Review of *A History of Data Visualization and Graphic Communication*, by Michael Friendly and Howard Wainer

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A History of Data Visualization and Graphic Communication
by Michael Friendly and Howard Wainer
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> "In recent years there has been a tremendous increase in the use of visual materials for the presentation of ideas and facts."[1]

We live in an era of abundant information. Data is generated and harvested at an unprecedented scale, with scientific, public, and commercial bodies increasingly relying on data and data analytics to solve problems. Media outlets strive to keep the world informed and updated on current world conditions, such as the COVID-19 pandemic, using maps, tables, and graphs depicting regional and global numbers of infections, deaths, recoveries, and vaccinations. Experts and laypeople alike seek information that can be readily accessed, and easily understood, so they can plan for and make decisions in the lab, the office, and at home. We live in an era of data dependence—never before have graphic representations of data been as essential and sought after as at this moment. Surprisingly, the quotation introducing this text was stated eighty-four years ago by H. Gray Funkhouser in his doctoral thesis *Historical Development of the Graphical Representation of Statistical Data*. Looking through a twenty-first century lens, his work represents a comprehensive history of data visualization by detailing evidence of how and why graphic depictions of numbers arose, which factors led to innovations in graphic displays of data, and which discoveries took place through the analysis of graphic data that would otherwise have been missed.[2]

Michael Friendly and Howard Wainer are highly regarded in the fields of statistics and visual cognition, and hence are firmly positioned to undertake such a significant and timely project. In addition to their wealth of article and book contributions, Friendly and Wainer are Fellows of the American Statistical Association. Friendly is Professor of Psychology at York University, Canada; coordinator of York's Institute for Social Research Statistical Consulting Service; and associate editor of *The Journal of Computational and Graphical Statistics*[3] and *Statistical Science*.[4] In the mid-90s, Friendly launched the Milestones Project:[5] an online, interactive platform showcasing the history of data visualization, alongside Daniel J. Denis, Professor of Quantitative Psychology at the University of Montana, USA.

Until his formal retirement in 2016, Wainer was a Distinguished Research Scientist at the US National Board of Medical Examiners and taught statistics at The Wharton School, University of Pennsylvania. He has written the "Visual Revelations" column in the statistics journal *Chance*[6] for the past thirty-two years. Among his many honors, he received the 2013 Psychometric Society Career Award for Lifetime Achievement and the 2021 ASA Statistical Computing and Graphics Award. He is Fellow of the American Educational Research Association and is currently on the board of editors of the British statistics magazine *Significance*.[7]

The ten chapters of this three-hundred and twenty-page tome are framed within a historical timeline that runs from the graphic activities of prehistoric humans up to present-day advances in data visualization and communications. One hundred and ten high-quality black and white drawings, maps, charts, and graphs are generously peppered throughout the book, with an additional twenty color images placed in a signature between chapters nine and ten. The book includes additional resources organized by chapter,[8] generous endnotes,[9] and twelve pages of references.[10]

Many of the names mentioned in the book, and the graphs displayed, will be familiar to readers acquainted with data visualization and graphic communications history. What sets this book apart from other such histories is the depth of analysis dedicated to the graphic instruments of science that emerged out of a need to explore complex issues, identify patterns, and reduce complexity in communication. Friendly and Weiner dive deep into numerical relationships, providing thoughtful analysis that highlights the strength of the graphs. And with a retrospective eye, they present critiques and contemporary alternatives.

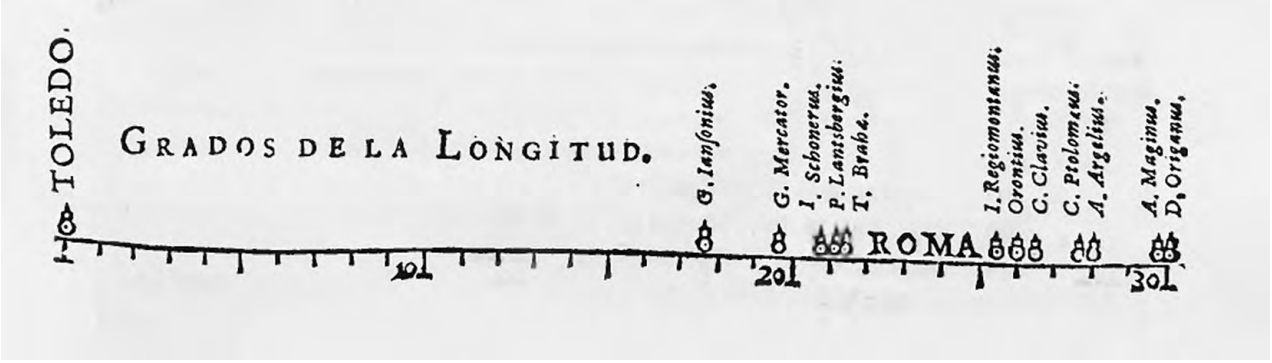
As with any good creation story, chapter one ("In the Beginning…")[11] transports the reader to prehistoric times, before pigments, when humans made marks by scratching and engraving on surfaces to record experiences and communicate information. The deliberate intention of mark-making, and humans' inquisitive nature and desire for discovery were the genesis of both the drive to refine human visual cognition and the graphic innovations to come.

There were some significant milestones along the path from our earliest attempts at mark-making to the development of picture writing systems. Centuries more would pass before societies communicated using numerals and the alphabetic symbols we know today, which eventually took precedence over pictures as forms of communication. Dutch cartographer Michael Florent van Langren — whom the authors credit with the first graphic statistical representation — calculated and depicted visually the longitudinal distance from Toledo to Rome in 1644, in service to the Spanish crown.[12] He used the graph to prove that existing methods for calculating longitude were incorrect. *La Verdadera Longitud por Mar y Tierra* (*True Longitude via Sea and Land*) is distinctive in its method, demonstrating the variability of longitude estimates at that time (Figure 1).

Among its numerous social, technological, and scientific advances, the seventeenth century was a time of increased data collection. Governments interested in social conditions gathered, tabulated, and analyzed demographic information on births, deaths, prostitution, unemployment, and education. In 1662, haberdasher and epidemiologist John Graunt collected data from the London Bills of Mortality[13] and published his *Natural and Political Observations*.[14] From them, Dutch polymath Christiaan Huygens constructed a graph of mortality (1669) that showed how many people from a birth sample of one hundred had survived to age eighty-six.[15] More than a century would pass before Scottish engineer William Playfair published *The Commercial and Political Atlas*,[16] establishing his legacy as the innovator of the linear/time-series graph, pie chart, and bar chart — graphic visualization techniques that are ubiquitous in many domains of contemporary professional activity (Figure 2).

The book extensively explores significant developments in the history of data visualization, including physician John Snow's London Broad Street Water Pump map,[17] which visualized clusters of cholera cases by plotting their location and volume around a water pump on Broad Street, London, in 1855. Florence

Figure 1
Van Langren's La Verdadera Longitud por Mar y Tierra, Antwerp, 1644. Reproduction courtesy of the Koninklijke Bibliotheek van België.



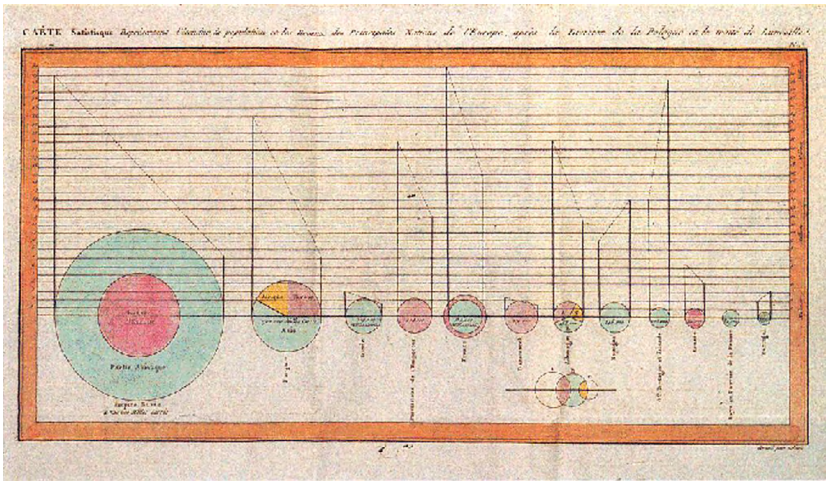


Figure 2 (top)
William Playfair's pie chart graph from *The Statistical Breviary*, 1801. Source: Wikimedia Commons, available at https://commons.wikimedia.org/wiki/File:Playfair_piecharts.jpg.

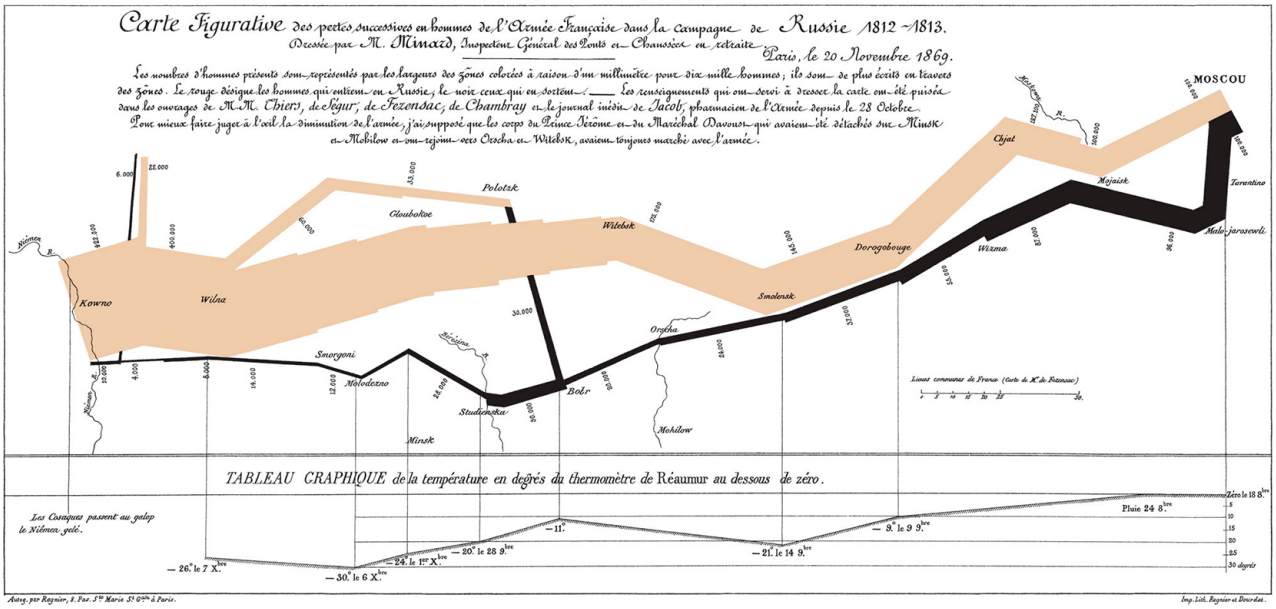


Figure 3 (bottom)
Charles Joseph Minard's 1869 *Carte Figurative* depicting the successive losses in men of the French Army in the Russian campaign 1812–1813. Source: Wikimedia Commons, available at https://commons.wikimedia.org/wiki/File:Minard.png.

Nightingale's now famous rose diagrams[18] reported the significant number of (preventable) deaths suffered by soldiers returning from the Crimean War (1853–56), despite hospital care.[19] Charles Joseph Minard's 1869 *Carte Figurative* (Figure 3), illustrating the significant losses of Napoléon's Grand Army as soldiers crossed the Niemen River into Russia, is also a classic in the history of graphs, one revisited in chapter ten: "Graphs as Poetry."[20]

The last half of the nineteenth century is crowned the "Golden Age of Statistical Graphics."[21] The authors credit Funkhouser for this designation as he surmised that conditions for the continued development of data graphics were aligned, creating the perfect storm. Past innovations were being refined and advanced internationally, and national collections of demographics, trade, and sociopolitical data were being transformed into beautiful statistical albums and census atlases. By the end of the nineteenth century, data collection practices, statistical theory evolutions, and new technology development had exploded. There was lithography and color printing, photography, moving images, and calculation machines. Various countries had produced statistical albums showcasing their achievements and containing "some of the most exquisite graphs ever produced, even to this day."[22] There was support for a universal visualization language to facilitate quantitative

and qualitative information exploration and communication, as well as an underlying belief that images better served memory and "were more vivid and indelible than words."[23] In 1885, English economist Alfred Marshall spoke of the benefits of graphics at the Silver Jubilee of the Royal Statistical Society, and French economist Emile Levasseur presented a systematic survey of all available graphics.[24]

The 1900s saw graphic displays enter the mainstream, with their introduction to business practice and education. Concurrently, science was shifting towards the precision of numbers and away from the ambiguity of the image. The book goes into great detail about the conflicts among statisticians concerning the use of images to represent numerical data. Some found graphic methods of great value, while others believed that the preciseness of numbers was lost in the image. The authors call this hibernation period of graphic innovation the "Modern Dark Ages of Statistical Graphics."[25] In 1914, Willard C. Brinton published his *Graphic Methods for Presenting Facts*, an index of various chart styles to guide the businessman, the social worker, and the legislator in finding options for presenting data based on their communication needs.[26] There were no template-driven software applications in the early twentieth century—calculations and graphs were drafted by hand with pen and ink. When a chart was selected, it would be passed on to a draftsperson to create.

By the 1960s, a renewed appreciation for graphic displays of data was emerging. French cartographer Jacques Bertin's *Sémiologie Graphique: les Diagrammes, les Réseaux, les Cartes* was translated into English in 1983.[27] The book offered general theory for composing graphs and maps. Earlier, in 1970, American statistician John W. Tukey had published his seminal book *Exploratory Data Analysis*.[28] In addition to human brainpower, the era was marked by increasing computational power, advances in large dataset processing capabilities, and the ability to generate visualizations without the use of human drafting skills.

The book closes with a chapter titled "Graphs as Poetry." In it, the authors pay special homage to graphs that succeed at depicting facts and embodying experiences of struggle, suffering, and resilience. Norman Maclean's 1993 book *Young Men and Fire* is one example. In this work of nonfiction, the author maps the path of the 1949 Mann Gulch fire in Montana according to the distance and pace of the blaze using crew estimations of their positions relative to the flames. Thirteen crew members lost their lives trying to subdue the forest fire.[29]

The modest yet refined execution of the Kovno Ghetto population pyramid—drawn in pencil on a sheet of graph paper—shows the numbers of living and deceased residents of a Lithuanian Jewish community. A horizontal column of age ranges runs down its central axis; males are listed on the left and females on the right. The graph shows the living and deceased one month after the massacre of October 1941, when Nazis killed most of the Jewish population in what is known as the Great Action.[30]

Charles Minard's *Carte Figurative* is revisited in this section. At the time of its creation, Minard was a retired civil engineer. His method of casting six types of data in two dimensions across a two-dimensional surface has been acclaimed as one of the best graphic representations of all time.[31]

The graphs created by African American Civil Rights Advocates W.E.B. Dubois and Booker T. Washington for the *Exhibit of American Negroes* presented at the 1900 World's Fair in Paris also receive considerable attention in this book. The exhibit displayed over sixty graphs describing the increase in the African-American population in the US. The graphs reported population in relation to time variables, the number of African-Americans compared to the white population growth in the US, and to total populations of other countries.[32]

Chapter ten ends with R. J. Andrews and Howard Wainer's *The Great Migration: A Graphics Novel*. Inspired by Dubois and Minard, the maps it contains illustrate the flows of non-white migrants in America between 1880 and 1940. The graphs are designed in muted colors with handwritten typefaces in the style of an earlier period. As with their predecessors, their beautiful execution embodies stories of struggle, demonstrating that numbers can be presented clearly and with aesthetic appeal.[33]

Undoubtedly—although understandably, given the scale of the project—some names and innovations have not received mention. This book represents, nevertheless, a commendable effort. The authors draw on their extensive historiography to explore the insights that emerge from some earlier findings, and use their deep knowledge as statisticians, historians, theorists, and practitioners to further conversations and investigate potential contributions to today's academy. For instance, the work of social scientist Otto Neurath[34] certainly deserves to be considered as part of the "Modern Dark Ages of Statistical Graphics."[35] Neurath popularized the use of pictorial

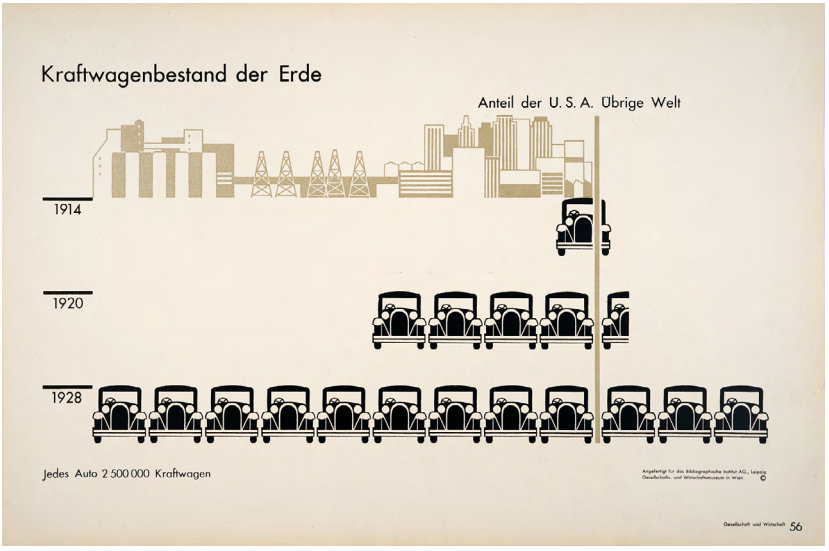


Figure 4
Number of Automobiles in the World. Kraftwagenbestand der Erde. Gesellschafts- und Wirtschaftsmuseum in Wien, *Gesellschaft und Wirtschaft*, Leipzig: Bibliographisches Institut AG, 1930. Otto and Marie Neurath Isotype Collection, University of Reading.

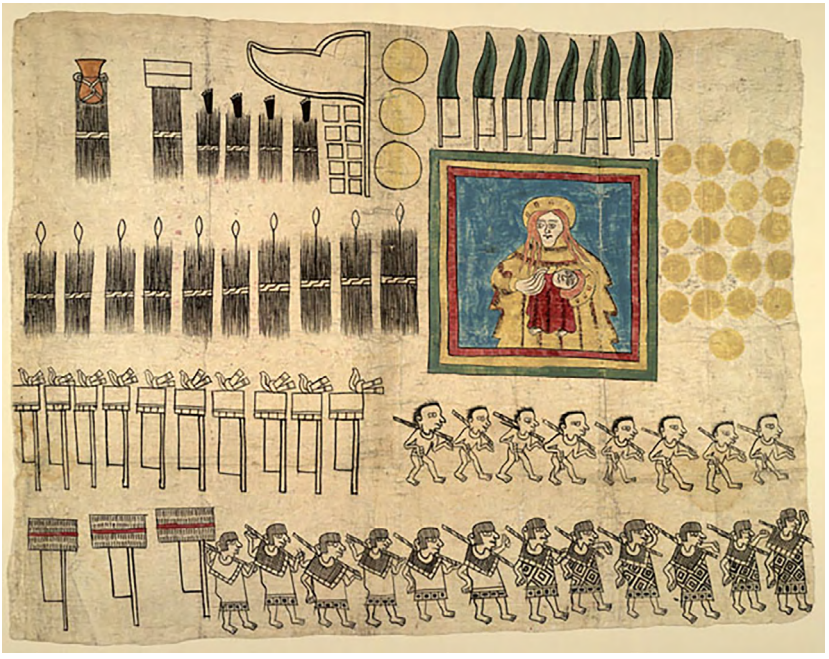


Figure 5
The Huejotzinco Codex, 1531. Reproduction courtesy of the US Library of Congress Collections.

statistics; his goal was to present complex information to the general public through symbol repetition, demonstrating that pictures play a role in communicating statistical information to specific audiences. *Number of Automobiles in the World* (Figure 4) is an example of a chart included in the publication *Gesellschaft und Wirtsschaft*, Society and Economy.[36] The x-axis is divided in two categories: the United States on the left and the rest of the world on the right. The years are represented on the y-axis. Each vehicle represents 2.5 automobiles, giving a general idea where the largest number of vehicles are located as well as the increase in numbers by noted years.

Similarly, the Huejotzinco Codex is a great example of pictorial statistics.[37] This sixteenth century pictorial manuscript was created by the Nahua people of South America to present evidence to the Spanish throne against the onerous and unfair taxing practices enforced by the colonial powers at the time. The graph uses glyphs — images of objects — to represent quantities. For instance, the top left row of Figure 5 shows

six bundles of reeds. Each reed is worth four hundred units of what each bundle represents: the first bundle represents liquid amber, the second represents cotton mantles, and the last four bunches represent pairs of sandals[38]. With a translation from Nahua into Spanish and the use of images this graph transcended cultural and linguistic barriers helping the Nahua win their case.

Although the book focuses on the visual representation of data and the technologies that advanced its innovation, it is important to consider alternative methods of data exploration that include other senses. For instance, sound recording technology has facilitated our ability to "hear" data—a method known as *sonification*. For her 2013 dissertation *Sound for the Exploration of Space Physics Data*, Wanda Diaz Merced—a blind astronomer—designed a method of "reading" data through sound. Sonification helps visually impaired and visually capable scientists detect data represented via sound. In the past, scientists preparing data for analysis may have overlooked or inadvertently discarded information that may only have been detectable through sound. Merced's experiments concluded that linking sound to data increased researchers' ability to detect data irregularities and recommended this method as a supplement to visualization, making it a viable tool for any scientist.[39]

Graphs were designed as tools of inquiry and discovery, and to better communicate information. *A History of Data Visualization and Graphic Communication* is a book about scientists and explorers who designed a visual language that would help them decipher data and uncover correlations, relationships, causalities, and patterns, and as a tool to search for the unknown. The book also underscores the importance of understanding the object of research in addition to having the skills to transform complex information into a visual language. Therefore, it is well positioned within the historical literature on data visualization and graphic communication. Followers of communication design are familiar with books such as Philip Meggs's *History of Graphic Design*[40] and Victor Margolin's *World History of Design*.[41] These highly influential books recount a historical narrative of graphic design and visual communication featuring an array of innovations, including the graphic representation of data. Margolin's two-volume book extends design history thanks to its encyclopedic presentation of Design. *A History of Data Visualization and Graphic Communication* concentrates on the historical developments of graphic innovations relating to the sciences. It also references several of Edward Tufte's[42] most cited publications on the history and analysis of the graphical displays of data. There is also an abundance of practice-based publications showcasing the beauty of the graphic artifact, which are too many to name in this review.

It appears that there has not been a publication of this scope on the evolution of graphic representation of qualitative and quantitative data since Funkhouser's work. The price of the book makes it accessible to a broad audience and serves many purposes: it can be used as a reference for further research, as a teaching tool, as a guide to better understand the development of graphic creative principles, or for the sheer joy of learning. Scholars, practitioners, lovers of statistics and data visualization, and anyone interested in understanding the methods and techniques of today will benefit from understanding the innovations that brought us to where we are.

Notes

1 H. Gray Funkhouser, "Historical Development of the Graphical Representation of Statistical Data," *Osiris* 3, no. 1 (1937): 270, available at https://www.jstor.org/stable/301591.
2 Michael Friendly and Howard Wainer, *A History of Data Visualization and Graphic Communication* (Cambridge, MA: Harvard University Press, 2021), 5.
3 *The Journal of Computational and Graphical Statistics* requires membership. For more information, please visit https://www.tandfonline.com/toc/ucgs20/current.
4 *Statistical Science* requires membership. For more information, please visit https://imstat.org/journals-and-publications/statistical-science.
5 Michael Friendly and Daniel J. Denis, "Milestones in the History of Thematic Cartography, Statistical Graphics, and Data Visualization," *Datavis.ca*, accessed August 10, 2021, https://www.datavis.ca/milestones/index.php?page=home.
6 See "Chance: Category Archive for 'Visual Revelations,'" Columns, American Statistical Association, last modified April 4, 2021, https://chance.amstat.org/category/columns/visualrevelations.
7 *Significance Magazine* is an open access publication. For more information, please visit https://www.significance-magazine.com.
8 Friendly and Wainer, *History of Data Visualization*, 251–56.
9 Ibid., 259–75.
10 Ibid., 277–89.

11 Ibid., 10.
12 Ibid., 30–31.
13 Ibid., 22–23.
14 Ibid., 48.
15 Ibid., 123.
16 Ibid., 99.
17 Ibid., 81–94.
18 Ibid., 234; Funkhouser, "Historical Development," 344; also see Florence Nightingale, "Diagram of the Causes of Mortality in the Army in the East," in *Notes on Matters Affecting the Health, Efficiency, and Hospital Administration of the British Army* (London: Harrison and Sons, 1858), 315, available at https://commons.wikimedia.org/wiki/File:Nightingale-mortality.jpg.
19 Friendly and Wainer, *History of Data Visualization*, 92–94.
20 Ibid., 231.
21 Funkhouser, "Historical Development," 330.
22 Friendly and Wainer, *History of Data Visualization*, 28.
23 Ibid., 27.
24 Ibid., 120.
25 Michael Friendly and Daniel Denis, "The Roots and Branches of Statistical Graphics," *Journal de la Société Française de Statistique* 141, no. 4 (2001): 53, available at http://www.numdam.org/article/JSFS_2000__141_4_51_0.pdf.
26 Willard Cope Brinton, *Graphic Methods for Presenting Facts* (New York: The Engineering Magazine Company. 1914), v.
27 Jacques Bertin, *Semiology of Graphics: Diagrams, Networks, Maps* (Madison, WI: University of Wisconsin Press, 1983).
28 John W. Tukey, *Exploratory Data Analysis*, limited preliminary ed. (Reading: Addison-Wesley, 1970).
29 Friendly and Wainer, *History of Data Visualization*, 232–33.
30 Ibid., 234–35.
31 Ibid., 235–36.
32 Ibid., 240–45.
33 Ibid., 245–47.
34 A good source of information on Otto Neurath's methods of pictorial statistics is *The Otto and Marie Neurath Isotype Collection* found at the University of Reading. "Typography & Graphic Communication: Otto and Marie Neurath Isotype Collection," University of Reading, accessed August 15, 2021, https://www.reading.ac.uk/m/typography/collectionsandarchives/typ-isotype-collection.aspx.
35 Friendly and Denis, "The Roots and Branches of Statistical Graphics," 53.
36 Society and Economy is a one hundred panel publication unveiled at the *Gesellschafts- und Wirtschaftsmuseum in Wien Weltwirtschaf*, Society and Economic Museum in Vienna, in 1930. This method was known as the Vienna Method of pictorial statistics, later trademarked as ISOTYPE (International System Of Typographic Picture Education) in 1935.
37 Friendly and Wainer, *A History of Data Visualization*, 10.
38 Warren J. Benedict, *The Harkness Collection in the Library of Congress: Manuscripts Concerning Mexico: A Guide* (Manuscript Division, Washington: US Library of Congress, 1974), 54–69.
39 Wanda L. Diaz Merced, *Sound for the Exploration of Space Physics Data* (Glasgow, UK: University of Glasgow, 2013), 17–20, 29, 54, 56, 123, 127, 167, 191, 197, 211, 213.
40 Philip B. Meggs and Alston W. Purvis, *Meggs' History of Graphic Design* (New York: Wiley, 2016).
41 Victor Margolin, *World History of Design: Two Volume Set* (London: Bloomsbury Academic, 2015).
42 For more on Edward Tufte, please visit https://www.edwardtufte.com/tufte.

References

Benedict, Warren J. The Harkness *Collection in the Library of Congress: Manuscripts Concerning Mexico: A Guide*. Manuscript Division, Washington: US Library of Congress, 1974.

Bertin, Jacques. *Semiology of Graphics: Diagrams, Networks, Maps*. Madison, WI: University of Wisconsin Press, 1983.

Brinton, Willard Cope. *Graphic Methods for Presenting Facts.* New York: The Engineering Magazine Companys, 1914.

Friendly, Michael, and Daniel Denis. "The Roots and Branches of Statistical Graphics." *Journal de la Société Française de Statistique* 141, no. 4 (2001): 51–60. http://www.numdam.org/article/JSFS_2000__141_4_51_0.pdf.

Friendly, Michael, and Daniel J. Denis. "Milestones in the History of Thematic Cartography, Statistical Graphics, and Data Visualization." *Datavis.ca.* Accessed August 10, 2021. https://www.datavis.ca/milestones/index.php?page=home.

Friendly, Michael, and Howard Wainer. *A History of Data Visualization and Graphic Communication.* Cambridge, MA: Harvard University Press, 2021.

Funkhouser, H. Gray. "Historical Development of the Graphical Representation of Statistical Data." *Osiris* 3, no. 1 (1937): 269–404. https://www.jstor.org/stable/301591.

Margolin, Victor. *World History of Design: Two Volume Set.* London: Bloomsbury Academic, 2015.

Meggs, Philip B., and Alston W. Purvis. *Meggs' History of Graphic Design.* New York: Wiley, 2016.

Merced, Wanda L. Diaz. *Sound for the Exploration of Space Physics Data*. Glasgow, UK: University of Glasgow, 2013.

Nightingale, Florence. "Diagram of the Causes of Mortality in the Army in the East." In *Notes on Matters Affecting the Health, Efficiency, and Hospital Administration of the British Army,* 315. London: Harrison and Sons, 1858. Available at https://commons.wikimedia.org/wiki/File:Nightingale-mortality.jpg.

Tukey, John W. *Exploratory Data Analysis,* limited preliminary ed. Reading, UK: Addison-Wesley, 1970.