Statistical Graph Literacy

Mikhail Popov

Analysis

Wikimedia Foundation / Discovery Department

v0.9.3

Data Visualization as Storytelling

Graphical displays should:

- Show the data
- Induce the viewer to think about the substance rather than graphic design or format
- Avoid distorting the data
- Present many numbers in a small space
- Make large data sets coherent
- Encourage the eye to compare different pieces of data

– Edward R. Tufte, *The Visual Display of Quantitative Information*

Types of Variables

Continuous variables have “an infinite”* range of possible values

Examples: time, age, weight, lengths (height, distance, time spent online), drug dosage

Categorical / discrete / qualitative

Nominal variables have two or more categories that do not have an intrinsic order

Examples: gender, ethnicity, controls vs test group, operating system

Ordinal variables are like nominal, but the categories have an ordering/ranking

Examples: Likert (rating) scale, number of visits to a website

* conceptually, but usually not practically :)

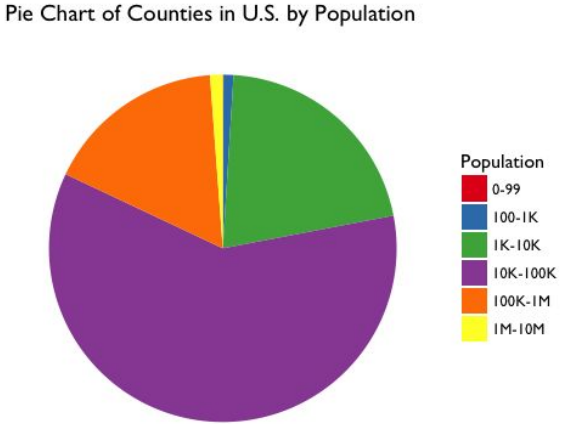
Things To Look For

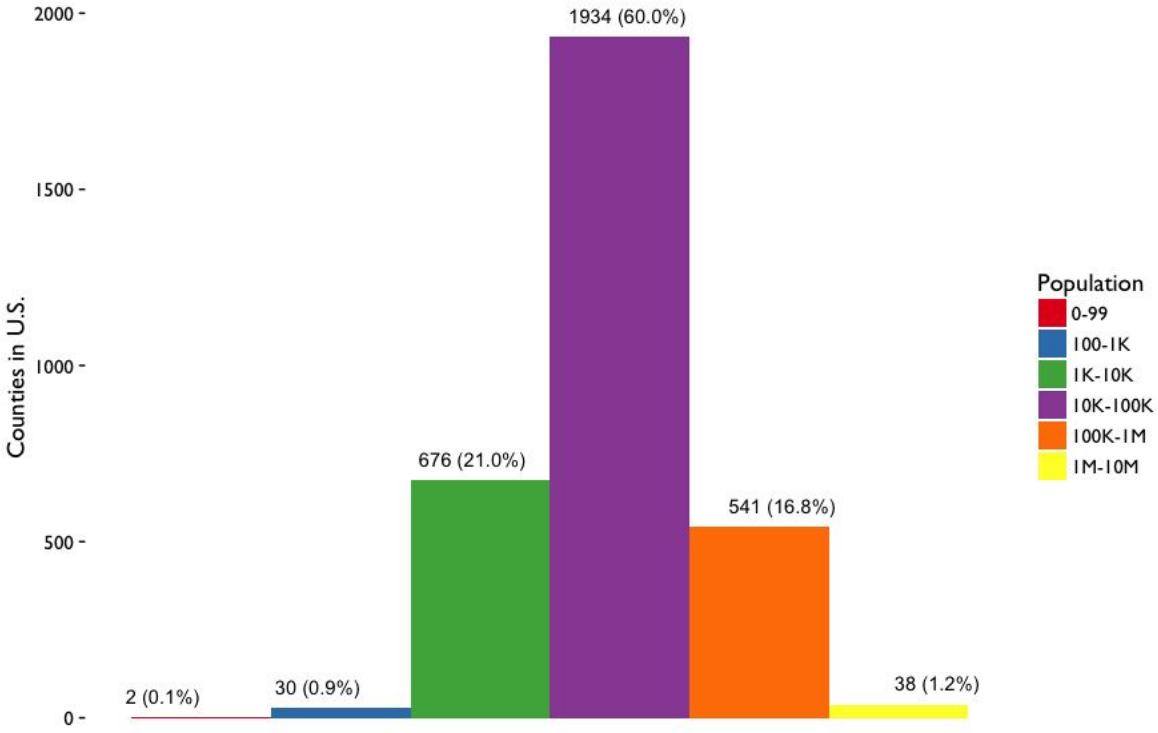
- Title (most plots should have this)
- Axis labels (almost all plots should have this)
- Type(s) of variable(s) being visualized
    - Including ones used to dictate colors, shapes, patterns, sizes, opacities, etc.
- Independent ("*predictor*") variables (e.g. time) are usually on the x axis
- Dependent ("*outcome*" / "*response*") variables are usually on the y axis
- Scales (especially log-transformed ones)

Some common data visualizations

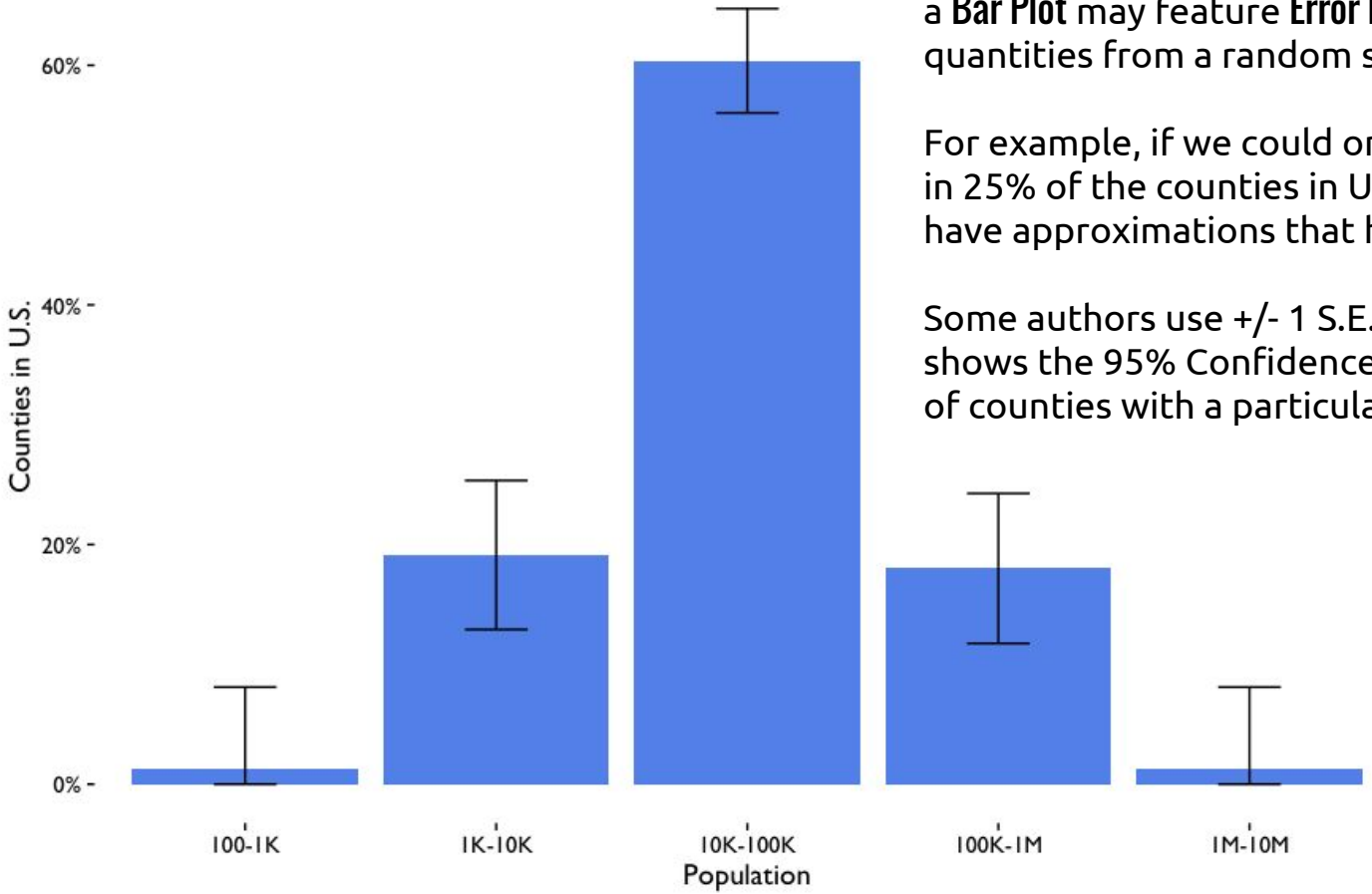
Population	Counties	Proportion
0-99	2	0.001
100-1K	30	0.009
1K-10K	676	0.210
10K-100K	1934	0.600
100K-1M	541	0.168
1M-10M	38	0.012

A **Pie Chart** (bottom left) and a **Bar Plot** (below) are an easy way to visually compare values in the table on the left. The **Pie Chart** is excellent for 2-4 categories, the table is for 1-8 categories, and the **Bar Plot** works great for comparing more than 5 categories.





Source: U.S. Census Bureau,'Statistical Abstract of the United States, 2003, HS-3



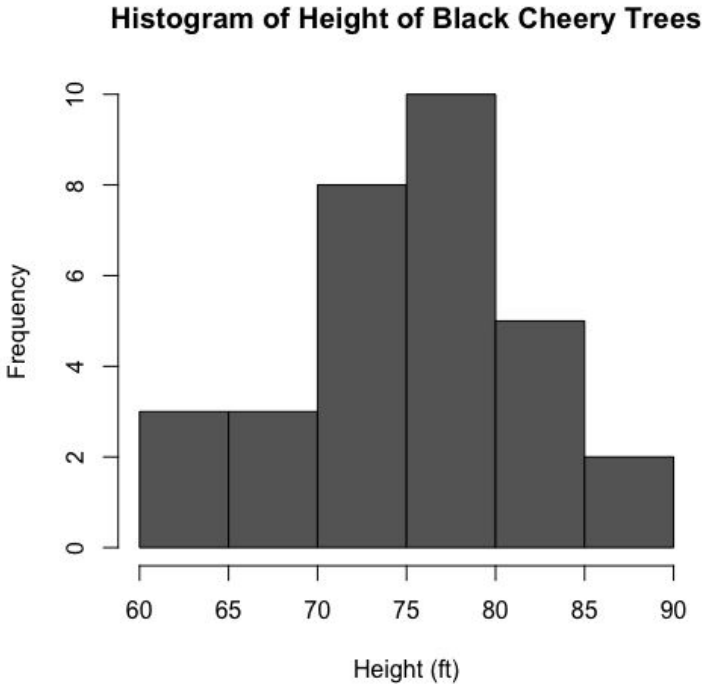
a **Bar Plot** may feature **Error Bars** when using estimated quantities from a random sample

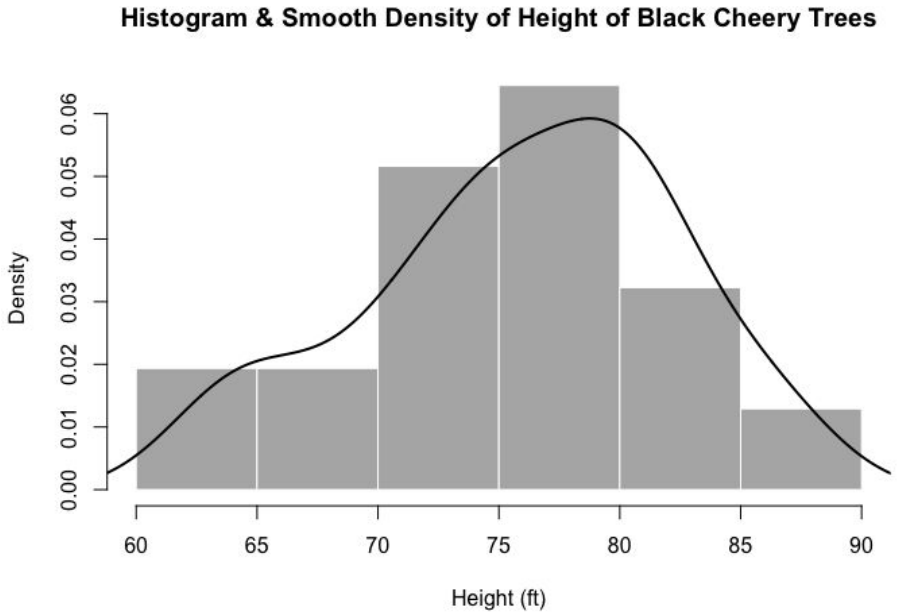
For example, if we could only measure the population in 25% of the counties in U.S. (805), we would only have approximations that have standard errors.

Some authors use +/- 1 S.E. for the bounds. This graph shows the 95% Confidence Interval for the proportion of counties with a particular population size.

Source: U.S. Census Bureau, Statistical Abstract of the United States, 2003, HS-3

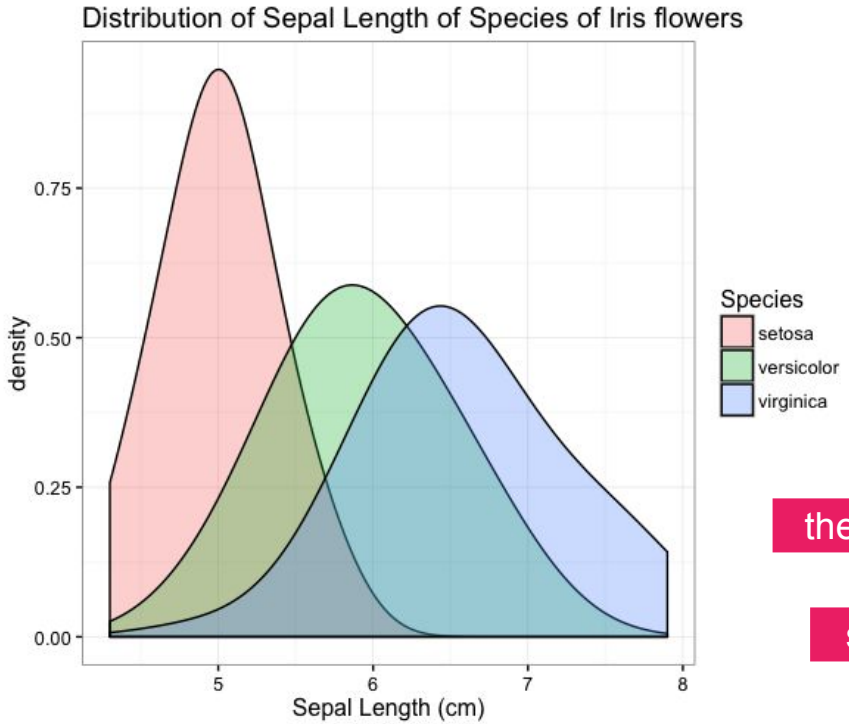
a **Histogram** or a **Density Plot** is a way to visualize a continuous variable's distribution



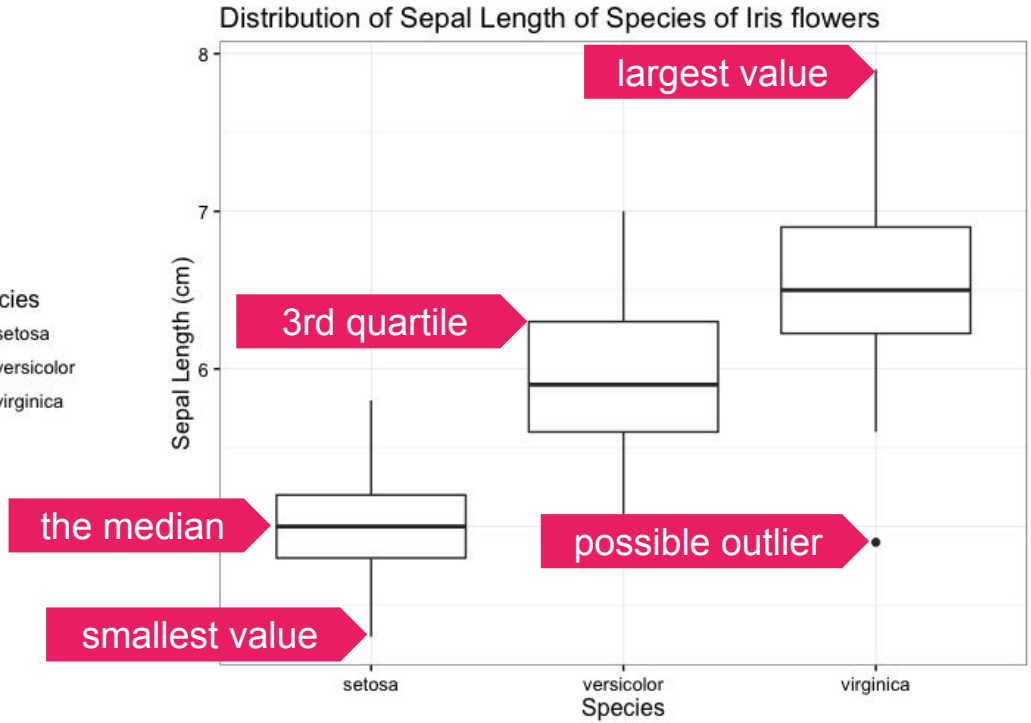


Trees dataset: Ryan, T. A., Joiner, B. L. and Ryan, B. F. (1976)
The Minitab Student Handbook. Duxbury Press.

a **Density Plot** makes it easy to compare (smoothed) distributions between groups



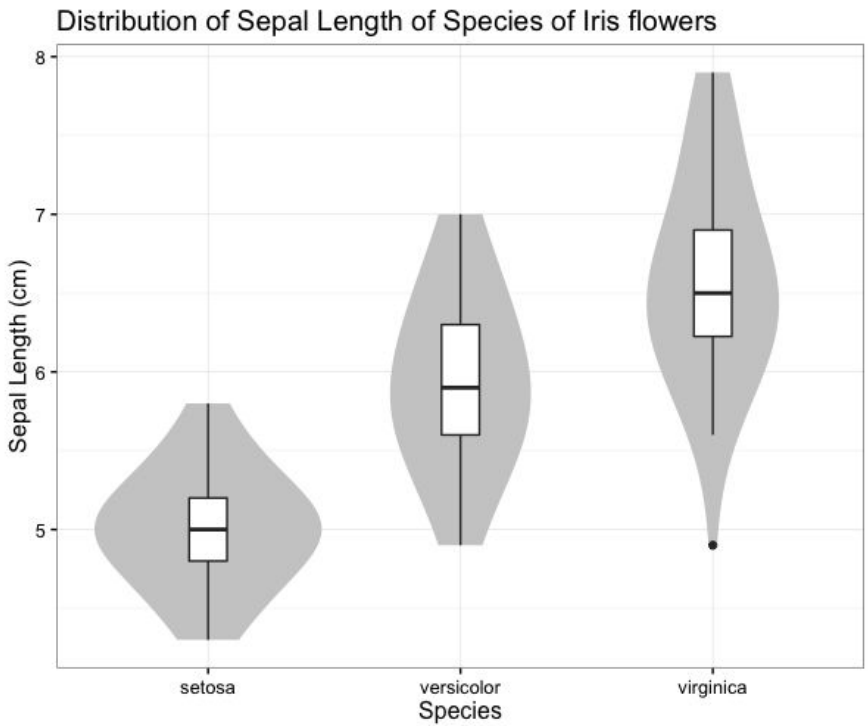
a **Box-and-Whiskers Plot** is a way to vaguely compare distributions between groups



Iris data collected by Anderson, Edgar (1935). The irises of the Gaspe Peninsula, Bulletin of the American Iris Society, 59, 2–5.

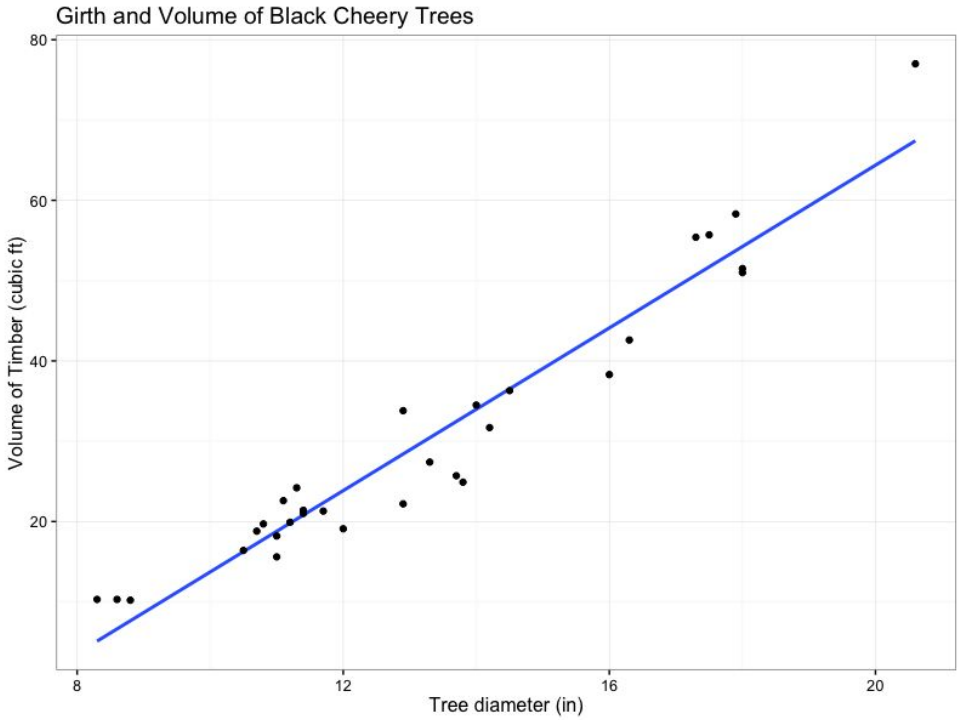
Violin Plot

Violin Plot + Box Plot

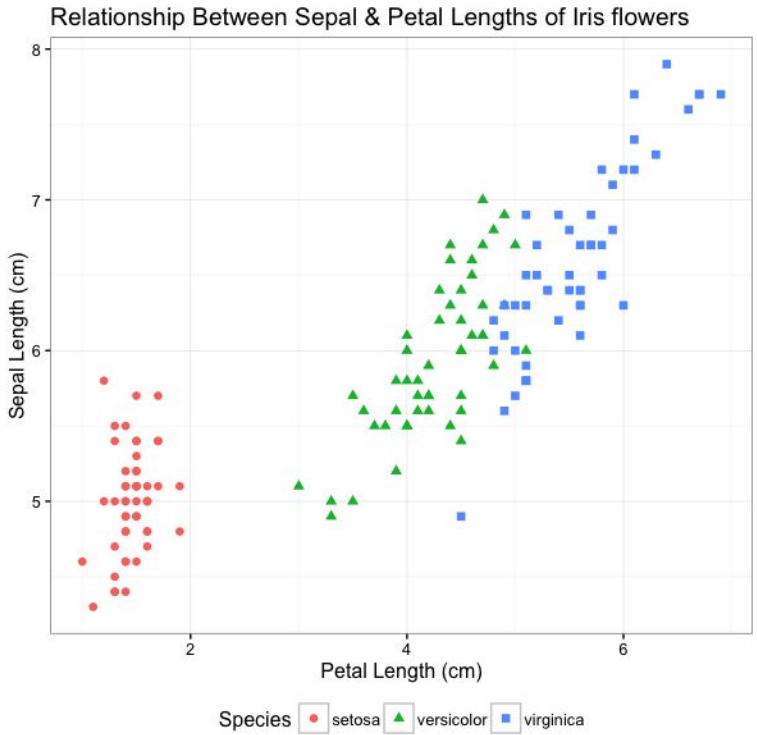


Iris data collected by Anderson, Edgar (1935). The irises of the Gaspe Peninsula, Bulletin of the American Iris Society, 59, 2–5.

Scatterplot with Trend Line (using Simple Linear Regression)

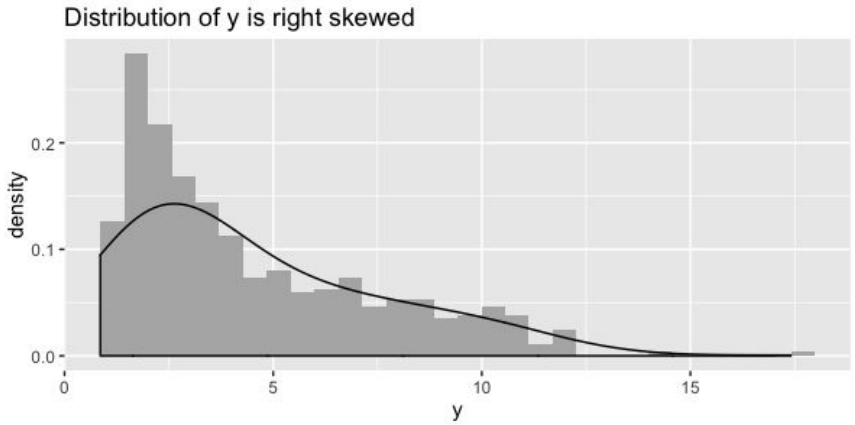


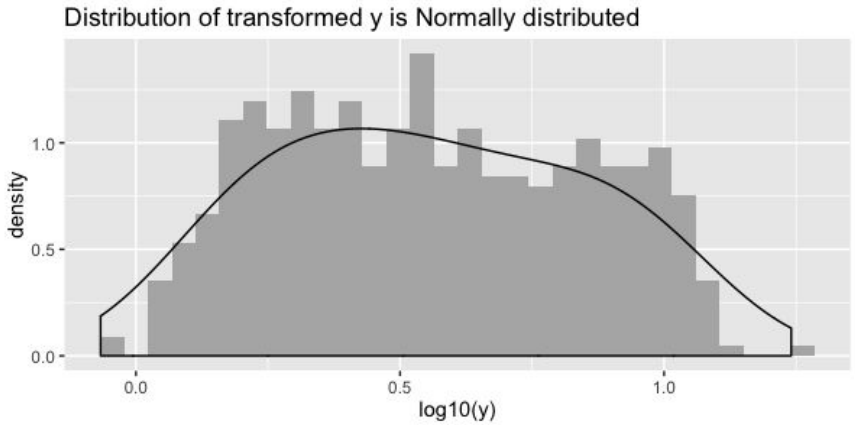
Scatterplot with Groups

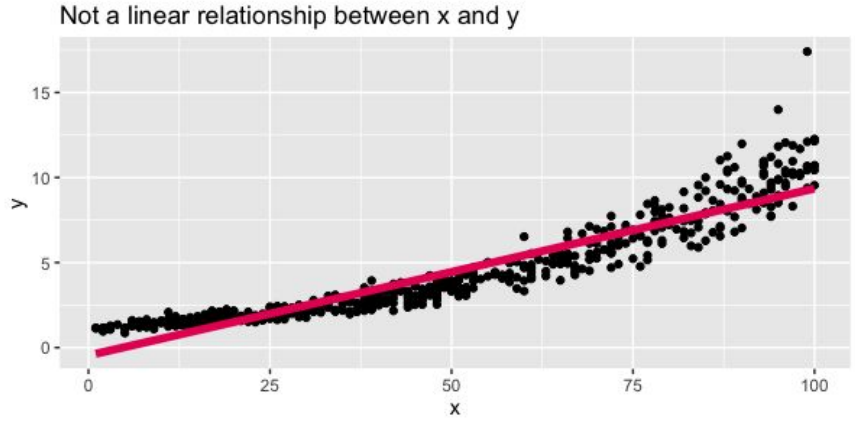


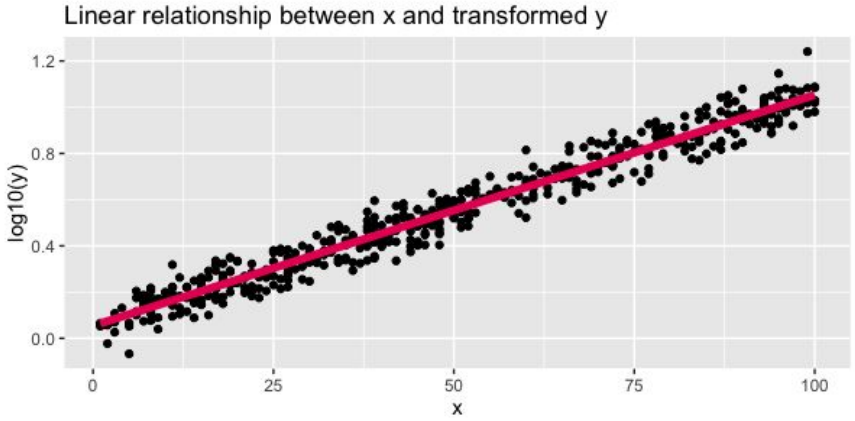
Iris data collected by Anderson, Edgar (1935). The irises of the Gaspe Peninsula, Bulletin of the American Iris Society, 59, 2–5.
Trees dataset: Ryan, T. A., Joiner, B. L. and Ryan, B. F. (1976) The Minitab Student Handbook. Duxbury Press.

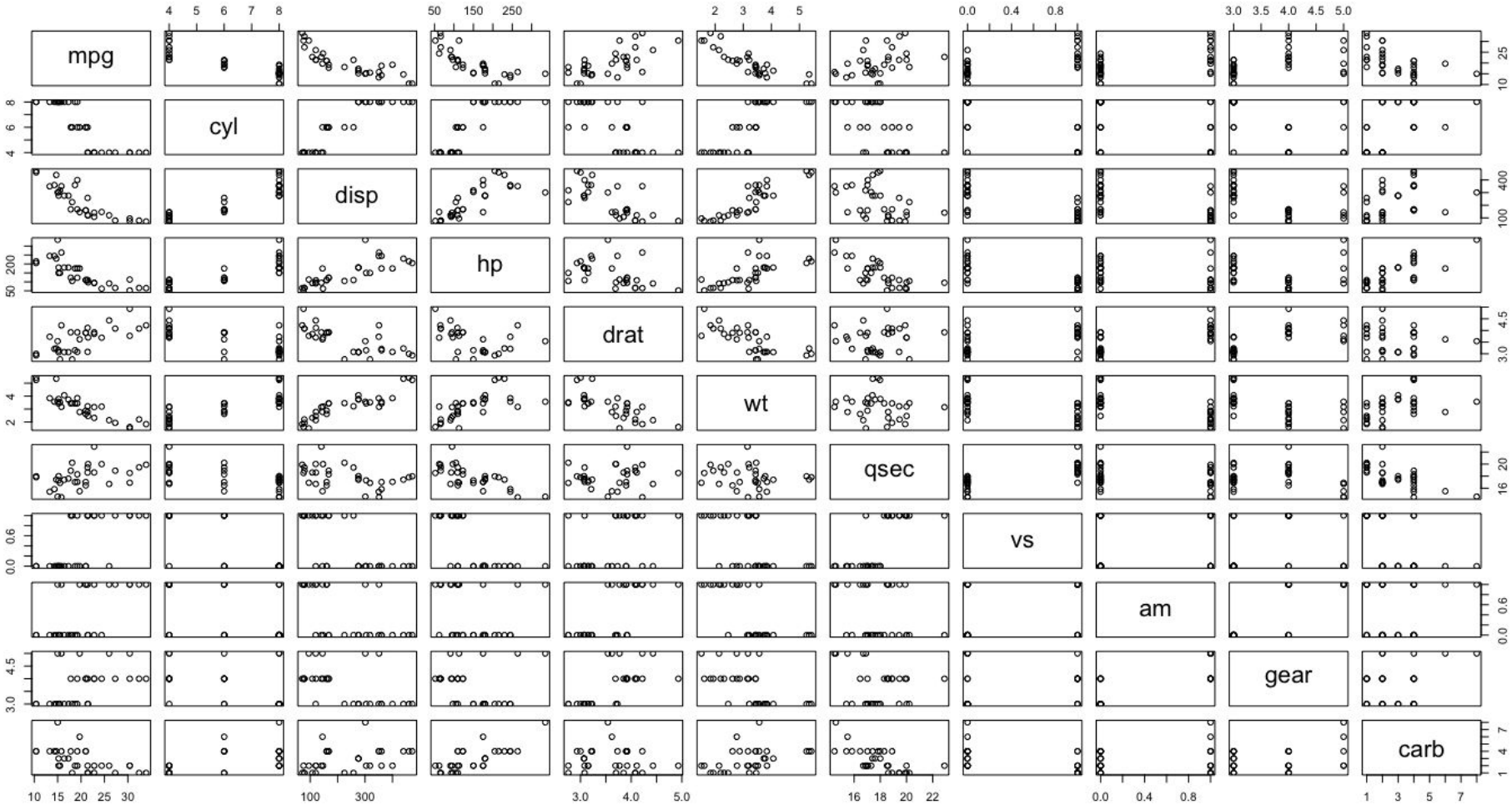
Histograms and **Scatterplots** sometimes employ variable transformations for skewed data & nonlinear relationships



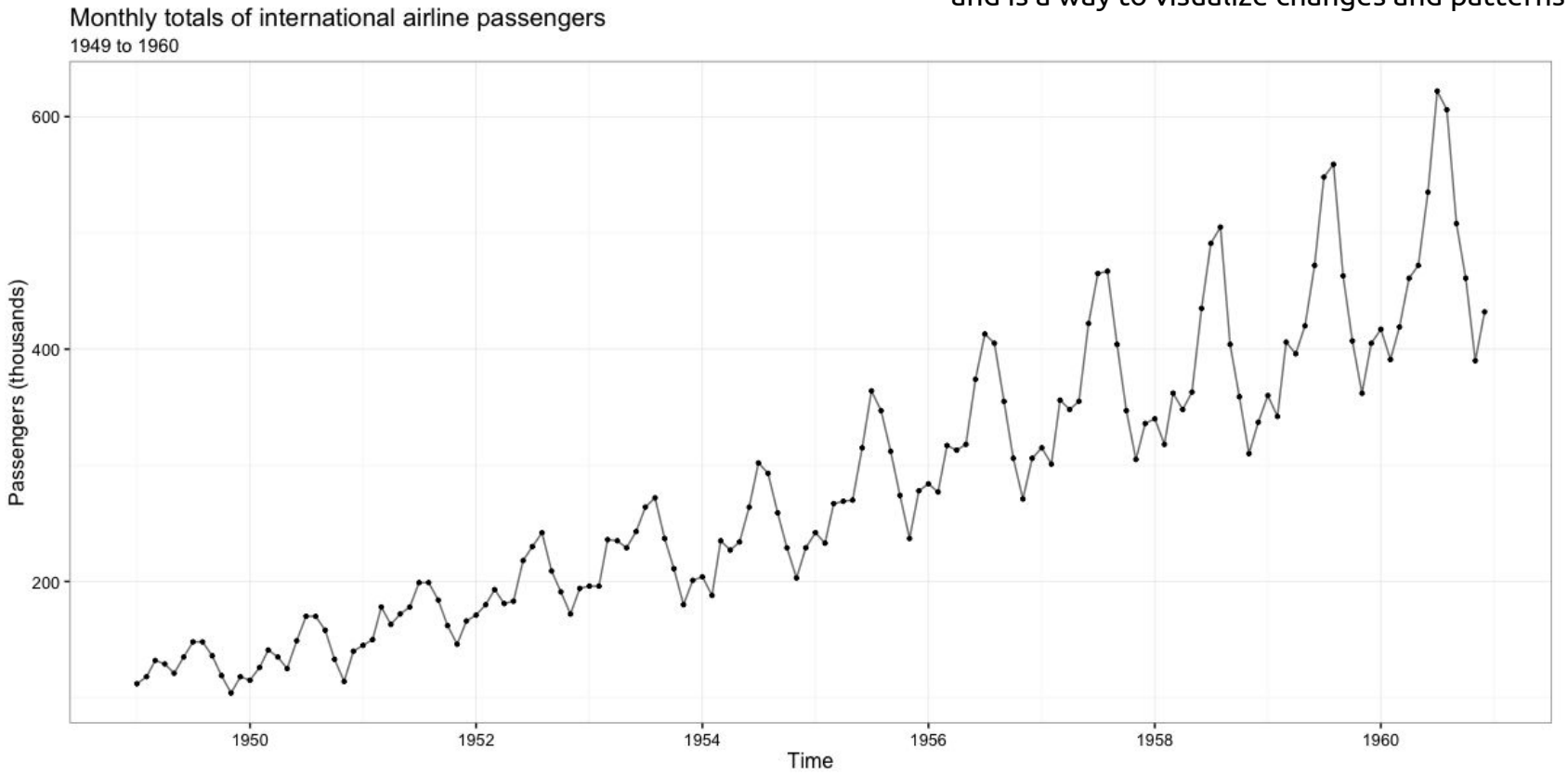






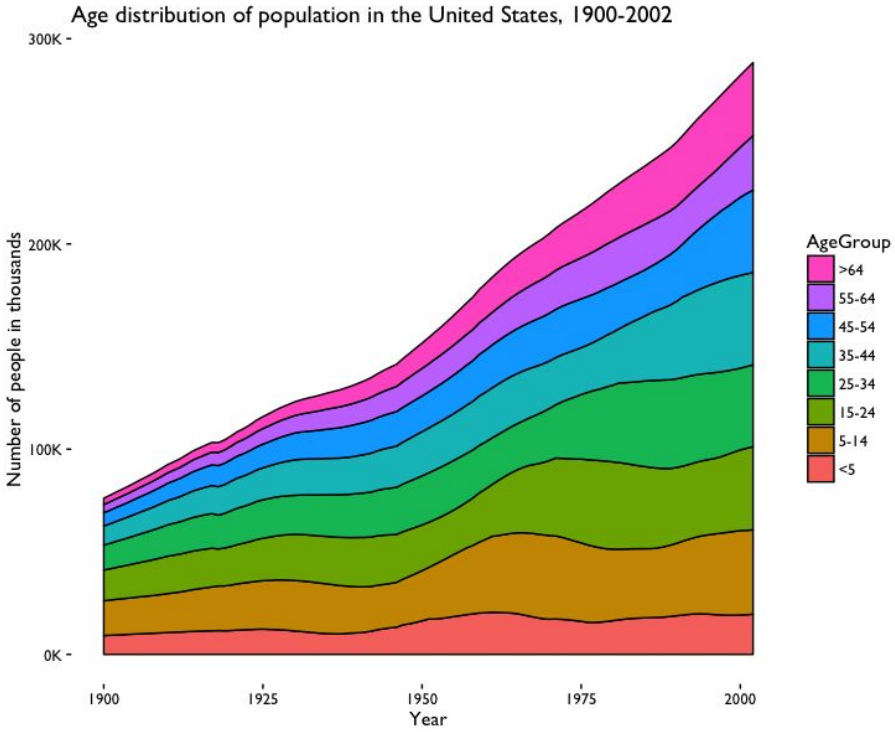

Scatterplot Matrix of 'Motor Trend' car road tests (1974)
mpg
cyl
disp
hp
drat
wt
qsec
vs
am
gear
carb

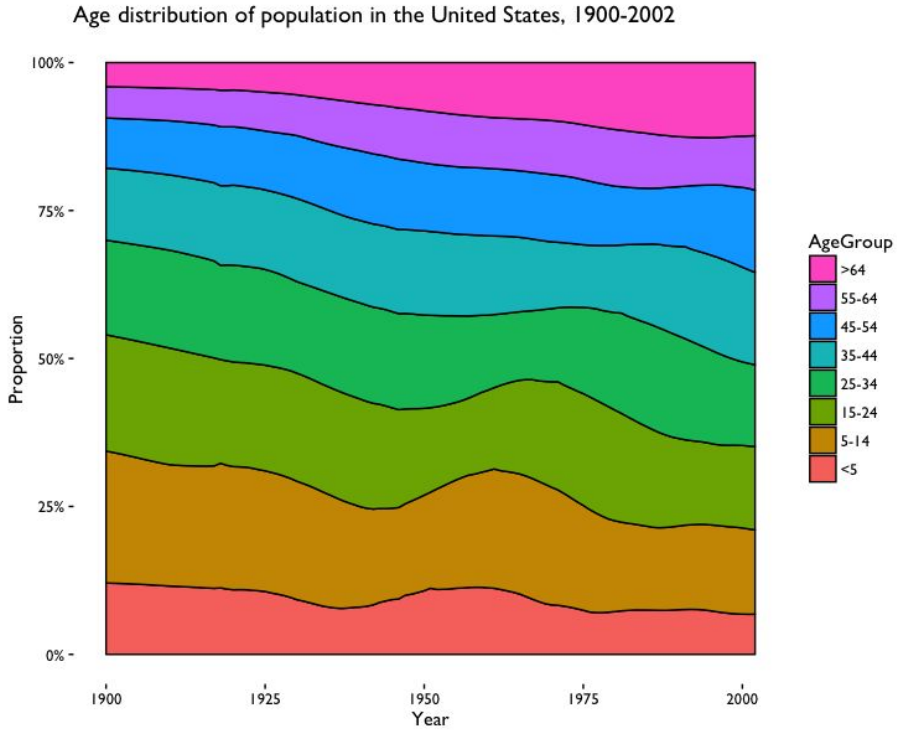
a **Time Series Plot** is a type of scatterplot with time on the x axis, and is a way to visualize changes and patterns over time



Box, G. E. P., Jenkins, G. M. and Reinsel, G. C. (1976) Time Series Analysis, Forecasting and Control. Third Edition. Holden-Day. Series G.

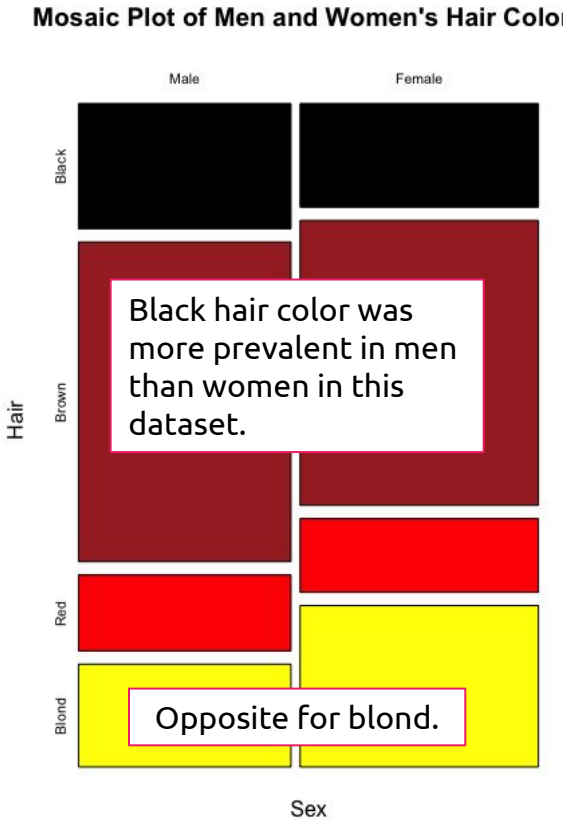
a **Stacked Area Plot** is a way to visualize multiple amounts/proportions changes over time

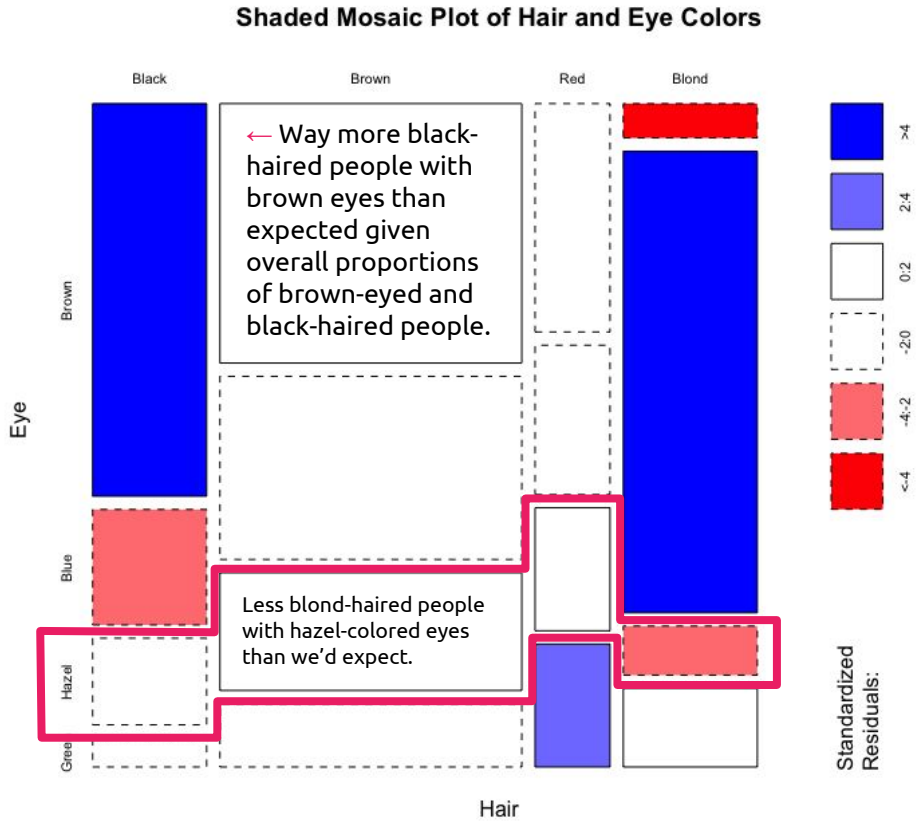




Source: U.S. Census Bureau, Statistical Abstract of the United States, 2003, HS-3

a **Mosaic Plot** is a way to visualize proportions in two or more categorical variables





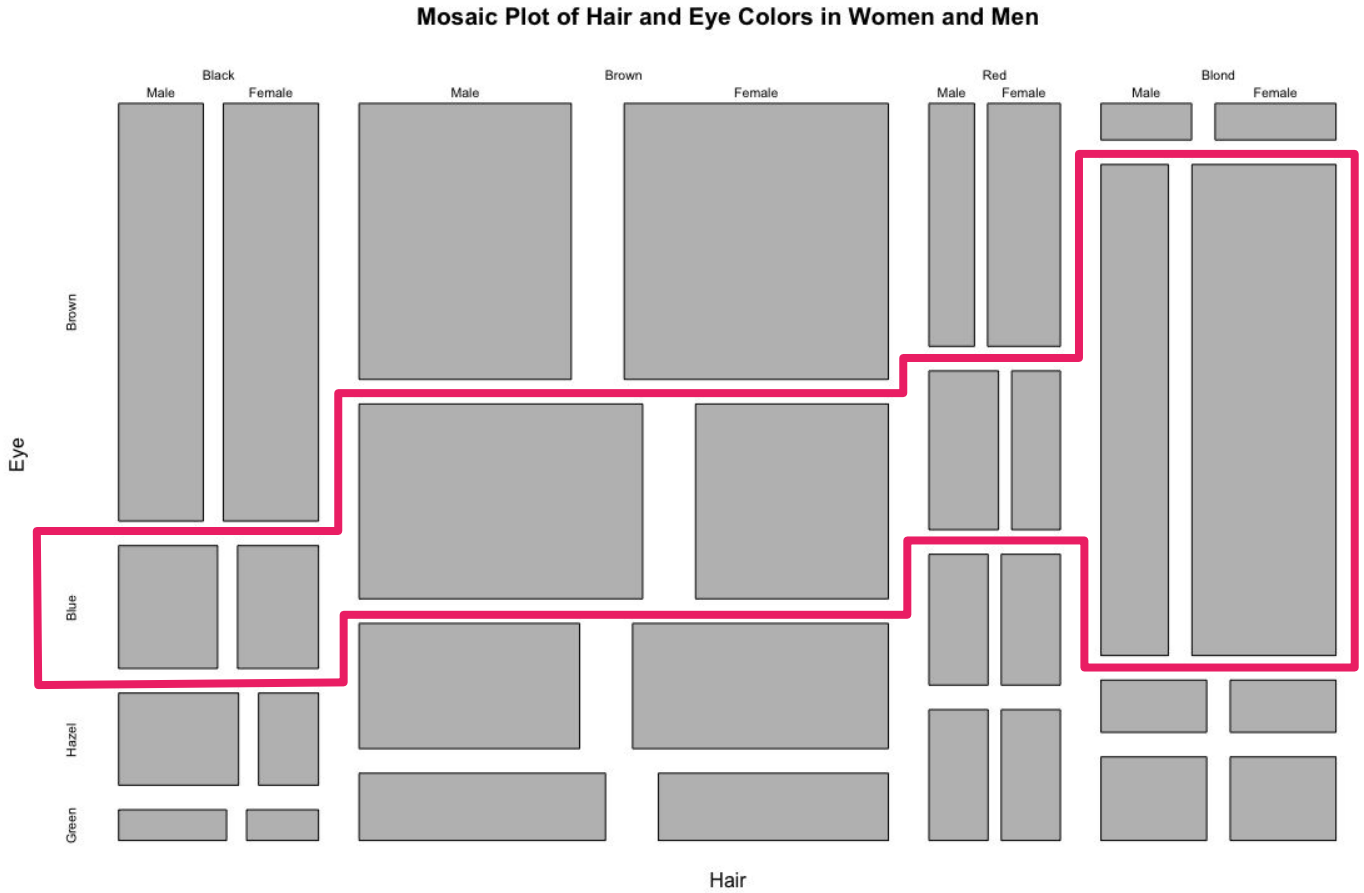
Hair & Eye Color Data by Snee, R. D. (1974) Graphical display of two-way contingency tables. *The American Statistician*, **28**, 9–12.

What this tells us…

Blond was the most prevalent hair color among those with blue eyes.

More brown-haired men had blue eyes than brown-haired women.

More blond-haired women had blue eyes than blonde-haired men.



Hair & Eye Color Data by Snee, R. D. (1974) Graphical display of two-way contingency tables. *The American Statistician*, **28**, 9–12.

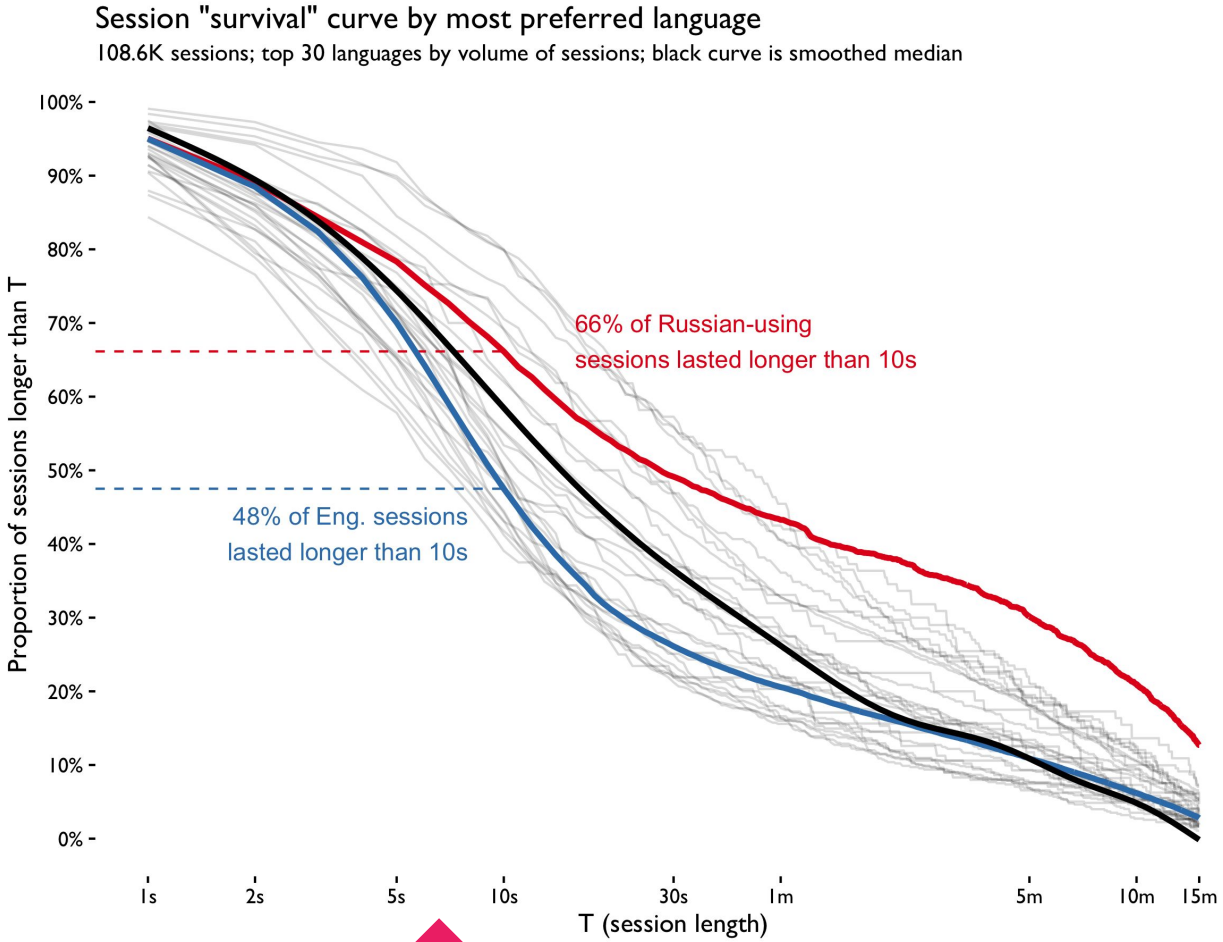
What this tells us…

On average, only half of the sessions last longer than about 10 seconds.

Users of different languages have different session lengths.

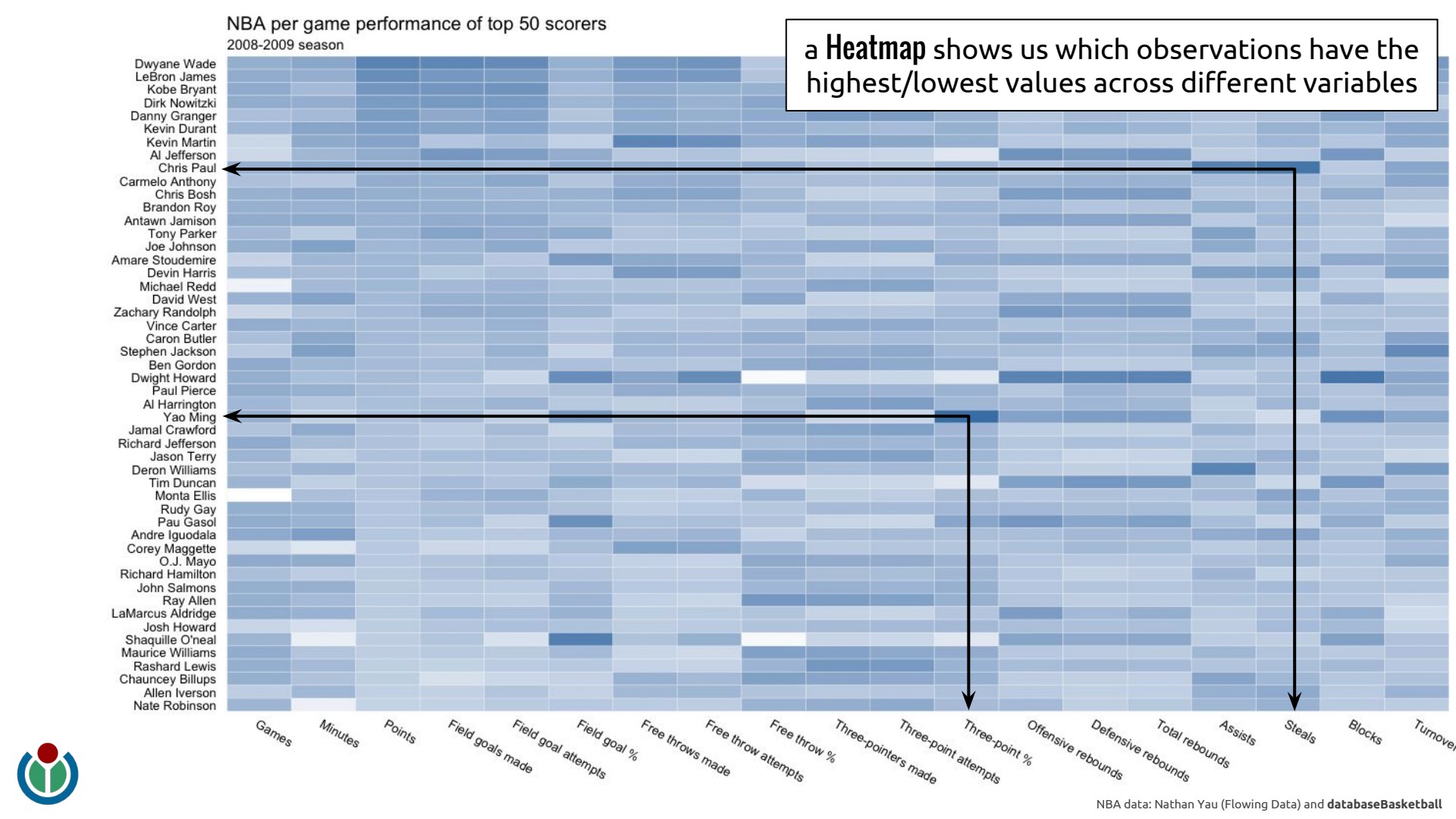
Russian-preferring users' sessions that are longer than English-preferring users' sessions.

Steeper means faster drop-out -- such as shorter time-to-clickthrough.

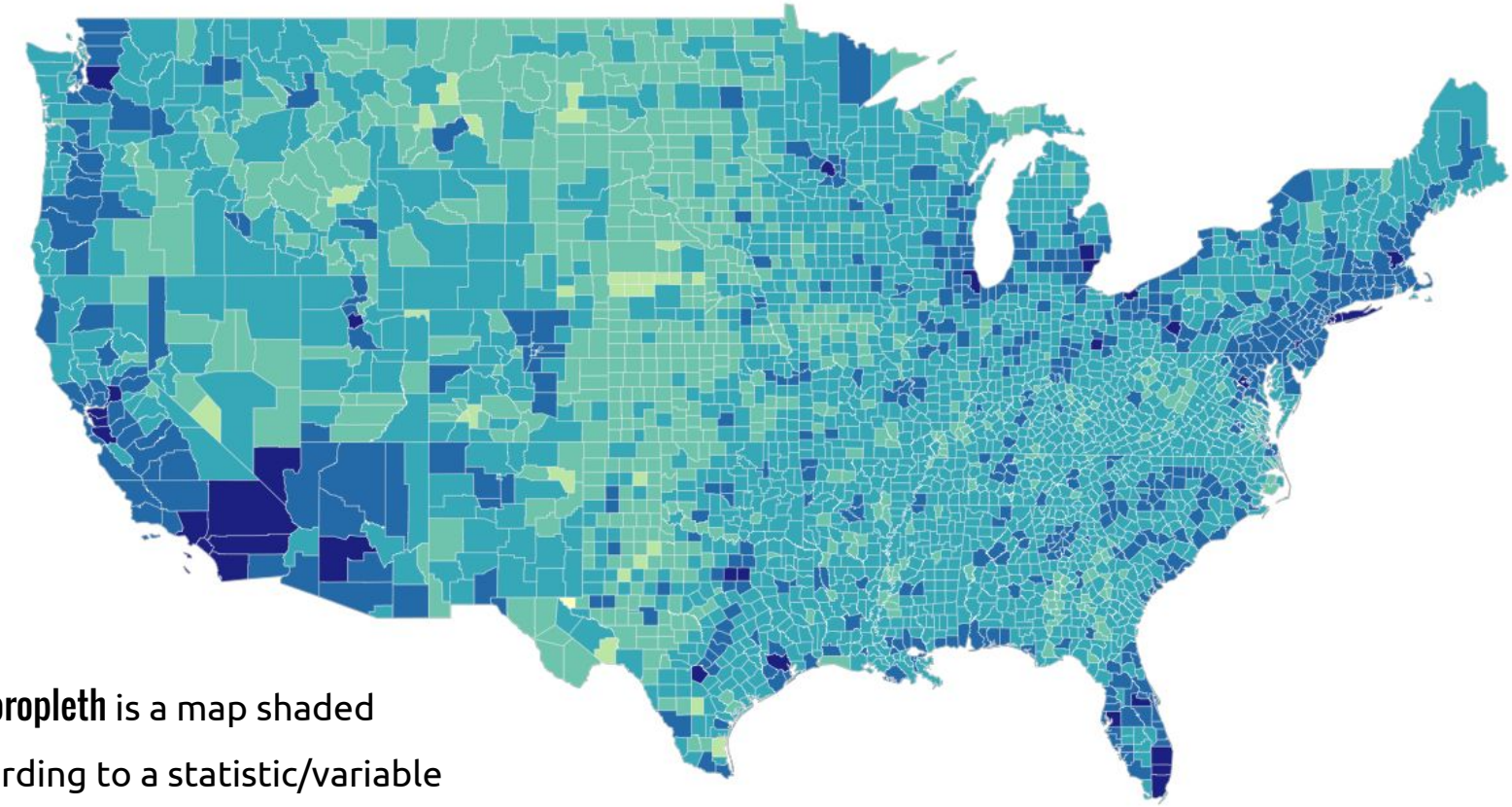


Caution! This is a log-transformed time axis.

Source: Wikipedia Portal Event Logging Data

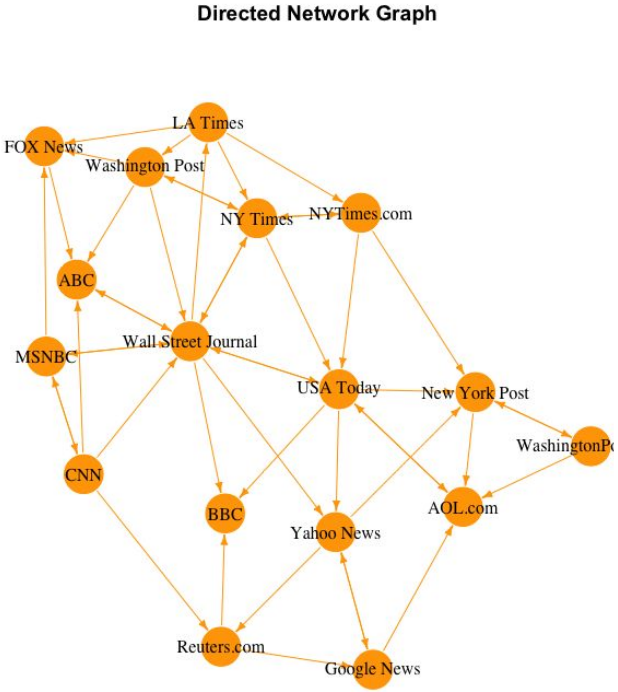


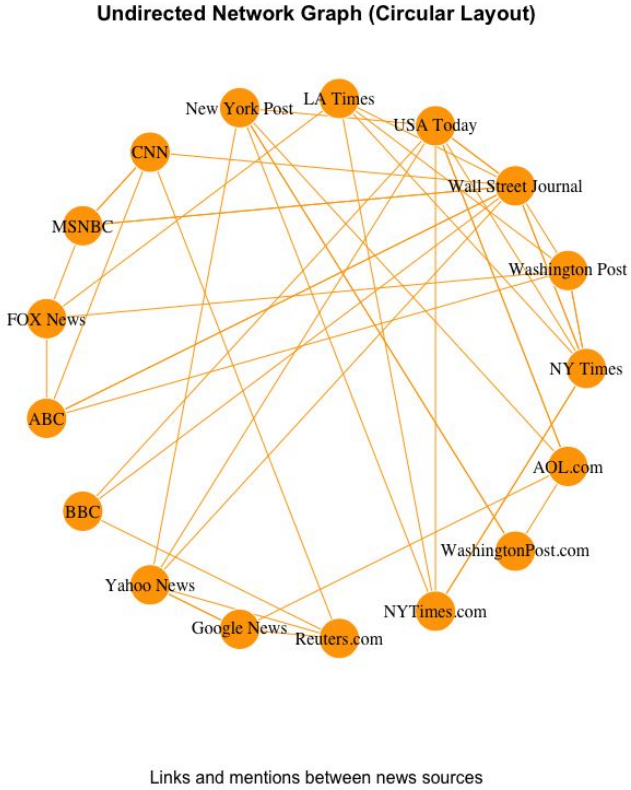
NBA data: Nathan Yau (Flowing Data) and **databaseBasketball**

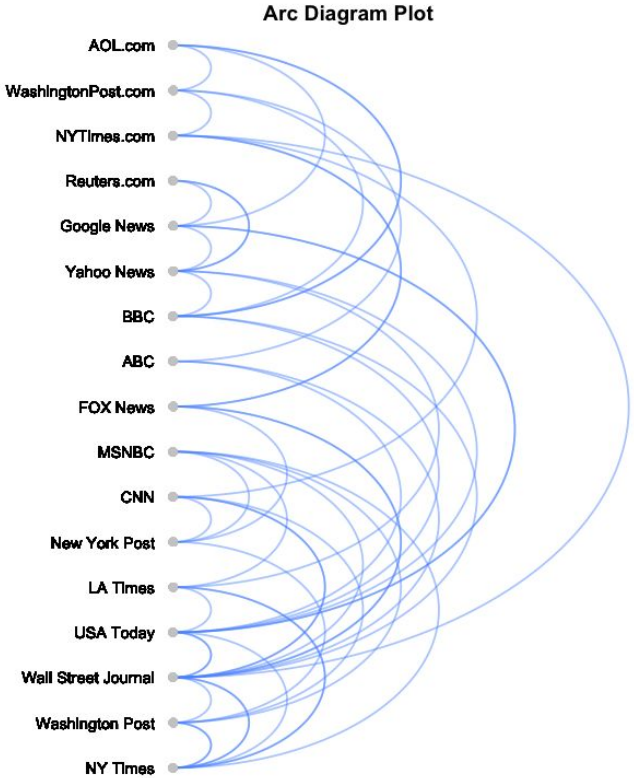


a **choropleth** is a map shaded

according to a statistic/variable







…and many more ways to visualize networks!

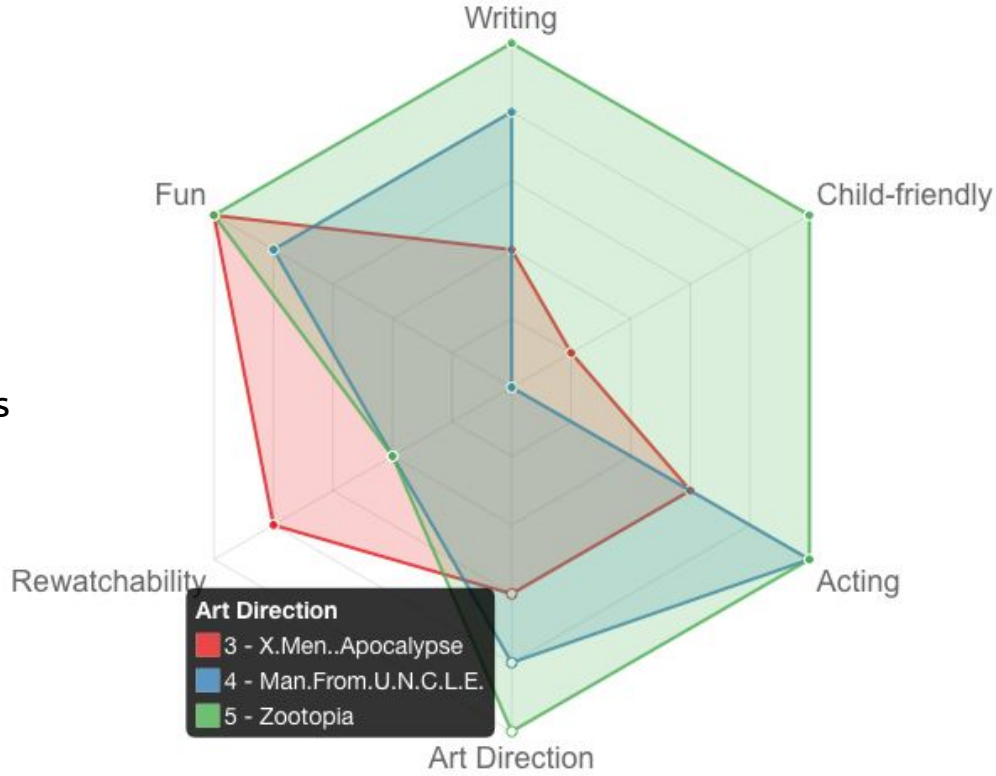
A **Radar Chart** (aka "**Spider Plot**") can be used to compare multivariate data.

They are especially useful when you have many variables/features but a few observations.

They can be used for a quick overview.

For example, you can see that I think *Zootopia* is outstanding across multiple metrics.

Here's my assessment of some movies I've seen recently:



Data: my mind

Questions?