# History of Statistics 2.    Origins of graphs in statistics – William Playfair (1759-1823)

You may be surprised that graphs were not always used to present statistical findings. Graphs were used to describe mathematical relationships as far back as the 1300s, but not for statistical purposes. In about 1360, for example, **Nicholas Oresme** in France drew a graph of velocity versus time (lower image on the right). It looks like a bar graph but is essentially the graph of a straight line, using "pipes" instead of dots. Furthermore, the horizontal "axis" does not represent categories of some discrete variable. Another reason for the unfamiliar appearance of the graph is that in 1360 there were no such things as *x* and *y* axes or even any algebraic notation. Oresme's Latin manuscript was written before there were printing presses (the first press in the west wasn't produced until about 1440). This book wasn't machine printed until 1482, a hundred years after he died.



Oresme, *De latinudinibus formarum* (1482 ed.)
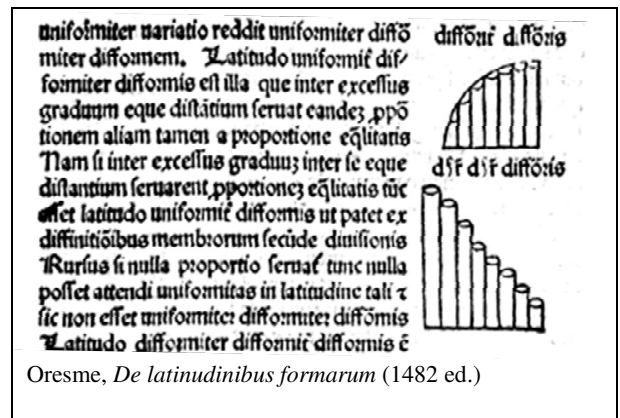
**The first significant statistical graphs** were published much more recently, usually credited to **William Playfair** (1759-1823), political economist and engineer from Scotland. As statistician Howard Wainer points out, this choice of "first" is not so much that no one had done somewhat similar graphs before, but that Playfair's work was so excellent and compelling. "Data-based graphics began to make an appearance in the mid-seventeenth century but their full value and great popularity can be traced to a single event and a single person." That event was the publication of Playfair's *Commercial and Political Atlas* in **1786**, a technical book for those interested in the British economy.

The figure on the right is

 facsimile of a graph from that book. (It was redrawn for Wainer's book.) This is one of the **first time-series line graphs**, which are now so common in financial data. Playfair's excellent representation of the data includes a third "dimension," labels of historical events that can help explain changes in the trends. He was very careful about choosing horizontal and vertical scales, giving his graphs good proportion - note that he extended the vertical axis above the highest data value. At the bottom of the graph he states that the "bottom" numbers are "years" and the right hand numbers are "money." There is virtually no difference between this



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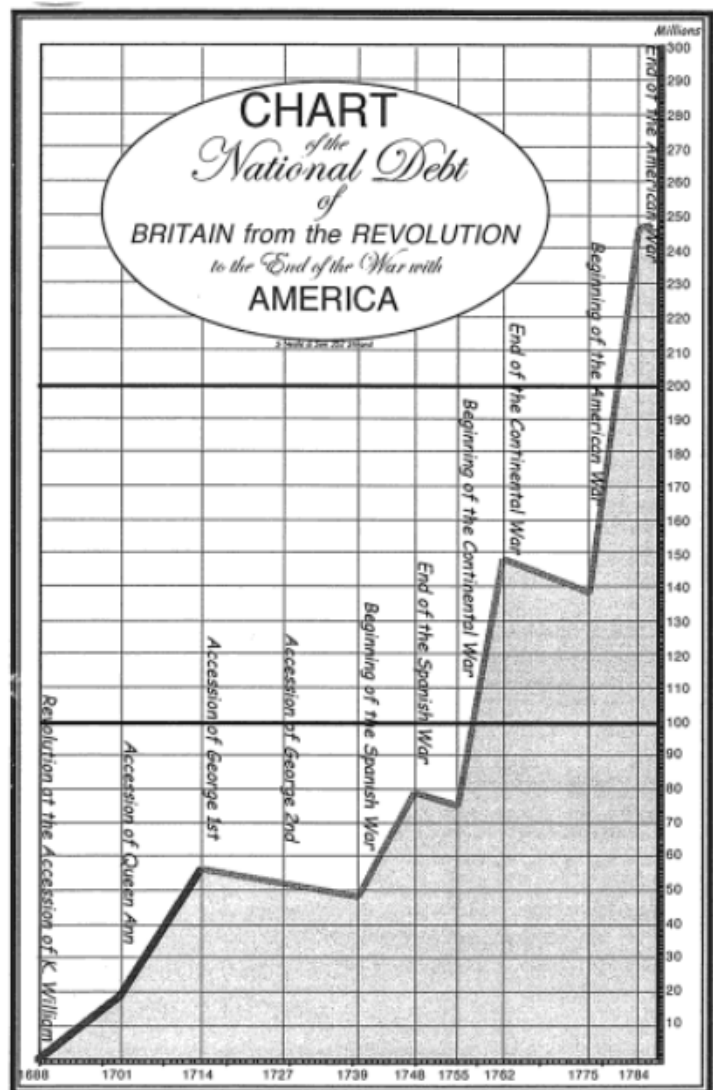
graph from 1796 and one we might make today.

A few years later, in 1801, Playfair produced a book, *The Statistical Breviary*, more for the general public. You can see in this quotation from the preface that he believes "statistical knowledge" is important to "all persons connected in any way with public affairs."

Statiſtical knowledge, though in ſome degree ſearched after in the moſt early ages of the world, has not, till within theſe laſt fifty years, become a regular objeɛt of ſtudy. Its utility to all perſons conneɛted in any way with public affairs, is evident: and indeed it is no leſs evident that every one who aſpires at the charaɛter of a well-in-formed man ſhould acquire a certain degree of know-ledge on a ſubjeɛt ſo univerſally important, and ſo gene-rally canvaſſed.

The preface also includes Playfair's primary reason for using graphs to convey numerical information that had up to that time ordinarily been presented in words and tables. It is "appeal to the eye" that provides "the best and readiest method of conveying a distinct idea."

I have compoſed the following work upon the prin-ciple of which I ſpeak; this, however, I never ſhould have thought of doing, had it not occurred to me, that mak-ing an appeal to the eye when proportion and magni-tude are concerned, is the beſt and readieſt method of conveying a diſtinɛt idea.

A graph that appears early in *The Breviary* is often considered the **first published pie chart**. It is the second circle from the left in the larger image. An enlarged version of that pie is shown on the right. In the complete chart you can see the scales on the axes, and get a better sense of how much information was being conveyed. The overall title is "Chart Representing the Extent, Population & Revenue of the Principal Nations in Europe after the Division of Poland & Treaty of Luneville." (This was in 1801 after a French victory under Napoleon Bonaparte.)

Some properties of the whole chart: Circles of various sizes stand for the total land areas of the countries. (The biggest one on the left is Russia.) The size of the land area is shown just below the horizontal diameter. The population size is indicated by the vertical line on the left of a circle; the tax burden is given by the vertical line on the right. The graph of England is the fourth circle from the right. Notice that for England the right hand line is longer than the left hand line, unlike most of the other circles. Playfair was a political economist and he had a story to tell about the state of the world economy in 1801. The tax burden in England was too high!
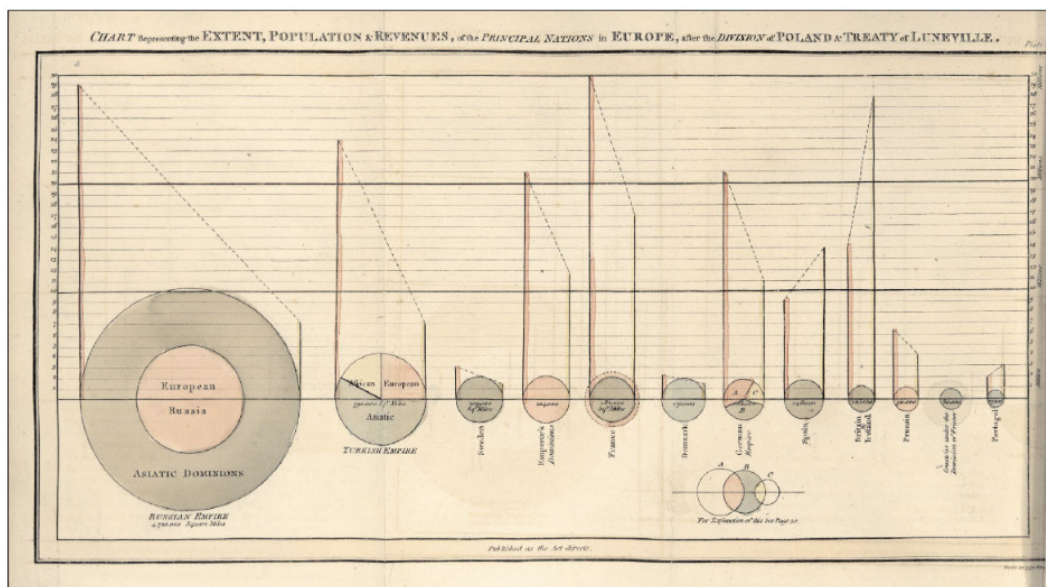


The pie chart describes the proportions of the Turkish Empire located in Africa, Europe, and Asia before 1789. In one printing he tinted the Asiatic slice green, signifying a maritime power, and the European red to denote a land power.

Historians, especially Ian Spence from the University of Toronto, have speculated about how William Playfair got the idea for a pie chart. One possibility is that his older brother, John, who became one of Scotland's most celebrated mathematicians, may have been influential. After the death of their father, John was responsible for William's education. William himself specifically mentions John's influence for other forms of graphs. But, Spence says, "… the pie remains a mystery; Playfair gives us no indication of his inspiration, and he devotes no discussion to the form."

Here is a figure from Spence's paper, *No Humble Pie: The Origins and Usage of a Statistical Chart*. These are graphs that John Playfair would have been familiar with; they had been developed for analysis of logic. John was a great admirer of Leibniz and Euler, praising them highly in the supplement he wrote on the history of mathematics for the 4th edition of the

Ramòn Llull
(1232 - 1316)

Giordano Bruno
(1548 - 1600)

G.W. Leibniz
(1646 - 1716)

Leonhard Euler
(1707 - 1783)

FIGURE 2. *Representative examples of logic diagrams from Llull, Bruno, Leibniz, and Euler. The words* Esse, Unum, Verum, *and* Bonum *in conjunction with the Venn-like diagram of Llull may be interpreted to mean, nothing* Exists *which does not possess* Unity, Truth *and* Goodness. *Note the use of unequal-sized segments in Bruno's diagram and the linear diagram that Leibniz favored over intersecting circles.*

*Encyclopedia Britannica*. He definitely would have talked about these mathematicians at home. Maybe William Playfair just thought it was "obvious" to use circle type graphs for statistical data. You can see in Leibniz's and Euler's sketches the foundations on which John Venn later built his own system of diagrams.
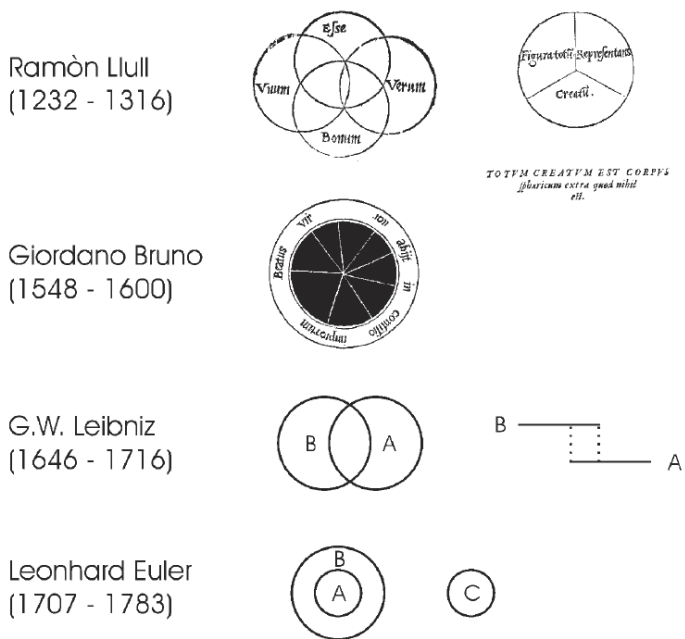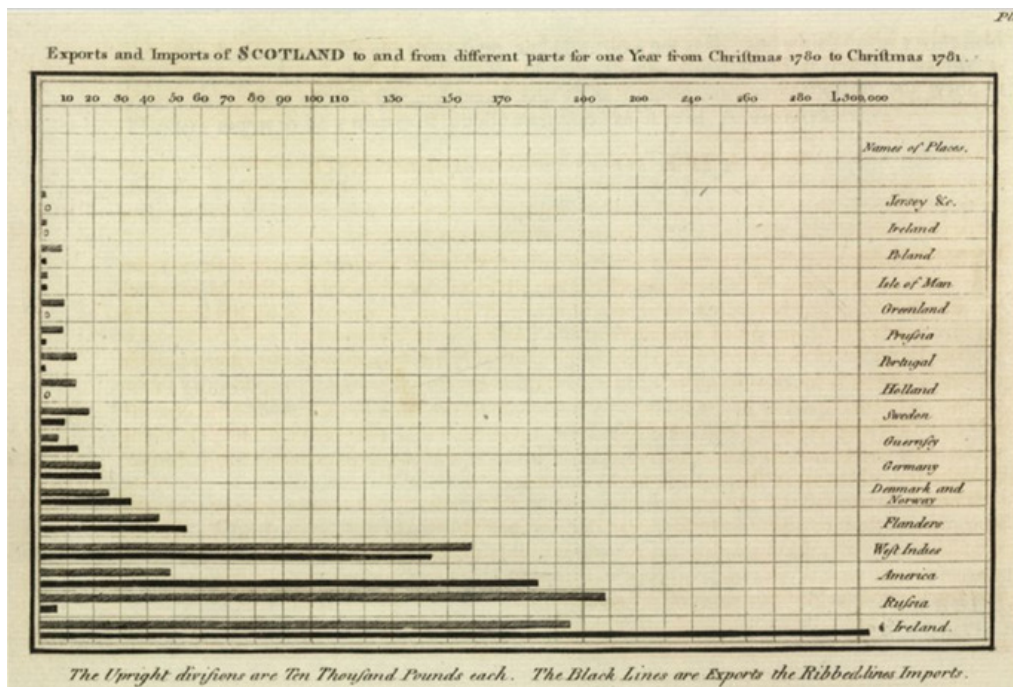
William Playfair also gets credit for the **first bar graph that represents economic data**. This chart appears in his *Commercial and Political Atlas* of 1796 and describes the money values of imports and exports from Scotland for the period "Christmas 1780 to Christmas 1781." The category axis represents countries, each with two bars – one for import and one for exports. The horizontal axis represents money in units of "Ten Thousand Pounds each." *This is the first statistical graph where neither axis represented time or distance.* The vertical variable axis consists of truly discrete categories.

Exports and Imports of SCOTLAND to and from different parts for one Year from Christmas 1780 to Christmas 1781.

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Even though the *Commercial and Political Atlas* was such a breakthrough in statistical graphics, it did not get much attention at first in England but was better received in France. Here is Playfair bragging about it.

> ``When I went to France in 1787, I found several copies there, and amongst others, one which had been sent by an English nobleman to the Monsieur de Vergennes, which copy he presented to the king, who being well acquainted with the study of geography, understood it readily, and expressed great satisfaction. This circumstance was of service to me, when I afterwards solicited an exclusive privilege for a certain manufactory, which I obtained. The work was translated into French, and the Academy of Sciences, testified its approbation of this application of geometry to accounts, and gave me a general invitation to attend its meetings in the Louvre; and at the same time did me the honour of seating me by the president during that sitting." (http://statprob.com/encyclopedia/WilliamPLAYFAIR.html )

You can also see in this paragraph that William Playfair was a businessman, something of a hustler, we might say today. He wasn't the most popular fellow; seems that he didn't always play fair.

William Playfair was an innovator, the first to popularize the use of the pie chart, the time-series line chart, and the bar graph. He missed only one of the familiar graphs we use today, the scatter plot, which didn't appear on the scene for almost another 100 years in the work of Francis Galton.

**Exercise:** Use Playfair's data to create a graph of your own design for Scotland Import/Export in 1780. Values are in English pounds.

| COUNTRY | EXPORTS | IMPORTS |
|---|---|---|
| Ireland | 305,167 | 195,685 |
| America | 183,620 | 49,826 |
| West Indies | 141,220 | 169,375 |
| Russia | 5,915 | 209,000 |
| Sweden | 4,793 | 18,793 |
| Flanders | 56,452 | 45,803 |
| Germany | 26,438 | 26,659 |
| Guernsey | 17,285 | 5,197 |
| Holland | 0 | 13,563 |
| Iceland | 0 | 465 |
| Portugal | 678 | 14,614 |
| Prussia | 82 | 96 |
| Poland | 161 | 7,389 |
| Greenland | 0 | 8,291 |
| "Isle of Man, Jersey" | 1,818 | 802 |
| Denmark and Norway | 35,011 | 28,118 |
| Total | 763,100 | 803,860 |

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**Sources:**
Playfair, William. *The Commercial and Political Atlas:*, Burton Printing, 1786
Playfair, William. *The Statistical Breviary,* Bensley Printing, London, 1801
Spence, Ian & Howard Wainer. William Playfair and His Graphical Inventions, *The American Statistician,* August 2005
Spence, Ian. No Humble Pie: The Origins and Usage of a Statistical Chart, *Journal of Educational and Behavioral Statistics, Winter 2005*
Wainer, Howard. *Graphic Discovery*, Princeton University Press, 2005
Data for Exercise: http://data.okfn.org/data/jrnold/playfair-data#data
Oresme graphs: https://archive.org/details/ita-bnc-in2-00001198-003
Graphs from The Statistical Breviary: https://archive.org/stream/statisticalbrev00playgoog
Image of circle graphs: Spence, Ian. No Humble Pie