

UNIVERSITY OF CALIFORNIA, SAN DIEGO

Contemporary Data Visualization: A Cultural History and Close Readings

A Dissertation submitted in partial satisfaction of the requirements for the degree
Doctor of Philosophy

in

Art History, Theory and Criticism

by

Tara Zepel

Committee in charge:

Professor Lev Manovich, Co-Chair
Professor Peter Lunenfeld, Co-Chair
Professor Benjamin Bratton
Professor William N. Bryson
Professor James Hollan
Professor Elizabeth Losh

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The Dissertation of Tara Zepel is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Co-Chair

Co-Chair

University of California, San Diego

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VITA

- 2006 Bachelor of Arts, Duke University
- 2008-2016 Teaching Assistant, Department of Visual Arts, University of California, San Diego
- 2007-2011 Teaching Assistant, Culture, Art and Technology Writing Program, University of California, San Diego
- 2016-2017 Lecturer, Media Arts, Society & Technology minor, Cal Poly, San Luis Obispo
- 2018 Doctor of Philosophy, University of California, San Diego.

PUBLICATIONS

“How to Compare One Million Images?” with Lev Manovich and Jeremy Douglass, 2011. Online at https://www.academia.edu/9813363/How_To_Compare_One_Million_Images.

“Revisiting the Twitter Experiment (In Context).” *The New Everyday* (March 2011): Online at <http://mediacommons.futureofthebook.org/tne/pieces/revisiting-twitter-experiment-context-0>.

“Cultural Analytics at Work: The 2008 U.S. Presidential Online Video Ads.” *Video Vortex Reader II*, edited by Geert Lovink and Somers Miles, 234-249. Amsterdam: Institute of Network Cultures, 2011.

FIELDS OF STUDY

Major Field: Art History

Studies in Media Studies, Digital Humanities, and Cognitive Science

ABSTRACT OF THE DISSERTATION

Contemporary Data Visualization: A Cultural History and Close Readings

by

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This dissertation is the first in-depth study of a new important area of contemporary visual and digital culture - data visualization. First developed at the end of the 18th and early 19th century, data visualization until recently has been understood as an analytic tool for expert use. However, a growing number of projects have challenged these assumptions. The expansion of a data visualization into art (including many exhibitions in leading art museums), social activities, and nearly every dimension of life that begins around 2004 indicates a far more complex set of interactions between representation, viewer, and data than it was assumed earlier. While a small handful of scholars have begun to investigate data visualization's untraditional or alternative uses, there is still no in-depth study of how and why data visualization functions in contemporary society and culture.

My work lays the groundwork for seeing data visualization as a socially and culturally situated medium and practice. I examine my subjects by combining methods and concepts from a number of disciplines: media studies, art history, cognitive science, and design. These disciplines have not been brought together so far in investigating contemporary data visualization culture, so this is a methodological innovation of the dissertation.

The presentation of the material is organized into two parts. The first part presents a cultural history of data visualization as it has developed alongside digital culture and technology since 1970s until the present. In the second part, I analyze how data visualization functions today in different contexts via close reading of select projects. Such close analysis is common in art history, film studies or literary studies,

but has not yet been applied to data visualization projects. My readings test theoretical ideas of the dissertation, while also showing how we can think of data visualizations as complex cultural objects not unlike paintings, films or novels.

INTRODUCTION

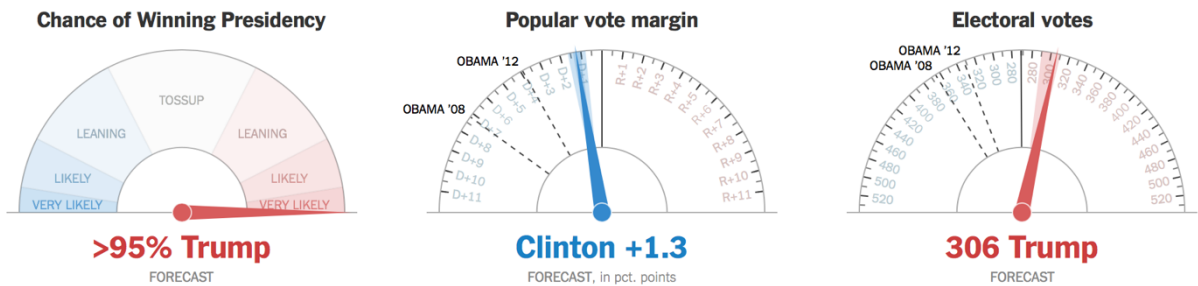


Figure 0.1 Screenshot of *The New York Times* interactive election graphic (2016).

November 8th, 2016. It was the evening of the U.S. Presidential election. The three gauges shown above featured prominently on the New York Times' website. As the various precincts began to report, the graphic took on life. Needles jittered back and forth. Numbers for each candidate changed. By eleven o'clock at night, it was clear who would become the next president of the United States.¹ I remember the experience of watching this graphic. Notably, it was on a computer screen. And notably, it made a large amount of information easier to understand. What I remember the most vividly, however, is the feeling with which I watched. Every time the dials moved, I felt. I felt captivated and alert. I felt my hopes for the country grow and fade. I felt the polarized nation. And I felt my stomach move. One viewer summarized the

¹ Several people, including the graphic's designers, posted about its design and effect after the fact. For a blogpost with screenshots at different intervals throughout the night, please see: J.K. Trotter, "The New York Times Live Presidential Election Meter Is Fucking With Me," Gizmodo.Com, November 8, 2016, <http://gizmodo.com/the-new-york-times-live-presidential-meter-is-fucking-w-1788732314>.

feeling well by calling the visual “an online widget [that] brilliantly correlates to my blood pressure.”² It seemed as though this graphic was determining the country’s political fate. Except it was not. It was simply representing data in a way that evoked tremendous social and political impact.

Data visualization is the visual representation of data of any type. *The New York Times* election meter is just one example of how data visualization and contemporary society interact. Once contextualized as a tool for expert use, data visualization now pervades. We have data visualizations about the human genome, data visualizations about our buying habits, data visualizations about our social networks, and data visualizations about our art. We use data visualizations analytically, to help us better understand large amounts of information; socially, to communicate and explore relationships with others; and culturally, to express identity and as art. When a NASA scientist plots temperature data to model the atmosphere on Mars, that is data visualization.³ When the feature on your smartphone app lets you map your run and share it with friends, that is data visualization.⁴ When a digital humanities scholar represents Shakespeare’s tragedies as network graphs, that is

² Trotter.

³ See Greg Shirah, *Mars’ Lost Atmosphere*, Data Visualization, 2015, <https://svs.gsfc.nasa.gov/12046>.

⁴ Several apps give you the ability to track exercise, set goals and share your progress with a larger community. Some, such as Map My Run and the Nike+ Running App, are for social network oriented. Others, such as Strava or vivoactive®HR, add the ability to visualize more than GPS data and run analytics.

also data visualization.⁵ Data visualization has essentially become another language through which we communicate and experience life.

This dissertation is about situating data visualization in its larger social, cultural, and historical contexts. What do I mean by this? At the most basic level, I mean recognizing that data visualization, just like any other representational medium and practice, is conditioned by a particular set of circumstances, a particular set of goals, and particular ways of knowing. The pages that follow offer the first book-length investigation of contemporary data visualization—that is data visualization as it has developed alongside computer culture and technology from the late 1970s to the present—in order to make the point that data visualizations must be understood as situated in the circumstances in which they are designed and seen. Combining ideas and methods from media studies, art history, cognitive science, and design, I look at how data visualization has become a pervasive socio-cultural form, what assumptions and influences are at play, and what this means for the way we conceptualize and approach data visualization research and design. I approach the study of data visualization much like the study of photography or film, through close reading and visual analysis. Why did contemporary data visualization emerge when it did? What factors were at play? What occurs in the relationship between viewer, representation, and environments? And how do formal as well as contextual elements influence the

⁵ See Martin Grandjean, “Network Visualization: Mapping Shakespeare’s Tragedies,” Personal Website, Martin Grandjean, (December 23, 2015), <http://www.martingrandjean.ch/network-visualization-shakespeare/>.

meaning, reception, and design of visualizations today? These are just some of the questions this dissertation asks.

In doing so, I intend to make a methodological argument about how to best move forward with visualization design and research. The past fifteen to twenty years have been characterized by data visualization moving outside of traditional research environments and into nearly every dimension of life. While a wide variety of scholars have noted this shift, only a handful have posed alternative or updated approaches to visualization research and design. These tend to be framework-driven or remain abstract. In beginning with the concrete, in-depth analysis of existing projects, I hope to perform that background work necessary to build such an approach. Data visualizations are not simply analytic representations of data, and it is time we stop seeing them as such.

Data Visualization as a Socio-Cultural Form

Recognizing that data visualization has become a pervasive socio-cultural form requires little work. The extent to which data visualization is implicated in how we understand and experience the world is vast. The examples given at the beginning of this introduction are just a few out of many. From the latest scientific research to how we interact with friends, data visualization plays a role. The question is what role does it play? Recent developments in visualization design and research have challenged the assumption that data visualization serves as an objective, analytic tool for data's

display. While we do use data visualizations analytically to help us understand data, we also use them to express, to communicate, to feel, and to persuade.

Take, for example, Stefanie Prosavec and Giorgia Lupi's *Dear Data* project. Created shortly following the designers met in 2014, it quite literally answers the question of can two people get to know each other through data alone. Every week, for an entire year, Prosavec and Lupi collected and measured a particular type of data about their personal lives (e.g. the times they laughed, the time they complained, the times they engaged in certain activities, etc...). They then represented this data on a postcard-sized sheet of paper and dropped the postcard in a mailbox to be delivered to the other's address. Prosavec lives in London; Lupi in New York. What resulted is a collection of rather intimate hand-drawn visualizations (Figure 0.2) that both record and give insight into a person's day-to-day life. Originally published as a website (dear-data.com/theproject), the project has since been turned into a book.⁶ Taken as a whole, the experience of viewing *Dear Data* is a bit like the experience of looking through a box of photographs or similar artifacts. Each is personal, each is data-based, and each takes on additional meaning because of something that is not physically represented on the screen (or page).

⁶ Giorgia Lupi and Stefanie Prosavec, *Dear Data* (Princeton Architectural Press, 2016), https://www.amazon.com/Dear-Data-Giorgia-Lupi/dp/1616895322/ref=sr_1_1?ie=UTF8&qid=1486748686&sr=8-1&keywords=dear+data+book.

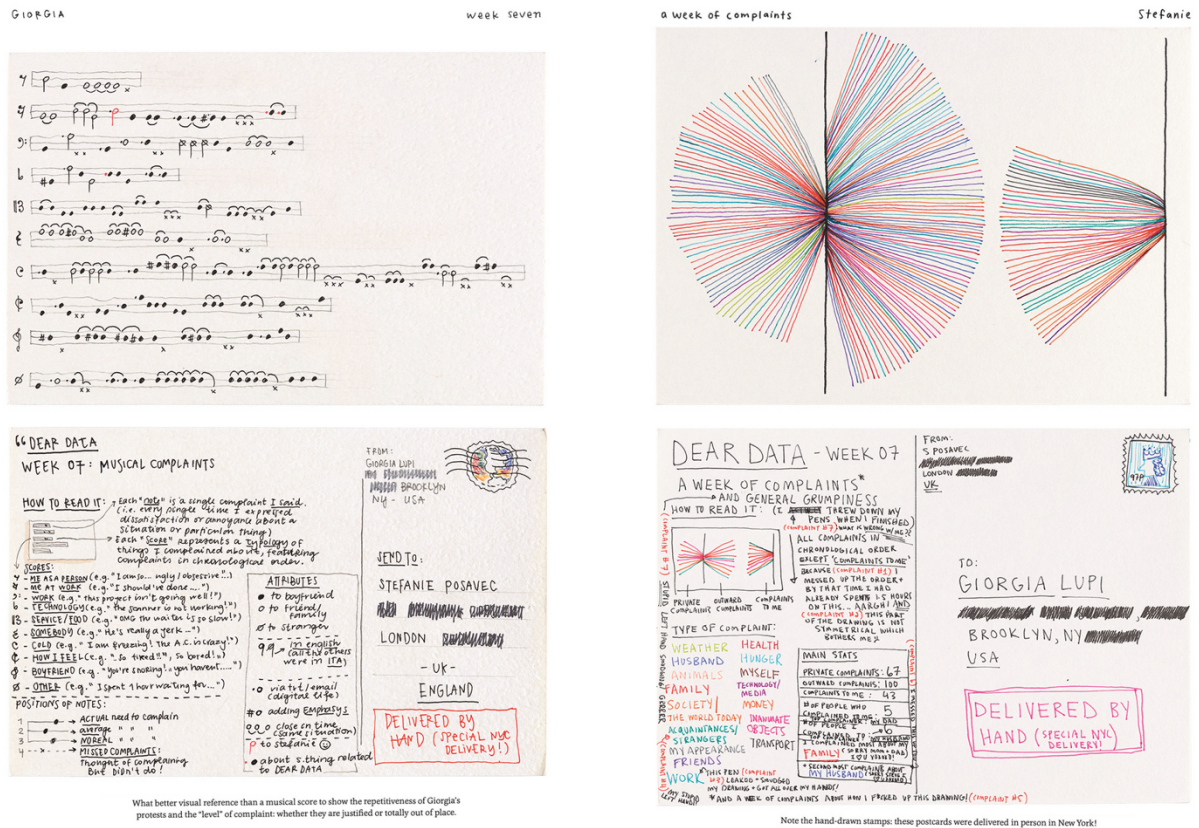


Figure 0.2 Stefanie Posavec and Georgia Lupi. Screenshot of *Dear Data* (2014).

This dissertation proceeds from the basic premise that data visualizations, like any other visual media, both reflect and affect how we see. In 1972, art historian John Berger wrote and starred in a television miniseries called *Ways of Seeing*.⁷ In it, he presents his insights on how our very sense of sight has been transformed. To see, he argues, is a political act. To look at an image is to engage in a historically and socially constructed process such that when and where we see something affects what we

⁷ John Berger, *Ways of Seeing* (London: BBC and Penguin Books, 1972).

understand from looking at it. In other words, seeing requires context. The same photograph of a woman driving means something different depending on where it is displayed, who is looking at it, and the circumstances in which it is seen. The idea that images are constructions and carry social and cultural meaning is an important tenant of visual culture, art history, and film studies, but one that is often not considered when looking at data visualizations. Why?

Data visualization has reached a critical point where it needs the same. As data visualization has become more and more a part of everyday life, questions about its values and ways of constructing knowledge arise. One prevalent critique coming out of the digital humanities has been that data visualization is overly positivistic.⁸ I would argue that the first step to addressing this is not to assume that positivism is inherent to the practice but rather the result of values and assumptions that have been put into place at specific points in time. In her forthcoming book *Data by Design*, Lauren Klein traces the rise of modern data visualization techniques to show how historical epistemologies, as much as form, continue to influence the design, reception, and rhetoric of visualization today. In many ways, this dissertation does the same except that the period and examples I focus on are drawn from the recent past and present. Instead of focusing on the development of techniques, I focus on the development of a contemporary visualization culture. It is only by understanding this culture and the various events and values that have influenced it that we can begin to understand our

⁸ Anne Burdick et al, *Digital_humanities* (Cambridge, MA: MIT Press, 2012), 44.

present relationship with data visualization and what we want out of it in the future. As data visualization becomes increasingly popular and pervasive, this is an increasingly important agenda. It is important to understand how we “see” and interact with data representations. This feedback is equally important for future visualization research and design. And it important for developing a basic visualization literacy.

Motivations and Related Work

The motivations behind my research are threefold. First and foremost, a cohesive history of contemporary data visualization has not been written. Most histories of data visualization begin in the late 1700s with the invention and popularization of many of the most common graphical forms still used today (e.g. bar chart, line graph, etc...). They then continue to lay out the work of key individuals and projects, which in retrospect explain the linear development of visualization as a cognitive tool for data analysis and comprehension. The official birth of the field in 1986 and its consequent explosion throughout the 1990s is then taken as a near ending point. There are two problems with this. First, the development of data visualization as a field and practice is and never has never been linear. Second, it stops short. While such overviews will often acknowledge data visualization’s continued diversification and growth, they stop short of examining and theorizing the present. The handful of articles and discussions that do exist remain scattered on

websites, in conferences, and on blogs. No in-depth, comprehensive account of contemporary data visualization exists.

Secondly, this dissertation responds to a call in the existing visualization literature for more critical reflection and theoretical work. The idea that we might need to change the way we conceptualize and approach data visualization is not my own. The rise of several untraditional forms of data visualization in the late 1990s and early 2000s raised questions about differing audiences, ideals, and goals. If data visualization could serve as art, or as a social facilitator, and reach non-expert audiences (among many other things), then traditional approaches to research and design were likely out of date. Most advancements to this regard occurred in the design of the projects themselves with only a handful of scholars stopping to reflect or theorize the changes that were taking place. Meanwhile, data visualization continued to change. Over the past fifteen years, data visualization has become more and more important to how we experience life. It makes sense that we might want to think about how data visualizations affect our understanding of the world, what values and assumptions they communicate, and what direction we want their future development to take.

There is a small body of literature coming out of the digital humanities and similarly interdisciplinary research that has begun to perform this work. Critical and feminist approaches to data visualization aim to uncover taken-for-granted assumptions about visualization and reflect on what values are portrayed. The same data can be represented in infinite ways. By focusing on how a particular visualization

is constructed and what expectations dominate the field, such approaches emphasize the need to think about the situational factors that influence a given display. Critical and feminist approaches to data visualization also aim to create more inclusive and nuanced experiences of interacting with data. This intention has been echoed by recent calls to humanize data and its representation.⁹ There seems to be a growing recognition that merely technical approaches to visualization need to change if we want to use data visualization to its fullest capacity. This dissertation is in conversation with this line of thought, which is explained in more detail in Chapter 2.

There is also a way that this dissertation is in conversation with a paradigm in cognitive science known as situated cognition. The idea that what we know and what we think are dependent on context spans a broad range of scholarly work in psychology, anthropology and cognitive science. In 1987, anthropologist Lucy Suchman wrote a book called *Plans and Situated Actions* in which she argues that every course of human action is constructed from dynamic interactions with the material and social world.¹⁰ Suchman grounds her investigation in the observation of human-machine communication, specifically the communication between novice users and the double-sided function of a copier. What she found was that users figured out

⁹ Giorgia Lupi, “Data Humanism: The Revolutionary Future of Data Visualization,” *Print Magazine*, January 30, 2017, <http://www.printmag.com/information-design/data-humanism-future-of-data-visualization/>; Giorgia Lupi, “Data Humanism – The Revolution Will Be Visualized” (IEEE VIS 2017, Pheonix, AZ, October 6, 2017), <https://www.youtube.com/watch?v=S0YkTtLFIDs>.

¹⁰ Lucy A. Suchman, *Plans and Situated Actions: The Problem of Human-Machine Communication* (Cambridge University Press, 1987).

how to use copy feature not as a result of any pre-conceived, rational plan but as an emergent property of the moment to moment interactions between actors and between actors and their environment. In other words, people use their circumstances to achieve mutual understanding and intelligent action. This approach to the study of context is known as the situated action model. It has been expanded upon by others and emphasizes the emergent and contingent nature of human activity.¹¹

Two related approaches in cognitive science that developed around the same time are activity theory and distributed cognition. Activity theory maintains that the constituents of an activity are not fixed but can dynamically change. It proposes a very specific notion of context – that of the activity system itself. Context is constituted through the enactment of relations involving people, operations and artifacts. There is no context out there inside which this interaction takes place.¹² Distributed cognition is an approach to cognitive science that studies the representation of knowledge both inside and outside individuals' heads. It sees cognition as distributed across a collection of individuals, artifacts, and/or time in a particular work setting.¹³ All three

¹¹ Jean Lave, *Cognition in Practice: Mind, Mathematics and Culture in Everyday Life* (Cambridge University Press, 1988); Lucy A. Suchman and Randy Trigg, "Understanding Practice: Video as a Medium for Reflection and Design," in *Design at Work: Cooperative Design of Computer Systems*, ed. Joan Greenbaum and Morten Kyng (Hillsdale, NJ, USA: L. Erlbaum Associates Inc., 1991).

¹² For summaries of activity theory, see: A. Leont'ev, "The Problem of Activity in Psychology," *Soviet Psychology* 13, no. 2 (1974): 4–33; Susanne Bødker, "A Human Activity Approach to User Interfaces," *Hum.-Computer Interact.* 4, no. 3 (September 1989): 171–195, https://doi.org/10.1207/s15327051hci0403_1; K. Kuutti, "Activity Theory and Its Applications to Information Systems Research and Development," in *Information Systems Research*, ed. H. E. Nissen (Amsterdam: Elsevier Science Publishers, 1991), 529–49.

¹³ Edwin Hutchins and Nick Flor, "Analyzing Distributed Cognition in Software Teams: A Case Study of Team Programming during Perfective Software Maintenance," in *Proceedings of the*

approaches to the study of context have contributed to the development of data visualization as a field and as a practice. However, context is something that is rarely accounted for in the visualization literature outside of material or technical specifications.

Developing an Updated Approach

If data visualization is constructed, if it must be read as situated in the circumstances in which it is designed and seen, then an updated, more reflective and human-focused approach to data visualization design and research is needed. The pages that follow largely perform the background work necessary for beginning this task. However, unlike existing research, I do not begin with a particular perspective or framework. Rather, I begin with close readings of the projects themselves. While frequently applied to the study of literature, film, and art, such close reading has not yet been applied to data visualization as a systematic method of research. Data visualization is an inherently interdisciplinary field. By beginning with close, concrete analysis of example projects, I hope to avoid the problem of starting with a disciplinary theory vocabulary that might not be applicable to all data visualizations or understood by all participants. In many ways, this dissertation makes the argument that all data

Fourth Annual Workshop on Empirical Studies of Programmers, ed. Jürgen Koenemann-Belliveau, Thomas G. Moher, and Scott P. Robertson (Norwood, N.J.: Ablex Publishing, 1991), 36–59; Edwin Hutchins, *Cognition in the Wild* (MIT Press, 1996).

visualizations must be read individually. The initial approach of close reading is an attempt to emphasize this specificity.

The dissertation proceeds in two parts. Part 1 (Chapters 1 and 2) charts the trajectory of what I am calling contemporary data visualization. In it, I analyze how key events, projects, and trends both inform and reflect the course of data visualization's development from the late 1970s to the present. Importantly, no single storyline or perspective is given preference. Rather, visualization's development is told through a complex array of social, cultural, technological, and political factors that were dominant at certain points in time. My aim is not to provide a comprehensive history. Rather my aim is to highlight some of the main influences in contemporary data visualization's development, and show how these, at least in part, are reflected in the way visualization is used, designed, and conceptualized today.

Chapter 1 examines the period leading up to and immediately following contemporary data visualization's birth. It spans from roughly the late 1970s to 2000. The chapter begins by introducing the term contemporary data visualization as a way to differentiate between earlier forms of data representation and the pervasive socio-cultural form that exists today. I then move on to examine three broad trends that set the stage from which contemporary data visualization emerged – the development of supercomputing, a timely interest in visual representation, and the development of computer graphics. No single storyline or perspective is given higher status. Social, cultural and technological factors are considered alongside together. The chapter then proceeds to tell the story of contemporary data visualization's birth, pointing to the

1986 *Visualization in Scientific Computing* (ViSC) Report as its official decree, and outline its earliest development.¹⁴ Scientific visualization and information visualization are examined as the two dominant genres that emerged during this period.

Chapter 2 picks up where the previous chapter left off. It examines the various ways in which contemporary data visualization has expanded outside of traditional research environments and into nearly every dimension of life. Several technological and social developments over the past fifteen years such the popularization of the Internet and lowered barriers to access for data and software have open visualization up to new audiences, settings, and goals. The chapter is structured as a survey of three broad areas in which this has arguably been the case – visualization as art, social data visualization, and visualization and the everyday. While these are not the only three areas in which data visualization has expanded, they are the most prominent. By conversing with example projects and relevant literature, I show in very concrete terms what is meant by the claim that data visualization has become a pervasive socio-cultural form. More importantly, I show a recognized need to rethink existing approaches to visualization design and research. The chapter concludes by introducing alternative approaches that have recently emerged in an effort to make data visualization more reflective and human-focused.

¹⁴ Thomas A. Defanti, Maxine D. Brown, and Bruce H. McCormick, “Visualization in Scientific Computing” (New York: ACM SIGGRAPH, 1987), <http://www.sciencedirect.com/science/article/pii/S0065245808601680>.

Part II (chapters 3, 4, and 5) shifts the discussion to the single project scale. It offers close readings of select visualization projects in order to expand upon ideas and concepts introduced in Part I. Part II additionally serves to model where any current approach to visualization must begin. Beginning with a preconceived framework risks not accounting for the true complexity and interdisciplinary that many contemporary data visualizations entail. Similarly, beginning with abstract concepts does not account for the specificity and context of individual projects. It is only by beginning with careful and close visual analysis of the projects themselves that we can begin to construct and theorize what an alternative or updated approach to data visualization research and design might be.

Chapter 3 analyzes Dustin Cable's *Racial Dot Map* through the lens of current socio-cultural events and personalized experience.¹⁵ It argues that data visualizations, much like documentaries, are representations that give evidence of the culture that produced them and the things represented in them. Importantly, what is represented – that is what is seen – takes on meaning based on context, audience and an array of external factors that may or may not be directly represented on the page or screen. In depicting racial diversity and distribution across America based on 2010 census data, the *Racial Dot Map* involves a whole lot more. It involves the country's consciousness at the time, it involves a shared racial history, and it involves personal geographic

¹⁵ <https://demographics.virginia.edu/DotMap/>

experience. Such external factors play a key role in the visualization's effectiveness and meaning.

One important aspect of seeing visualization as a socially and culturally situated practice is recognizing that visualizations may have an agenda. This does not necessarily mean that they are not accurate representations. Chapter 4 investigates how rhetorical purpose and emotion are incorporated into the design of *U.S. Gun Deaths*.¹⁶ Through first-person accounts and close visual and textual analysis, I show how the careful incorporation of emotive details can be used strengthen the message of a visualization without necessarily obscuring or misrepresenting the data. To this regard, the chapter addresses questions of ethics, data selection and social activism through data visualization.

¹⁶ <http://guns.periscopic.com/?year=2013>