Florence Nightingale and Victorian data visualisation

Nightingale's visualisations of Crimean War deaths retain much of their power and beauty today, more than 160 years on. But at the time they were produced, when statisticians preferred tables to graphs, they were even more striking, says **Alison Hedley**

In our digital age, data visualisation has become a familiar form of communication for audiences ranging from statistical specialists to members of the general public. Practitioners of modern data visualisation have long made a practice of cataloguing graphical techniques and surveying their history; in our present cultural moment, there is more enthusiasm than ever for tracing the evolution of visual information expression.

The design and aesthetics of visual information are of particular interest because these have become essential criteria for exhibiting data, especially to general audiences. It is for this reason that Florence Nightingale's diagrams of mortality data from the Crimean War have become icons of graphic design innovation (Figure 1), placed in a canon alongside, for example, the map of Napoleon's Russian campaign developed by Charles Minard in 1869 (Figure 2, page 28) and the charts of African American life that W. E. B. Du Bois created for the Paris Exhibition in 1900 (Figure 3, page 28). Assuredly, Nightingale's images deserve this prominent place, representing as they do both an innovation on existing graphical techniques and a much-needed intervention in the medical establishment.

But what made Nightingale's graphs particularly iconic was their powerful use of visual rhetoric to make an argument about data. This quality was fundamental to how her work was an outlier in its time and place. It is also a useful criterion for understanding the history of data visualisation in Britain more broadly.

Design in context

To more fully appreciate the historical significance of Nightingale's graphs, we must situate them in nineteenth-century Britain. The celebratory histories of modern data visualisation that appear in the blog posts and glossy coffee-table books of graphic designers tend to replicate an established narrative that emphasises breadth over depth. There is little sense of the impact made by different graphical innovations as they appeared – or where they appeared – over the eighteenth and nineteenth centuries. Techniques from different regions, including continental Europe, the United States, and Great Britain, are flattened to fit on a single timeline, suggesting that the evolution of data display was unified.

Certainly, historical data practitioners from across the world compared notes with one another as they gathered and analysed statistics, but their techniques could be quite different in some respects. Just as importantly, the cultural functions of data and their visualisation varied between regions and periods. Nightingale's polar area graphs – as well as many other iconic visualisations emerging from Victorian Britain, such as John Snow's cholera map (bit.ly/3bLBvAJ) – were outliers in their national context, rather than quintessential cases, as documented by historians such as John Aldrich[3,4] and Eileen Magnello.[5] Most Victorian statisticians preferred to rely on tables to organise even large data sets. Understanding *how* Nightingale was an outlier in her time is itself revealing of an important chapter in data visualisation history.

What follows is a survey of Victorian data visualisation that uses as a pivot point Nightingale's exemplary work in this field. The nineteenth century saw a dramatic shift in statisticians' attitudes towards the visual modelling of data. As members of the Statistical Society of London and other practitioners embraced visualisation's potential to model persuasive arguments about the meaning of data, the variety of graphical techniques increased and reached wider audiences than ever before.

Arguments in pictures

How do visualisations make arguments about data? Visualisation involves transitioning from a mass of particulars – an itemised data set – to a generalised overview. The process involves selecting one or more specific relationships in the data – the relation of month to frequency of mortality types, for example – and modelling this relationship in a visual form, either by plotting it on a Cartesian graph, with the familiar x- and y-axes, or some other type, such as a pie chart or choropleth map.

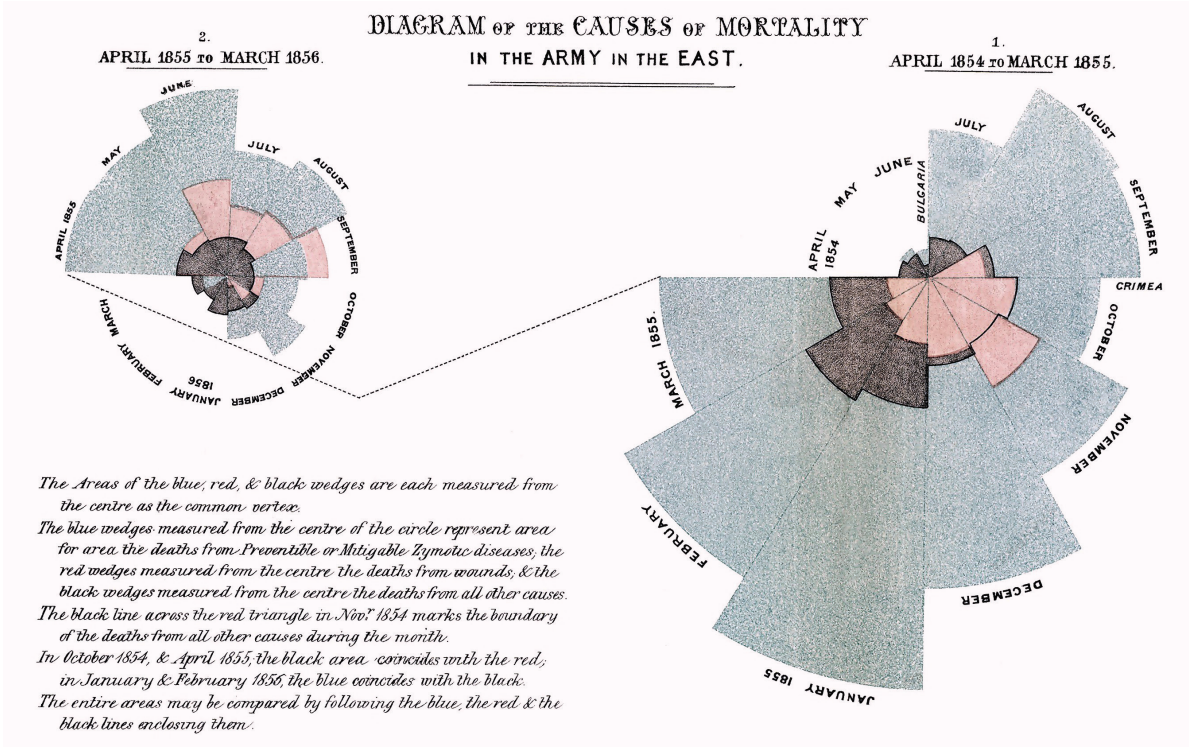

FIGURE 1 Florence Nightingale's polar area chart, "Diagram of the causes of mortality in the army in the East".[1]

The introduction of a visual model is the development of an interpretation of the data. The visualiser perceives a pattern among data instances, a causal or correlative relationship between variables that is meaningful in some way. Viewed in this light, a data graphic's characteristics can be understood as rhetorical techniques selected by the visualiser to help foreground a pattern they perceive in the data. This selection and curation process is tantamount to presenting an argument about the data's meaning. The visuality of the information, including design features such as shape, colour, size of components, and spatial layout, is what makes this argument accessible and persuasive, even to audiences unfamiliar with the details of the original data set.

To be clear, nineteenth-century British statisticians did not necessarily think of visualisation in these exact terms. However, their reluctance to use visualisation was motivated, at least in part, by wariness of two aspects of visualisation that I have just related: first, *data generalisation* (the shift in focus from individual instances to the collective whole); and, second, the *affective potential* of the graphics themselves (their capacity to persuade audiences as much through visual design rhetoric as through quantitative rigour, if not more). Statisticians considered tables, which comprehensively itemise every single datum in a set, to be superior to visualisations that aggregate, isolate and summarise into an aesthetically meaningful story.

So, despite early British innovations in modern data visualisation, such as Joseph Priestley's timeline graphs and William Playfair's pie graphs, Victorian statisticians generally preferred tables to Cartesian graphs and other visual forms of data display. When they used graphics, it was primarily to explore data, rather than present findings to a broader audience.[6] Very few visualisations appeared in the *Journal of the Statistical Society of London*, although it printed the occasional time series graphic, histogram or thematic map. Members of the Society who championed the use of visual techniques, such as W. S. Jevons and Ernst Ravenstein, were met with ambivalence from their peers.

By the late nineteenth century, visualisation was a more widely accepted practice, but enthusiasm for its potential was still modest at best. In *Elements of Statistics*, published in 1901, the pioneering statistician Arthur Bowley considers that graphics have some practical uses, such as teaching statistical concepts and conveying the "relative magnitude of numbers" to non-specialist readers and lecture audiences.[7] Even so, Bowley contends that graphics "do not add anything to the significance of the figures". This pattern of resistance to statistical visualisation is all the more notable because it contrasted with attitudes towards visualisation in continental Europe and the United States, where the use of graphical techniques for data exploration and argumentation – for specialists and general audiences alike – was more prevalent.

A pivot point

Situated in this context, Nightingale's use of visual methods to make persuasive claims about data seems all the more remarkable. She drew on existing visualisation practices,

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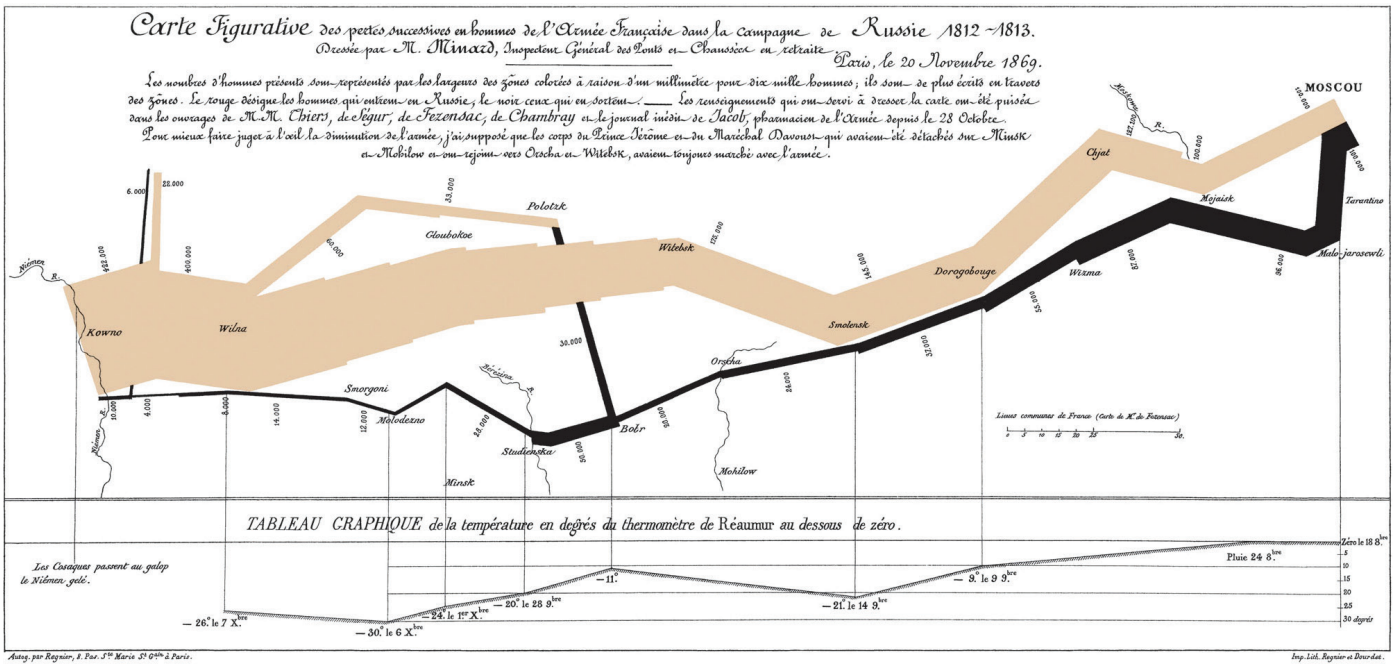

FIGURE 2 Charles Minard's 1869 map showing, according to the English translation of its French caption, "the successive losses in men of the French Army in the Russian campaign 1812–1813". Source: Wikimedia Commons

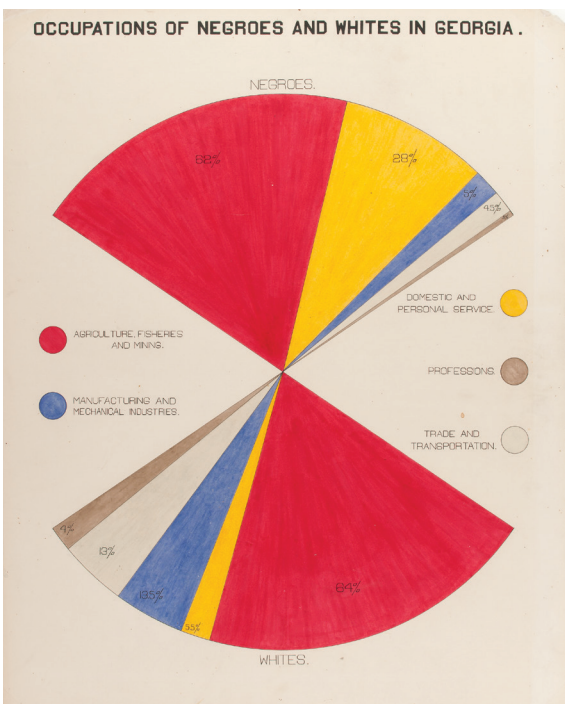

FIGURE 3 A pie chart or circle graph of sorts, from W. E. B. Du Bois's collection of charts of African American life created for the Paris Exhibition in 1900. The chart shows the percentage of African Americans and whites in various occupations in the state of Georgia.[2]

particularly the polar graphing technique that her colleague William Farr had used to chart cholera data for the General Registrar's Office in the late 1840s.[5] What makes Nightingale's polar area graphs innovative is their skilful deployment of visual rhetoric to drive home an evidence-based argument to an audience that included both political elites and a broader public.

The polar area graph was among many visualisations that Nightingale used to highlight the relationship between mortality and sanitation that she perceived based on both her first-hand experience as a nurse and the medical data gathered at war hospitals. Many of these graphs appeared first in a Royal Commission Report on the war, published in 1856; the polar area graph was printed in her own publication, *Notes on Matters Affecting the Health, Efficiency, and Hospital Administration of the British Army*, in 1858.[1] As Magnello relates, Nightingale's book circulated among British royalty and politicians, and copies of her graphs were displayed in pertinent administrative offices.[5] But the graphs also reached a wider public through two avenues: reviews of Nightingale's graphs appeared in several periodicals, and a handful of her figures, including the iconic polar area graph, were reproduced in a general-audience publication, *England and Her Soldiers*, on which Nightingale collaborated with the author Harriet Martineau.[8]

Like Farr, Nightingale intuited that visualisation would be an effective way to present her findings to elite but non-specialist audiences, such as politicians and bureaucrats, who were not accustomed to deciphering patterns in tabular data. Certainly, in terms of their design and aesthetics, the polar area graphs

convey a powerful argument about the role of disease in the Crimean catastrophe and the need for the reform of the Army Medical Service.

The colour palate of the graphs exemplifies Nightingale's attention to affective design. Associated with violence, the colour red is thematically suited to depicting deaths from war wounds; black is an ominous choice for "all other" deaths. The blue depicting "deaths from preventable or mitigable zymotic diseases" offers a stark contrast to the red and black that is important to Nightingale's argument about the staggering number of preventable deaths during the war. The blue also aligns this statistical category with impotent bureaucracy, symbolised for the Victorians by parliamentary reports referred to as "blue books".

The use of circular graphs, rather than a more linear time series format, was also an astute choice. Invoking a cyclical progression of time, the graphs suggest that the pattern evident in their data has the potential to fluctuate on a continuous cycle, meaning that without reform, the mistakes of the war will be repeated. At the same time, the reduced mortality rates in the smaller graph of the second year demonstrate how medical intervention can begin to alter the pattern.

It is due to the affective force of their visual arguments that the legacy of Victorian visualisers such as Nightingale is well documented by graphic design enthusiasts today. Perhaps in part due to the influence of these figures, statisticians warmed to visualisation by the 1880s. The proceedings of the Jubilee meeting of the Statistical Society of London, published in 1885, attest to this general change of attitude: the publication includes a few papers on graphical topics, including one by French geographer Emile Levasseur, an invited guest at the meeting.[9]

Other factors in the changing attitude of statisticians to visualisation included the rise of statistical mathematics, which relied more heavily on graphs, and the increasing use of statistical methods in scientific fields that had already embraced other types of visual thinking. Another key factor was the ever-increasing volume of data available to work with. After all, the nineteenth century was the first age of information overabundance. Data sets eventually became too large for even the most eagle-eyed statistician to interpret when arranged in tables that itemised every number. It became a practical necessity to take the more distant view of data that visualisation afforded.

Popular graphics

At the same time that visualisation became a more common method in specialised statistical domains, it began to circulate more prominently in popular culture. The history of popular data visualisation is distinct from specialised data practices, but it warrants attention because popular data graphics much more readily embraced the generalising and affective capacities of visualisation that are evident in Nightingale's graphs. Unfortunately, however, popular data graphics tended to be less rigorous than specialised ones such as Nightingale's. In this sense, they manifest the oversimplification that earlier nineteenth-century statisticians had sought to avoid by using tables instead of graphics. In their efforts to maximise audience impact, the creators of popular graphics prioritised visual rhetoric and generalisation over statistical accuracy.

The tendency to emphasise impact over rigour is particularly evident in popular uses of the pictogram. First appearing in Michael G. Mulhall's *Dictionary of Statistics* in 1884,[10] pictograms became the most popularised form of statistical visualisation in late Victorian print media. They began to appear with semi-regularity in pictorial magazines, such as the *Strand* and *Pearson's*, and newspapers, such as the *Daily Graphic*, in the 1890s. The popularity of these graphics may have been due to their accessibility to audiences with little literacy in statistics, graphs, or other forms of visualisation. Pictograms resemble the items their data describe, if in a simplified form, and the relative proportions of the quantities they represent, if not the specific volumes, are easy to ascertain by even the inexpert eye. However, the simplicity that makes pictograms accessible can eschew quantitative precision.

Figure 4, from an article by statistician and actuary John Holt Schooling, published in *Pearson's Magazine* in 1898, exemplifies this lack of precision in popular data graphics. "The Mathematics of Marriage" surveys statistics on British marriage, framing them in playful commentary intended to edify and entertain readers.[11] The article includes several pictogram visualisations that use photographic human figures as their measures. The overall effect is lively, but less than rigorous.

A visualisation of all the British women who marry in one year depicts the number of marriages in three age demographics compared to one another and the total number ▶

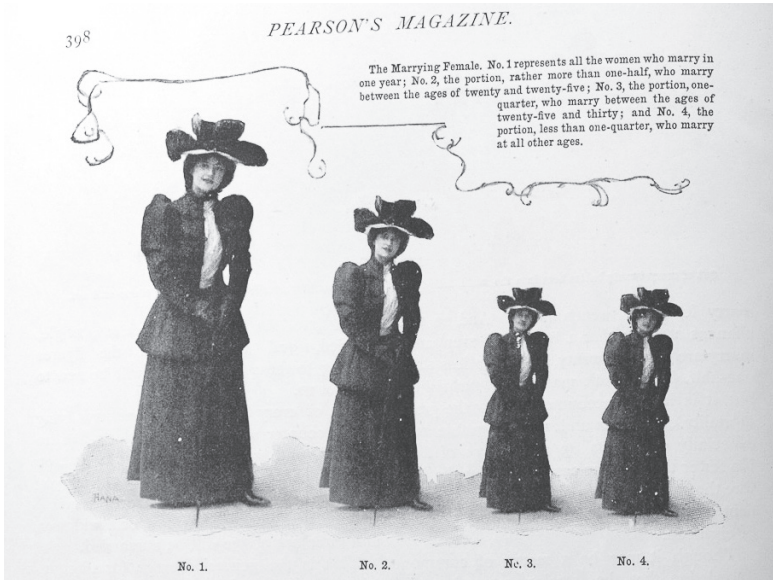

FIGURE 4 A pictogram of "the marrying female", from "The Mathematics of Marriage" by John Holt Schooling.[11] Figure no. 1 represents all women who marry in one year; no. 2 represents the proportion who marry between the ages of 20 and 25; no. 3 is the proportion who marry between the ages of 25 and 30; and no. 4 is the proportion who marry at all other ages.

of marrying women. The same figure, a young woman with a walking stick and stylish hat, is reproduced four times at different sizes to enable this comparison. The graphic effectively conveys its general message: in a given year, the majority of marrying women are between ages 20 and 25. Two other demographics are significant enough within the total to display in the visualisation: marrying women aged 25 to 30, and marrying women of all other ages.

Although the sequence of this pattern is clear, the exact proportion of each demographic relative to the others and to the whole is poorly represented. The figure labelled "no. 2" represents slightly more than 50% of figure no. 1's proportions but occupies closer to 75% of her size on the page. Figures no. 3 and no. 4 occupy identical quantities of page space, even though no. 3 represents 25% of the total marrying female population in a year and no. 4 represents less than this amount. Why they are the same size is unclear. It may be that *Pearson's* producers were unwilling to sacrifice image quality by photomechanically reproducing the figure at a further reduced size. The facial features of the smaller figures are already somewhat difficult to distinguish.

This visualisation exemplifies how popular data graphics tended to prioritise affect over rigour. Tables of the visualised statistics and detailed information about data provenance are nowhere to be seen among these graphics and their accompanying letterpress; this was the case for virtually all popular data visualisations of this era. If visualisation's strength is its capacity to foreground general patterns in a data set, popular Victorian data graphics fully exploited this power, but at the expense of the details – the specific quantities – that are equally important to understanding fully the significance of a data set.

Schooling wrote and illustrated many articles like "The Mathematics of Marriage" in the 1890s; there was a brief craze for them in popular illustrated magazines. These articles depicted the traditional fields of statistics: vitality, population and economics. By no coincidence, these were also knowledge fields central to the success of the nation. The bureaucratic state that developed in Britain over the eighteenth and nineteenth centuries prioritised population health and economic strength. As data visualisation became more common in Britain, it became a useful tool for the many general-interest periodicals with a nationalist bent to promote the priorities of the state while entertaining readers with the visual novelty of the figures. In this regard, the emphasis of visualisation producers on rhetorical affect over statistical rigour was all the more potent, encouraging readers to interpret visualisations through a lens of nationalist sentiment rather than cultivating a critical data literacy.

Then and now

We continue to see an emphasis on rhetorical impact in twentieth- and twenty-first-century statistical visualisation in journalism. Graphic designers continue to strive for the kind of affective argumentation that Nightingale achieved with her polar area graphics. For example, an information graphic created by the *Guardian* in 2012, and updated regularly for several years, uses a radial bar chart to compare gay rights across the USA, state by state (bit.ly/37zF61D); a visualisation developed by Fathom Information Design in 2016, titled "The measure of a nation", similarly deploys a polar format to compare country rankings on a range of metrics (measure.fathom.info). Like Nightingale's graphs, both of these figures use a circular format to emphasise inequalities in the data that correlate with varying quality of life among human populations. They also use affective colour schemes that imbue variables with cultural associations.

Unfortunately, the trend away from quantitative precision that was already evident in popularised data visualisation at the end of the nineteenth century also persists today. Nightingale's graphs accompanied a variety of other forms of data expression, including tables and written narratives, that readers could put in conversation to understand more critically the arguments that the graphics mobilised. Some contemporary data graphics are accompanied by written commentary, particularly those published in online journalism (see, for example, the visualisations of the *Guardian* and *New York Times*). However, it is rare indeed for even such detailed publications to link to the itemised data sets they draw upon.

In our age of big data, visualisation's importance as a tool for interpreting and communicating information continues to increase across many areas of culture and society. But, as Nightingale's work with data attests, summative visualisations and itemised data sets offer two equally important and complementary perspectives on statistical information. We would do well to pair these in order to foster critical data visualisation literacy among members of the general public. ■

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