CHRISTINE VON OERTZEN*

Datafication and Spatial Visualization in Nineteenth-Century Census Statistics

ABSTRACT

This essay argues that the explosion of visual graphics in nineteenth-century population statistics was closely linked to a shift in statistical epistemologies and practices of data collection. Taking German census statistics as a case in point, I illuminate concepts and practices that referred to data as a category of the here and now, enabling spatial representations of current phenomena. I argue that seeing and abstracting the world as data opened new avenues not only for producing tables with multiple variables, but also for forging such refined results into graphical visualizations of data. These in turn made empirical relationships in the social order evident and thus modifiable through intervention and reform. This essay is part of a special issue entitled *Histories of Data and the Database* edited by Soraya de Chadarevian and Theodore M. Porter.

KEY WORDS: data, practices, compilation, census statistics, nineteenth century, graphical representation

Visuals have become the engine of our data-driven world, an absolute necessity to make sense of the deluge of information overwhelming us.[1] That said, the amalgamation of data and visualization practices is a phenomenon not bound to the computer era. As David Sepkoski and I argue in this issue, the emergence of data-driven visual graphics dates back to the nineteenth century, to an era that Michael Friendly has coined the Golden Age of Graphical Statistics: the period between roughly 1850 and 1900 that witnessed a highly innovative

*Senior Research Scholar, Max Planck Institute for the History of Science, Boltzmannstrasse 22, D-14195 Berlin, Germany, coertzen@mpiwg-berlin.mpg.de

1. See Hallam Stevens, "Seeing Data," *Historical Studies in the Natural Sciences* 46 (2016): 252–59.

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and explosive growth in both the general use of graphic methods and the range of topics to which they were applied.[2]

Using German censuses as case studies, I claim that the explosion of visual graphics in nineteenth-century population statistics was closely linked to a shift in statistical epistemologies and practices of data collection. These in turn opened new possibilities for the spatial projection of data onto graphical representations. I call this process datafication, because the change toward compiling multivariable tables and creating graphical representations in new ways went hand in hand with the explicit use of the term "data." I argue that seeing and abstracting the world as data opened new avenues not only for producing tables with multiple variables, but also for forging such refined results into visualizations that offered insights going beyond tabular presentation. The resulting graphics were easier to grasp at first sight, but they were not just tools to simplify. Rather, they were ways of identifying new phenomena among the data that would not be observable otherwise. Graphical representations of data thus yielded novel and unexpected insights. They were part and parcel of turning population statistics into a data-driven undertaking, which made empirical relationships in the social order evident and thus modifiable through intervention and reform.

German census statisticians were not the first or the only experts to resort to data in this way. Rather, the nineteenth century witnessed a new, innovative reflexivity toward cumulative, quantifying scientific methods in many disciplines, a development that rested not only on a ubiquitous trust in numbers, but equally on a trust in data.[3] This trust in data and the practices built on it could take quite different orientations: Whereas naturalists like Alexander von Humboldt and Heinrich Georg Bronn abstracted the world as data to develop graphical projections of deep time, this essay illuminates concepts and practices in German census statistics that referred to data as a category of the here and now, enabling spatial representations of current phenomena.

2. Michael Friendly, "The Golden Age of Statistical Graphics," *Statistical Science* 23 (2008): 502–35.

3. David Sepkoski, "Data in Time: Statistics, Natural History, and the Visualization of Temporal Data," in this Issue. On the emergence of quantitative thinking and practice, see Theodore Porter, *The Rise of Statistical Thinking, 1820–1900* (Princeton, NJ: Princeton University Press, 1986); Ian Hacking, *The Taming of Chance* (Cambridge, MA: Cambridge University Press, 1990); Alain Desrosieres, *The Politics of Large Numbers. A History of Statistical Thinking* (Cambridge, MA: Harvard University Press, 2007); Lorenz Krüger, Lorraine Daston, and Michael Heidelberger, eds., *The Probabilistic Revolution* (Cambridge, MA: MIT Press, 1987).

In scrutinizing the role that data played in redefining German population statistics, I demonstrate that the explicit usage of the term marked a distinctive epistemological shift accompanied by methodological and technical innovations to gather and compile enumeration material. At the core of these denouements was the introduction of a new paper device, the so-called counting card. The practicalities of this moveable compilation tool I have explicated in detail elsewhere.[4] Here, I sketch German statisticians' attempts to visualize the newly achieved statistical complexity beyond tabular presentation, in both theoretical and practical terms. I focus on the work of Hermann Schwabe and Georg von Mayr, two major proponents engaged in theorizing on statistical visualization and internationally lauded for their graphical exploration of census data.

SEEING AND MOVING DATA

The term "data" was used rarely by German census statisticians before the 1860s.[5] Even though numerical assessments on the state's behalf became quite common during the eighteenth century, these numbers rather referred to notions such as information or items of interest (*Merkwürdigkeiten*).[6] When "data" was used at the beginning of the nineteenth century, the term carried directive weight, signalling an important epistemological convention that would contribute to the rise of visualization some fifty years later. In 1804, August Ludwig von Schlözer, a leading statistician and professor at Göttingen University, made explicit reference to data in his effort to establish statistics as a science in its own right. Schlözer's statement describing the specificities of this new science as "stationary history" (*still stehende Geschichte*) is well known; much less attention has been paid to his emphasis that the art of pursuing this

4. Christine von Oertzen, "Machineries of Data Power: Manual versus Mechanical Census Compilation in Nineteenth-Century Europe," *Osiris* 32 (2017): 129–50.

5. This observation mirrors Daniel Rosenberg's assessment of the linguistic usage of the term prior to the computer era; see Daniel Rosenberg, "Data Before the Fact," in "*Raw Data*" *Is an Oxymoron*, ed. Lisa Gitelman (Cambridge, MA: MIT Press, 2014), 15–40. See also Daniel Rosenberg, "Data as Word," in this Issue.

6. See Lars Behrisch, ed., *Vermessen, Zählen, Berechnen. Die politische Ordnung des Raums im 18. Jahrhundert* (Frankfurt/M.: Campus, 2016). In rare cases, such measurements were also transformed into graphical visualizations; see Sybilla Nikolow, "A.F.W. Crome's Measurements of the 'Strength of the State'," in *The Age of Economic Measurement*, eds. Judy L. Klein and Mary S. Morgan (Durham, NC: Duke University Press, 2001), 23–56.

new science was "to see and value statistical data (*statistische Daten*), and to collect and arrange them."[7] In 1808, Wilhelm Butte, a theologian and cameralist trained at the University of Gießen, aligned himself with Schlözer's dictum and clarified in more detail what the art of "seeing and valuing data" entailed epistemologically. In his treatise *Statistik als Wissenschaft bearbeitet*, Butte pleaded that at least among statistical experts, the notion of data should be used consistently, and distinctly be set apart from facts, for the *factum*, he maintained, was "historically forged" (*historisch erwirkt*) and should never be included in statistics. The *datum* alone deserved this privilege, as it had the exclusive capacity to "directly adhere to the present state of being" (*sich unmittelbar an den Tatbestand des Seienden zu halten*).[8]

Butte explained that "fact" and "datum" could—and often did—refer to the same object, namely a specific number. But whereas a fact encompassed more information than just the number itself and explained something, the datum simply referred to the number itself. To give an example, Butte stated that the kingdom of Bavaria measured 1,569 square miles. As a fact, this information implied an historical explanation: how Bavaria had reached its current size. As a datum however, the number was a numerical value of Bavaria's present latitude and nothing more. In other words, the only relationship this datum had was with other, commensurable numerical data, and any explanations derived would be from examining the relationships between such data, and not from any prior information or context lying outside the domain of those numbers. In this distinction Butte saw a fundamental divide between a historical account of state affairs (*Staatengeschichte*) on the one hand and quantifying numerical statistics on the other, and the latter, based on "data" strictly de-coupled from causal context, should henceforward be the main effort of the science of statistics.[9]

The goal of statistics as Butte proposed it was thus explanatory, but in a strictly relational sense. Gathering data at a fixed moment defined as now (*Jetztzeit*) served as a method of abstraction from time and causal context, essential to assess how the state's intended purpose materialized in reality.[10]

7. Ludwig August Schlözer, *Theorie der Statistik. Nebst Ideen über das Studium der Politik überhaupt* (Göttingen: Vandenhoeck und Rupprecht, 1804), § 25.

8. Wilhelm Butte, *Die Statistik als Wissenschaft bearbeitet* (Landshut: Thormann, 1808), 248–49.

9. Ibid., 249.

10. "Wissenschaftliche Darstellung derjenigen Daten, aus welchen das Wirkliche der Realisation des Staatszwecks gegebener Staaten, in einem als Jetztzeit fixierten Momente, gründlich erkannt wird—das ist mir Statistik." Ibid., 245.

The newness of this procedure, Butte insisted, was to "give the scattered matter a scientific form, to render a vast amount of heterogeneous yet indispensable data into a commensurable form and order." Rather than a randomly accumulated "caboodle of numbers" (*Zahlenkram*),[11] a carefully tailored selection of data collected at the same moment alone would allow one to gain a truly thorough understanding of state matters. Distilled from time, the state of things past, present, and future would consequently be measured and analyzed by comparison, not as a continuum progressing according to historical theory popular at the time that effectively ignored particulars in favor of sweeping claims based on laws.[12] Population and state statistics based on data was thus clearly distinguished from history, but not confined to the present; rather, the new science perceived temporal change as a sequence of frozen stills.[13]

How exactly Schlözer's and Butte's take on data spread within and beyond cameralist circles remains an unresolved puzzle. But their approach resonated with attempts to deploy statistics for more than exhaustive accounting of the states' resources. In Heidelberg, cameralists developed what Sepkoski and Tamborini call an "aggregate statistical approach" vested in data management, analysis, and visual representation.[14] Throughout Europe, statisticians expanded and standardized census enumeration efforts to establish statistical regularities on the basis of quantification that would explain causalities between social and economic conditions of the state.[15] By the 1860, statisticians had created a discipline, in which only impartial numerical data were to be considered in statistical analysis. A growing number of statisticians and

11. Ibid., 272.

12. "Der Akt dieses Fixierens ist eigentlich ein Abstrahieren von aller Zeit. Denn die Zeit ist ein Strömen, aber hier ist nur Stillstand, und die Gegenwart zieht den Charakter des Zeitlichen nur durch die Vergleichung an, in welcher sie mit Vergangenheit und Zukunft bemessen wird." Ibid., 267.

13. This redefining of the past as a sequence of data-based stills is similar to what Harro Maas describes as "repackaging" of historical events as "data" in nineteenth-century economics, a precondition for what Maas calls the "timing of history," which in turn facilitated the development of visual graphics; see Harro Maas, *William Stanley Jevons and the Making of Modern Economics* (New York: Cambridge University Press, 2005), 220. In much the same fashion, paleontologists projected data as a narrative progression in visual space, see Sepkoski, "Data in Time," in this Issue.

14. David Sepkoski and Marco Tamborini, "'An Image of Science': Cameralism, Natural History, and the Visual Language of Statistics in the Nineteenth Century," *Historical Studies in the Natural Sciences* 48 (2018): 56–109, on 60. See also, Porter, *The Rise of Statistical Thinking* (ref. 3), 5.

15. Theodore Porter, "Statistics and Statistical Methods," in *The Cambridge History of Science*, eds. T. Porter and D. Ross (Cambridge: Cambridge University Press: 2003), 238–50.

natural historians used numerical data to produce aggregate summaries, rather than just collecting numbers in huge lists.[16]

Longer than almost anywhere else in Europe, Prussian census officials had adhered to statistics as a "historical science" that rested on eclectic collections of numerical information in lists and abstained from judgement and interpretation.[17] It was not until 1860 that the notion of data fully came to bear in Prussian census statistics, denoting a change not only in semantic terms, but also in a fundamental vicissitude regarding the concepts and methods of census taking. The actual use of the term "data" in Prussian population statistics went hand in hand with measures to produce scientifically sound depictions of the population (*Volksbeschreibungen*), by re-defining the basic unit of recording, by standardizing enumeration procedures, and by radically revising the tools and practices of compiling the numerical data. As part of this epistemological shift, graphical visualization beyond tabular representation emerged as a technique to see what those numbers had to say.

DATA, LIST, TABLE

The protagonist of such significant conceptual as well as technical changes in Prussian census work was Ernst Engel, a mining engineer from the Mining Academy in Freiberg, Saxony, who was appointed director to the Prussian Statistical Bureau in 1860.[18] Among historians of science, Engel's reputation has suffered by Ian Hacking's damning assessment of the Prussian director's limited abilities in statistical probability.[19] Nonetheless, in his zeal for numbers Engel was not content in piling up arbitrary particulars. Far from it, Engel was committed much in line with von Schlözer, Butte, and other proponents of the turn to data, to systematically choose, acquire, compile, and utilize information most relevant to achieve a comprehensive and accurate quantitative description of present conditions (*Zustandsschilderung der Gegenwart*):

16. Staffan Müller-Wille, "Names and Numbers: 'Data' in Classical Natural History, 1758–1859," *Osiris* 32 (2017): 109–28.

17. So Leopold Krug, the first director of the Prussian census bureau, *Ideen zu einer staatswissenschaftlichen Statistik* (Berlin: 1807), ix.

18. For a detailed account of Engel's work as director of the Prussian Statistical Bureau in Berlin, see Michael Schneider, *Wissensproduktion im Staat. Das Königlich-Preußische statistische Bureau, 1860–1914* (Frankfurt am Main: Campus, 2014), esp. 223–82.

19. Ian Hacking, "Prussian Numbers, 1860–1882," in *The Probabilistic Revolution. Bd. 1: Ideas in History*, eds. Lorenz Krüger et al. (Cambridge, MA: Cambridge University Press, 1987), 45–68.

a numerical snapshot of society frozen in time, in which the main features of current social and economic conditions would become evident.[20] When describing the three steps necessary to achieve this goal in mid-nineteenth century population statistics, Engel made explicit use of the term "data": "Statistics are defined by methods. These methods vary depending on whether they aim at the gathering, the collection, or the utilization of data [*Daten*]."[21]

In his attempt to revise Prussian population statistics according to state-of-the-art standards developed by the International Statistical Congress (of which he was a founding member), Engel envisioned to gain a multifaceted description of the populous "composed of the detailed descriptions of each individual."[22] What description and its scientific representation involved in methodological and practical terms should by no means be underestimated. It entailed an inductive process of gathering particulars and their classification, numerical abstraction, sorting, grouping, and re-combination, which allowed carving out defining structures from the otherwise indiscernible and constantly changing complexity of social and economic occurrences.

To achieve this data-driven snapshot, the particulars gathered in lists had to be transformed into statistical information represented in tables. In contrast to lists, tables contained what Engel called "a condensed result, a summary and a grouping of information, in which the specimen or individual is no longer visible."[23] The crucial epistemological difference between list and table was that in the former, each datum referred to one specific object or category, whereas in the latter, groupings of different sorts related the data to one another, allowing for patterns and structures to emerge. In order to morph gathered data from list to table, each particular datum had to be unlocked from its fixed place in the list's grid and moved around freely to eventually be subsumed under more general categories and—most importantly—various combinations thereof.[24]

The core technical component in this epistemological shift toward processing census data was a new paper tool, the so-called counting slip. Inspired by playing cards, counting slips reflected the belief that data should be understood as objects

20. Emil Blenck, "Zum Gedächtnis an Ernst Engel. Ein Lebensbild," in *Zeitschrift des königlich preußischen statistischen Bureaus* 36 (1896): 231–38, on 235.

21. Ernst Engel, "Die Methoden der Volkszählung. Mit besonderer Berücksichtigung der im Preussischen Staate angewandten," *Zeitschrift des königlich preußischen statistischen Bureaus* 1 (1861): 149–212, on 162.

22. Ibid., 156.

23. Ernst Engel, "Die Methoden der Volkszählung," 163.

24. Ibid., 163.

free of context or associations until they were re-grouped and aggregated in statistics. The slips made the data move: once all particulars of one individual were transferred from the list onto a slip, they could be swiftly sorted and re-sorted according to different combinations of criteria. The moveable data carriers functioned much in the same way as the later punch cards introduced in American census taking in 1890. They enabled statisticians to speed up the compiling effort and, at the same time, to greatly enhance statistical complexity, as they allowed assessing combinations of data from different categories readily.[25]

TABLES, GRAPHS, MAPS

To Engel and his colleagues in Germany and beyond, the comprehensive statistical assessments resulting from processing data via slip or, later, counting card were never meant to be an end in themselves. Quite the contrary, as much as they were aiming to portray society's present condition as accurately as possible, statisticians wanted the results of their efforts to be put to use. For this reason, Engel produced census results within the tightest possible time frames; a carefully nurtured workforce including many women working from home ensured that the tables for the Prussian state were delivered promptly.[26] Additionally, a whole flotilla of new publications filled with complex tables and comments issued by the bureau created what Hacking bashed as a "moraine of cluttered numbers" for the absence of probabilistic ambition.[27]

However, what Engel and other European census officials produced were results derived from the classifying, sorting, combining, and aggregating of what they saw as numerical objects freed from causal context. To convey how the data related to one another was the core purpose of the new procedure, and consequently strategies of spatial visualization took center stage. Whereas tabular representation remained the prior method to portray the main features of their analysis, census statisticians experimented with graphical visualization to communicate and further explore the explanatory potential of data-driven population statistics.

25. In Prussia, counting slips were replaced by bigger counting cards in 1871 to further streamline the procedure; see von Oertzen, "Machineries of Data Power" (ref. 4), 164–68.

26. Christine von Oertzen, "Keeping Prussia's House in Order: Census Cards, Housewifery, and the State's Data Compilation," in eds. Carla Bittel, Elaine Leong, Christine von Oertzen, *Working With Paper: Gendered Practices in the History of Knowledge* (Pittsburgh: University of Pittsburgh Press, forthcoming 2019).

27. Hacking, *Taming Chance* (ref. 3), 189f.

Engel's colleague Hermann Schwabe, the director of the census commission in the city of Berlin, provided a widely acknowledged early example of how this could be done. Schwabe had introduced counting slips in 1867 to establish a detailed survey of Berlin's population structure, as well as the occupational and housing conditions in the Prussian (and later Imperial German) capital.[28] The results of his efforts were published in two parts. The main part consisted of tables teeming with numbers in small print to demonstrate the relational complexity achieved by the new data-processing technology. To these tables Schwabe added a total of twenty-four carefully crafted graphical visualizations, which yielded at least as much praise among statistical experts as his multivariable schedules.

Schwabe's graphical visualizations included a map showing the varying degrees of population density in each city district, a population pyramid, and a bar chart showing the age structure in more detail. Each of the graphs was accompanied with detailed written explanations of what should be immediately evident but might not be obvious to the untrained eye: the high rate of childhood mortality, leaving a sharp dent in the age bar chart; the large number of women (single, married, or widowed) dependent on gainful employment; or the insufficient supply of gas and water conduit in rear compared to front buildings. Several detailed area diagrams identified Berlin's trouble spots, i.e., those parts of the inner city that showed the highest percentage of non-related people living under one roof, combined with the most overcrowded apartments, and the highest percentage of non-resident lodgers.[29]

As Schwabe emphasized in his 1872 textbook-like treatise on the theory and methods of visualization commissioned by the International Statistical Congress, such graphical representations were "spatial depictions of statistical quantities" drawn from numbers.[30] Responding to criticism that graphs were inferior to numbers with regard to statistical accuracy, Schwabe stressed their efficacy to communicate statistical results. His graphs were not one-to-one depictions of the tables. Rather, they were further abstractions of the fine-grained number charts, designed to foreground structures distilled from the flood of statistical data that he considered most essential. The graphs were destined to render distinct results of population statistics ascertainable "at first

28. Hermann Schwabe, *Die Resultate der Berliner Volkszählung vom 3. Dezember 1867* (Berlin, 1869).

29. Ibid., Figs. 19–22.

30. Hermann Schwabe, *Theorie der graphischen Darstellungen. Im Auftrage der k. russischen Vorbereitungskommission des achten internationalen statistischen Kongresses* (St. Petersburg: Trenké & Fusnot, 1872), 19.

Fig.23.

Räumliche Darstellung des Verhältnisses, in dem in Würtemberg, Preussen und Berlin die geschiedenen Frauen vertreten sind.

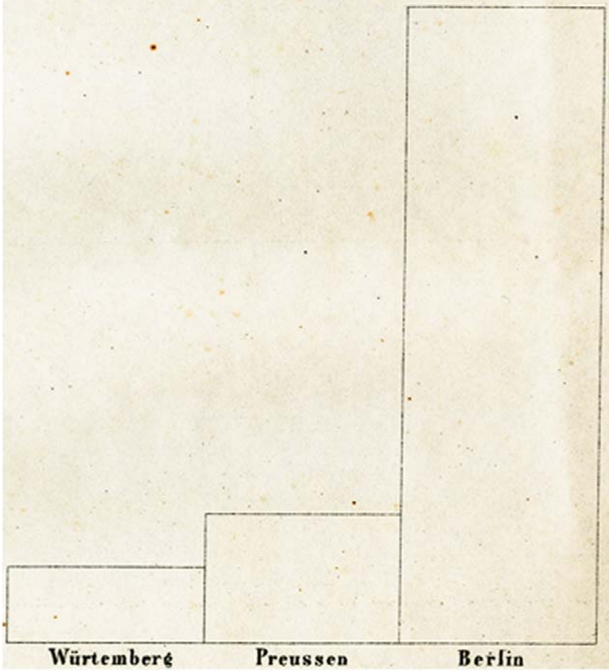

FIGURE 1: Spacial depiction of the relation of divorced women in Württemberg, Prussia, and Berlin. *Source:* Hermann Schwabe, *Theorie der graphischen Darstellungen. Im Auftrage der k. russischen Vorbereitungskommission des achten internationalen statistischen Kongresses* (St. Petersburg: Trenké & Fusnot, 1872), Fig. 23.

sight," an aspiration familiar from efforts in cartography to create panoramic views of knowledge on one page.[31]

Schwabe explained that graphics could mediate statistical evidence more effectively, as they could make certain statistical findings jump into the beholder's eye—an effect rarely achieved with numbers alone. To proof his point, Schwabe used a simple area diagram (Fig. 1).[32] It showed three area

31. Nils Güttler, *Das Kosmoskop. Karten und ihre Benutzer in der Pflanzengeographie des 19. Jahrhunderts* (Göttingen: Wallstein 2012), 23; Lorraine Daston, "On Scientific Observation," *ISIS* 99, no. 1 (2008): 97–110, on 108.

32. Hermann Schwabe, *Theorie der graphischen Darstellungen* (ref. 30), Fig. 23.

bars of dramatically different sizes, exhibiting the huge gap in the number of divorced women depending on whether they lived in rural southwestern Germany, Prussia, or Berlin, Germany's fastest growing city. The number of Berlin's 2,464 female divorcés alone he considered meaningless; it could only speak in relation to data from other regions. But even then, the numbers underlying Schwabe's diagram seemed much less alarming to him (13, 22, 101 out of 10,000). Brought into spatial scale however, the data could be turned into arguments with unmitigated moral implications.[33]

Whereas Schwabe underscored the communication benefits of graphical methods, his Bavarian colleague Georg von Mayr emphasized their epistemic value. Having introduced counting slips to compile Bavarian census tables in 1871, Mayr saw the benefits of enhanced statistical complexity for cartographic visualizations of census data.[34] Much like naturalists in the search of patterns for plant distribution, Mayr mapped his census results onto the Bavarian landscape, hoping to unearth law-like natural correlations like climatic particulars or differences in soil and rock formation that would explain the astounding variability of birthrates across the Bavarian kingdom. His tables, organized from highest to lowest values or by alphabetical order of the enumeration districts, produced but random discrepancies. However, by mapping the data onto a cartogram (Fig. 2), Mayr uncovered distinct regional specificities reaching across administrative boundaries. What Mayr regarded as proof of a "real triumph" of the geographic method of statistical visualization was the dark red area north of Munich in his cartogram, stretching across the cities of Regensburg, Freising, and Ingolstadt.[35]

This large area had by far the highest birthrates in the whole of Bavaria. However, combined with other mappings of census data on child mortality, his cartogram revealed an alarming reality: in the region where the most children were born, infants also had the least chance to survive their first year of life.[36] For Mayr, the cartograms at first seemed to suggest that the high birth and death rates were somehow rooted in the soil; but the region in question stretched over

33. Ibid., 72.

34. Georg von Mayr, "Über die Anwendung der graphischen und geopraphischen Methode in der Statistik," in *Zeitschrift des königlich-bayerischen statistischen Bureau* 6 (1874): 36–44.

35. Georg von Mayr, "Die Geburtenhäufigkeit in Bayern. Mit besonderer Berücksichtigung der geographischen Vertheilung derselben," in *Zeitschrift des königlich-bayerischen statistischen Bureau* 9 (1877): 243–50, on 247.

36. "Kindersterblichkeit in Süddeutschland (Cartogram), 1862–1869," in *Cartogramme und Diagramme zur Statistik Bayerns* (Munich: Königlich bayerisches statistisches Bureau, 1880) 19; see http://daten.digitale-sammlungen.de/db/0001/bsb00018090/images/index.html?id=00018090&groesser=&fip=yztseayaewqxseayaewqqrseayasdasxs&no=31&seite=19

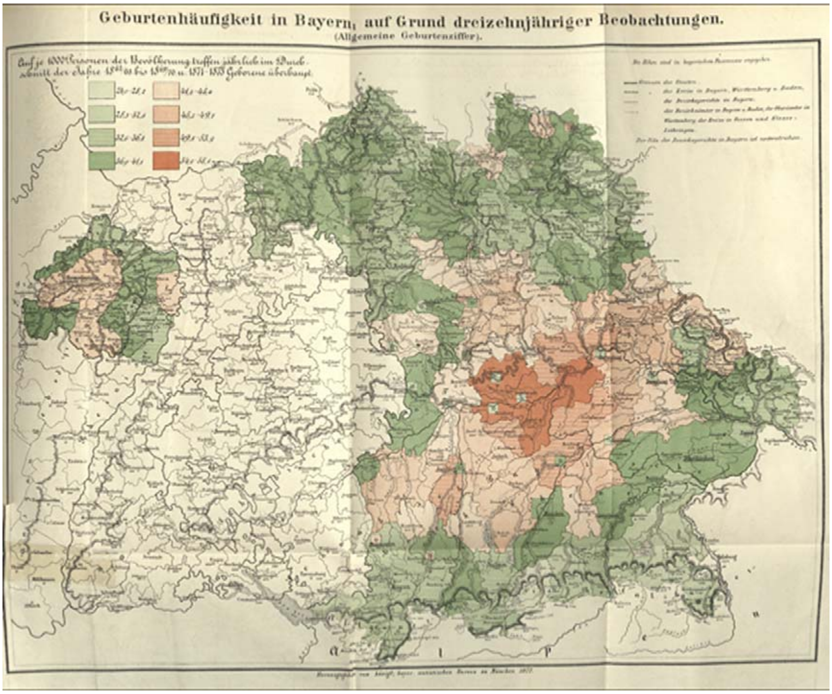

FIGURE 2: Cartogram of birthrates in Bavaria, compiled over thirteen years. *Source:* Georg von Mayr, "Die Geburtenhäufigkeit in Bayern. Mit besonderer Berücksichtigung der geographischen Vertheilung derselben," *Zeitschrift des königlich-bayerischen statistischen Bureau* 9 (1877): 243–50, on 250.

so many different soil formations, as well as ethnic and cultural boundaries, that Mayr saw himself forced to reject such law-like natural correlations to explain this phenomenon. Rather, he diagnosed an "endemic fever in the social life of our people," which needed further exploration on the ground, namely with regard to the babies' nutrition and the conditions of their mothers' employment.[37]

CONCLUSION

Early nineteenth-century statisticians like August von Schlözer and Wilhelm Butte distinguished data from facts, defining the former as a numerical category de-coupled from causal context that could only be made to speak in relation to other data. Put to use in population statistics by Prussia's and

37. Ibid., 250.

Bavaria's mid-nineteenth-century census reforms, the concept marked a fundamental change in census taking. Moveable paper tools enabled statisticians to implement the relational, data-driven approach, yielding compellingly rich, multivariable tabular representations; additionally, the new approach encouraged spatial graphical visualizations and the geographical mapping of census data. Data-driven tabular and graphical visualizations revealed empirical relationships in social phenomena such as alarmingly high children's mortality rates in poverty-stricken regions of Bavaria or in the miserable tenement basements of Berlin's inner city.

Concepts to see, tools to compile, and methods to visualize were all geared toward conveying relations among the gathered data. Tabular as well as spatial graphical visualizations served as tools of spatial analysis to uncover patterns and structures among population data. Creating statistical facts through graphical visualization yielded new insights in the social structure of Germany's quickly changing society. The wave of nineteenth-century statistical graphics rendering such changes evident was also a manifestation of data-driven modes of knowledge production.

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