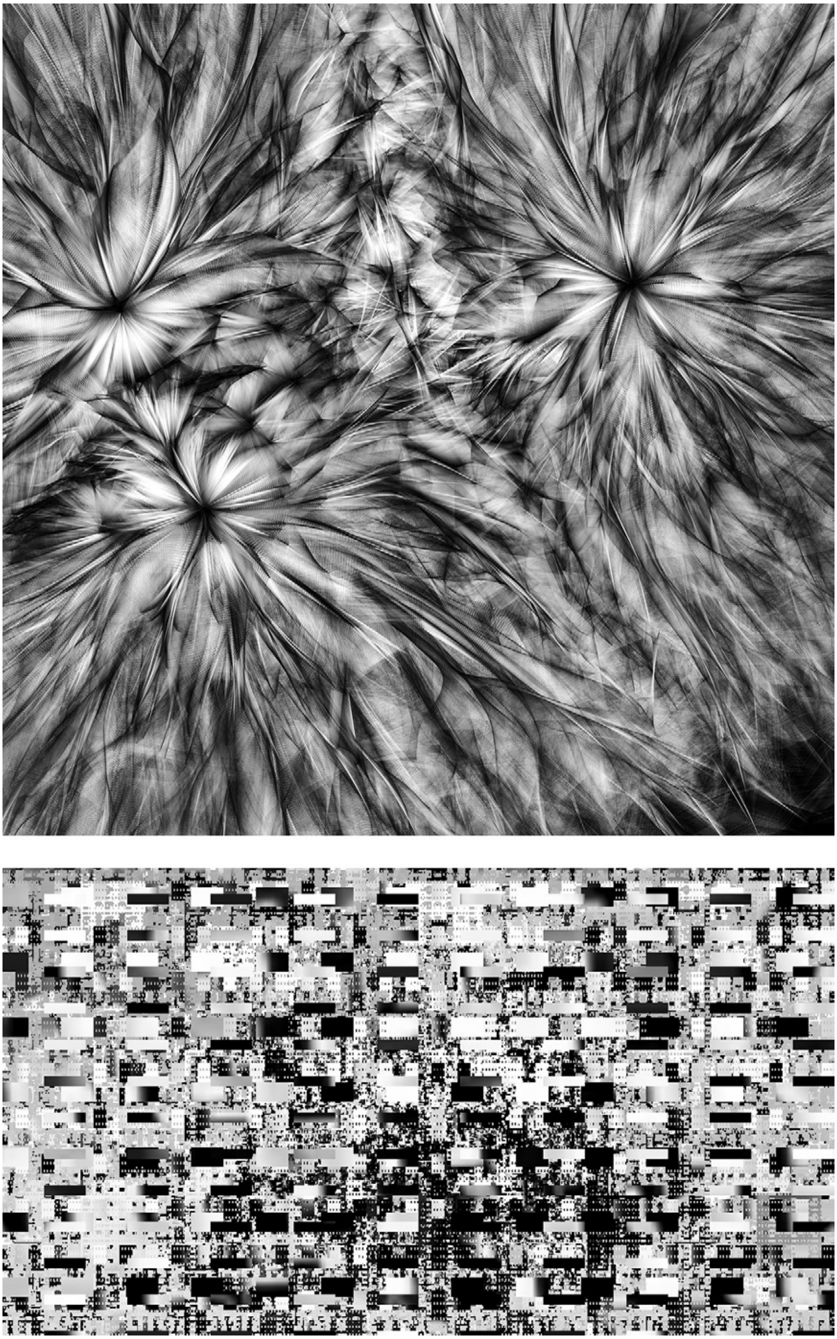

Figure 1.10

This juxtaposition of images from Casey Reas's *Process* and *Signal to Noise* series illustrates two divergent strategies of negotiation between image and data. Top: *Process 6* (2010). Bottom: *Magic Nude* (2013). Images courtesy of Casey Reas.

is it the infinite reproducibility or reflection of cultural values excerpted by Andy Warhol. Even within the oceanic flow of televisual images, Reas finds evidence of nascent "data structures" waiting to be amplified and elaborated through software. The *Signal to Noise* engine thus inverts Reas's own logic of a predefined library of elements. Whereas the *Process* works imbue purely computational systems with signs of life, *Signal to Noise* transforms the living stream of television into algorithmic abstractions.

Related works during this period include *Infinite Command Team* (2013), *100% Grey Coverage* (2013), *Pfft!* (2013), *Tox Screen* (2013), and *Control Room* (2013), which together may be thought of as Reas's "televisual period." As a whole, they offer a TV-oriented counterpoint to Benjamin Grosser's *Computers Watching Movies*. Whereas Grosser envisions for the computational consciousness a focused singular gaze scanning the surface of each cinematic frame, Reas suggests that something very different occurs when computers watch TV. Reas's Processing algorithm attempts to account for everything at once, consuming whole grids of televisual pixels, reordering, classifying, and redistributing them in real time. In its motion video form, the works of *Signal to Noise* preserve their televisual origins in the dynamic cadences with which the underlying imagery changes from one framing to the next. The visual effect is an intense pulsing assault that is as unrelenting and variable as television itself.

The trajectory described by Reas's work, from his fascination with organic structures in *Process* to the mechanical grid patterns and geometric shapes of *Signal to Noise*, suggests two divergent critical trajectories. The works have become colorful, prismatic investigations of media and movement; at the same time, they have lost the viscosity of the organic structures, the resemblance to mammalian tissue, cell division, and neurological networks. The later works are, ironically, both more lively and less life*like*. Although still not mimetic in any conventional sense, they are entangled with images of and from the world in a way that the *Process* series never was.

In conjunction with the incorporation of mass media artifacts into his work, Reas began paying increased attention to the content of the images sampled. *Ultraconcentrated* (2013) posed the first explicit—though, in some sense, still implicit—critique of the content of broadcast television. Rather than simply receiving broadcast signals as random or undifferentiated streams of pixels, *Ultraconcentrated* uses identical instructions for the image processing to treat "violent and horrific" images from "fictional police dramas" on one screen, along with identically processed advertisements aired during the same broadcast on another.[111] On the surface, this juxtaposition might seem to reflect a bad-object critique of televisual violence and consumerism. Stripped of the sound that ordinarily overdetermines viewers' reception, *Ultraconcentrated* invites a rare reconsideration of basic elements of the televisual image—color, movement, cutting—suggesting that even TV's most reviled content carries the potential for aesthetic pleasure. Although the processing of the image stream is recognizably algorithmic, the technical apparatus used to create it remains enigmatic. Grids and patterns of rounded rectangles suggest a connection to midcentury TV screens or perhaps sprocket holes, fragmenting, amplifying, and scattering flattened surfaces across the screen. Specific functions of the software may be hypothesized, but the visual experience remains irreducible to a set of instructions or operations by the computer. In these works, arguably—and contrary to conventional wisdom on the subject—noise is as deserving of attention as signal.[112]

Conclusion

In this chapter I have proposed a series of two-way linkages between artifacts of the visual and computational registers. The ability to envision computation and to translate visual information into computable form represents a necessary foundation for the following chapters' discussions of space and surveillance. Data serves both ideological and epistemological functions, and it is no coincidence that its ascendance in the discourse of popular culture has been accompanied by a moral panic about a loss of authenticity allegedly exacerbated by digital information networks. Data analysis, like statistical analysis before it, requires a specialist class to translate quantitative abstractions into meanings that are understandable by the general public. Likewise, visualization is part of a discourse of authenticity that is beholden to regimes of truth. Like all truth claims, visualization operates according to rules and limits that are established, contested, and disrupted as much through social dynamics as through computational ones. By deemphasizing the translational properties of visualization—which might be mistaken for neutral or automated—in favor of its participation in processes of negotiation and contestation, my hope is to emphasize the inherently political nature of data visualization.

We should expect that data, in all its forms, will continue to be actively deployed in issues of immediate and lasting social consequence. Vigilance is needed to critically examine truth claims derived from both data and its visualization. This chapter has focused on the rhetorical aspects of data visualization rather than the challenges associated with its practical application, but attention to both domains will be required if we are to produce and recognize reliable information about the world. Appearances to the contrary, data knowledge must continue to be understood as partial, fragmented, and situated. As such, it will be increasingly important to be able to interrogate and clearly articulate the systems of evidence and analysis used to support the validity of one's arguments. Whereas theorists of postmodernism once posed deliberately provocative and sometimes playful challenges to the very existence of truth, these challenges responded to purportedly stable models of established knowledge, evidentiary methods, and rational interpretation. In the absence of such stability, more nuanced—but perhaps no less playful—forms of provocation will be required. Data visualization itself should be seen as neither culprit nor antidote in the crisis of authenticity associated with digital media. Ultimate responsibility for the veracity of data and the ethics of knowledge production falls not to algorithmic processes but to cultural and social ones.