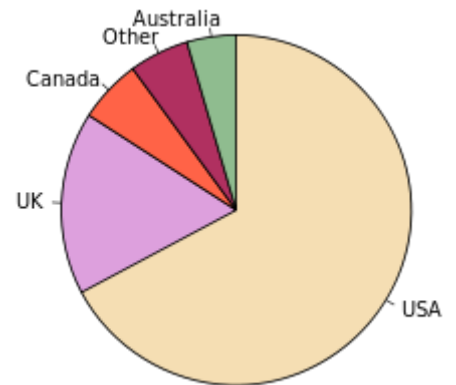


Pie chart

A **pie chart** (or a **circle chart**) is a circular statistical graphic which is divided into slices to illustrate numerical proportion. In a pie chart, the arc length of each slice (and consequently its central angle and area), is proportional to the quantity it represents. While it is named for its resemblance to a pie which has been sliced, there are variations on the way it can be presented. The earliest known pie chart is generally credited to William Playfair's *Statistical Breviary* of 1801.^{[1][2]}

Pie charts are very widely used in the business world and the mass media.^[3] However, they have been criticized,^[4] and many experts recommend avoiding them,^{[5][6][7][8]} pointing out that research has shown it is difficult to compare different sections of a given pie chart, or to compare data across different pie charts. Pie charts can be replaced in most cases by other plots such as the bar chart, box plot or dot plots.



Pie chart of populations of English native speakers

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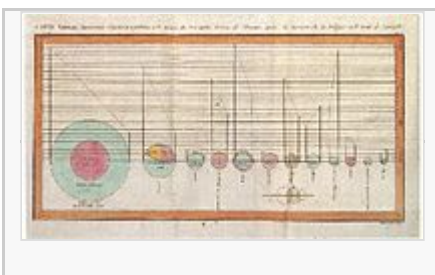
References

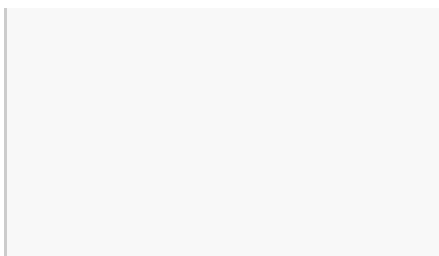
Further reading

History

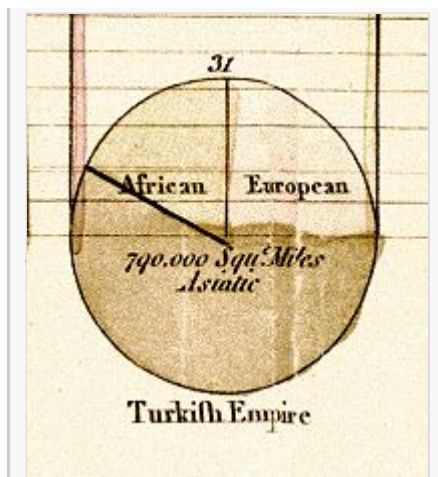
The earliest known pie chart is generally credited to William Playfair's *Statistical Breviary* of 1801, in which two such graphs are used.^{[1][2][9]} Playfair presented an illustration, which contained a series of pie charts. One of those charts depicting the proportions of the Turkish Empire located in Asia, Europe and Africa before 1789. This invention was not widely used at first,^[1]

Early types of pie charts in the 19th century





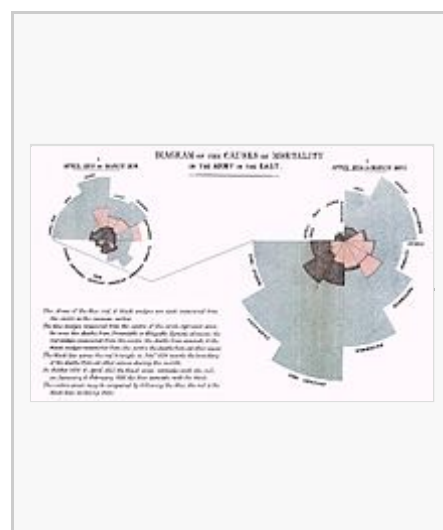
Pie charts from William Playfair's "Statistical Breviary", 1801



One of the pie charts, 1801



Minard's map, 1858



Polar chart by Florence Nightingale, 1858

The French engineer Charles Joseph Minard was one of the first to use pie charts in 1858, in particular in maps. Minard's map, 1858 used pie charts to represent the cattle sent from all around France for consumption in Paris (1858).

Playfair thought that pie charts were in need of a third dimension to add additional information.^[10] It has been said that Florence Nightingale invented it, though in fact she just popularised it and she was later assumed to have created it due to the obscurity of Playfair's creation.^[11]

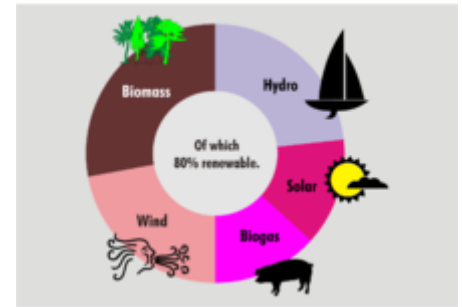
Variants and similar charts

3D pie chart and perspective pie cake

A 3d pie chart, or perspective pie chart, is used to give the chart a 3D look. Often used for aesthetic reasons, the third dimension does not improve the reading of the data; on the contrary, these plots are difficult to interpret because of the distorted effect of perspective associated with the third dimension. The use of superfluous dimensions not used to display the data of interest is discouraged for charts in general, not only for pie charts.^{[7][12]}

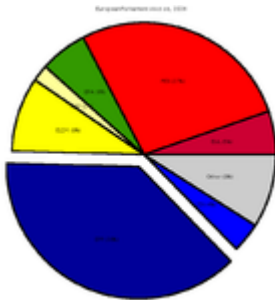
Doughnut chart

A doughnut chart (also spelled donut) is a variant of the pie chart, with a blank center allowing for additional information about the data as a whole to be included. [13][14] Doughnut charts are similar to pie charts in that their aim is to illustrate proportions. This type of circular graph can support multiple statistics at once and it provides a better data intensity ratio to standard pie charts.^[15] It does not have to contain information in the center



Information on the data as a hole in the center of a doughnut chart

Exploded pie chart



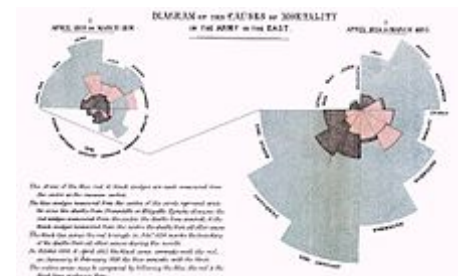
Exploded pie chart for the example data (see below), with the largest party group exploded.

A chart with one or more sectors separated from the rest of the disk is known as an *exploded pie chart*. This effect is used to either highlight a sector, or to highlight smaller segments of the chart with small proportions.

Polar area diagram

The polar area diagram is similar to a usual pie chart, except sectors have equal angles and differ rather in how far each sector extends from the center of the circle. The polar area diagram is used to plot cyclic phenomena (e.g., counts of deaths by month). For example, if the counts of

deaths in each month for a year are to be plotted then there will be 12 sectors (one per month) all with the same angle of 30 degrees each. The radius of each sector would be proportional to the square root of the death count for the month, so the area of a sector represents the number of deaths in a month. If the death count in each month is subdivided by cause of death, it is possible to make multiple comparisons on one diagram, as is seen in the polar area diagram famously developed by Florence Nightingale



"Diagram of the causes of mortality in the army in the East" by Florence Nightingale.

The first known use of polar area diagrams was by André-Michel Guerry, which he called *courbes circulaires*, in an 1829 paper showing seasonal and daily variation in wind direction over the year and births and deaths by hour of the day.^[16] Léon Lalanne later used a polar diagram to show the frequency of wind directions around compass points in 1843. The wind rose is still used by meteorologists. Nightingale published her rose diagram in 1858. Although the name "coxcomb" has come to be associated with this type of diagram, Nightingale originally used the term to refer to the publication in which this diagram first appeared--an attention-getting book of charts and tables--rather than to this specific type of diagram.^[17]

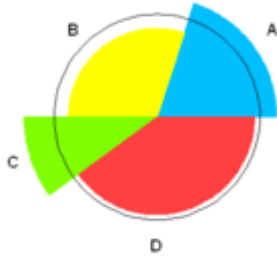
Ring chart, sunburst chart, and multilevel pie chart

A ring chart, also known as a sunburst chart or a multilevel pie chart, is used to visualize hierarchical data, depicted by concentric circles.^[18] The circle in the center represents the root node, with the hierarchy moving outward from the center. A segment of the inner circle bears a hierarchical relationship to those segments of the outer circle which lie within the angular sweep of the parent segment.^[19]

Spie chart

A variant of the polar area chart is the spie chart designed by Dror Feitelson.^[20] This superimposes a normal pie chart with a modified polar area chart to permit the comparison of two sets of related data. The base pie chart represents the first data set in the usual way, with different slice sizes. The second set is represented by the superimposed polar area chart, using the same angles as the base, and adjusting the radii to fit the data. For example, the base pie chart could show the distribution of age and gender groups in a

Ikasle kopuruak eta ikasleko kostuak ikastetxeetan

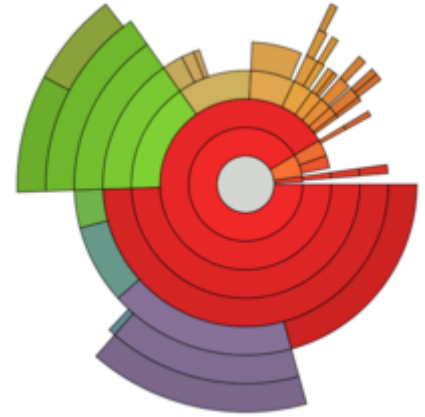


A spie chart comparing number of students with student costs across four different schools

population, and the overlay their representation among road casualties. Age and gender groups that are especially susceptible to being involved in accidents then stand out as slices that extend beyond the original pie chart.

Square chart

Square charts are a rare form of pie charts that use squares instead of circles to represent percentages. Similar to basic circular pie charts, square pie charts take each percentage out of a total 100%^[21]



Multi-level pie chart representing disk usage in a Linux file system

Example

The following example chart is based on preliminary results of the election for the European Parliament in 2004. The table lists the number of seats allocated to each party group, along with the derived percentage of the total that they each make up. The values in the last column, the derived central angle of each sector, is found by multiplying the percentage by 360°.

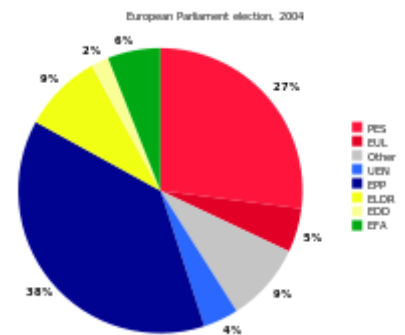
Group	Seats	Percent (%)	Central angle (°)
<u>EUL</u>	39	5.3	19.2
<u>PES</u>	200	27.3	98.4
<u>EFA</u>	42	5.7	20.7
<u>EDD</u>	15	2.0	7.4
<u>ELDR</u>	67	9.2	33.0
<u>EPP</u>	276	37.7	135.7
<u>UEN</u>	27	3.7	13.3
Other	66	9.0	32.5
Total	732	99.9*	360.2*

*Because of rounding, these totals do not add up to 100 and 360.

The size of each central angle is proportional to the size of the corresponding quantity, here the number of seats. Since the sum of the central angles has to be 360°, the central angle for a quantity that is a fraction Q of the total is $360Q$ degrees. In the example, the central angle for the largest group (European People's Party (EPP)) is 135.7° because 0.377 times 360, rounded to one decimal place, equals 135.7.

Use and effectiveness

An obvious flaw exhibited by pie charts is that they cannot show more than a few values without separating the visual encoding (the “slices”) from the data they represent (typically percentages). When slices become too small, pie charts have to rely on colors, textures or arrows so the reader can understand them. This makes them unsuitable for use with larger amounts of data. Pie charts also



A pie chart for the example data

Atmospheric air content	
Gas	percentage
Nitrogen	78.00%
Oxygen	21.00%
Others	1.00%



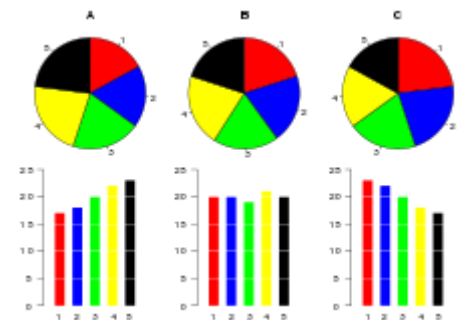
Pie chart showing Atmospheric air components percentage

three pie charts, and, below each of them, the corresponding bar chart representing the same data. Most subjects have difficulty ordering the slices in the pie chart by size; when the bar chart is used the comparison is much easier.^[23] Similarly, comparisons between data sets are easier using the bar chart. However, if the goal is to compare a given category (a slice of the pie) with the total (the whole pie) in a single chart and the multiple is close to 25 or 50 percent, then a pie chart can often be more effective than a bar graph!^{[24][25]}

take up a larger amount of space on the page compared to the more flexible bar charts, which do not need to have separate legends, and can display other values such as averages or targets at the same time!^[7]

Statisticians generally regard pie charts as a poor method of displaying information, and they are uncommon in scientific literature. One reason is that it is more difficult for comparisons to be made between the size of items in a chart when area is used instead of length and when different items are shown as different shapes.^[22]

Further, in research performed at AT&T Bell Laboratories, it was shown that comparison by angle was less accurate than comparison by length. This can be illustrated



Three sets of percentages, plotted as both piecharts and barcharts. Comparing the data on barcharts is generally easier.



An example of a pie chart with 18 values

The example (left) is of a pie chart with 18 values, having to separate the data from its representation. Note also that several values are represented with the same color, making interpretation difficult.

Several studies presented at the *European Visualization Conference* analyzed the relative accuracy of several pie chart formats,^{[26][27][21]} reaching the conclusion that pie charts and doughnut charts produce similar error levels when reading them, and square pie charts provide the most accurate reading.^[28]

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