Developing Data Products

SC4125

Module 4

Visualization

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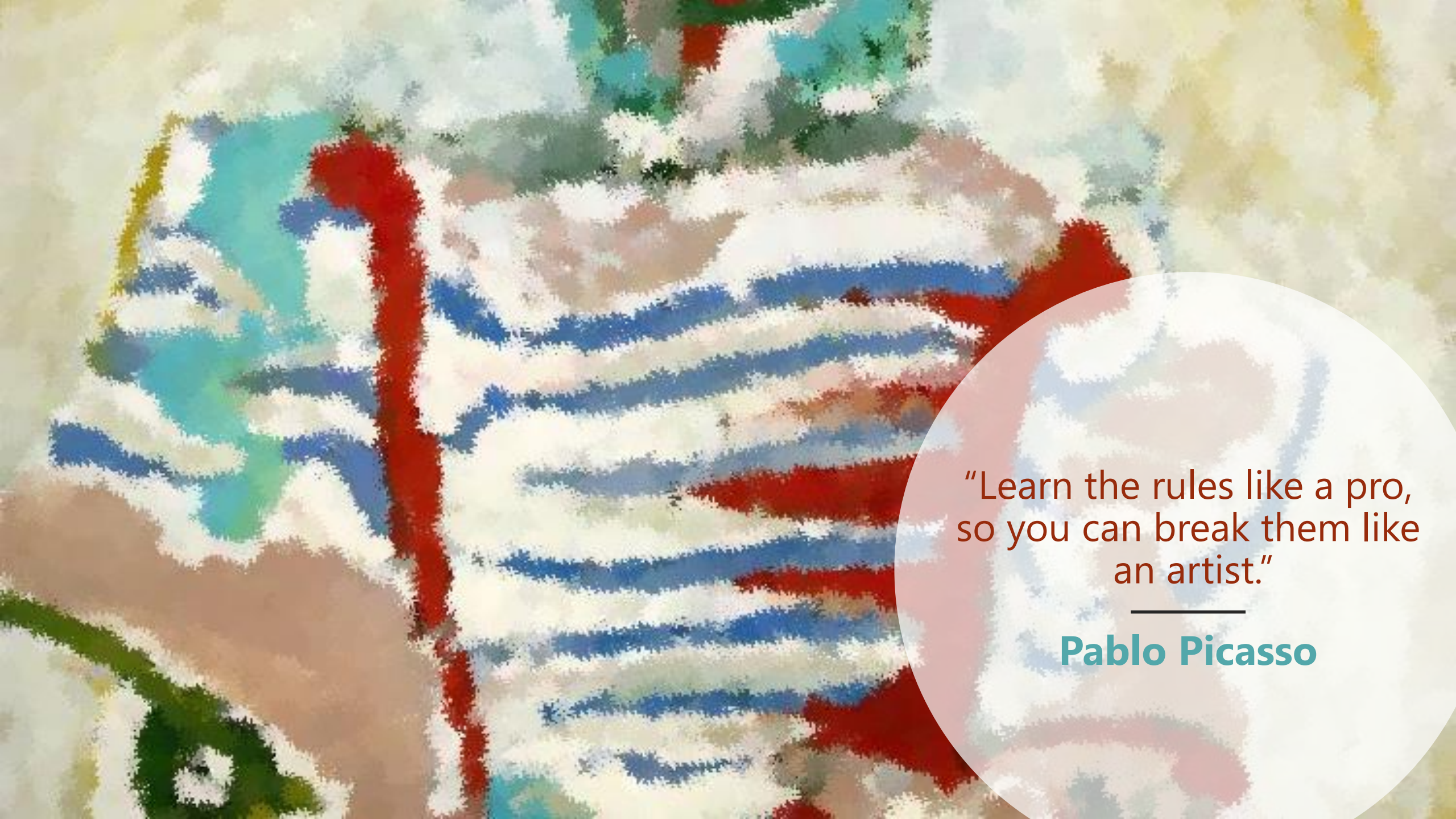
Contact: Anwitaman@ntu.edu.sg

Data Visualization

Various purposes of data visualization

- Exploration of the data while cleaning it and creating your analytics pipeline
- Communicate information and results
- Dashboards & UIs (potentially incorporating interactivity)


“Learn the rules like a pro, so you can break them like an artist.”
Pablo Picasso

Some prominent influencers

- Edward Tufte: Considered as a pioneer in the field of data visualization

  Reference book: The visual display of quantitative information

- Alberto Cairo: Popularized the idea that data visualization should be seen as “functional art” vs. fine art

  Reference book: The functional art

The sketch of E. Tufte was illustrated by Merchant for the Brunswick Review, Image source: https://washingtonmonthly.com/
The sketch of A. Cairo is created using MS Office’s artistic effect using image from: https://com.miami.edu/profile/alberto-cairo/

Conveying Information

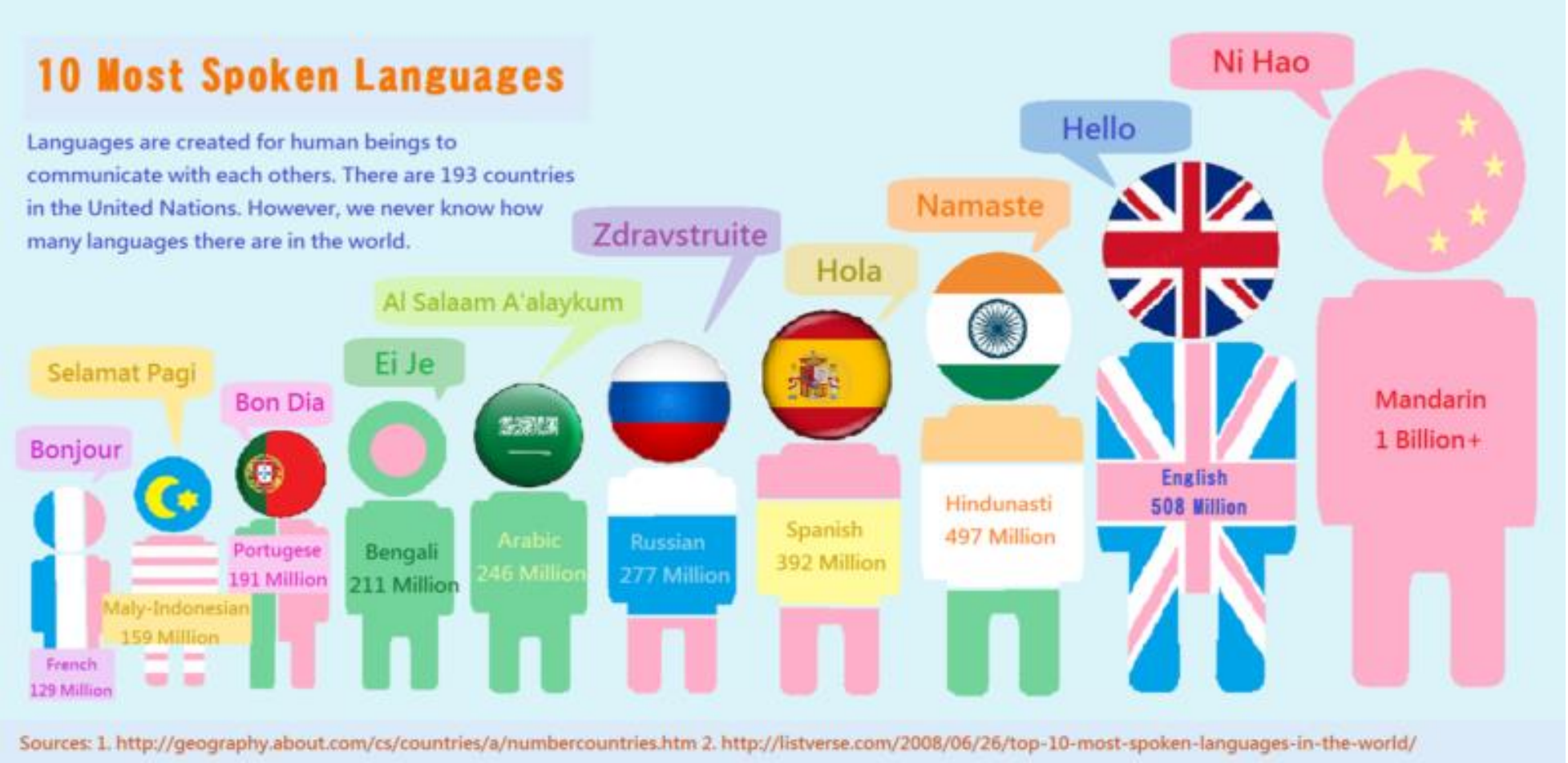


Image source: https://www.plato-edu.com/

Conveying Information

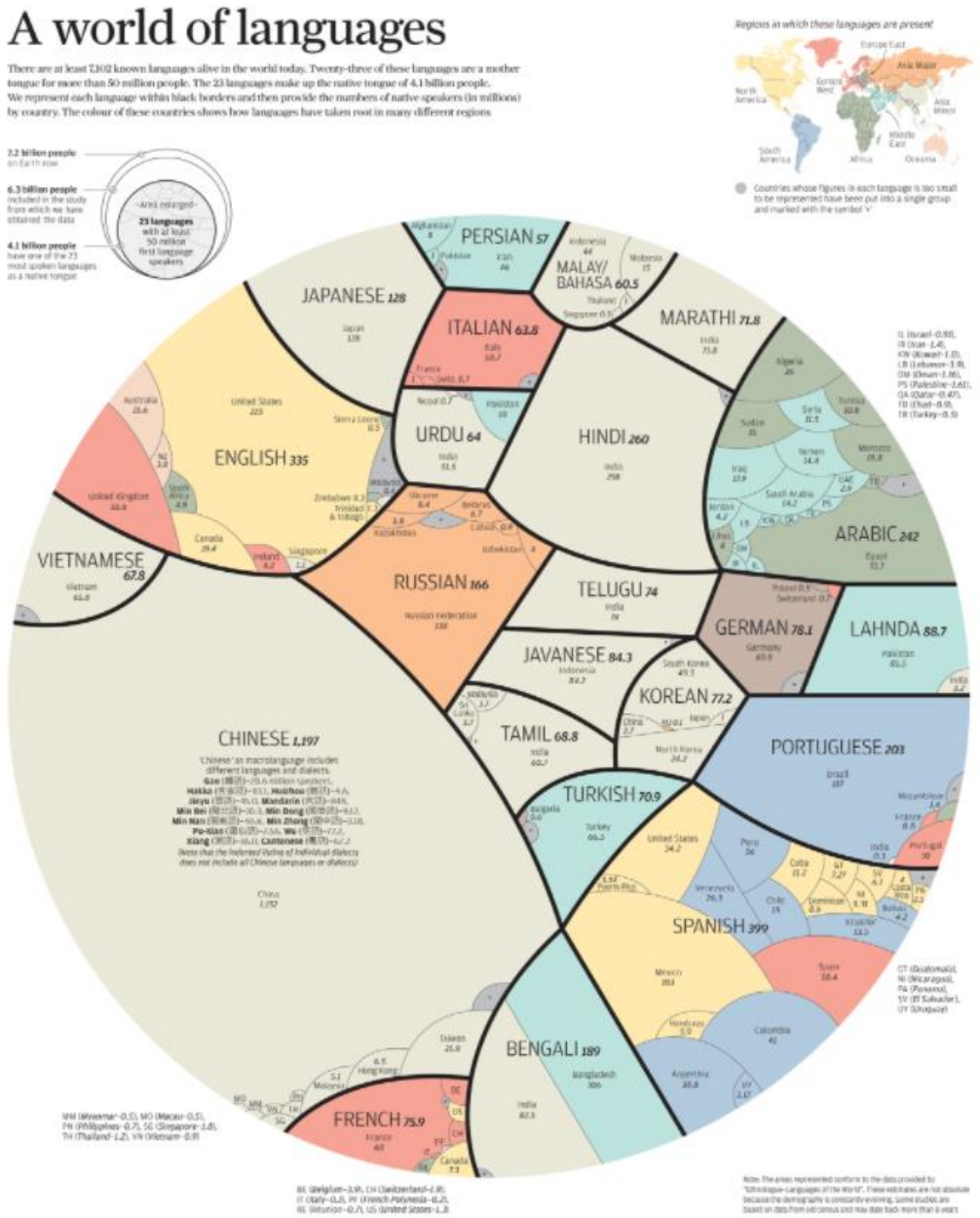


Image source: https://www.scmp.com/

Conveying Information

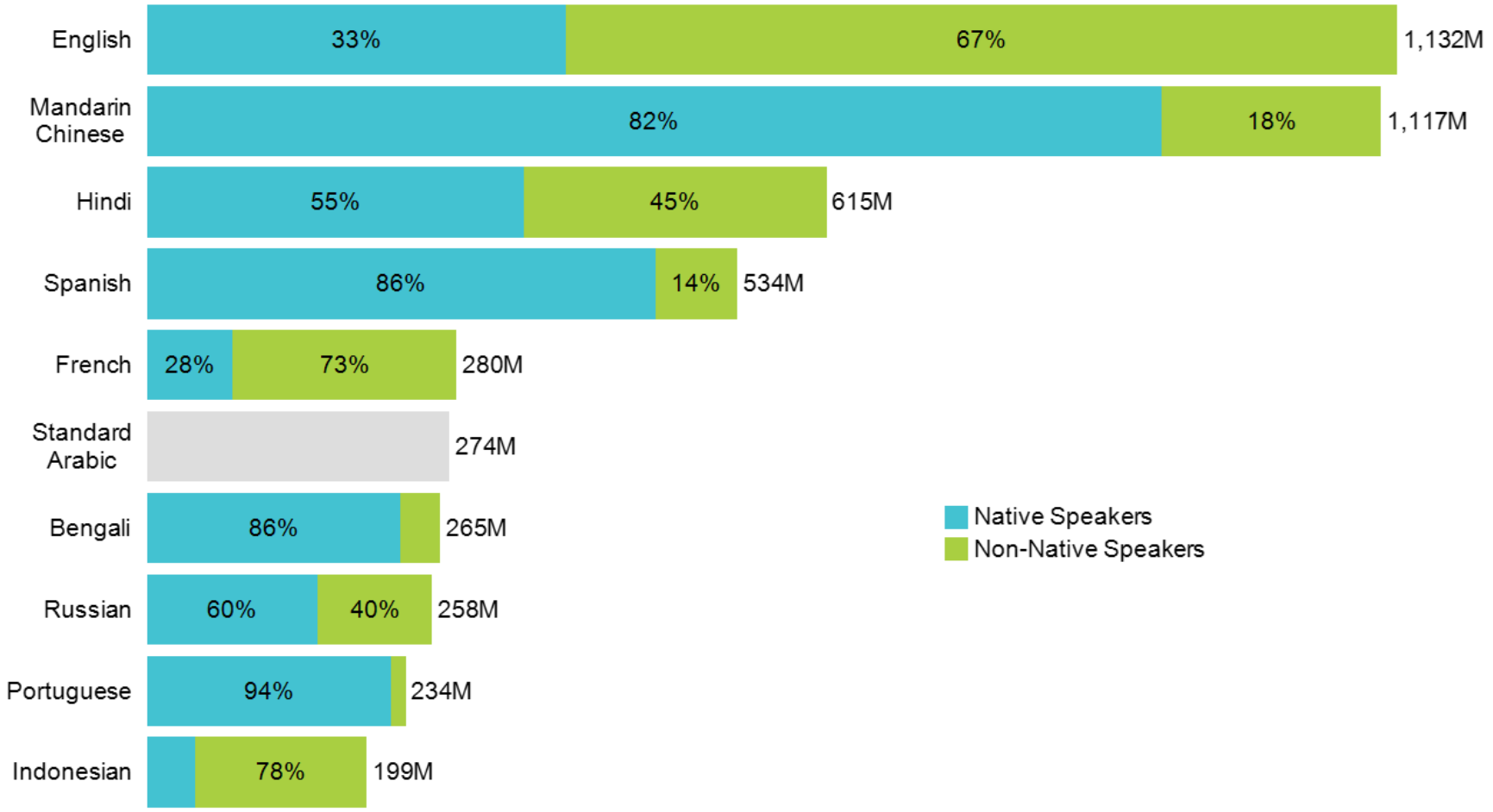


Image source: https://www.mekkographics.com/10-most-spoken-languages/

Conveying Information

Chartjunk

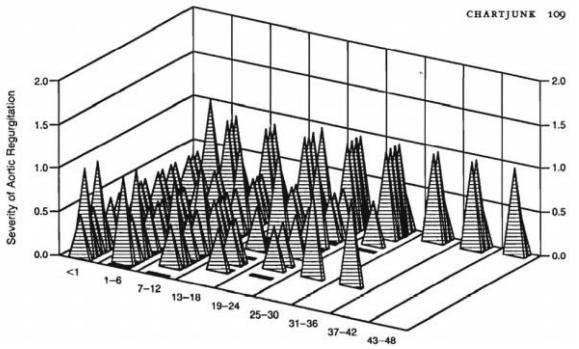
The interior decoration of graphics generates **a lot of ink** that does not tell the viewer anything new. The purpose of decoration varies—to make the graphic appear more scientific and precise, to enliven the display, to give the designer an opportunity to exercise artistic skills. Regardless of its cause, it is all non-data-ink or redundant data-ink, and it is often chartjunk. **– Edward Tufte**, The visual display of quantitative information

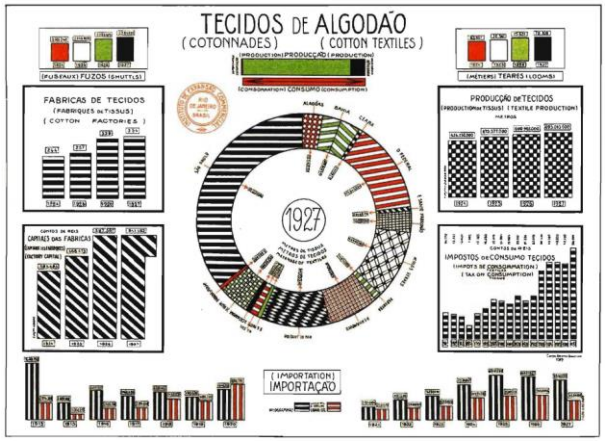
A plot with higher data-ink ratio

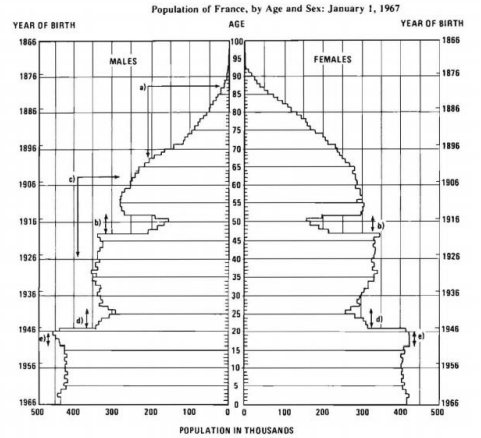
Chartjunk examples

Vibrations (e.g., Moiré effect), Grids, Ducks

Graphics do not become attractive and interesting through the addition of ornamental hatching and false perspective to a few bars. Chartjunk can turn bores into disasters, but it can never rescue a thin data set.







Source: The visual display of quantitative information by Edward Tufte

Conveying Information

Chartjunk

- may sometimes work well if **done right?**

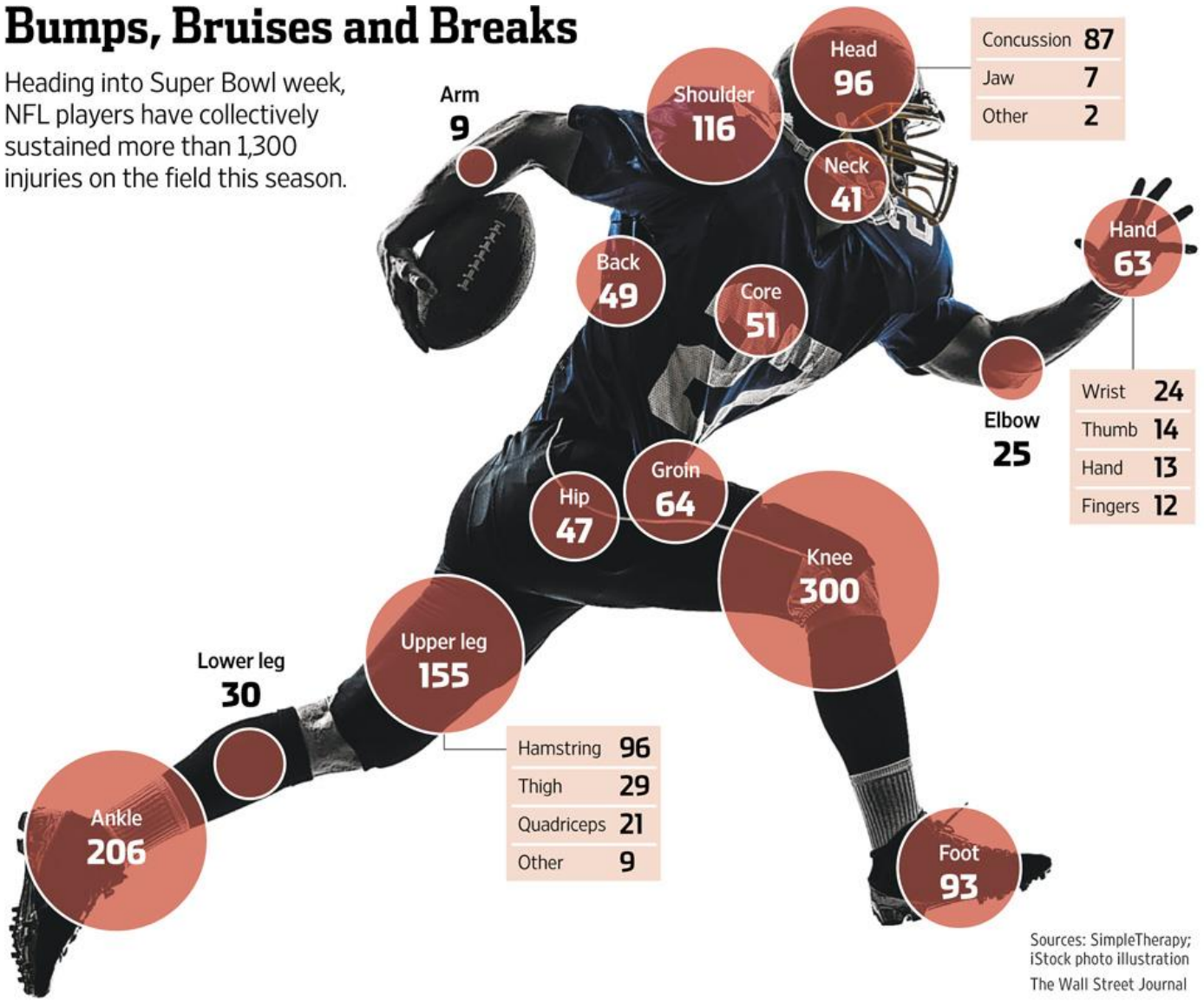


Image source: https://www.wsj.com/articles/SB10001424052702303277704579344753369526502

Displaying Information

Chartjunk

- may sometimes be useful if **done right?**

The uncanny valley is a well-known hypothesis in the field of robotics that correlates our comfort level with the human-likeness of a robot. Here, the point was to **convey is the idea itself, rather than any precise data**.

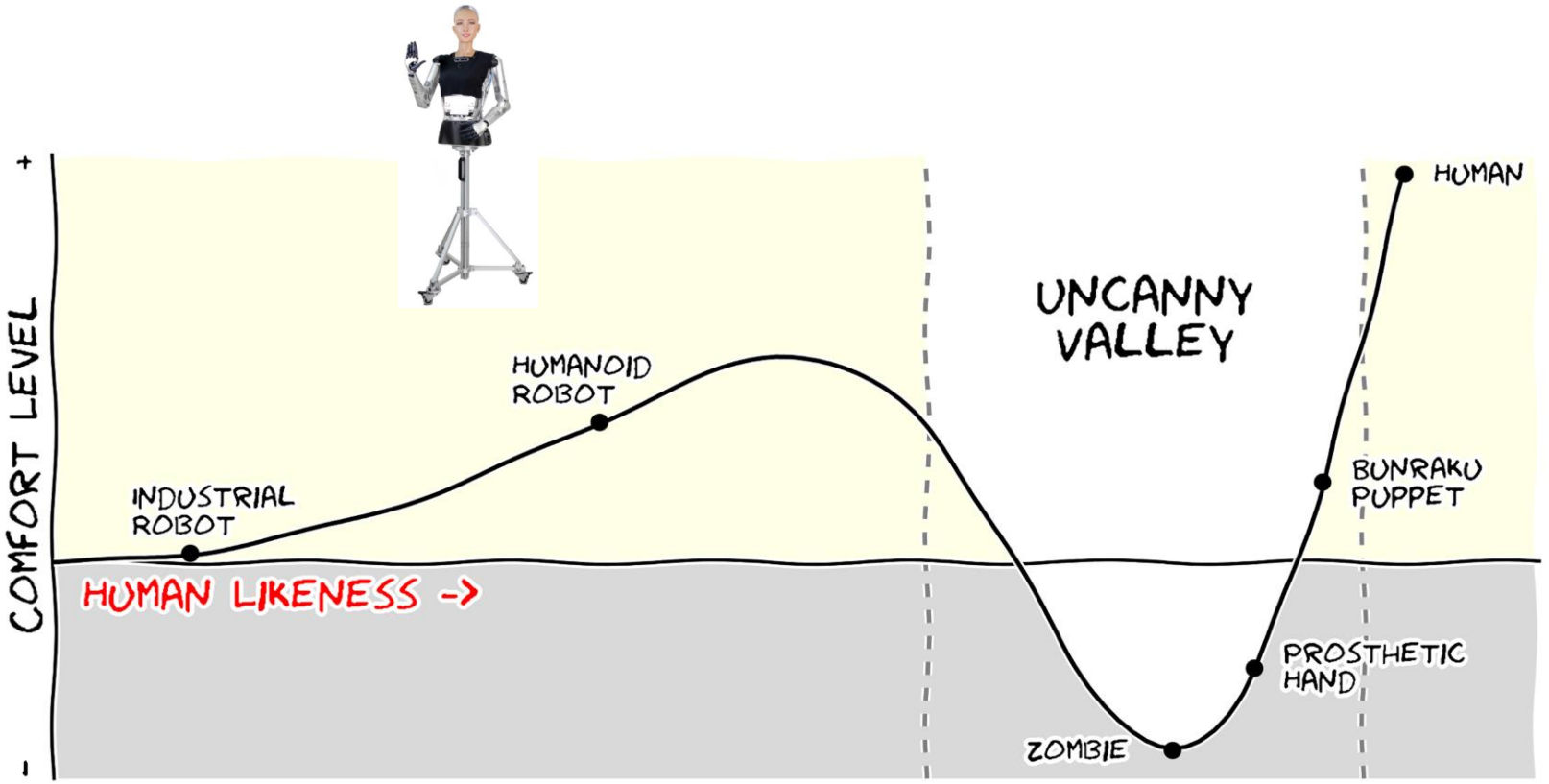


Image sources:
https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1003833
https://www.robotshop.com/de/en/hanson-robotics-sophia-2020-rd-version.html

Conveying Information

Chartjunk

- may sometimes work well if **done right?**
- may work in **non-scientific**, e.g. mass-media, settings?

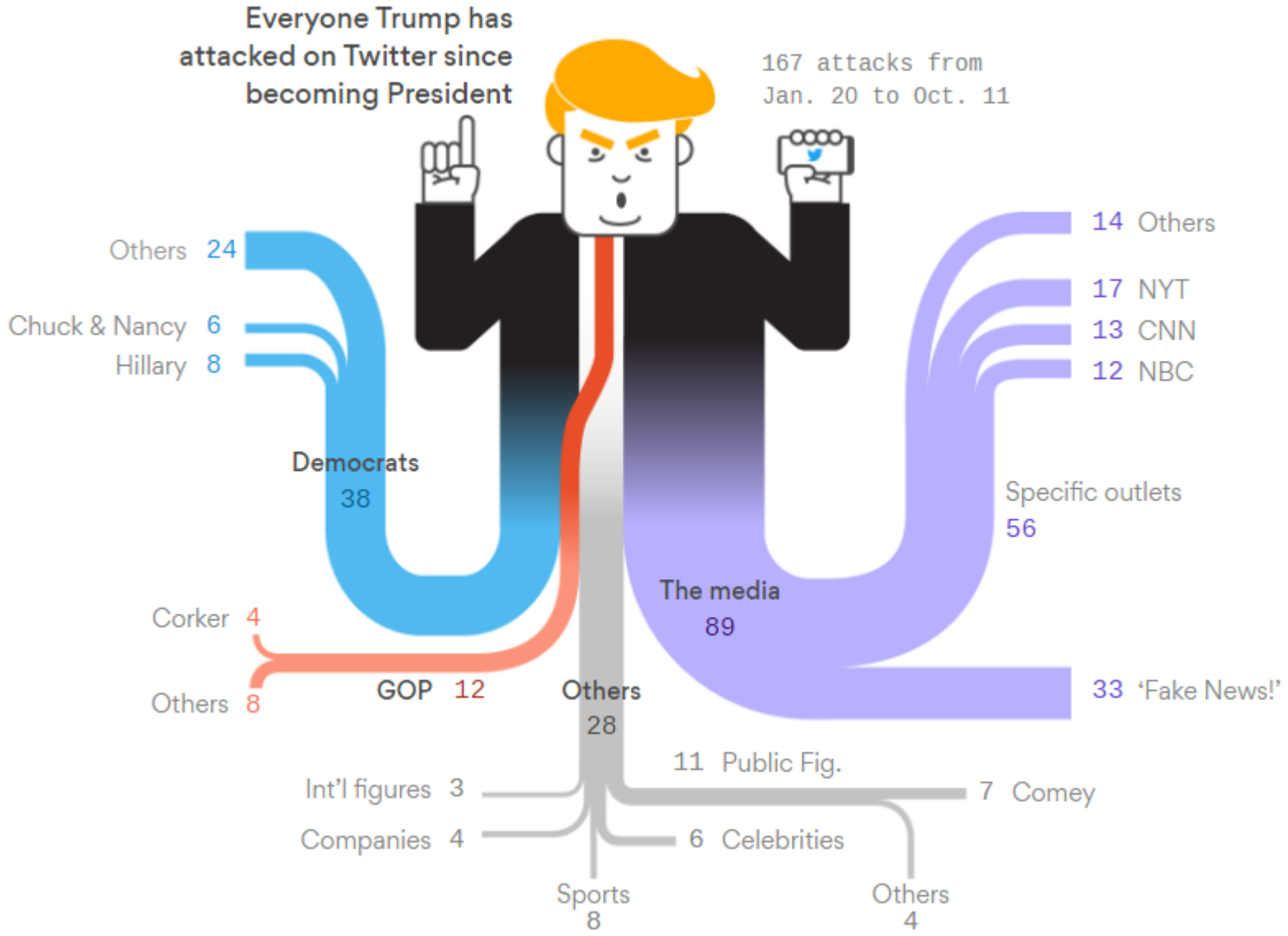


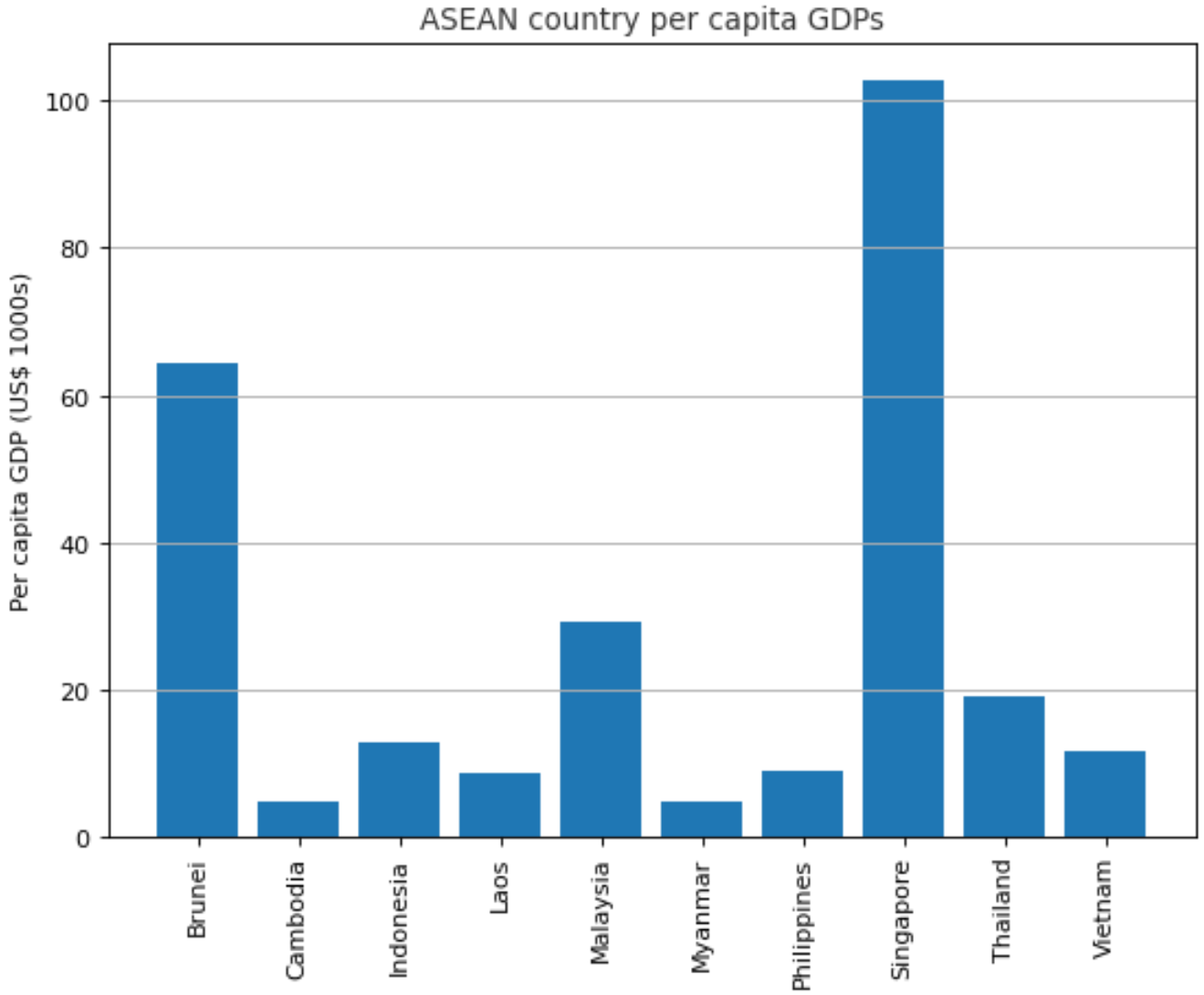
Image source: https://www.axios.com/who-trump-attacks-the-most-on-twitter-1513305449-f084c32e-fcdf-43a3-8c55-2da84d45db34.html

Example: A bar plot

Data-ink

- Edward Tufte's maxim:

1. **Above all else show the data.**
2. Maximize the data-ink ratio
3. Erase non-data-ink.
4. Erase redundant data-ink.
5. Revise and edit.



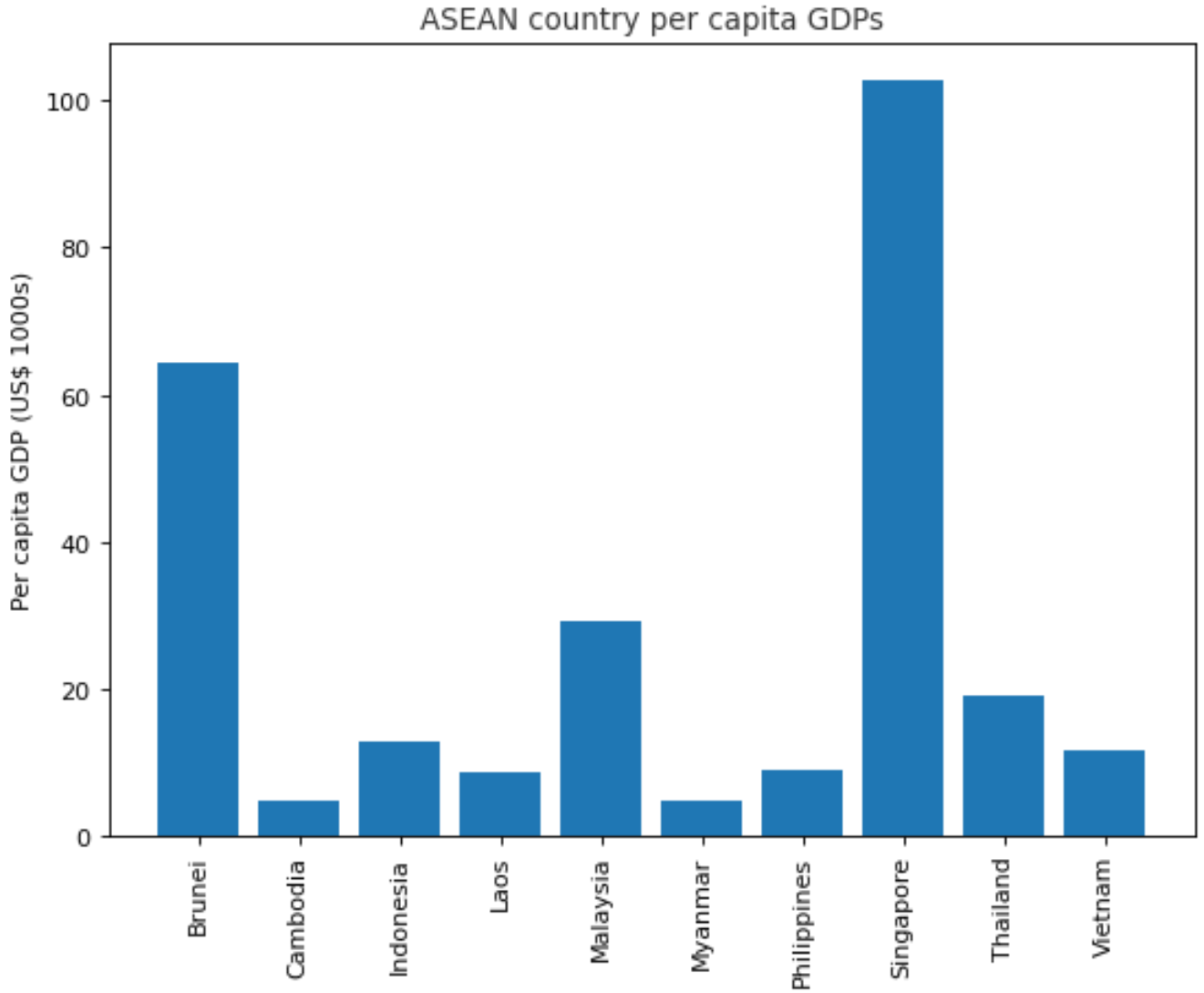
Data source: https://en.wikipedia.org/wiki/List_of_ASEAN_countries_by_GDP (accessed/as on 27 August 2021)

Step by step …

- Edward Tufte's maxim:

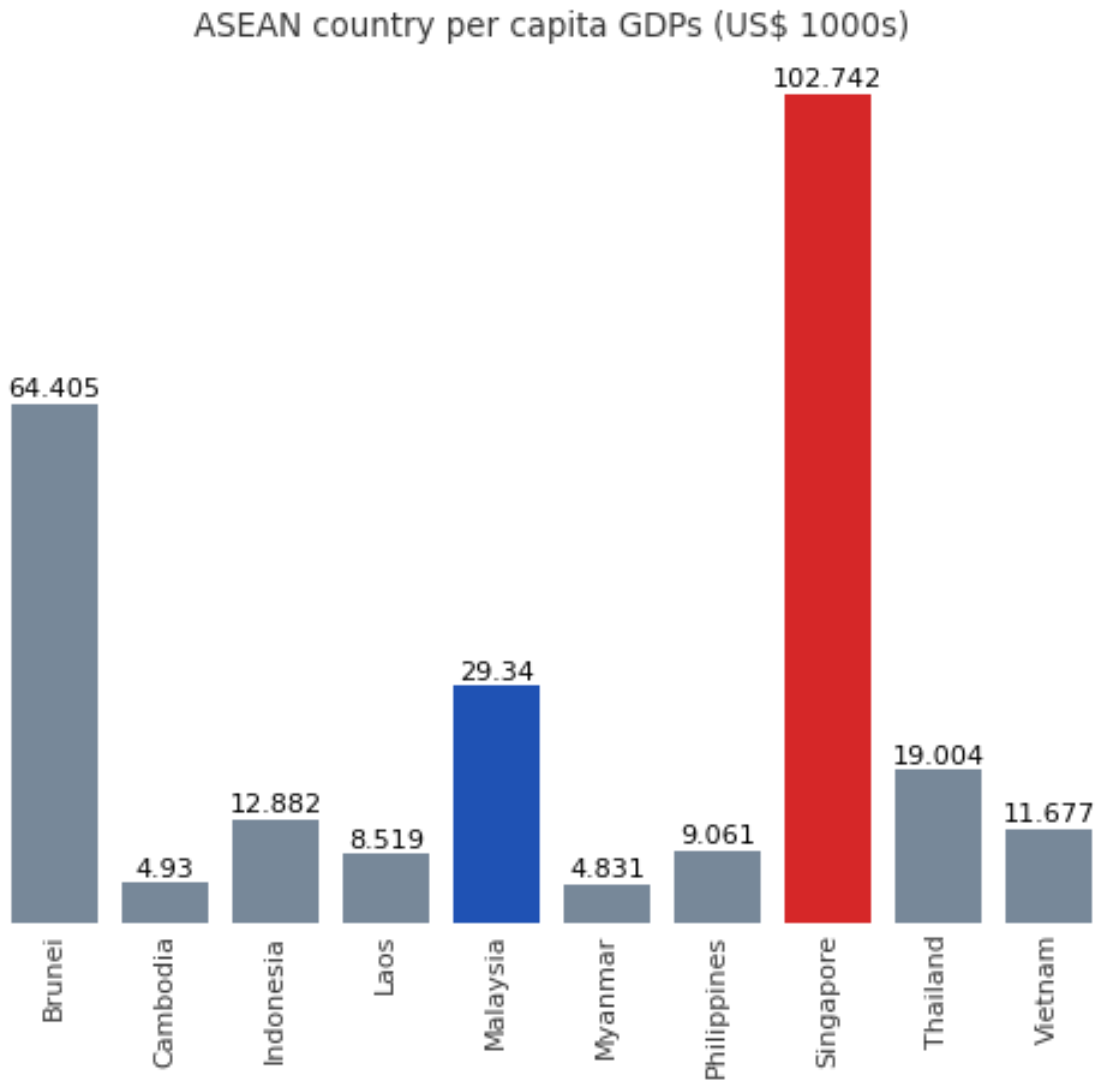
1. Above all else show the data.
2. Maximize the data-ink ratio
3. Erase non-data-ink.
4. Erase redundant data-ink.
5. Revise and edit.

Let's start by removing the grid lines

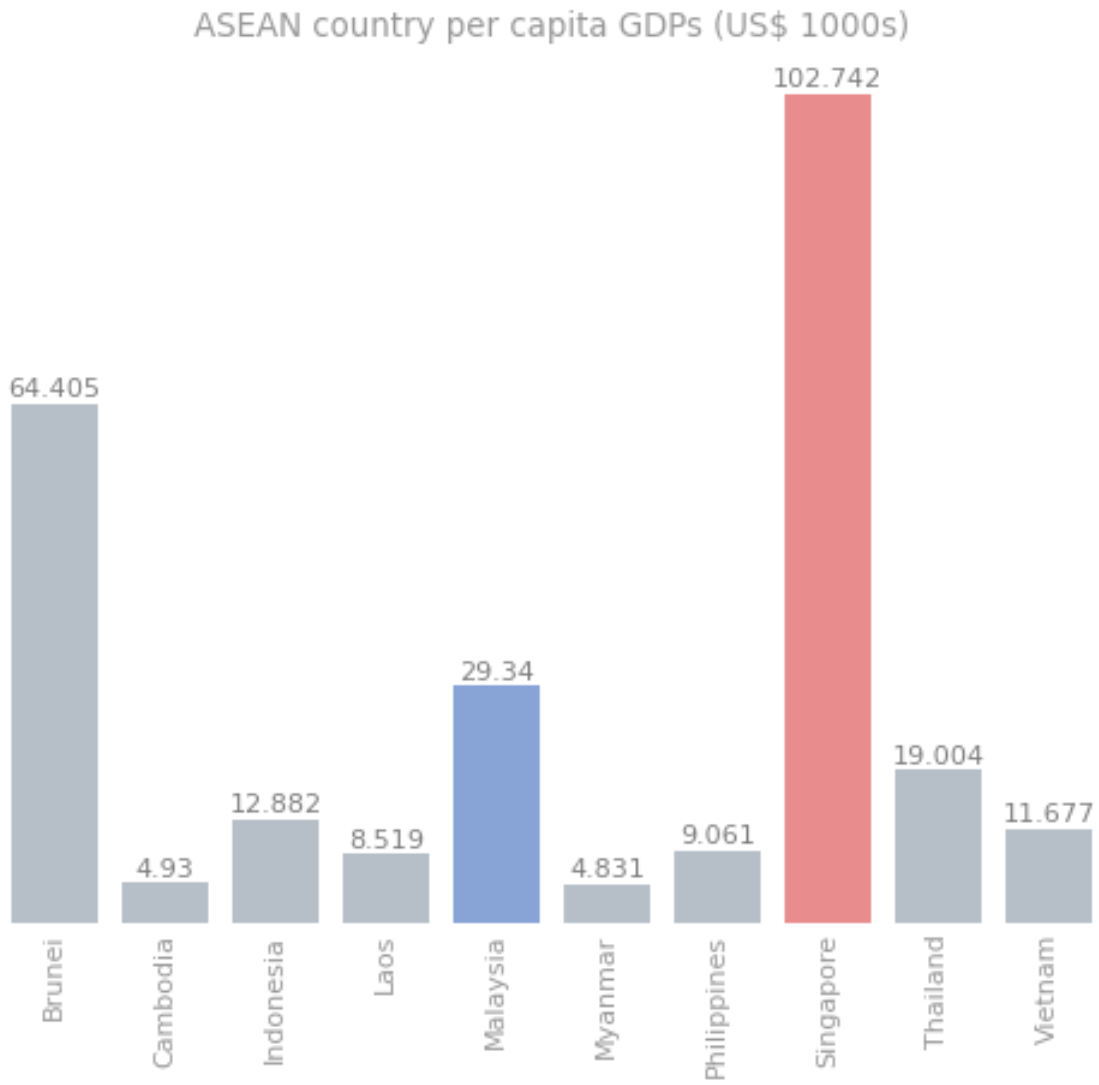


A plot with higher data-ink ratio

- With emphasis on some data records



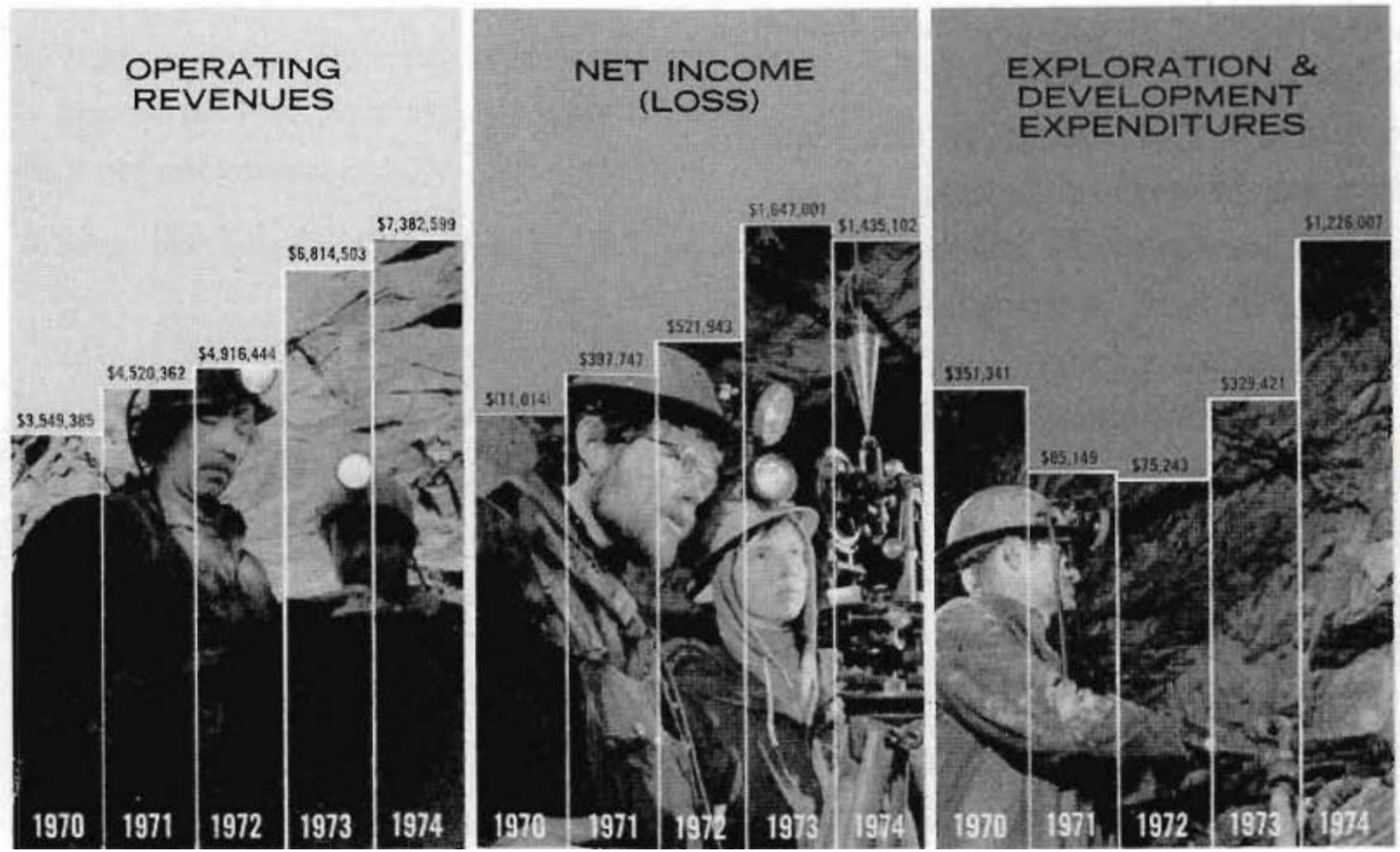
A plot with higher data-ink ratio



Ungraded task 4.1: Create a similar plot using your favourite tools (using same, or similar data).
If you have ideas to further improve data-ink ratio, share the ideas and your final results too!

Ungraded task 4.2: Identify some other plots (which is not a bar plot) from a public source, which do not have a good data-ink ratio in your judgement. Consider how you may improve them, and share your improved results along with the 'original' you improved upon.

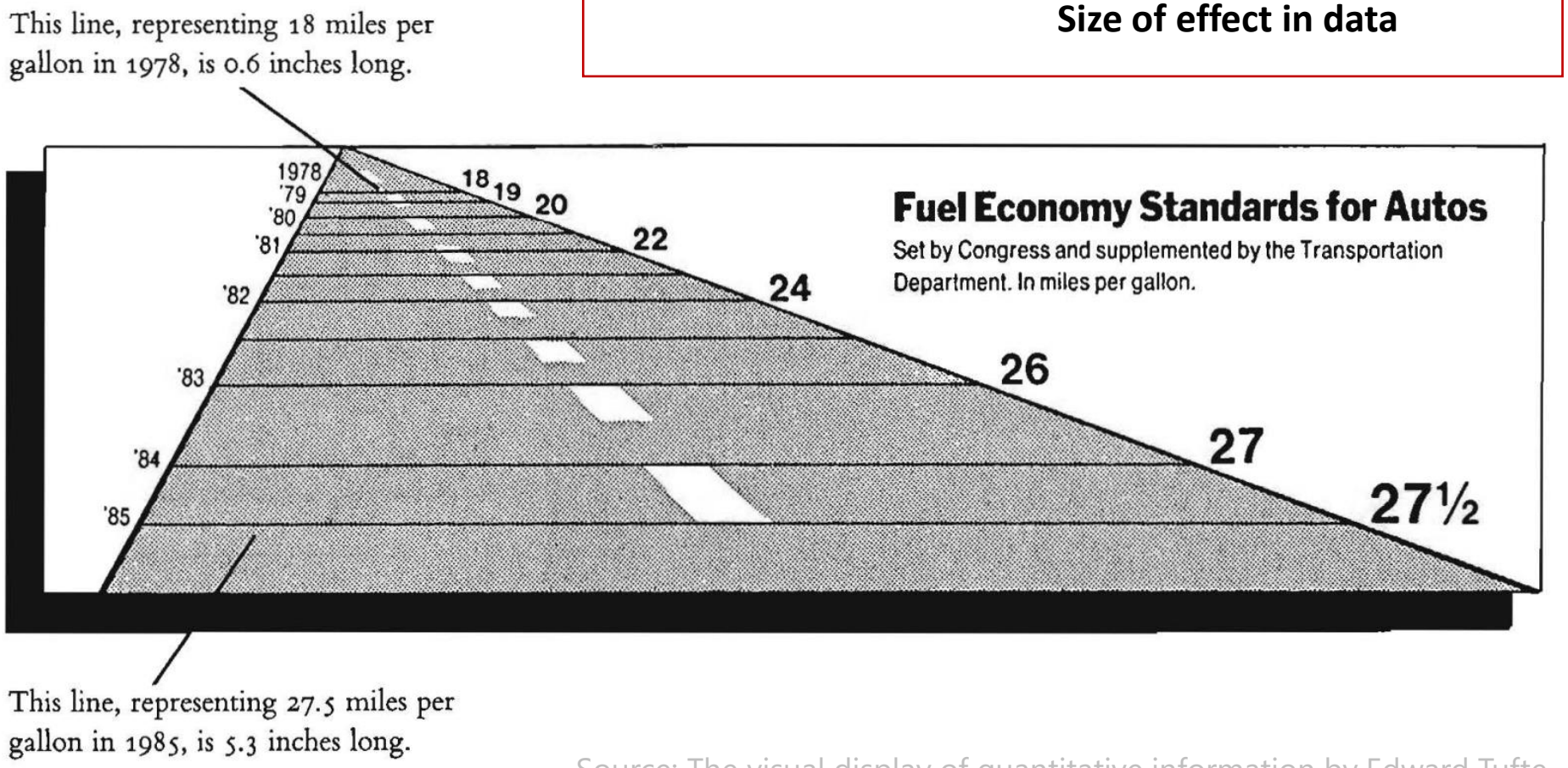
What is wrong with this graphic? (beside the chartjunk)



Source: The visual display of quantitative information by Edward Tufte

Graphical integrity and the lie-factor

$$\text{lie-factor} = \frac{\text{Size of effect shown in graphic}}{\text{Size of effect in data}}$$



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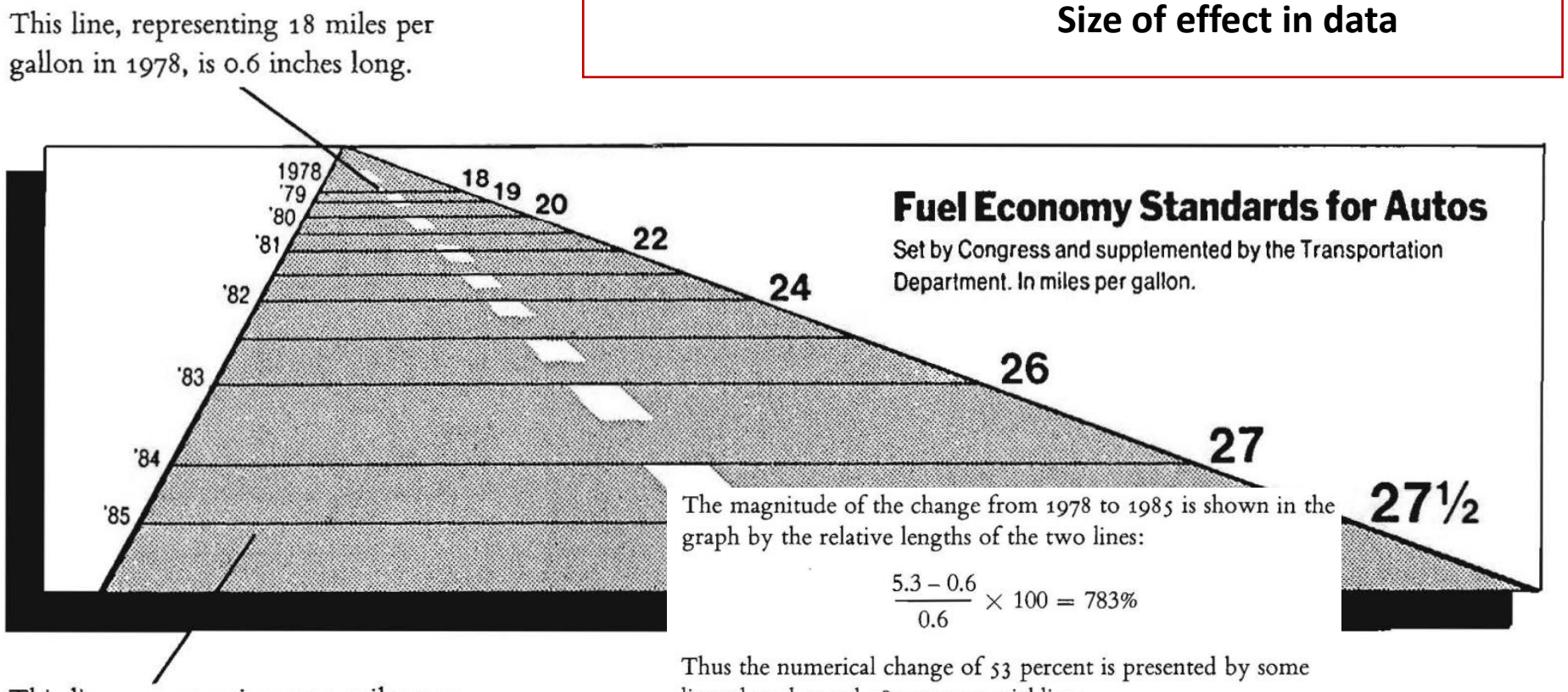


A few key take-aways on visualization by Edward Tufte

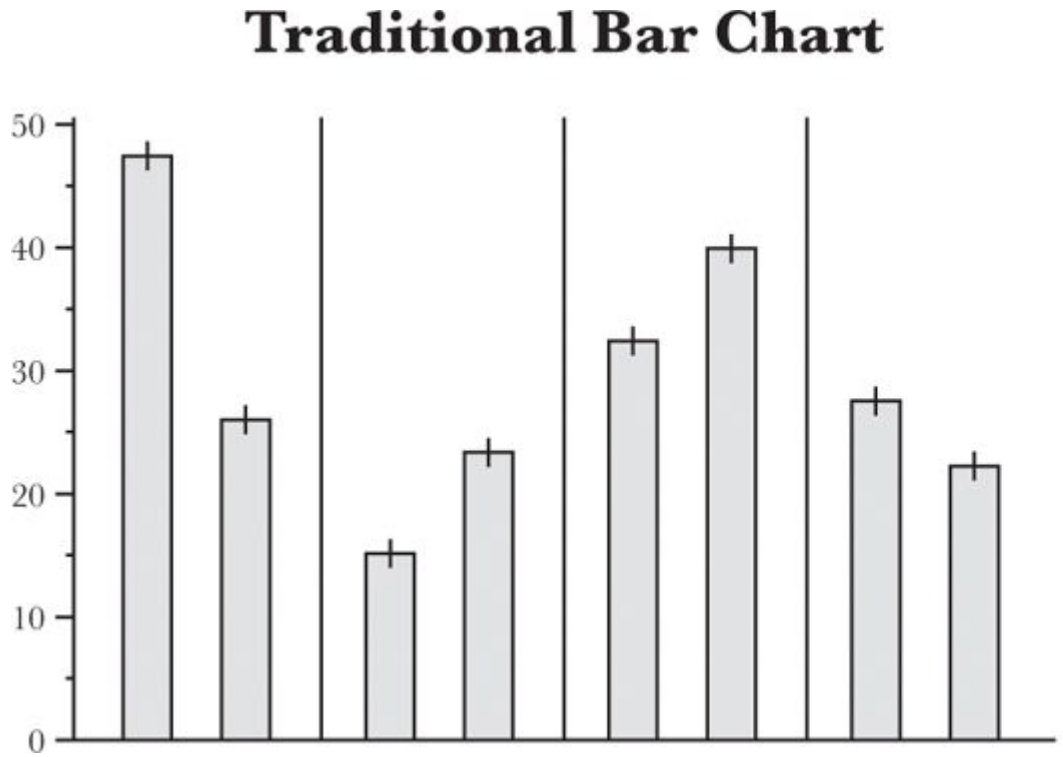
- Maximize **data-ink ratio**

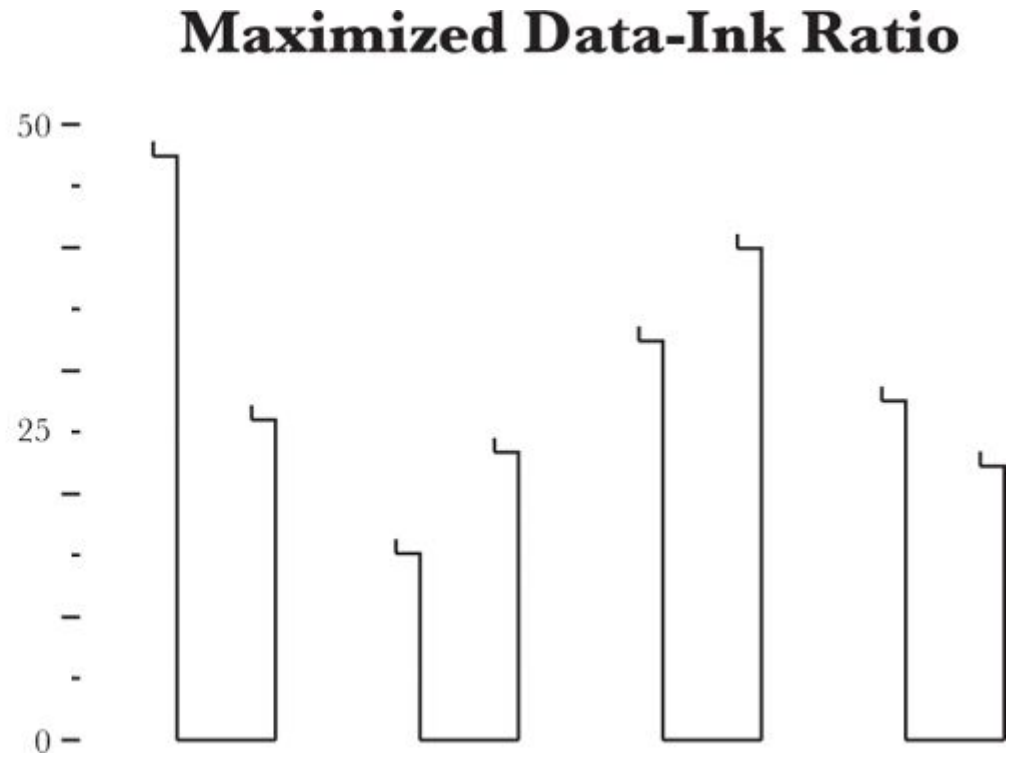
- Get rid of **chartjunk**
  - **Caveat:** Chartjunk done right, may work!

- Aim for **no/low lie-factor**

A word of caution: Extremes are easy, strive for balance

Which do you like better?





Source: The functional art by Alberto Cairo

More on graphical integrity: Misleading graphics

- Spurious correlations!

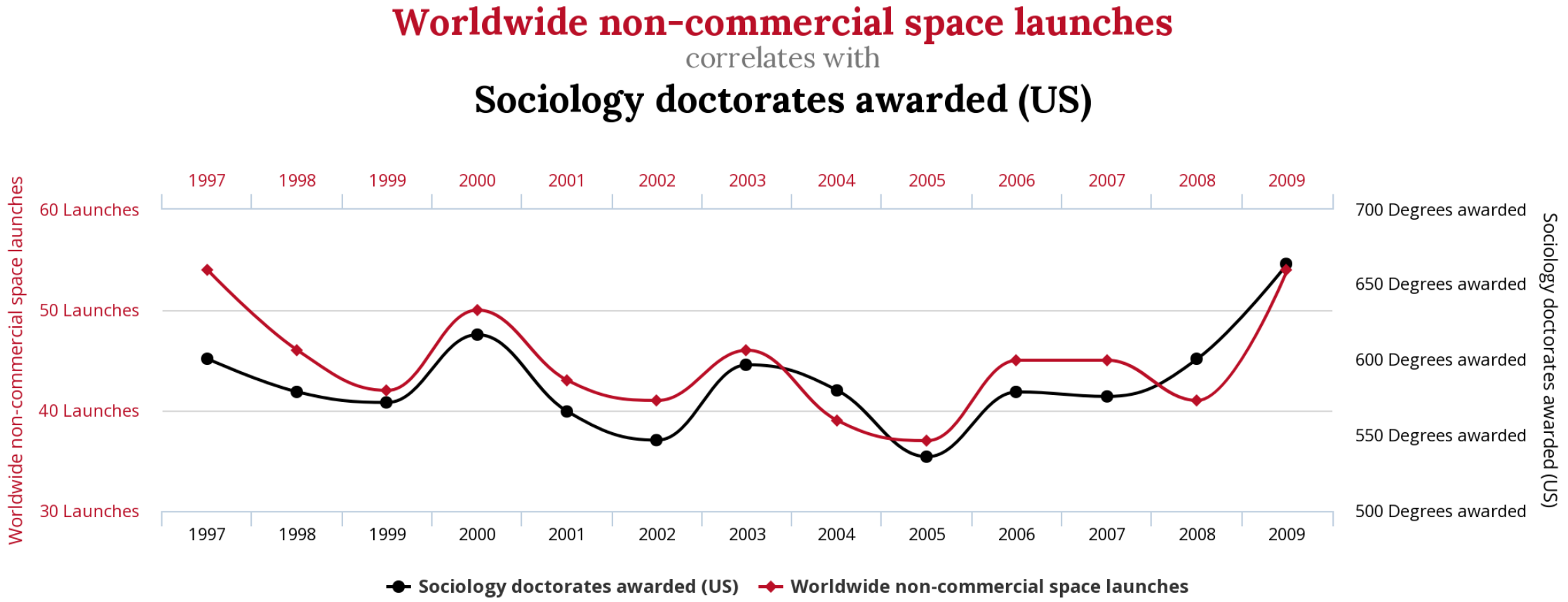
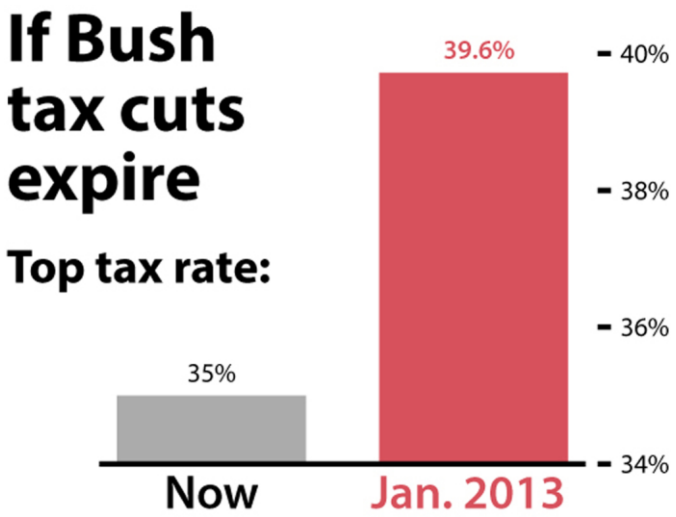


Image source: http://www.tylervigen.com/spurious-correlations

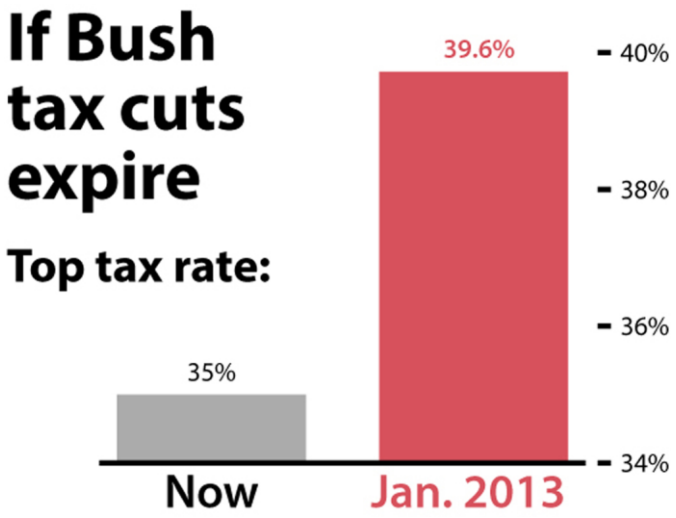
More on graphical integrity: Misleading graphics



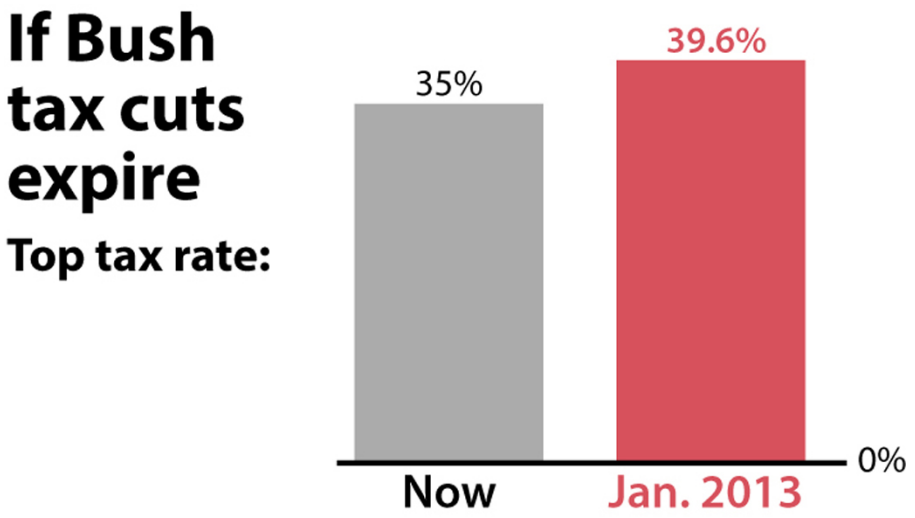
Source: How charts lie by Alberto Cairo

More on graphical integrity: Misleading graphics

- Chart baseline is not at 0!

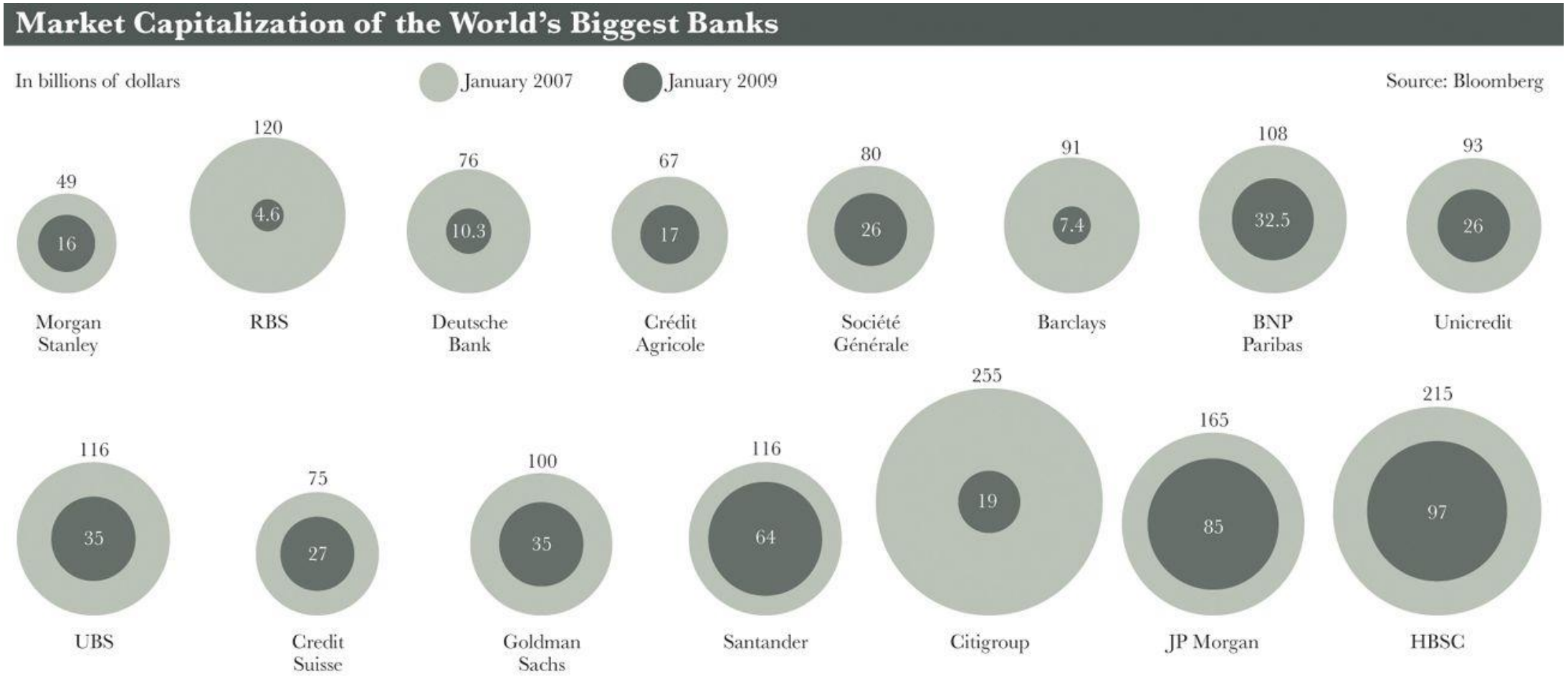


VS



Source: How charts lie by Alberto Cairo

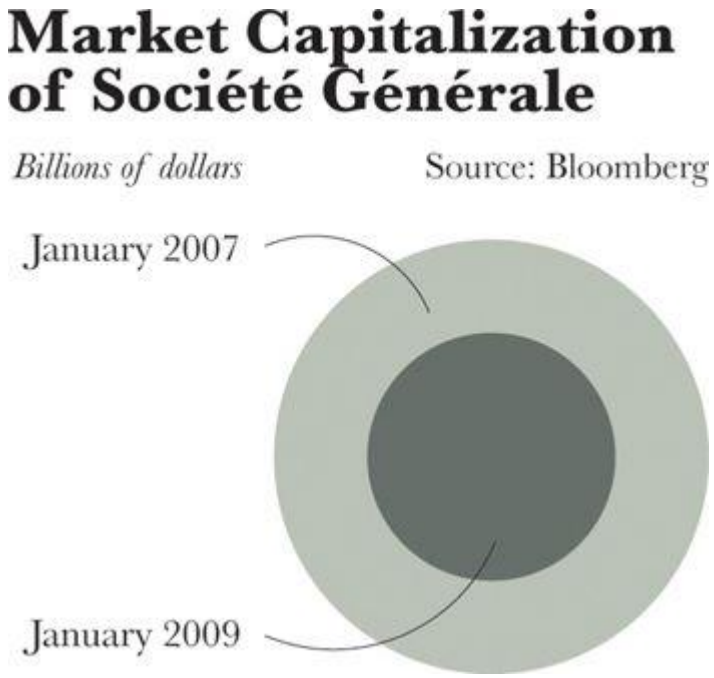
More confusing graphics



Source: The functional art by Alberto Cairo

More confusing graphics

- The Outer bubble represents $80 billion.
  What does the second bubble represents?

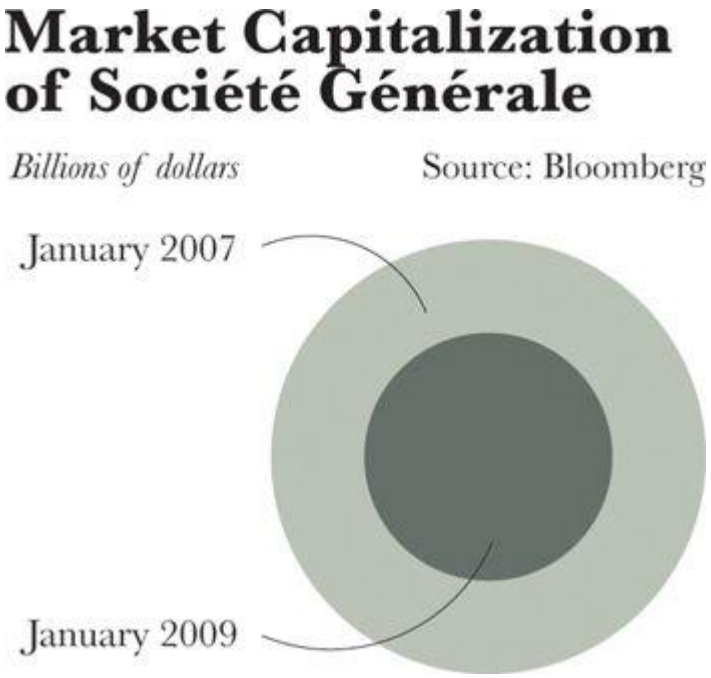


Source: The functional art by Alberto Cairo

More confusing graphics

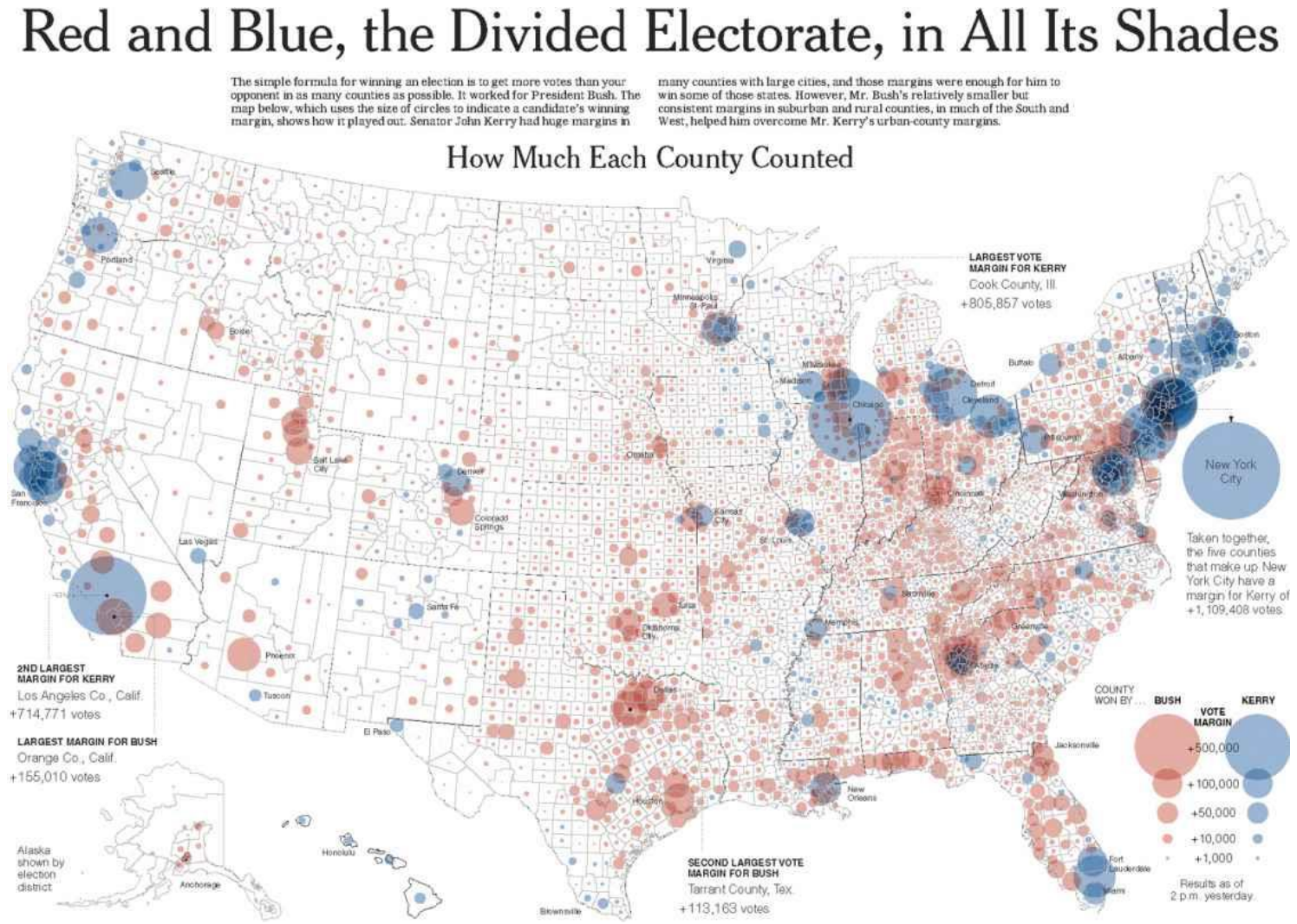
- The Outer bubble represents $80 billion.
  What does the second bubble represents?

Want readers to **compare areas**.
But many tend to compare heights.



Source: The functional art by Alberto Cairo

Bubbles are generally ok for the Big Picture

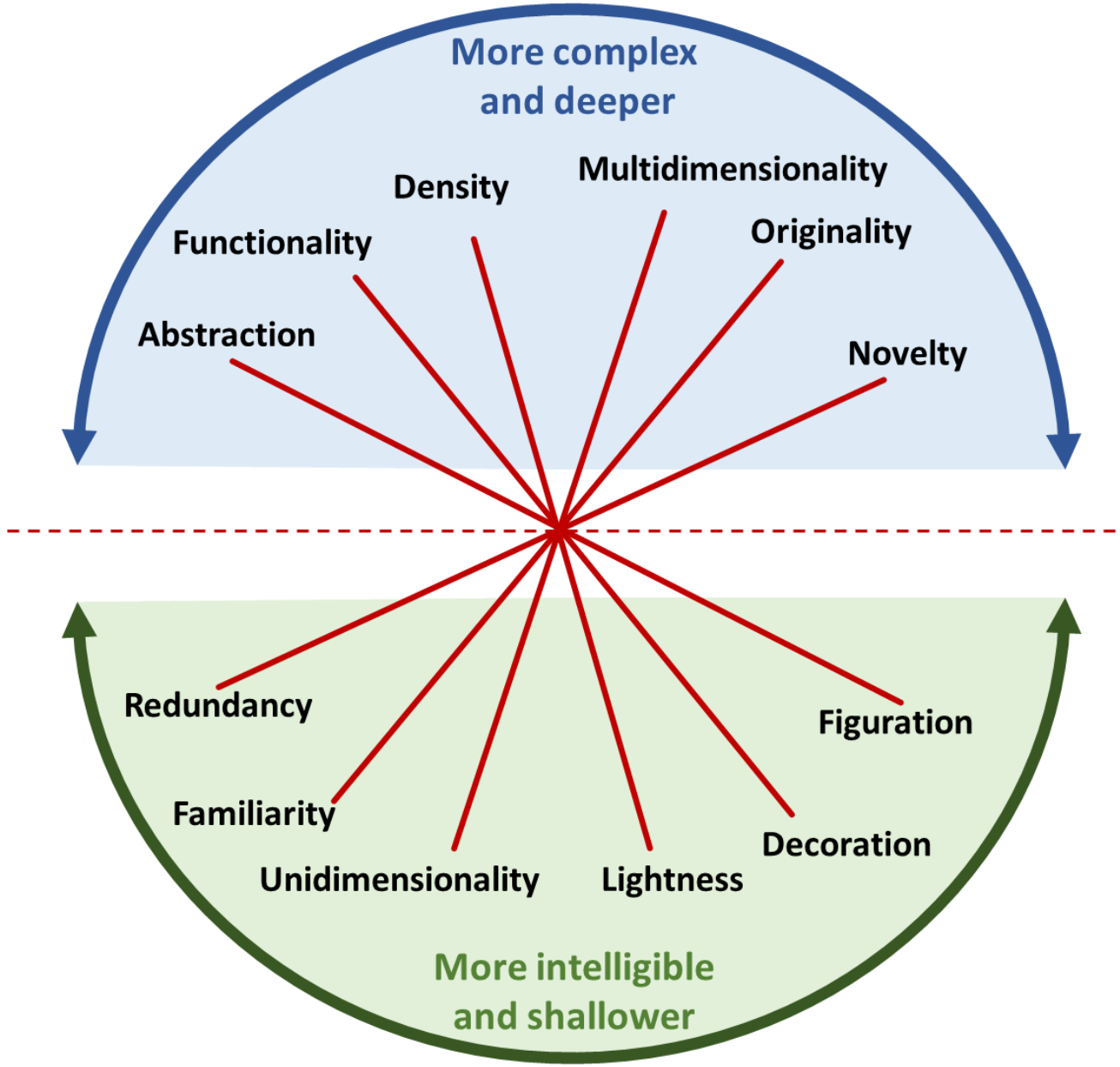


Source: The functional art by Alberto Cairo

Planning your visualization

- Visualization Wheel – Alberto Cairo

An exercise in meta-visualization:
a ***visualization for planning visualizations***

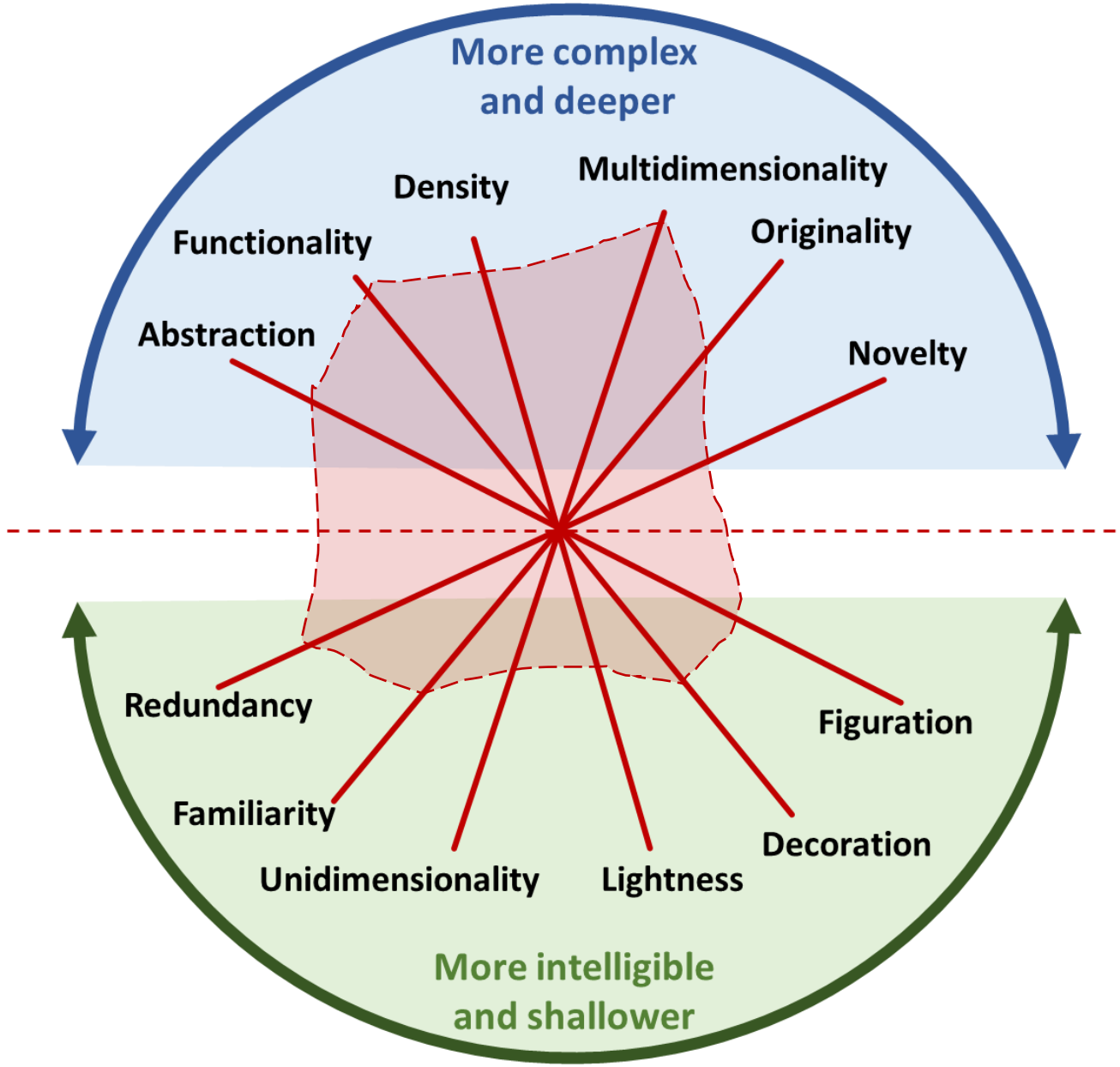


Redrawn. Original concept of visualization wheel is from The functional art by Alberto Cairo

A hypothetical visual …

- Visualization Wheel – Alberto Cairo

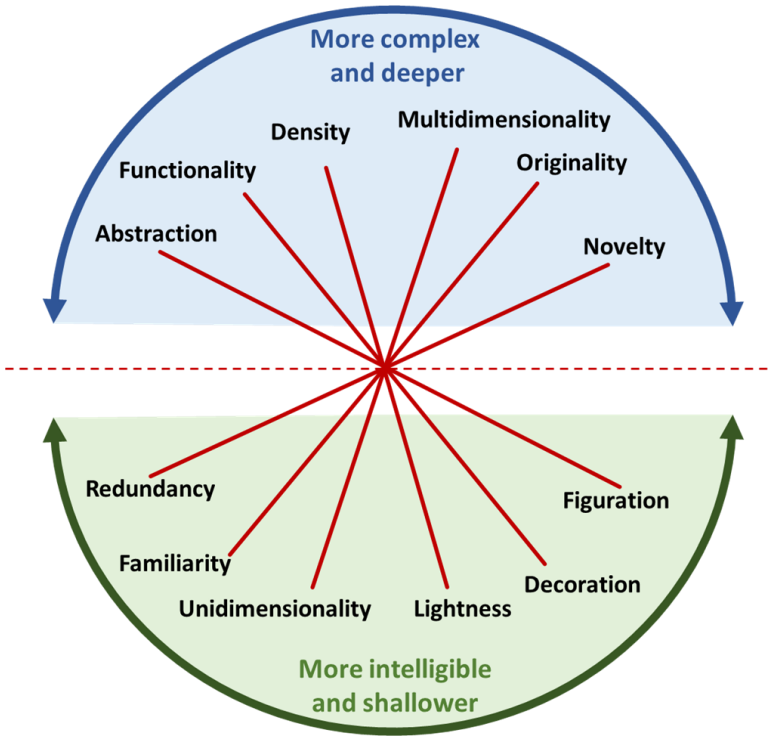
An individual visualization may have a specific combination of characteristics.
Caution: This is highly subjective.

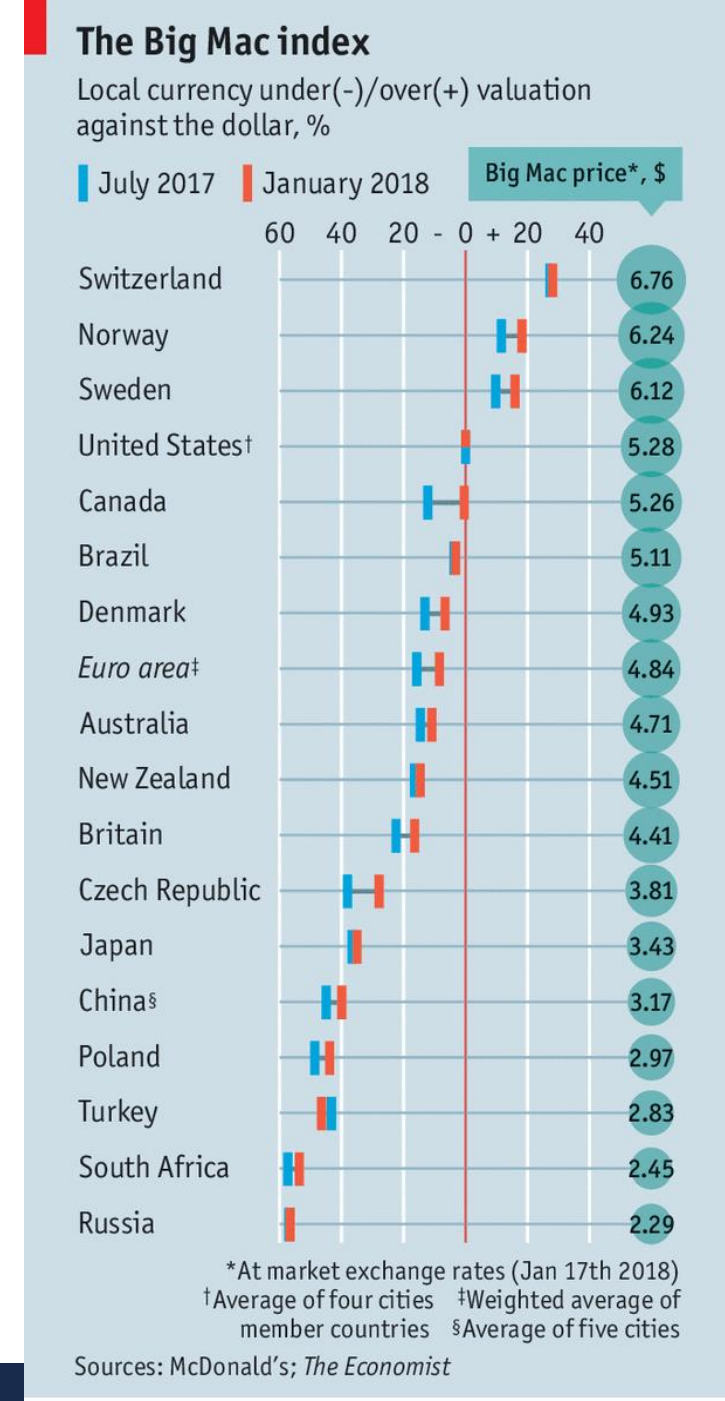


Where on the Visualization Wheel is The Big Mac Index?

Visualization Wheel – Alberto Cairo

Where does the Big Mac Index figure from The Economist fit in?

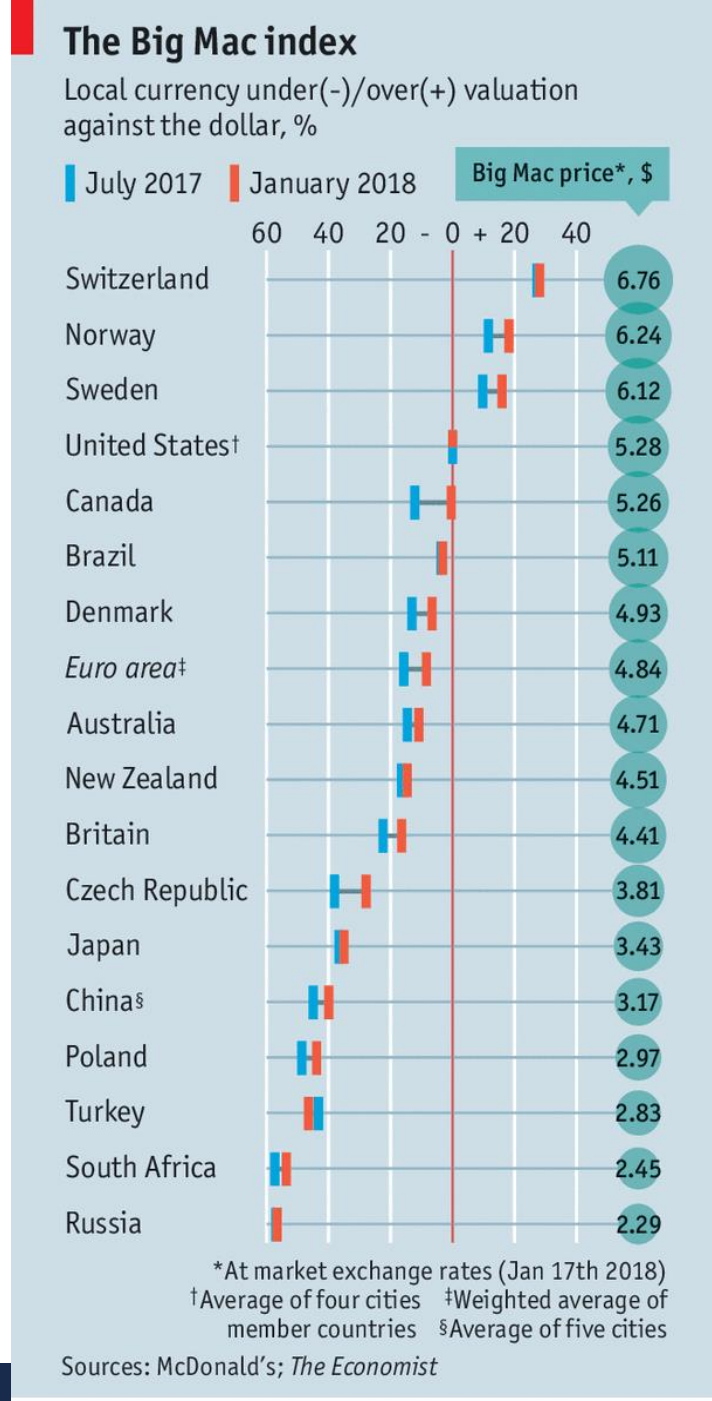




Try it yourself

Here's the Big Mac Index data
https://github.com/TheEconomist/big-mac-data

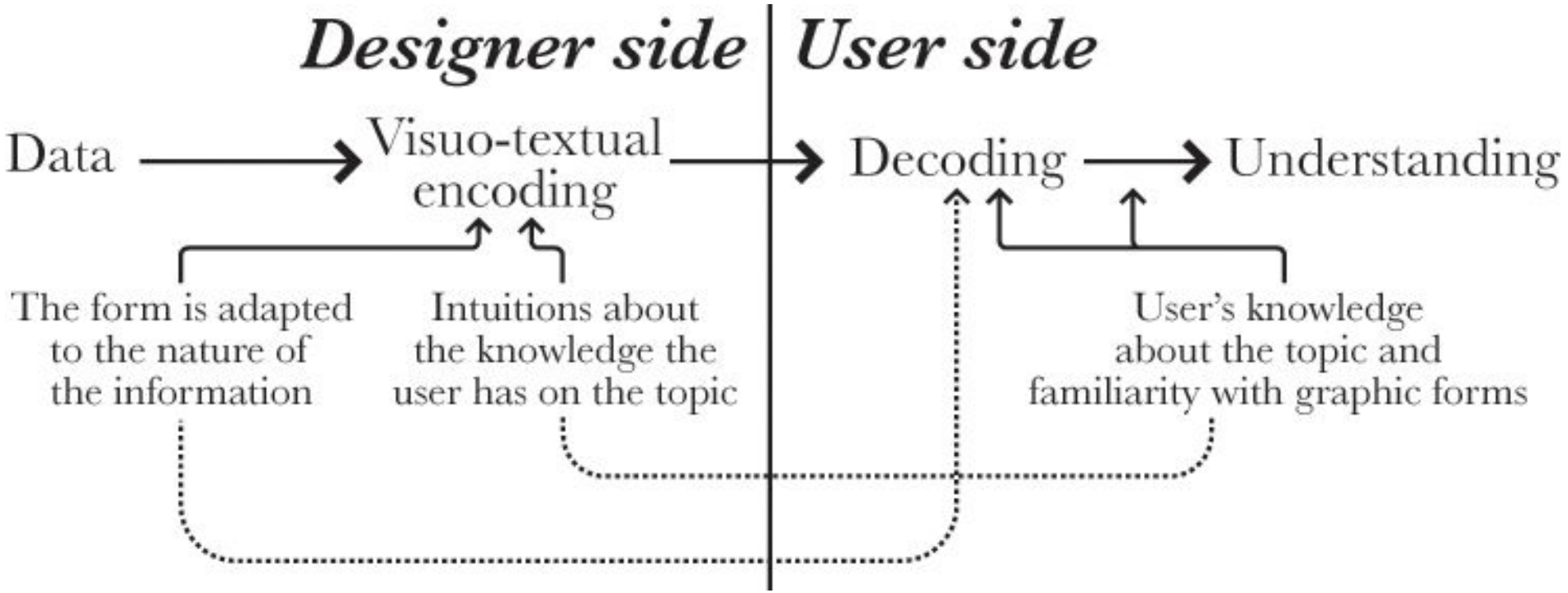
Ungraded task 4.3: Create a similar plot with the data, using framework of your choice. Share your code & plot result.



Complexity adapted to the audience

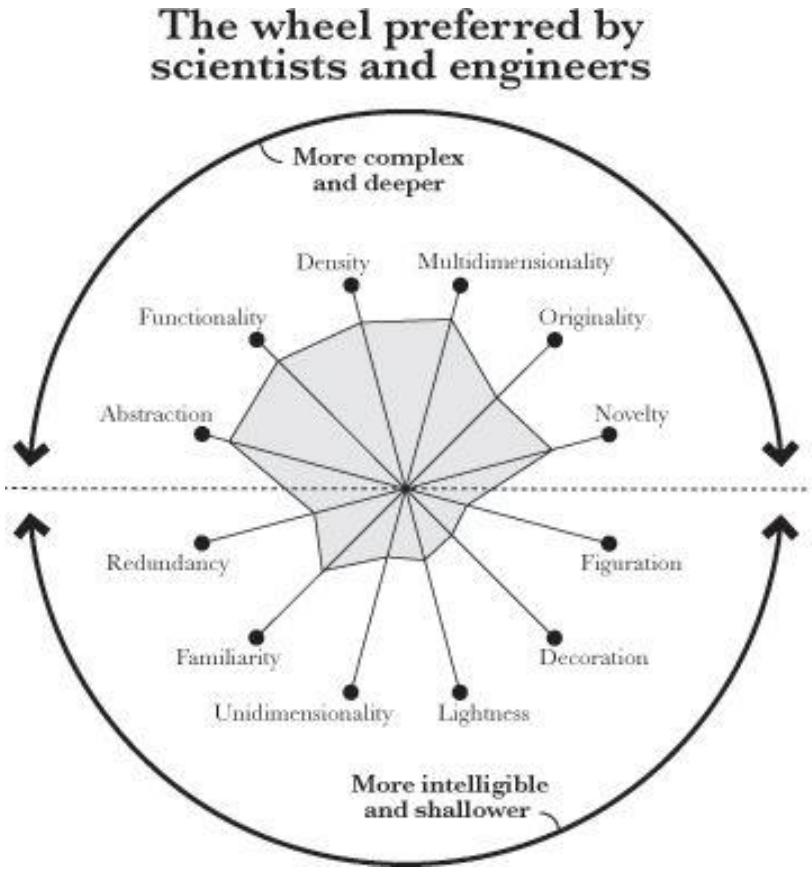
- If the subject is complex

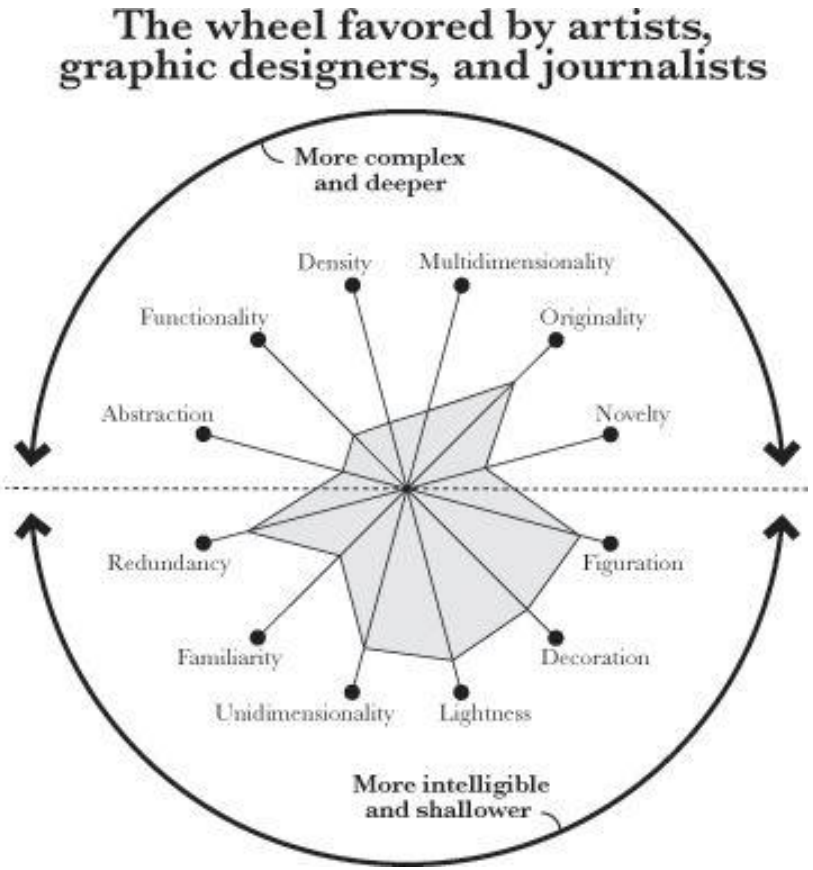
Aim should be to clarify, rather than simplify/dumb it down



Source: The functional art by Alberto Cairo

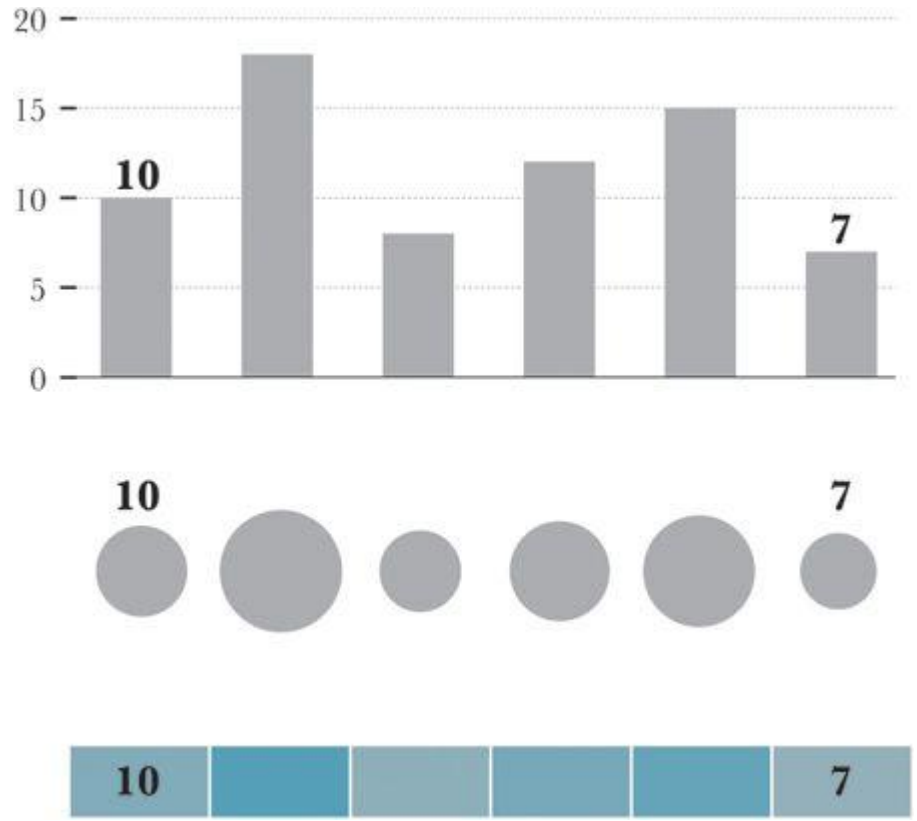
Complexity adapted to the audience & purpose



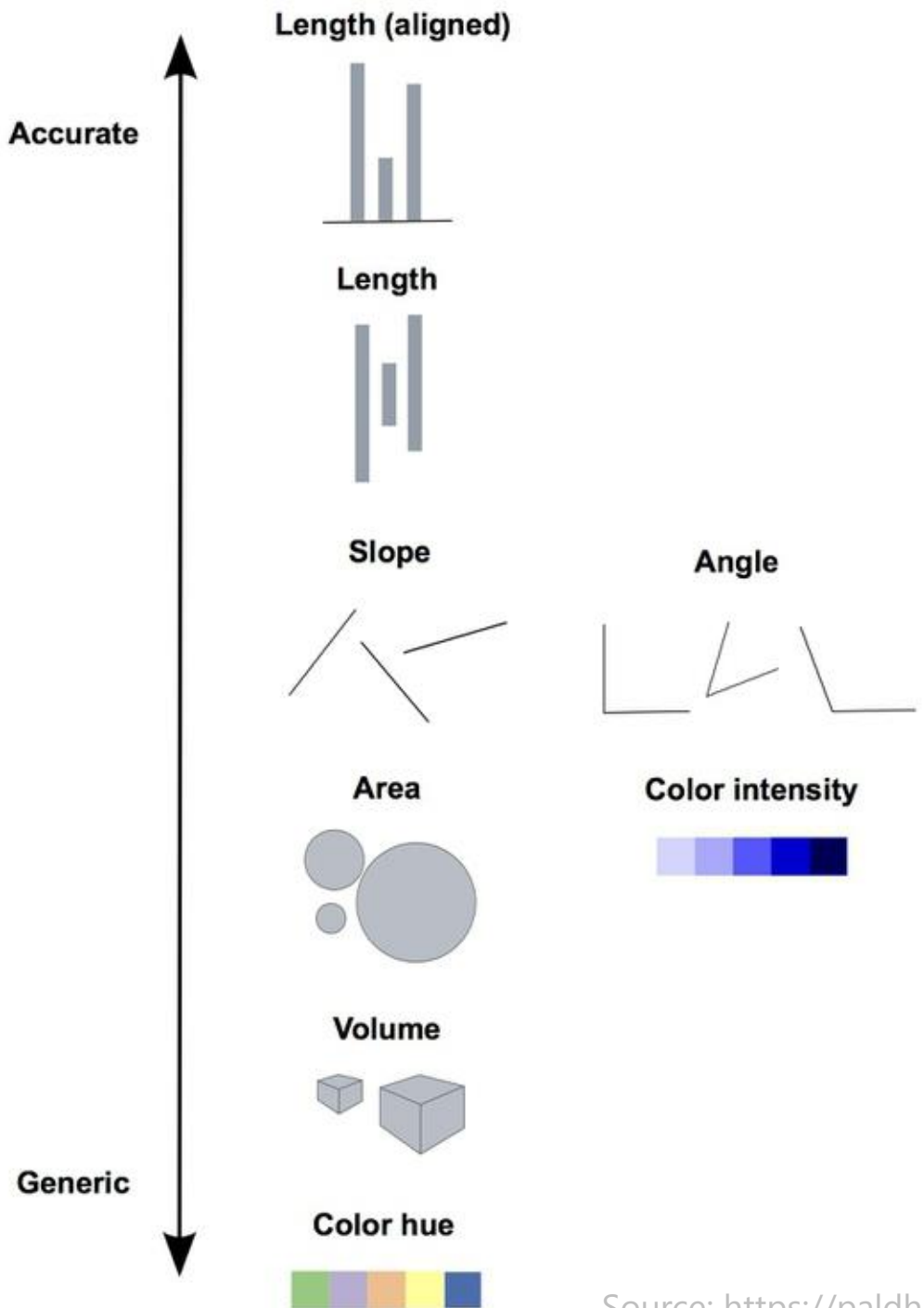


Source: The functional art by Alberto Cairo

Same information, different ways to display



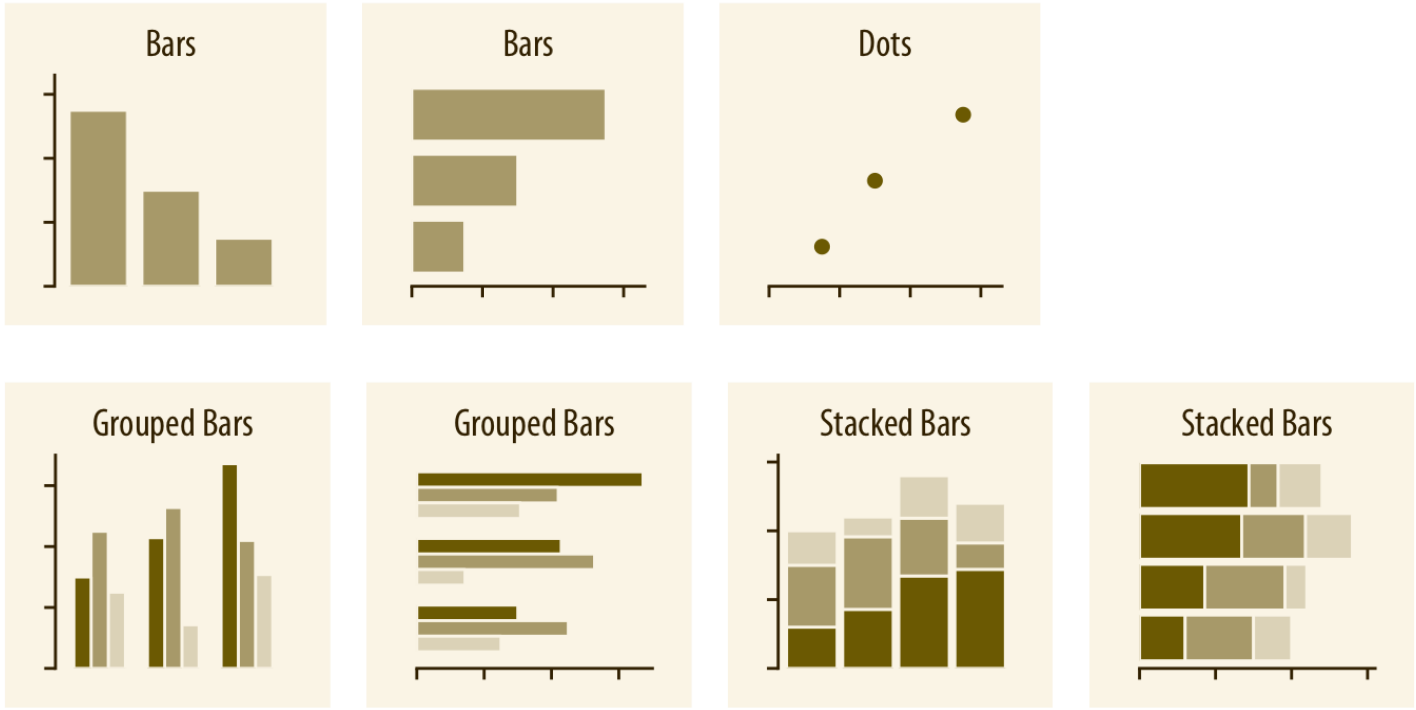
Source: The functional art by Alberto Cairo



Source: https://paldhous.github.io/ucb/2016/dataviz/week2.html

A directory of visualizations

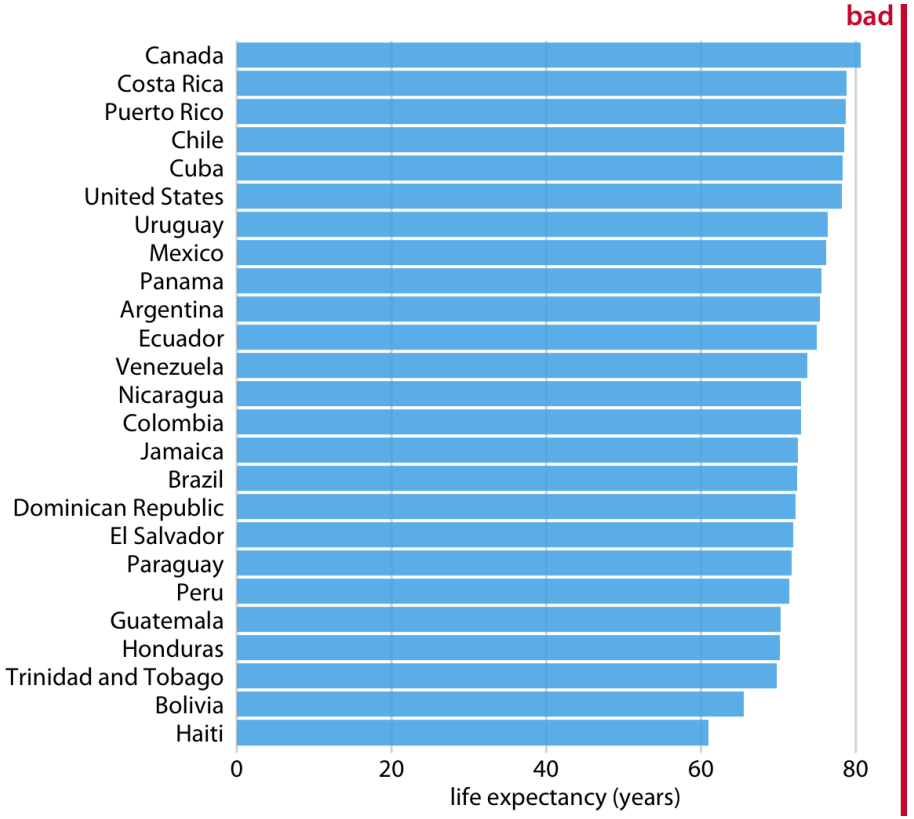
Amounts

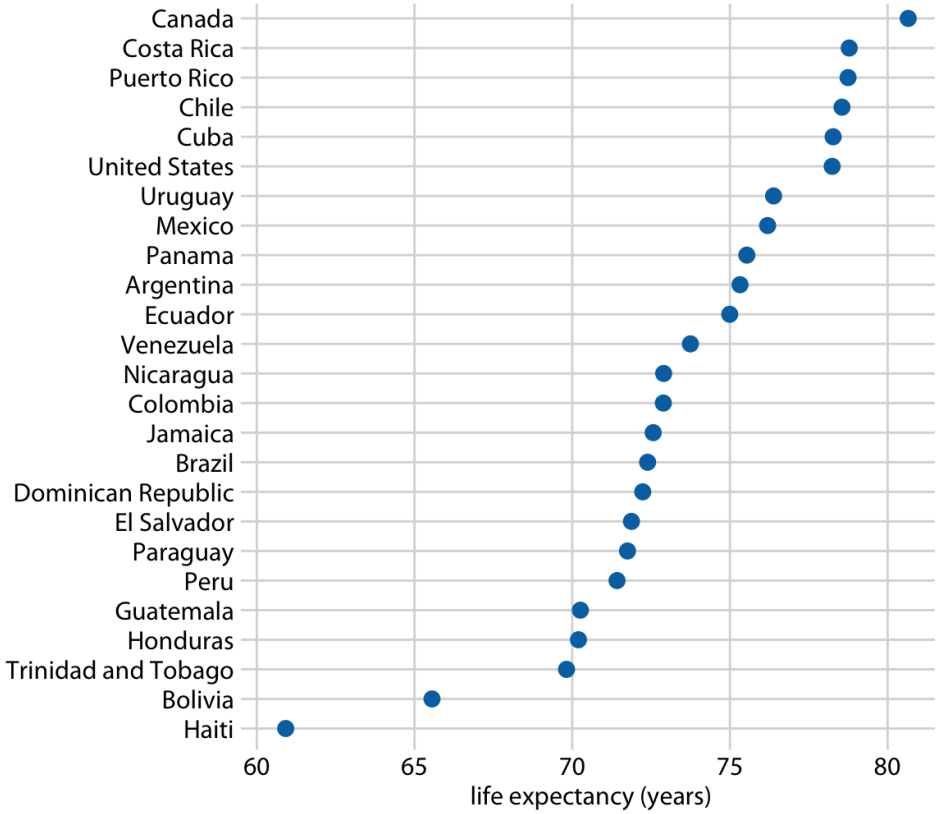


Source: Fundamentals of Data Visualization by Claus O. Wilke

Examples

Amounts

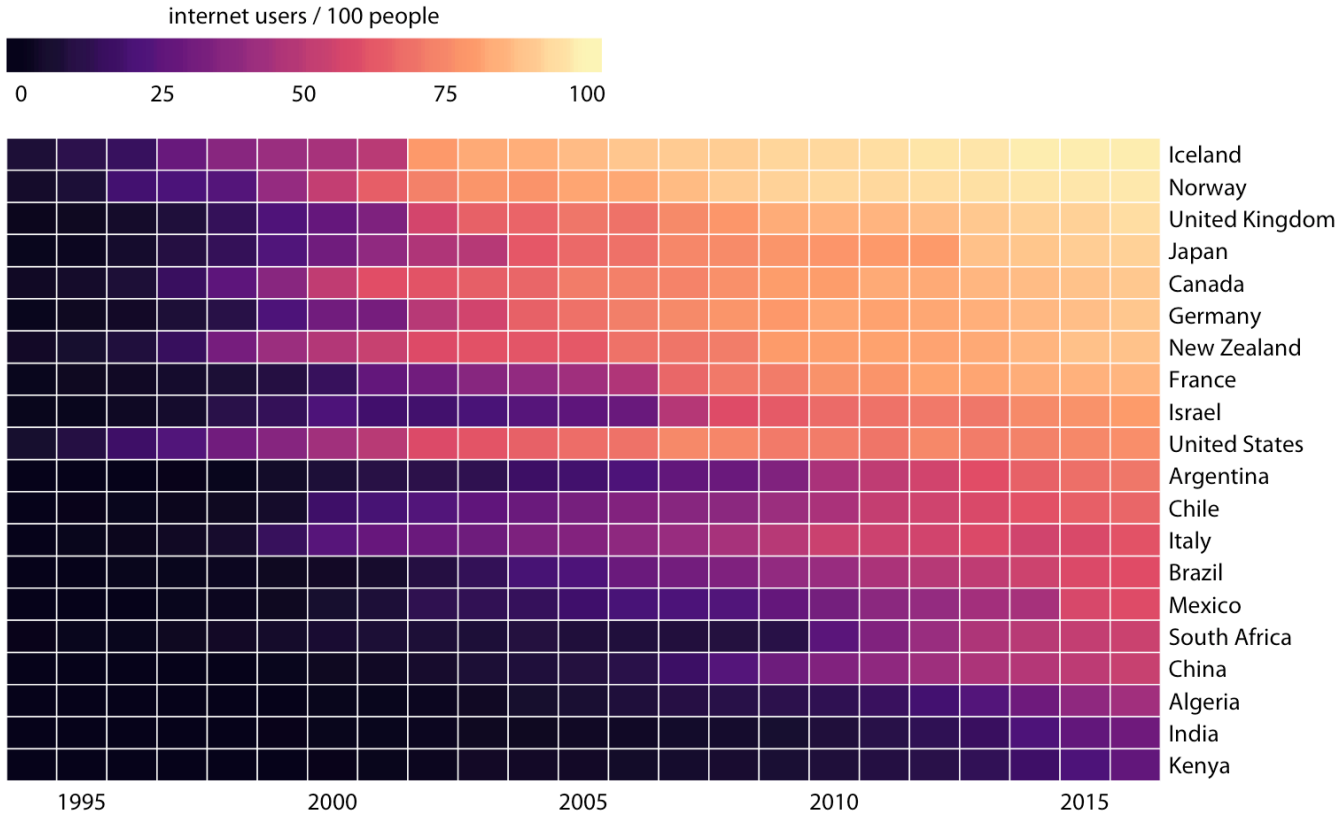




Source: Fundamentals of Data Visualization by Claus O. Wilke

A more sophisticated example

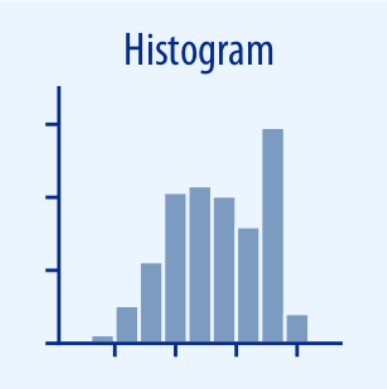
Amounts: Heatmap to capture temporal dimension

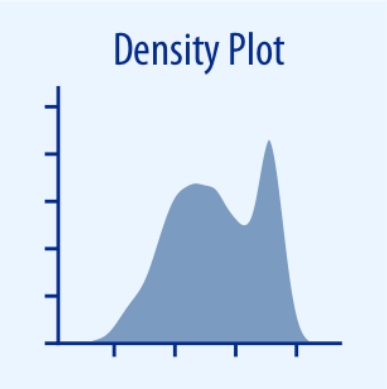


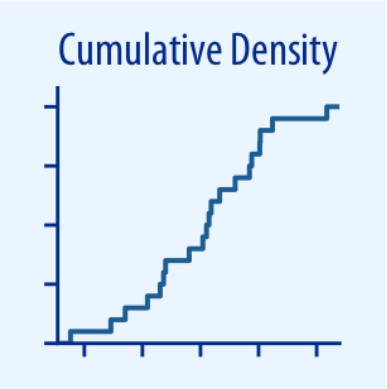
Source: Fundamentals of Data Visualization by Claus O. Wilke

A directory of visualizations

- Distributions



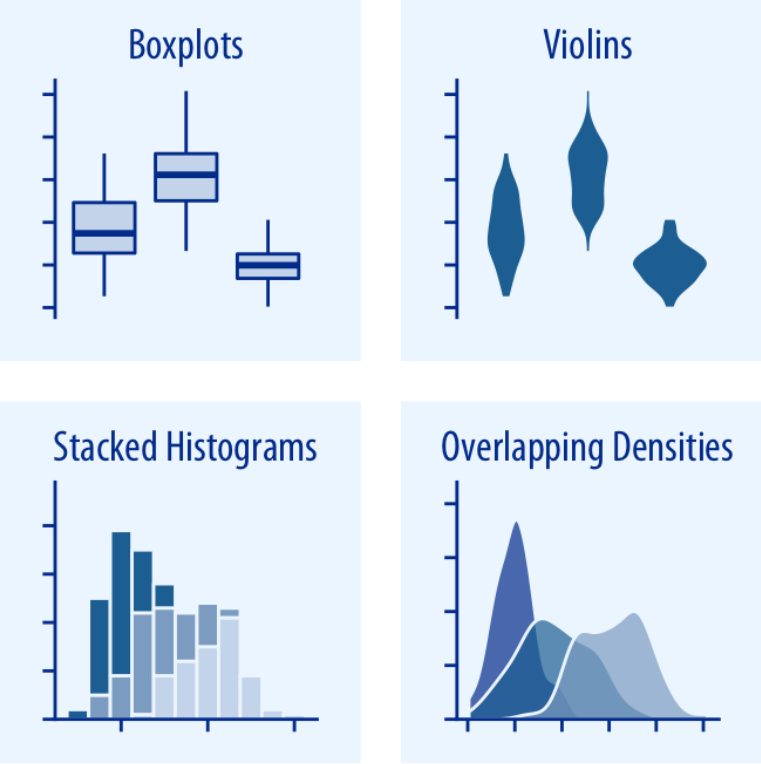




Source: Fundamentals of Data Visualization by Claus O. Wilke

A directory of visualizations

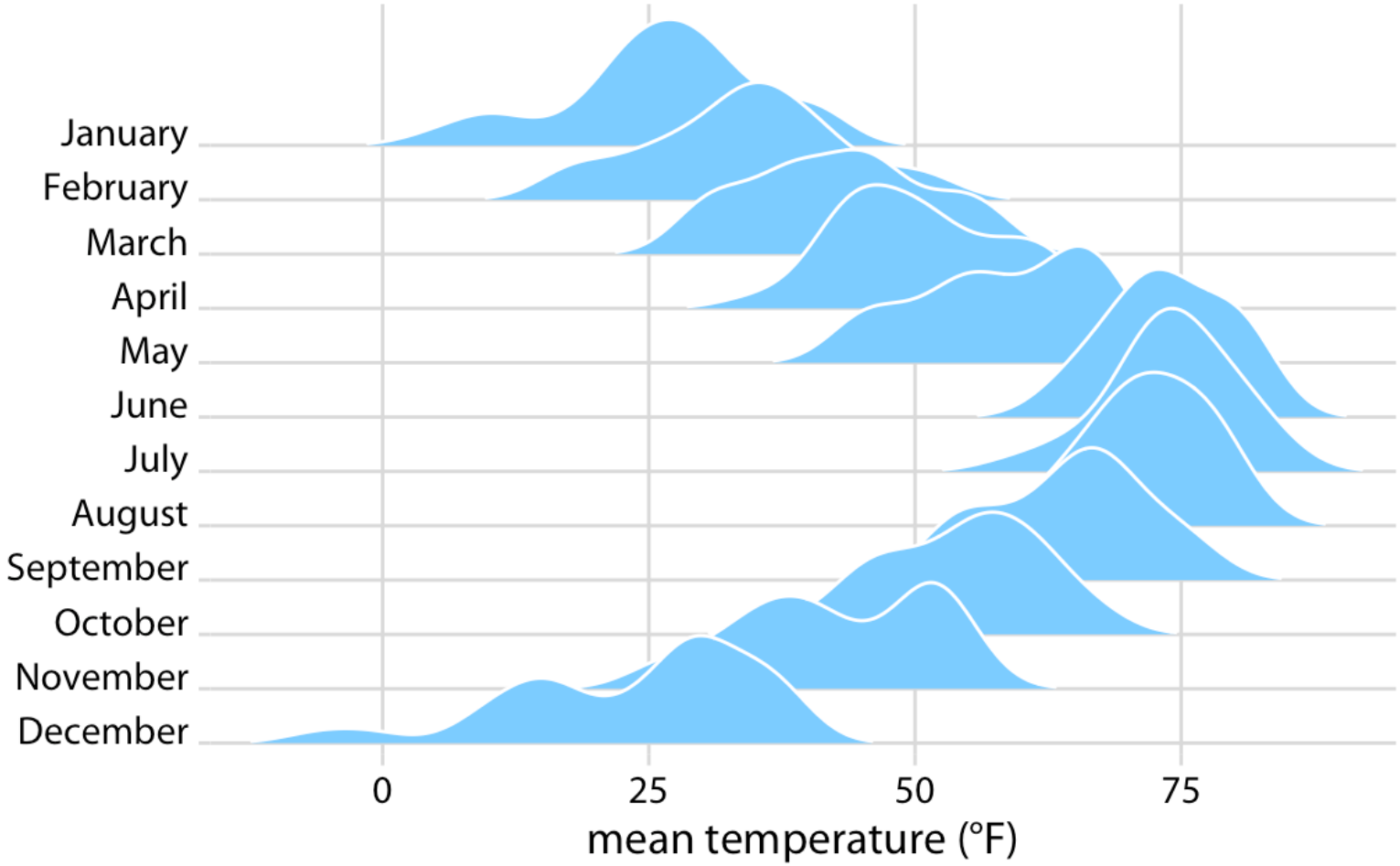
Distributions



Source: Fundamentals of Data Visualization by Claus O. Wilke

Example

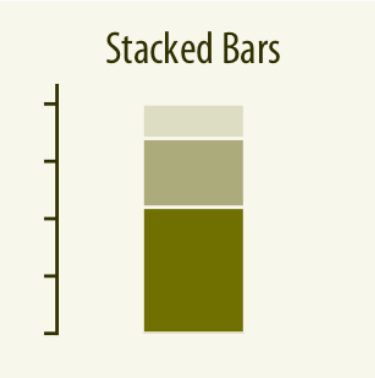
- Distributions



Source: Fundamentals of Data Visualization by Claus O. Wilke

A directory of visualizations

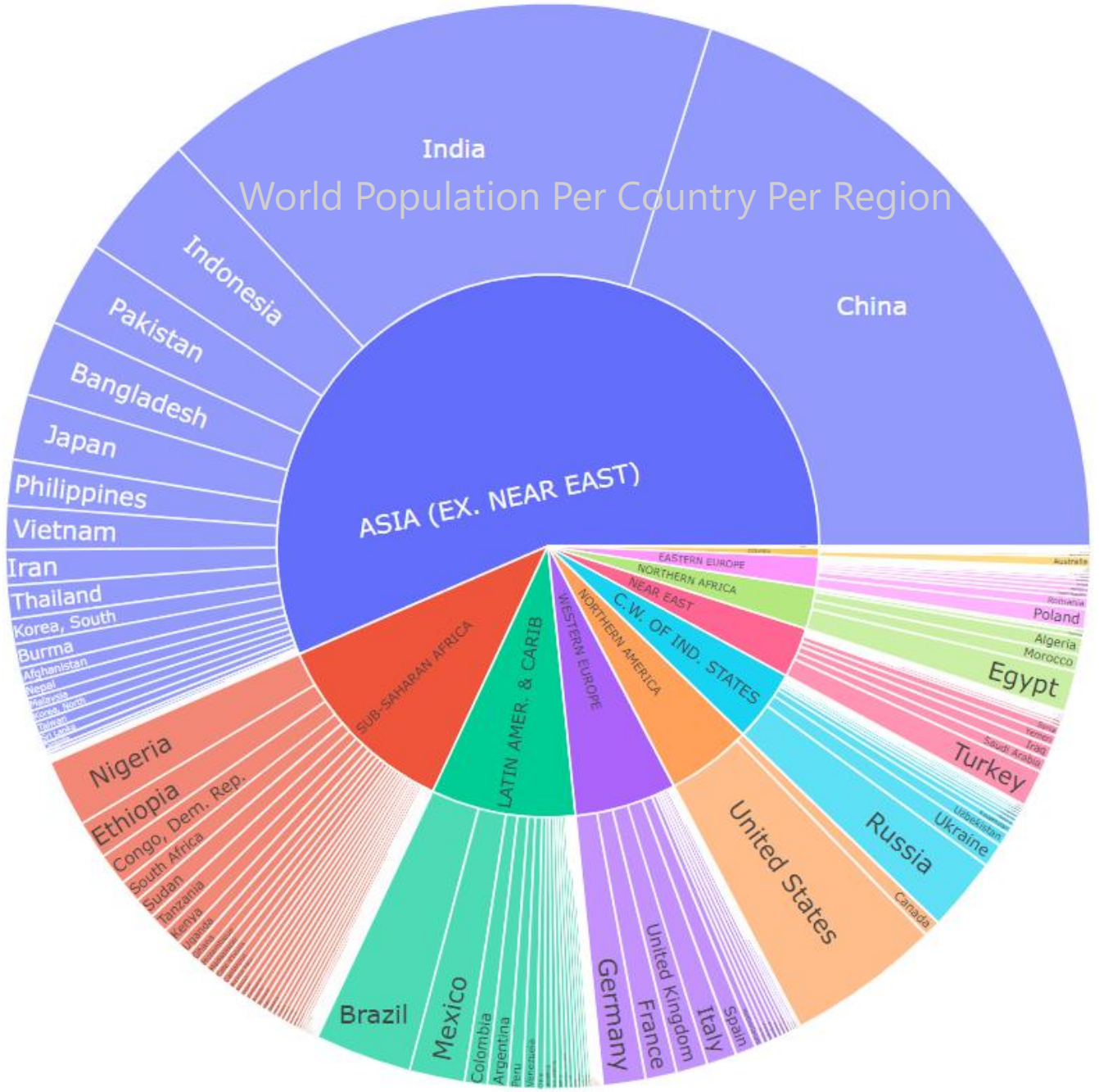
Proportions



Source: Fundamentals of Data Visualization by Claus O. Wilke

Example

- Proportions: Sunburst chart to capture hierarchical information



Data source: Countries of the world (as used in Module 2)

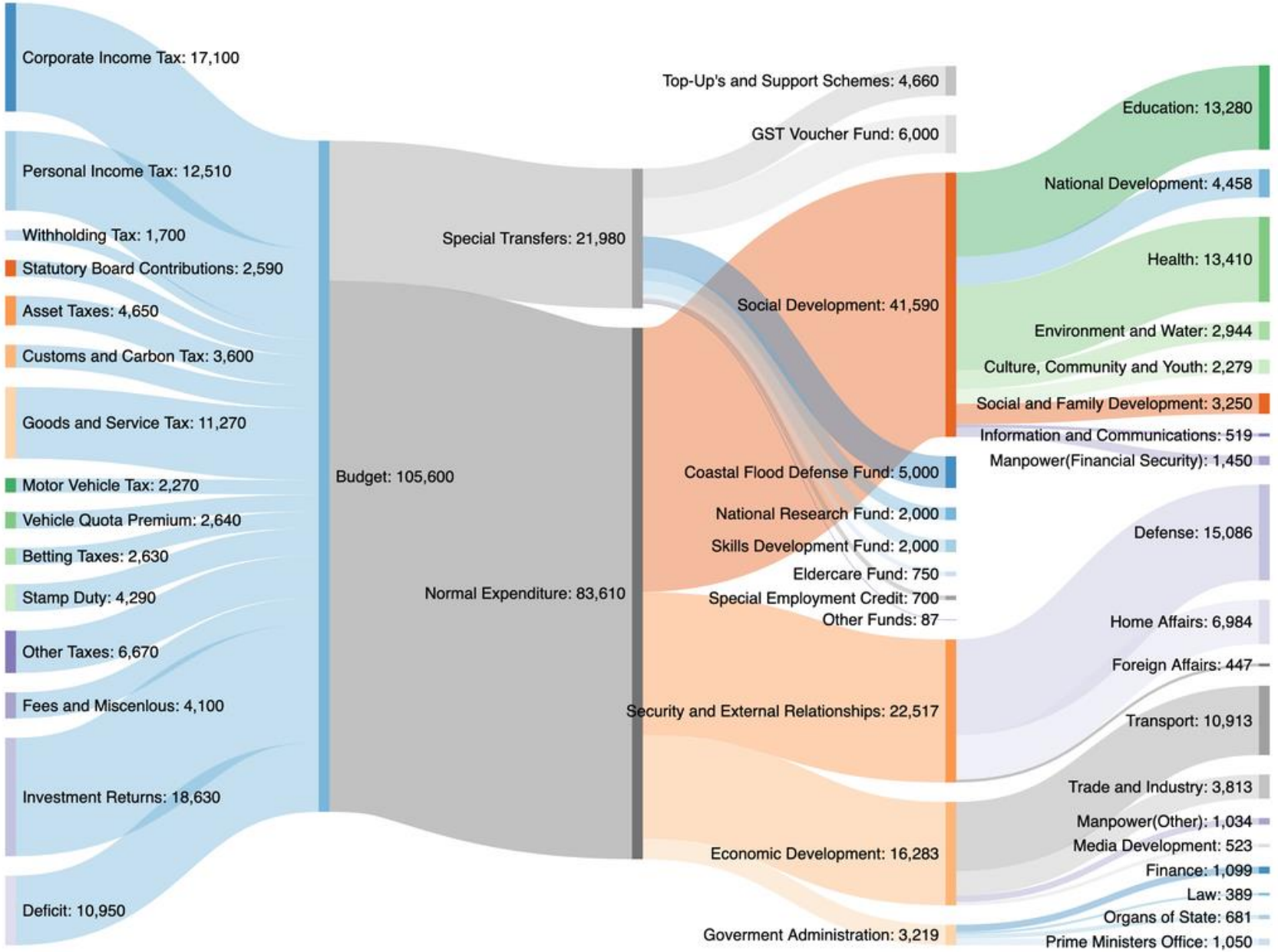
A directory of visualizations

Proportions

Source: Fundamentals of Data Visualization by Claus O. Wilke

Example

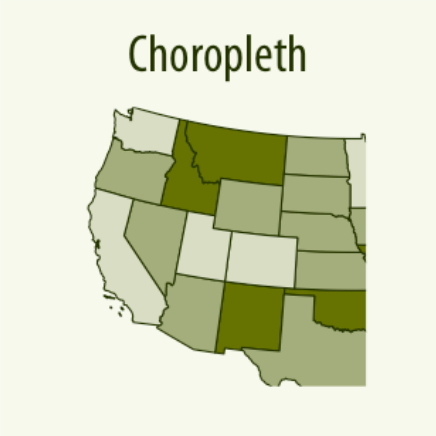
- SG Government's Projected Revenue and Expenditure 2020 (In Millions of SGD)

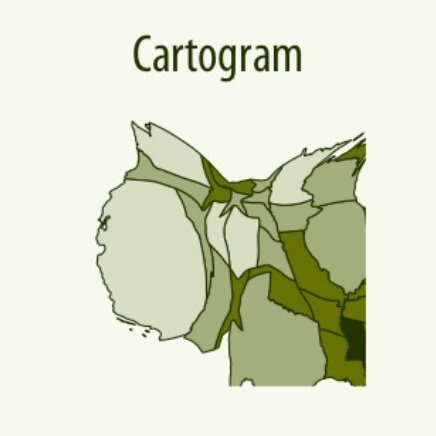


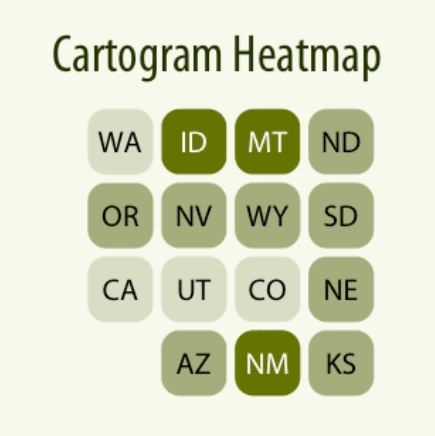
Source: https://www.reddit.com/**r/dataisbeautiful**/comments/f62y0g/ocsingapore_governments_projected_revenue_and/

A directory of visualizations

- Geospatial data

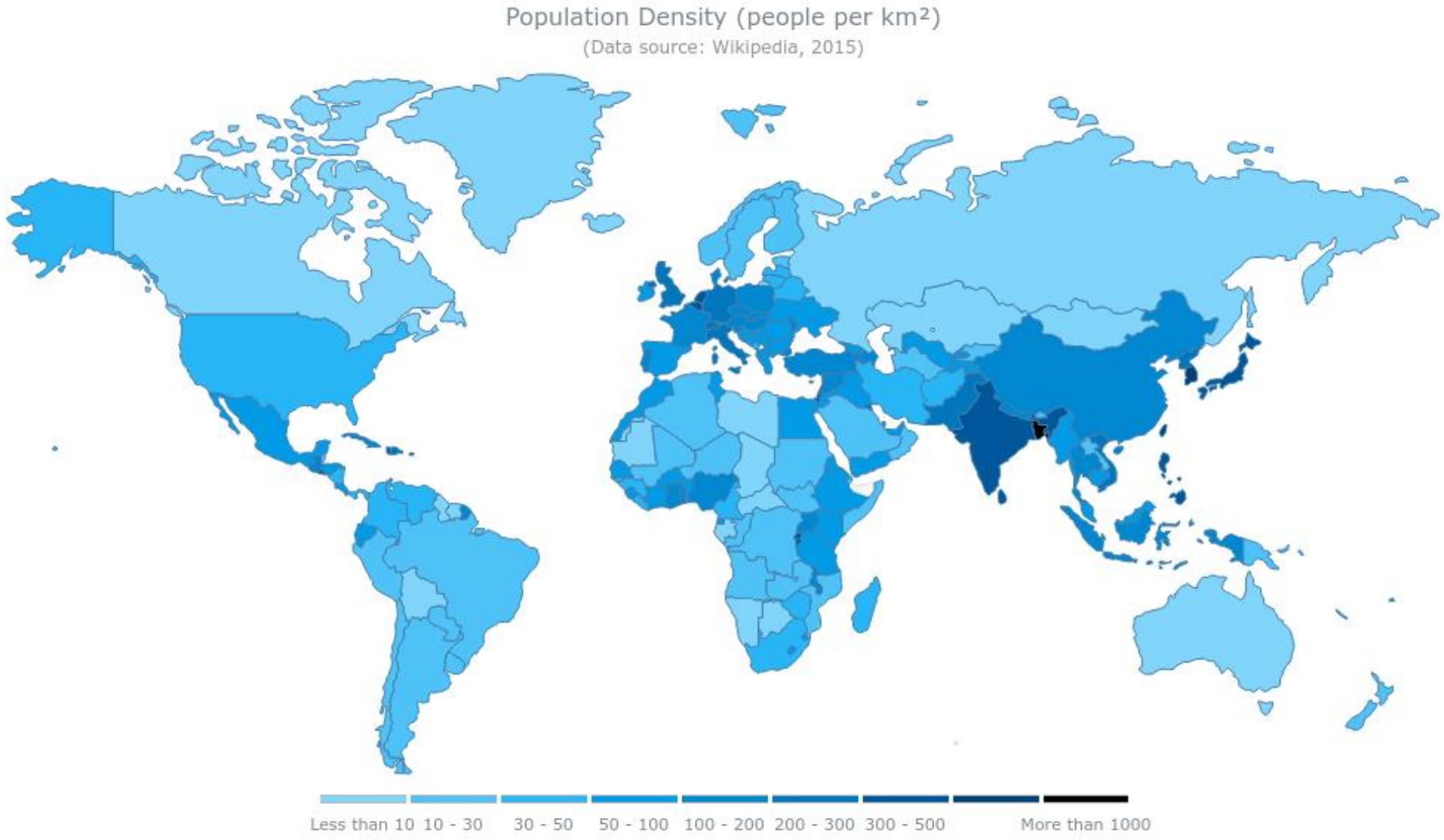






Source: Fundamentals of Data Visualization by Claus O. Wilke

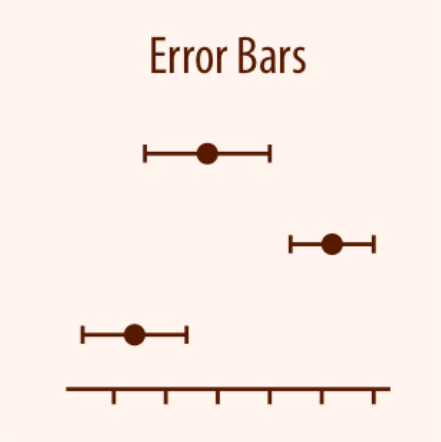
Example

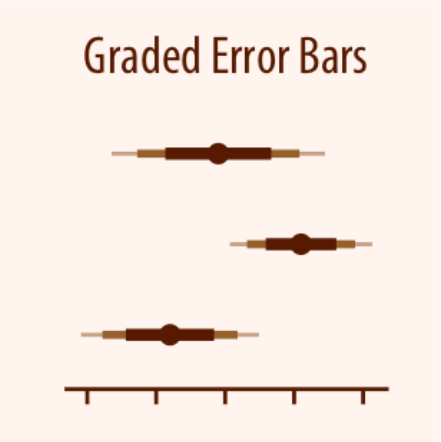


Source: https://www.anychart.com/products/anymap/gallery/Maps_General_Features/World_Choropleth_Map.php

A directory of visualizations

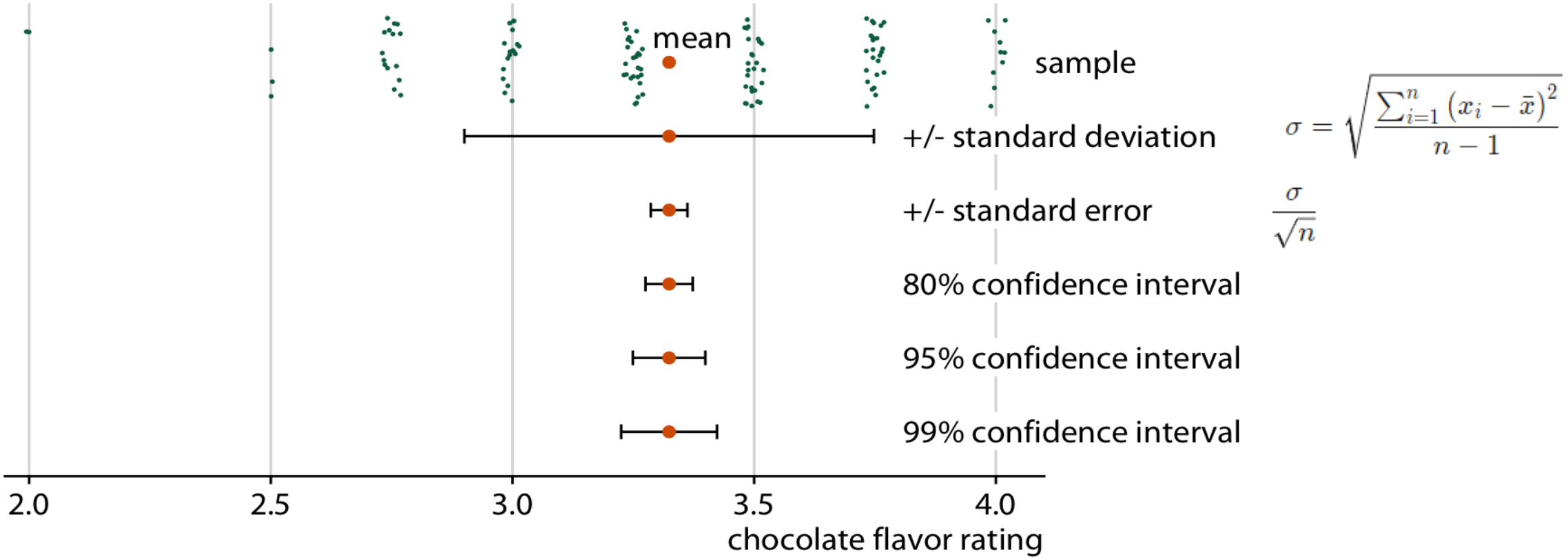
Uncertainty





Source: Fundamentals of Data Visualization by Claus O. Wilke

Example

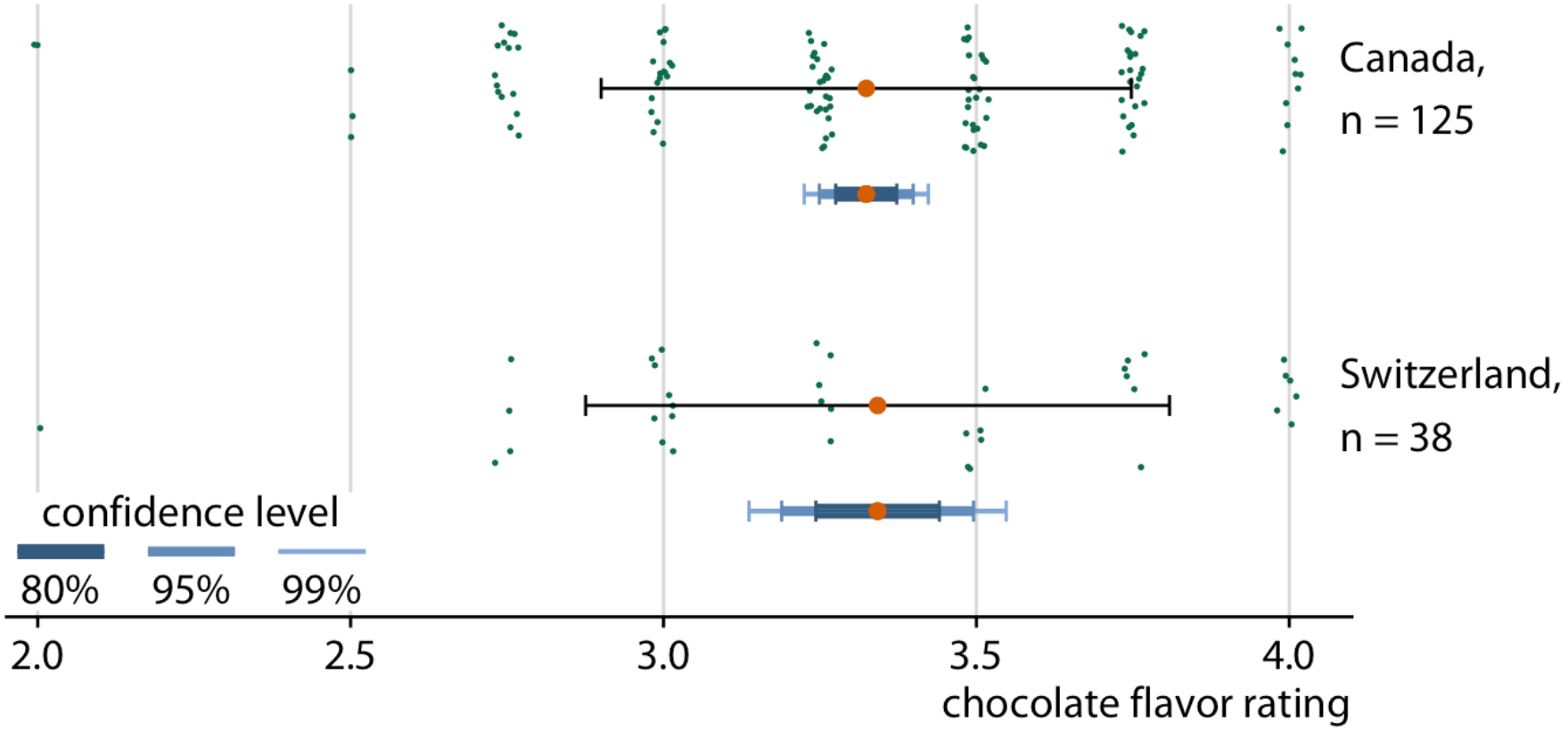


$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

$$\frac{\sigma}{\sqrt{n}}$$

Source: Fundamentals of Data Visualization by Claus O. Wilke

Example

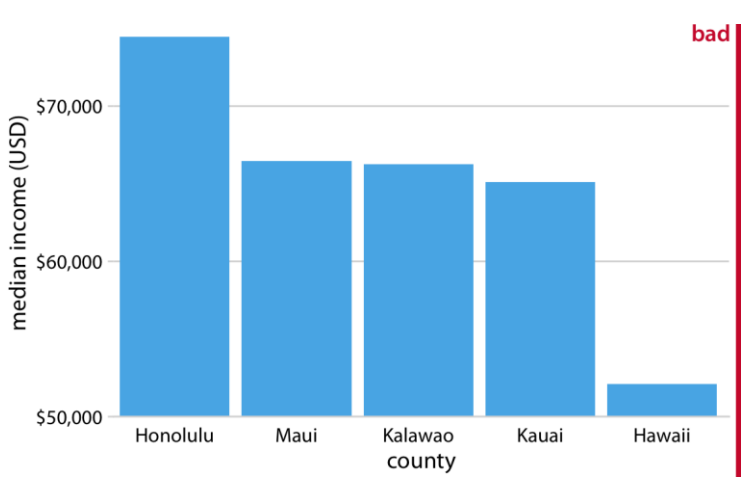


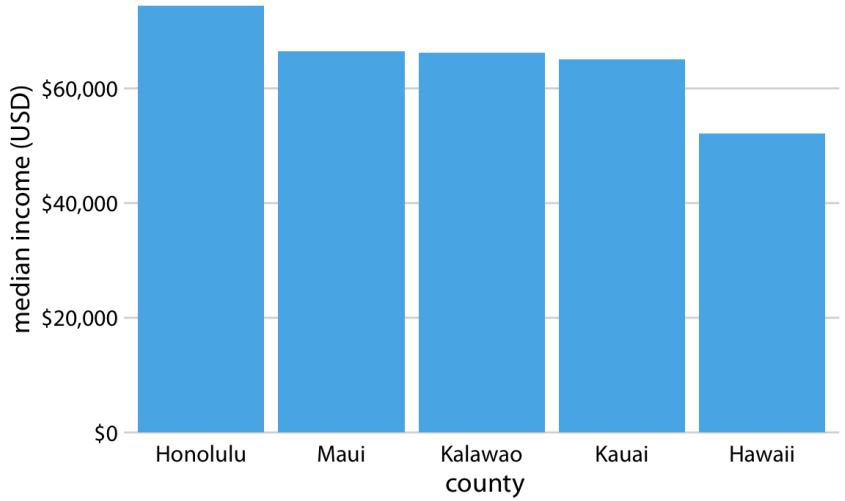
Source: Fundamentals of Data Visualization by Claus O. Wilke

Principle of proportional ink

The sizes of shaded areas in a visualization

need to be proportional to the data values they represent





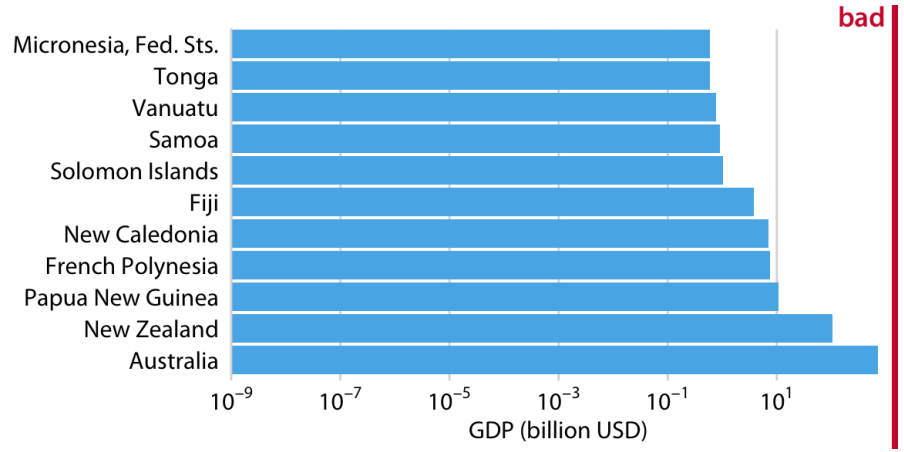
Example with a linear scale

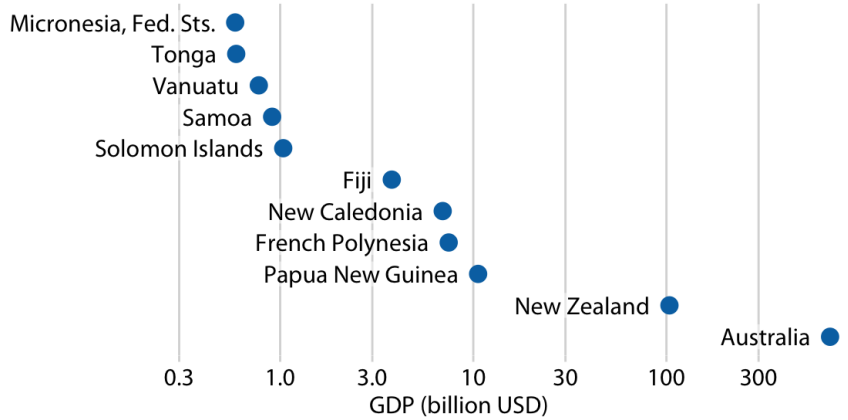
Source: Fundamentals of Data Visualization by Claus O. Wilke

Principle of proportional ink

The sizes of shaded areas in a visualization

need to be proportional to the data values they represent





Example with a logarithmic scale

Source: Fundamentals of Data Visualization by Claus O. Wilke

Accessibility: Mind the c 

lorblind people

3(+1) principles of Color Universal Design

- Choose color schemes that can be easily identified by people with all types of color vision
- Use not only different colors but also a combination of different shapes, positions, line types and coloring patterns, to ensure that information is conveyed to all users
- Clearly state color names where users are expected to use color names in communication
+ Moreover, aim for visually friendly and beautiful designs

This material on accessibility for the colorblind people is based on: https://jfly.uni-koeln.de/color/

Accessibility: Mind the c  lorblind people

How colorblind people see colors?

Non color blind

Protanope
(red cone cells defective)

Deureranope
(green cone cells defective)

Tritanope
(blue cone cells defective)

This material on accessibility for the colorblind people is based on: https://jfly.uni-koeln.de/color/

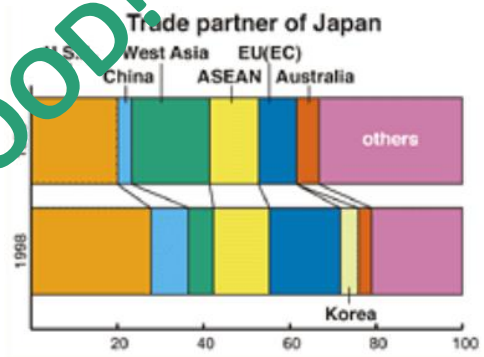
Accessibility: Mind the c  lorblind people

- Depending on the category

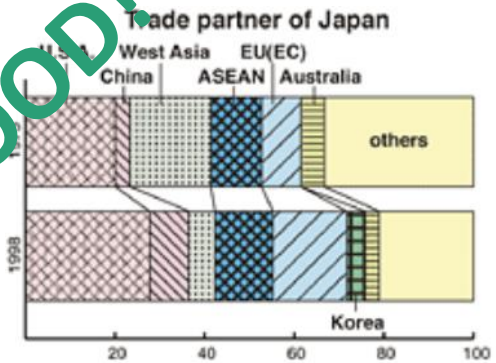
difficulty differentiating different combinations of color-pairs

BAD!

GOOD!



GOOD!



Though Tufte discouraged
This sort of fill!

This material on accessibility for the colorblind people is based on: https://jfly.uni-koeln.de/color/

Accessibility: Mind the c  lorblind people

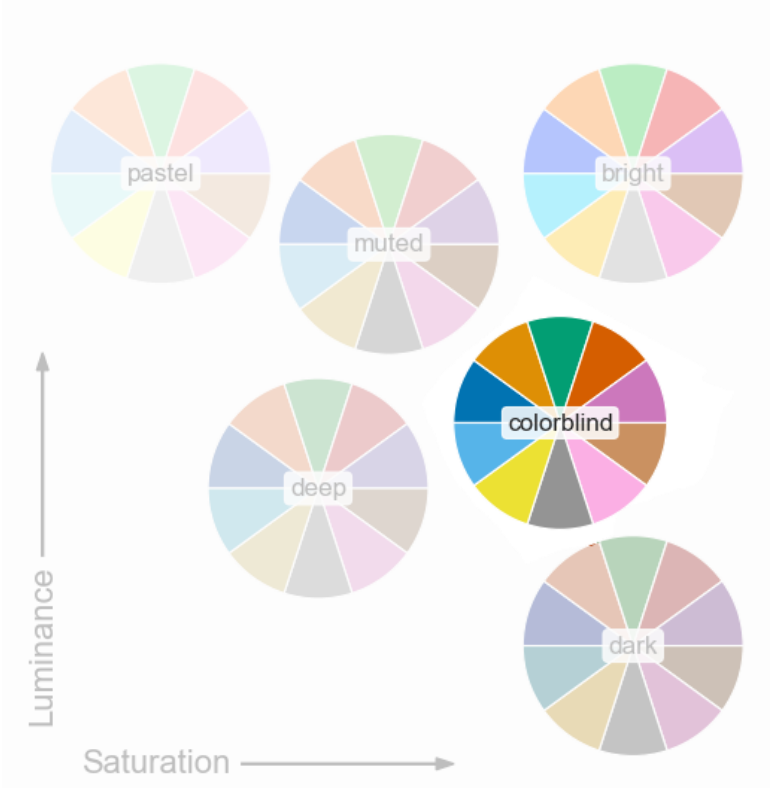
- Set of unambiguous colors for everyone!

	Original	Simulation: Protan	Simulation: Deutan	Simulation: Tritan		Hue	C,M,Y,K (%)	R,G,B (0-255)	R,G,B (%)
1					Black	– °	(0,0,0,100)	(0,0,0)	(0,0,0)
2					Orange	41°	(0,50,100,0)	(230,159,0)	(90,60,0)
3					Sky Blue	202°	(80,0,0,0)	(86,180,233)	(35,70,90)
4					bluish Green	164°	(97,0,75,0)	(0,158,115)	(0,60,50)
5					Yellow	56°	(10,5,90,0)	(240,228,66)	(95,90,25)
6					Blue	202°	(100,50,0,0)	(0,114,178)	(0,45,70)
7					Vermilion	27°	(0,80,100,0)	(213,94,0)	(80,40,0)
8					reddish Purple	326°	(10,70,0,0)	(204,121,167)	(80,60,70)

This material on accessibility for the colorblind people is based on: https://jfly.uni-koeln.de/color/

Accessibility: Mind the c  lorblind people

- Some plotting tools have in-built suitable color palettes



Source: https://**seaborn**.pydata.org/tutorial/color_palettes.html

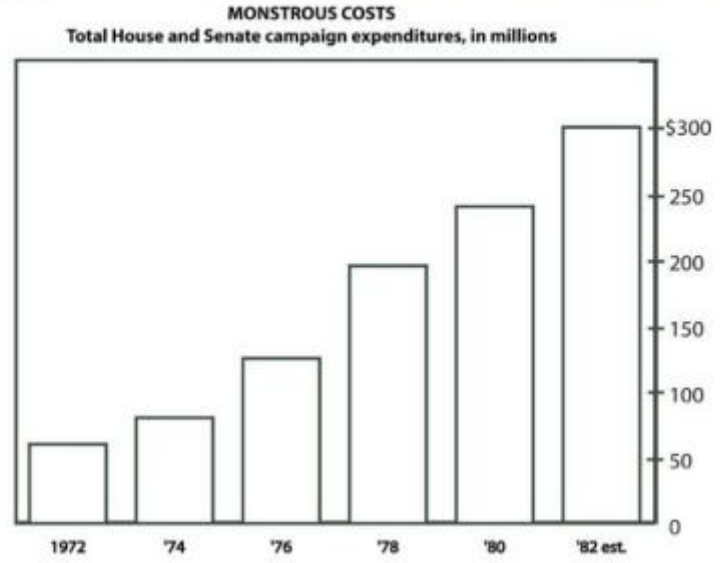
Ungraded task 4.4: Create some visualizations using the `countries of the world' dataset (following the principles we explored in this module), to expose the resulting data you had obtained after cleaning it as per Module 2, ungraded task 2.2.

Share your code & results, and discuss which all principles you tried to follow, and how!

Recommended readings

Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts

Scott Bateman, Regan L. Mandryk, Carl Gutwin,
Aaron Genest, David McDine, Christopher Brooks
Department of Computer Science, University of Saskatchewan, Saskatoon, Saskatchewan, Canada
scott.bateman@usask.ca, regan@cs.usask.ca, gutwin@cs.usask.ca,
aaron.genest@usask.ca, dam085@mail.usask.ca, cab938@mail.usask.ca



http://www.stat.columbia.edu/~gelman/communication/Bateman2010.pdf

Recommended readings

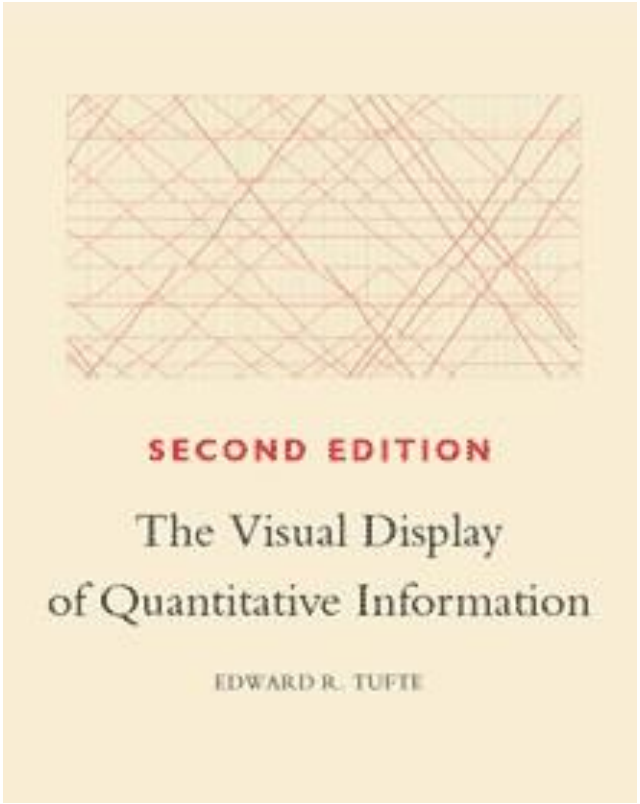
Color Universal Design (CUD)
- How to make figures and presentations that are friendly to Colorblind people -

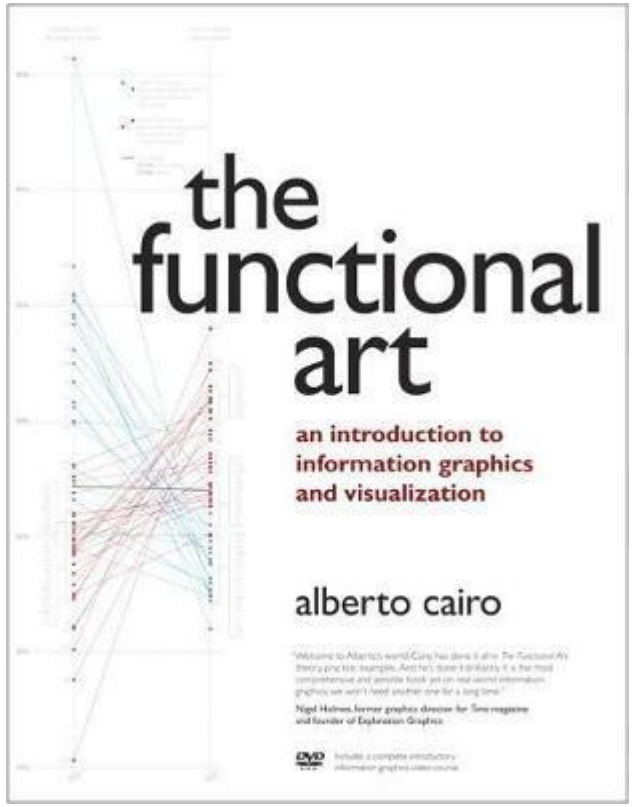
Masataka Okabe
Jikei Medial School (Japan)

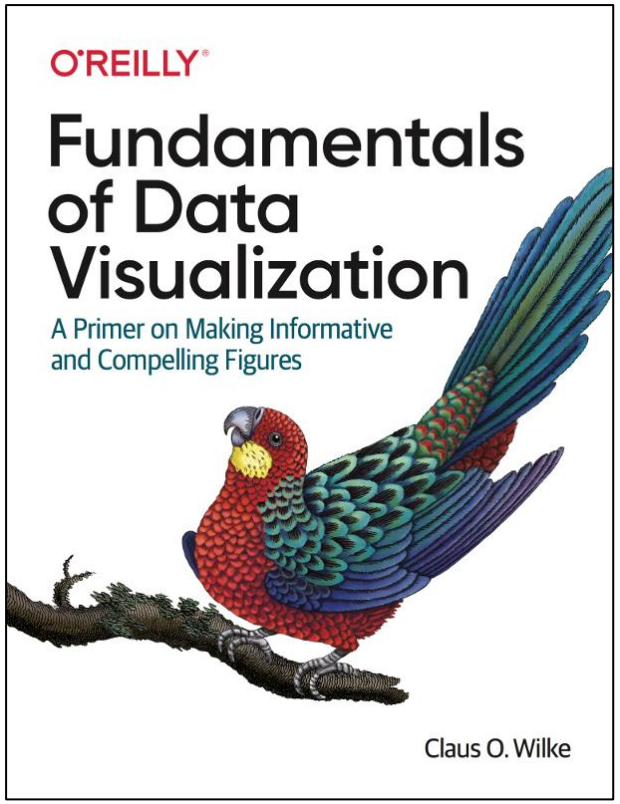
Kei Ito
University of Tokyo, Institute for Molecular and Cellular Biosciences (Japan)

https://jfly.uni-koeln.de/color/

Selected References







https://clauswilke.com/dataviz/

A guide to choose your plot type

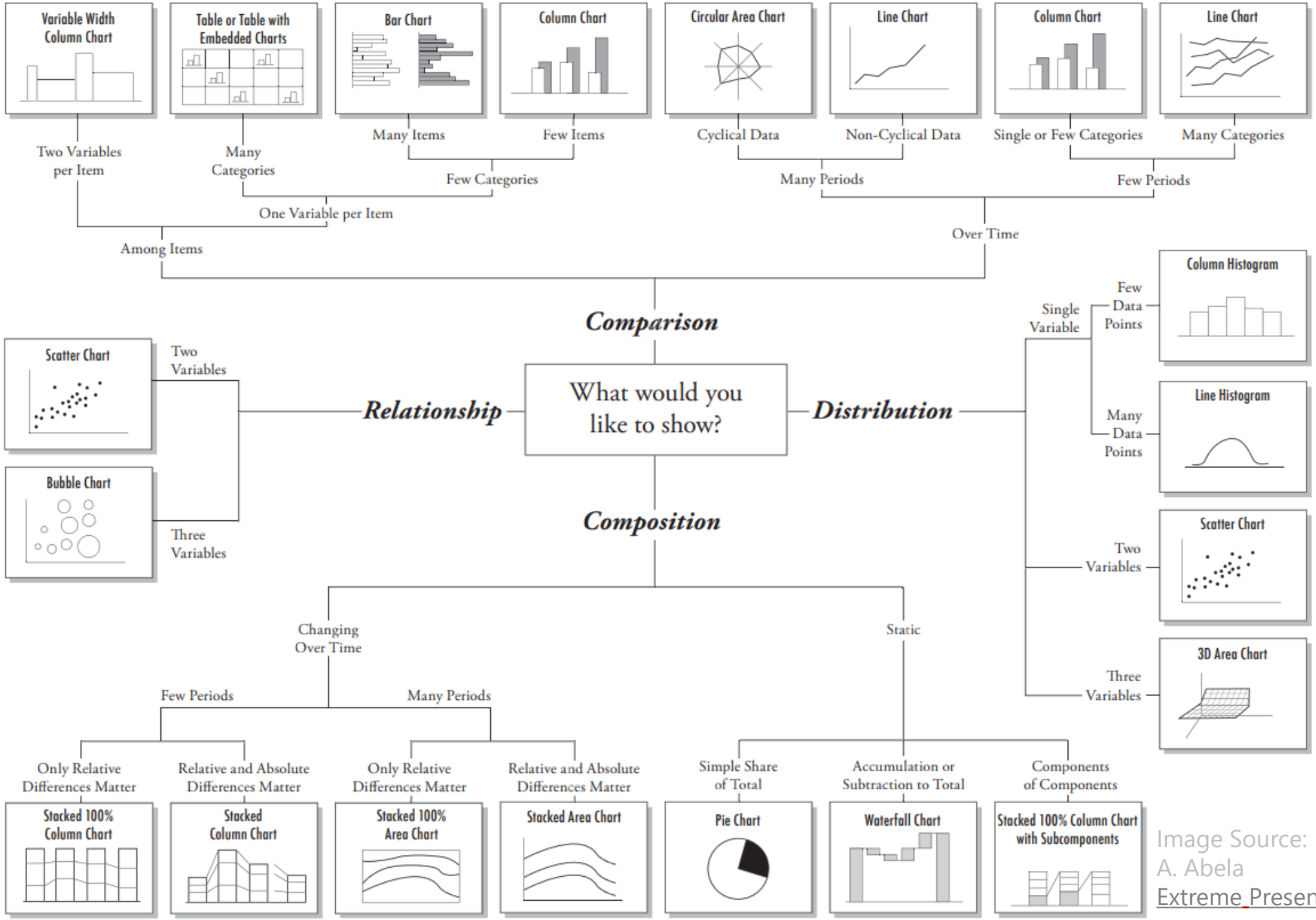


Image Source:
A. Abela
Extreme Presentation