

HISTORY OF GRAPHICAL REPRESENTATION OF DATA

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Today it is considered that graphical presentation of data is natural and obvious. However, history of development of graphical representation of data suggests that it is a complex task. A certain level of social and scientific potential was necessary for creation and development of simple and efficient methods of graphical representation of data. In this paper we shall give brief overview of history of graphical representation of data which will be a starting point for further research.

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GRAPHICAL REPRESENTATION OF DATA

The beginnings of the visualisation are deep in our history. Roots of graphical *representation* can be found in cartography. According to Herodotus (books II and IV), the author of the first world map was Anaximander from Miletus (550 BC). Cartography and statistical graphics share common goals of visual representation for exploration and discovery. Cartographic visualisation is primarily concerned with representation constrained to a spatial domain, while statistical graphics applies to any domain in which graphical methods are employed in the service of statistical analysis. Beside this difference, cartographic visualisation and statistical graphics share common historical themes of intellectual, scientific, and technological development.

In the 16th century techniques and instruments for precise observation and measurement of physical quantities were well developed (Friendly, 2009). In the 17th century “the rise of analytic geometry, theories of errors of measurement, the birth of probability theory, and the beginnings of demographic statistics and political arithmetic” were observed. With statistical thinking visual thinking evolved.

The 17th century was considered as the one in which visual thinking began. The main problems were those concerned with physical measurement of time, distance and space; for astronomy; surveying, map making, navigation and territorial expansion. In the 18th century, abstract graphs and graphs of function were introduced, along with the early beginnings of statistical theory and the systematic collection of empirical data. In 1748, the term “statistik”, before that, “statist”, “statista” and almost forty years later, in 1787, Zimmerman uses word “statistics” as it is known today (Friendly, 2009). Between 1786 and 1801, the circle diagram, the pie chart and bar chart were invented and published by William Playfair (Playfair, 1801). Playfair also improved a line graph for representation of economic data. At this time

... illustration in serious writing was viewed with suspicion. It would have been unthinkable to introduce pictorial material to bolster an argument where tabular presentation would have been seen as sufficient and certainly more accurate. (Spence & Wainer, 1997, p. 31)

Williams’ graphical innovations were not accepted by his contemporaries, but their importance grew after the second half of the 19th century, when Charles-Joseph Minard (1781-1870) and Jacques Bertillon (1851-1922) used some of Playfair’s methods in their cartographical work (Spence & Wainer, 2005b). The fact that graphical representation of data which he invented have the same form today, after psychological research about human perception of charts, suggests that we need to pay more attention to this visionary.

DEVELOPMENT OF NEW GRAPHIC FORMS FOR REPRESENTATION OF DATA

William Playfair (1759-1823) had wide mathematical and philosophical education. His older brother John Playfair (1748-1819), professor of mathematics (1785) and natural philosophy (1805) at Edinburgh University, taught him mathematics. According to Spence (2006), William was acquainted with work of philosophers Dugald Stewart (1753-1828) and Tomas Reid (1710-1796), whose preoccupations were perception and memory. Besides that, while working for Andrew Meikle (1719-1811) and James Watt (1736-1819), he acquired skills like drawing, using shading and labelling (Spence, 2006). All of that had a great impact on the development of the idea of necessity for graphical representation of data. He understood the advantages of graphical representation and knew that charts were a universal language applicable in science and economy. He thought that graphical representation contributed to a faster and easier reading and interpretation of data (Playfair, 1801, xii; Sachs, 2012).

William Playfair was the first to use a graphical representation for quantitative data (mainly economic) and to publish a book to contain statistical graphs. This book was his *Commercial and Political Atlas* (Playfair, 1786) which contained 44 charts (Funkhouser, 1937). Graphical representations before Playfair had been graphical representations (line diagrams) of functions and they had not been based on quantitative or statistical data. On the contrary, Playfair included raw data “in accompanying tabular form for many of the charts” (Spence, 2006, p. 2427), so it is clear that his line diagrams “are not mathematical function derived from theory” (Spence, 2006, p. 2427). Moreover, Playfair’s graphical representations had “graduated and labeled axes; grid lines; a title; labels” (Spence, 2006, p. 2427) and other characteristics typical of today’s graphical representation of data.

Playfair himself explained motivation for introducing visual displays of data in the following way:

This method has struck several persons as being fallacious because geometrical measurement has not any relation to money or to time yet here it is made to represent both. The most familiar and simple answer to this objection is that if the money received by a single man in trade were all guineas and every evening he made a single pile of all the guineas received during the day, its height would be proportioned to the receipts of that day, so that by this plain operation time, proportion and amount would be physically combined. (Playfair, 1801, according to Royston, 1956, p. 242.)

Today, “the piles of guineas” are called object graphs. It is interesting to note that, in contemporary teaching practice in elementary schools, it is common for object graphs to be used in the first stage of the development of graphic representation skills and understanding of data.

According to him, credits belong also to his brother John.

... my brother, ..., made me keep a register of a thermometer expressing the variation by lines on a divided scale. He taught me to know that whatever can be expressed in numbers may be represented by lines. The chart of the thermometer was on the same principle whit those given here (in Atlas), the application only is different. (Playfair, 1805, xvi; according to Royston, 1956, p. 242 and Sachs, 2012, p.4)

Playfair was the first to use charts to “support his economic and political arguments” (Spence, Fenn, & Klein, 2017, p. 20-21; Spence, 2005a). It seems that he was aware that his graphical forms would not be easily accepted and understood, so he gave detailed descriptions of his charts.

Another Playfair’s contemporary saw the value of graphical representation of data. A. F. W. Crome (1753-1833) was a professor of Statistics and Public Finance at Giessen University from 1786 until 1831. Crome first applied geometric

representation as an aid to teaching (Royston, 1956). In 1820 Crome for the first time used circle graphs for representation of data. Playfair's circle diagram is clear and simple; on the contrary, Crome's one is similar, but complicated. Playfair's circle diagram had been published before Crome's, but there is no evidence that Crome had used Playfair's idea. According to Royston (1956) it is possible that Playfair and Crome worked independently.

GRAPHICAL REPRESENTATION OF DATA SINCE THE 19TH CENTURY UNTIL TODAY

In the 19th century, statistical graphics experienced a big revelation. At the beginning of this period (in 1801), the first large-scale geological map of England and Wales was created, setting the pattern for geological cartography, and founding stratigraphic geology.

By the second half of the 19th century all necessary tools for data representation were discovered, statistical offices were established throughout Europe and some statistical theories from the past started to collect and represent large sets of data. This period is characterized by a several breakthrough in the representation of data such as:

Representation of data started to be used more often in different everyday situations and scientific fields: mining meteorology, politics, demography, advocacy, medicine, transport, traffic, etc. New types of graphs were used for the first time or in a new way: Coxcombs, Semi logarithmic grid, stereogram, Semi-graphic table to display a data, table by shading levels, Bilateral histogram, two-variable colour map, divided square in the modern form for data representation, Polar diagrams and Star plots, Pictogram, Alignment diagrams, Anamorphic maps, Area rectangles on a map, etc. The term graph was introduced, referring to diagrams in chemistry; the first mature attempt at a systematic classification of graphical forms is made by Statistical Society of London, which gave a comprehensive review of all available statistical graphics and several international conferences and exhibitions were organized. The first international statistics conference was organized in 1853 by International Statistical Institute Belgium. Statistical diagrams started to be used in school textbooks. Diagrams were incorporated in museums (Outlook Tower, Edinburgh, Scotland, 1892). Consequently, the second half of the 19th century is often called Golden Age of data graphic.

At the beginning of the 20th century, enthusiasm for visualization was reduced due to the rise of statistical models in the social sciences. Only few new diagrams were presented (Butterfly diagram, Hertzprung-Russell diagram, Gantt chart, Path diagram, Nomogram, Ideograph). By the mid-1930s previous

graphical methods found new application and use in government, commerce, astronomy, physics, biology and other sciences and entered textbooks (the USA and England). For the first time several scientific societies published standards for graphical representation, and commercial correspondence courses in graphical methods started.

After WWII data visualization experienced its own rebirth in mid 1960s thanks to the three significant developments: publication of papers “The Future of Data Analysis” and “Semiologie Graphique”, and the beginning of computer data processing. Invention of different software tools, languages (C, UNIX, etc.), display and input technologies, provide new ways for expressing and implementing data graphics, which is in progress even today. Nowadays it is very hard to provide an overview of the most recent developments because they are spread across a wider range of disciplines.

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