Scientific visualization

Nelle Varoquaux

What is scientific visualisation?

“Visualisation is a method of computing. It transforms the symbolic into the geometric, enabling researchers to observe their simulations and computations. Visualisation offers a method for seeing the unseen. It enriches the process of scientific discovery and fosters profound and unexpected insights.”

Visualisation in Scientific Computing, NSF report, 1987

“For example, about 50 percent of the cerebral cortex of primates is devoted exclusively to visual processing, and the estimated territory for humans is nearly comparable.”

The MIT Encyclopedia of the Cognitive Sciences

Anscombe's quartet, 1973

	x1	x2	x3	x4	y1	y2	y3	y4
1	10.00	10.00	10.00	8.00	8.04	9.14	7.46	6.58
2	8.00	8.00	8.00	8.00	6.95	8.14	6.77	5.76
3	13.00	13.00	13.00	8.00	7.58	8.74	12.74	7.71
4	9.00	9.00	9.00	8.00	8.81	8.77	7.11	8.84
5	11.00	11.00	11.00	8.00	8.33	9.26	7.81	8.47
6	14.00	14.00	14.00	8.00	9.96	8.10	8.84	7.04
7	6.00	6.00	6.00	8.00	7.24	6.13	6.08	5.25
8	4.00	4.00	4.00	19.00	4.26	3.10	5.39	12.50
9	12.00	12.00	12.00	8.00	10.84	9.13	8.15	5.56
10	7.00	7.00	7.00	8.00	4.82	7.26	6.42	7.91
11	5.00	5.00	5.00	8.00	5.68	4.74	5.73	6.89

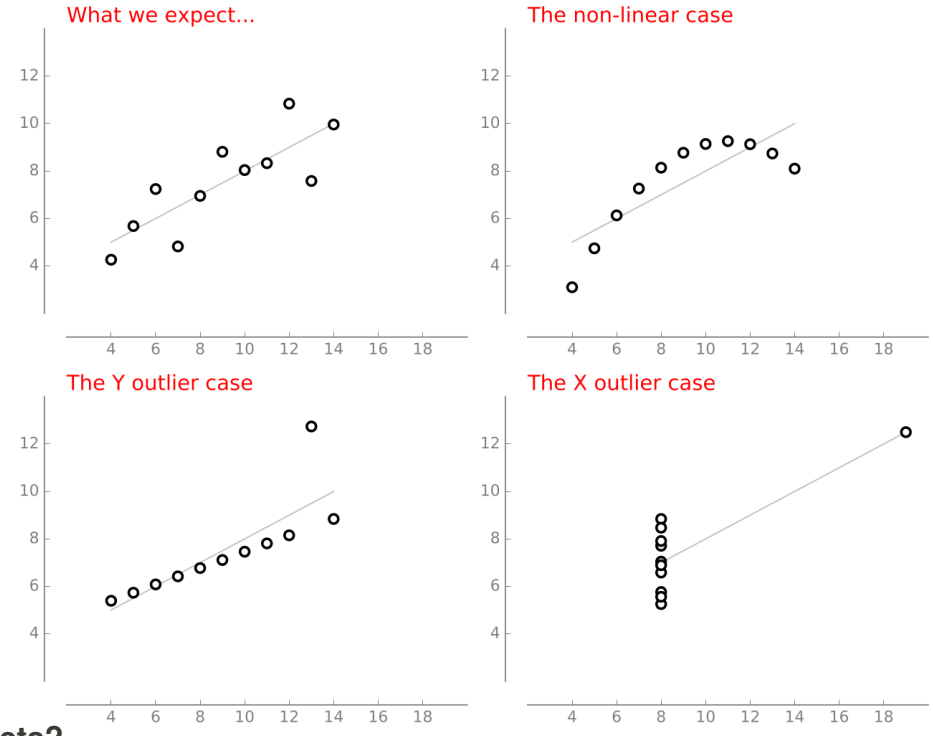
What is common to those data sets?

Mean of x	9
Variance of x	11
Mean of y	7.50
Variance of y	4.12
Linear regression	$y = 3. + 0.5x$
R^2	0.666
p-value	0.0021

"The purpose of computing is insights, not numbers."

Richard Hamming, 1962

Anscombe's quartet, 1973



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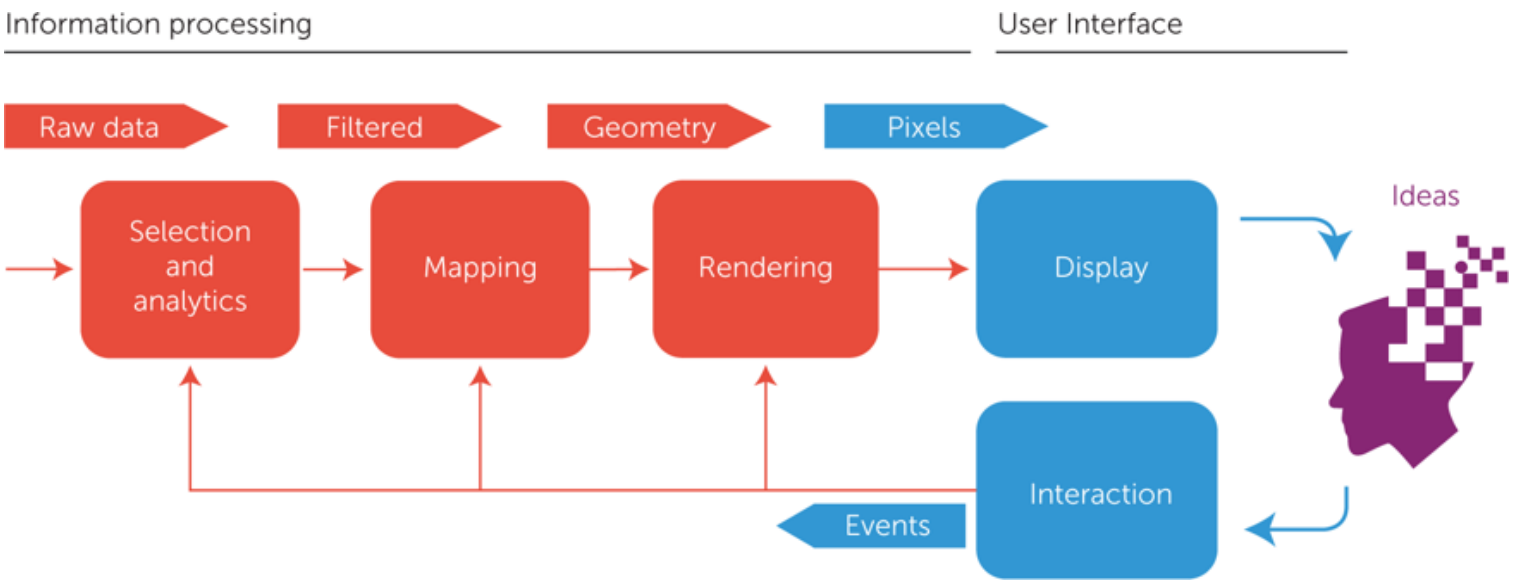
"A computer should make both calculations and graphs"

Francis Anscombe (1918-2001)

Visualization pipeline



Data type

Quantitative: values or observations that can be measured

- Continuous (e.g. temperature)
- Discrete (e.g. number of inhabitants)

Categorical: values or observations that can be sorted into groups or categories

- Nominal (e.g. nationality)
- Ordinal (e.g. months)
- Interval (e.g. age groups)

Graphical elements

A scientific figure can be fully described by a set of graphic primitives with different attributes:

- Points, markers, lines, areas, ...
- Position, color, shape, size, orientation, curvature, ...
- Helpers, text, axis, ticks, ...
- Interaction, animation, ...

But who want to describe each individual elements? Describing a figure in terms of such graphic primitives would be a very tedious and complex task.

This is exactly where visualization libraries are useful because they will automatize most of the work (more or less depending on the library).

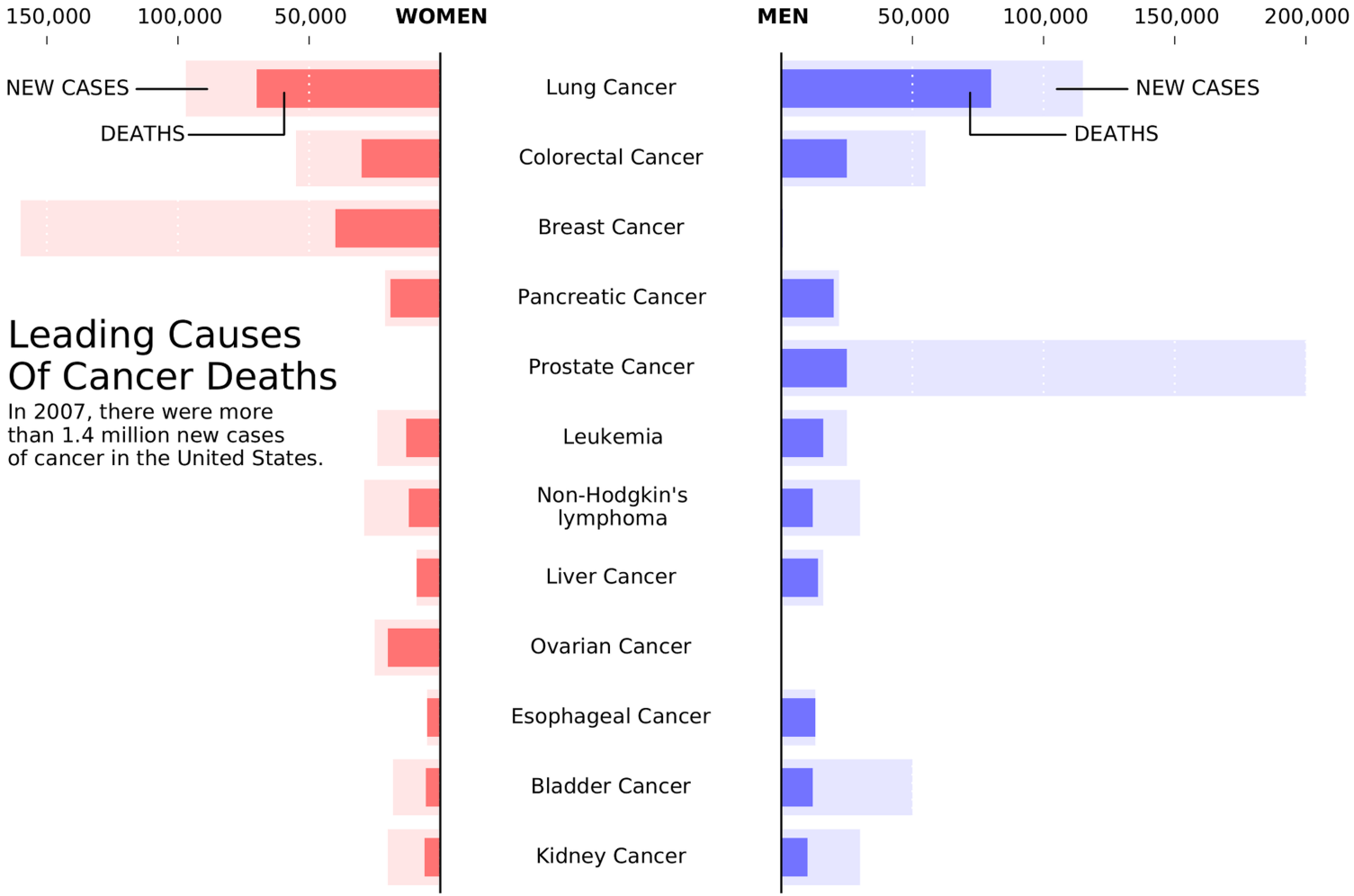
Visualization types

Data Visualisation catalogue by S. Rebecca

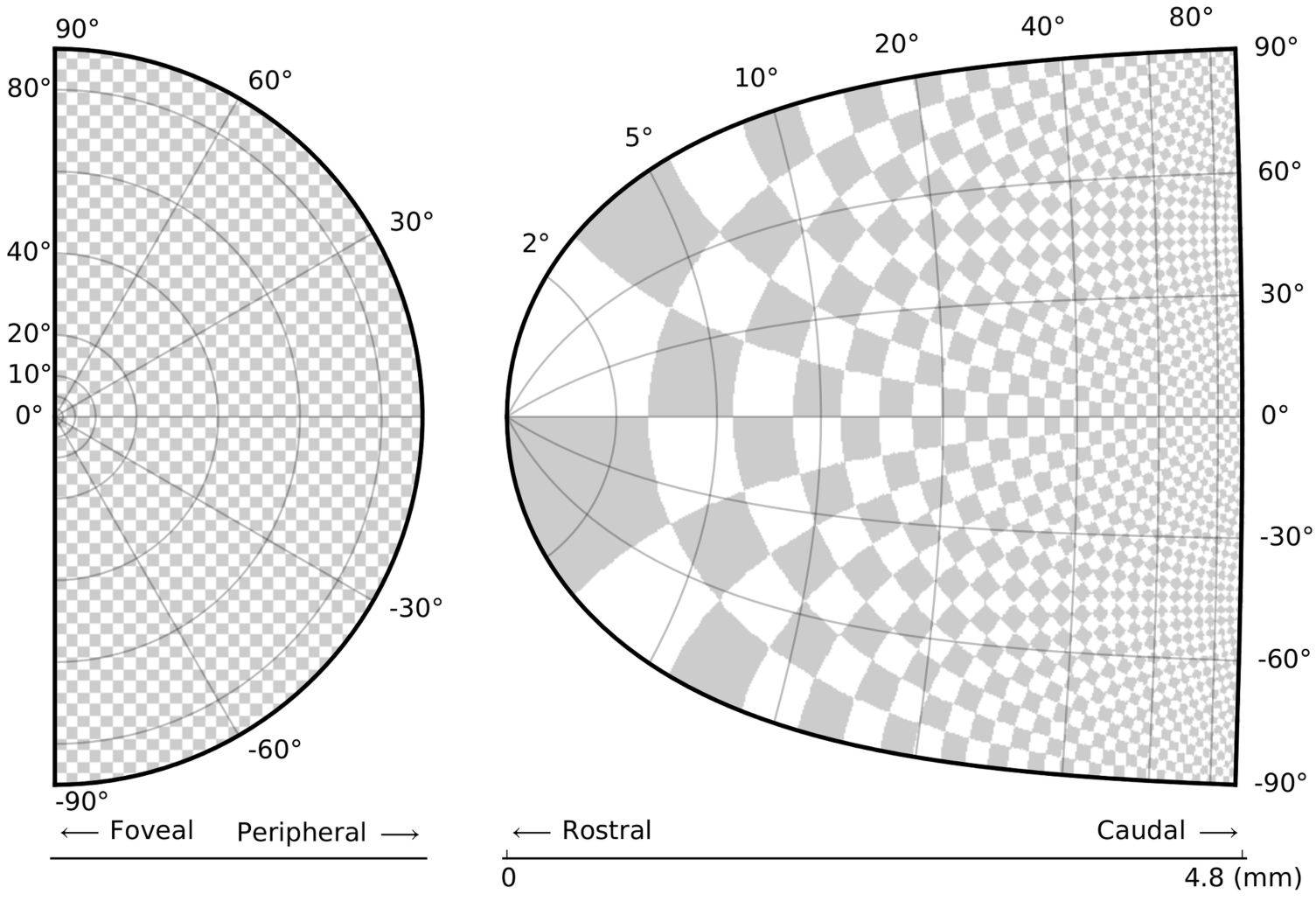
10 Simple Rules for Better Figures

Nicolas Rougier, Mike Droettboom
and Philip Bourne.

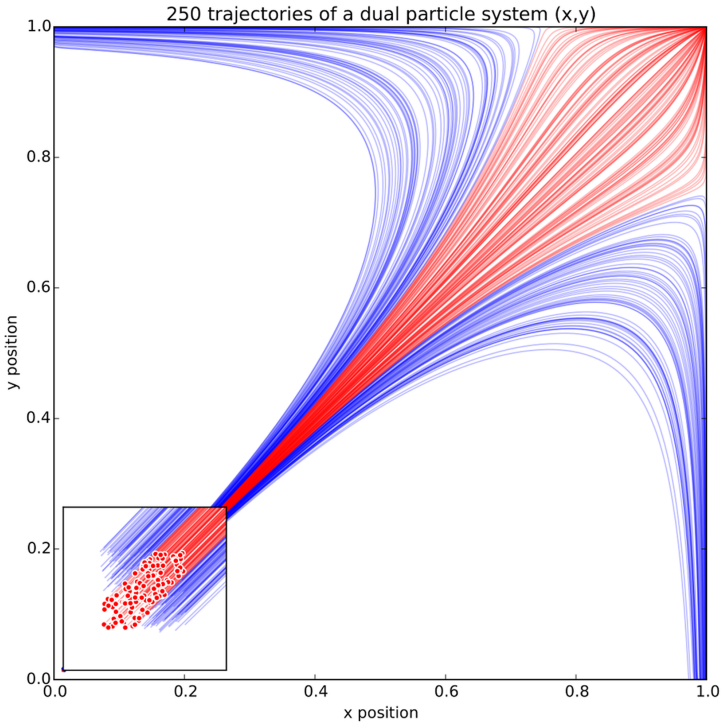
Rule 1: Know your audience

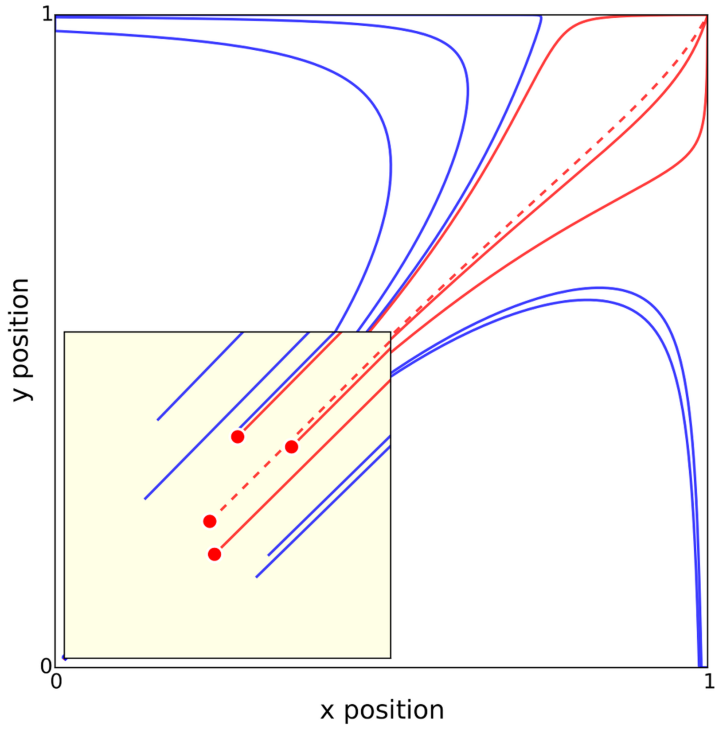


Rule 2: Identify your message

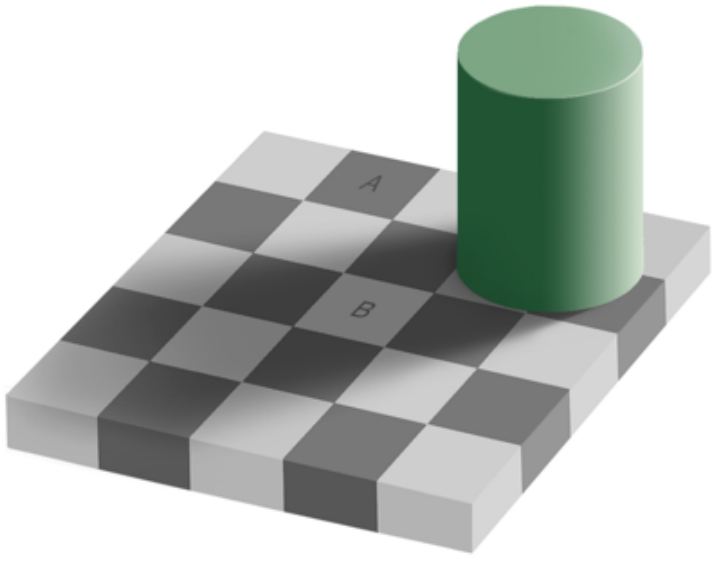


Rule 3: Adapt the figure

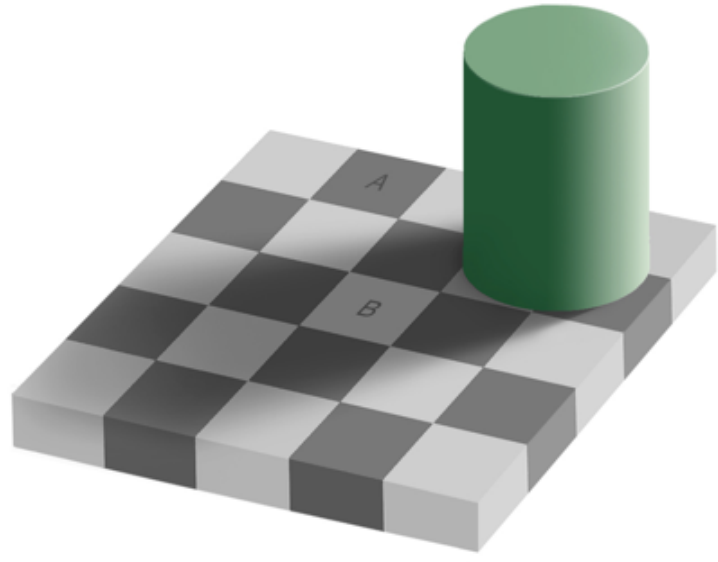




Rule 4: Captions are not optional

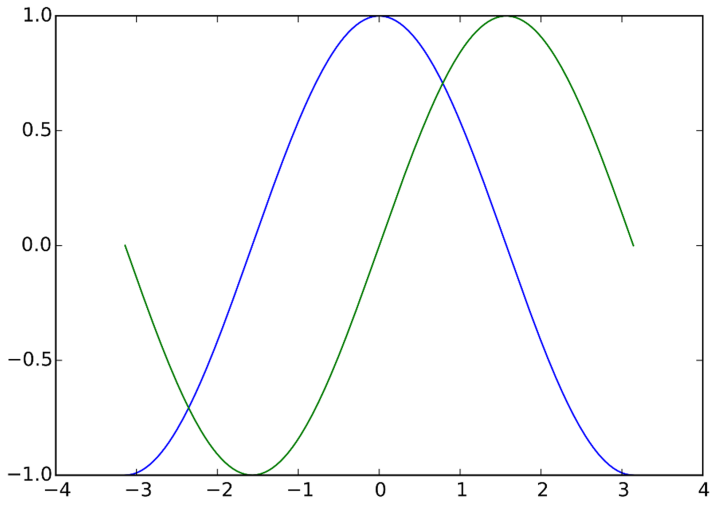


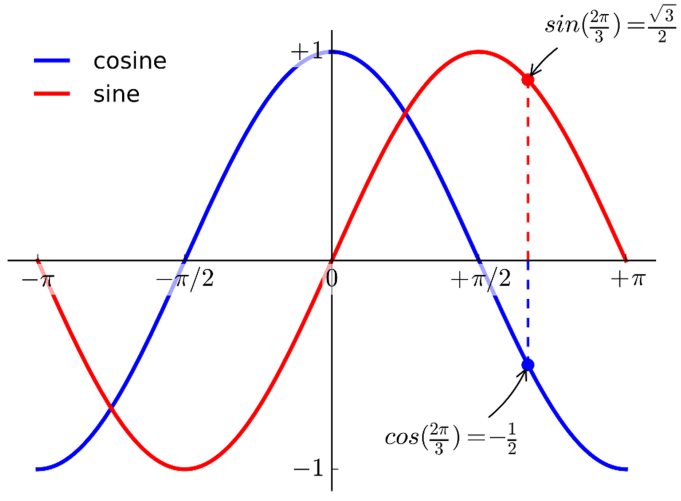
Optical Illusion



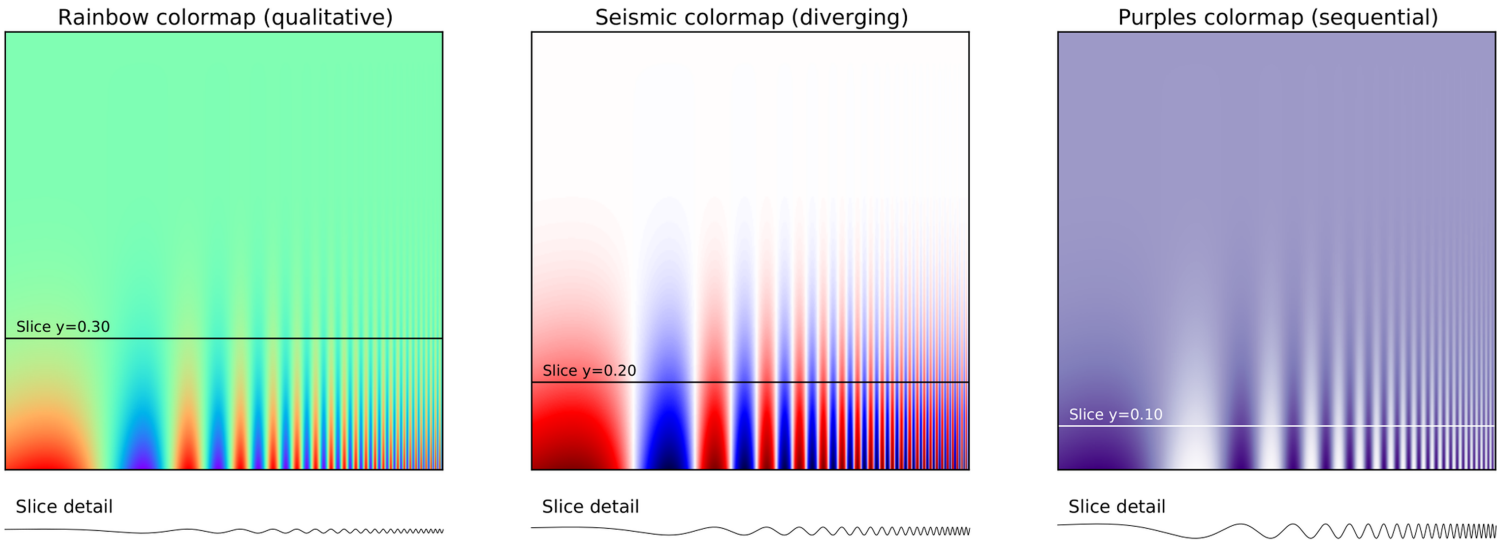
The A and B patches are actually the same color even though we perceived them at being different color.

Rule 5: Do not trust the defaults



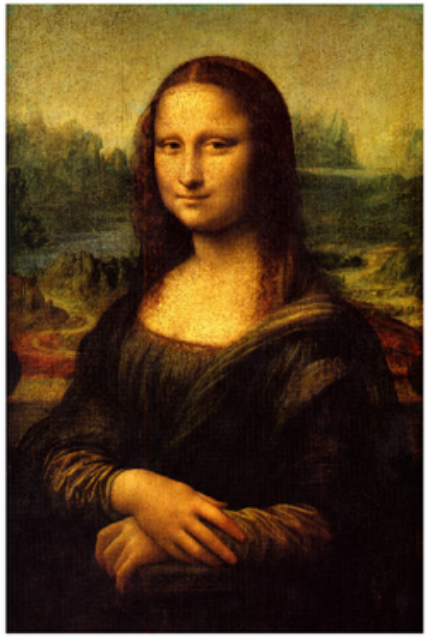


Rule 6: Use color efficiently

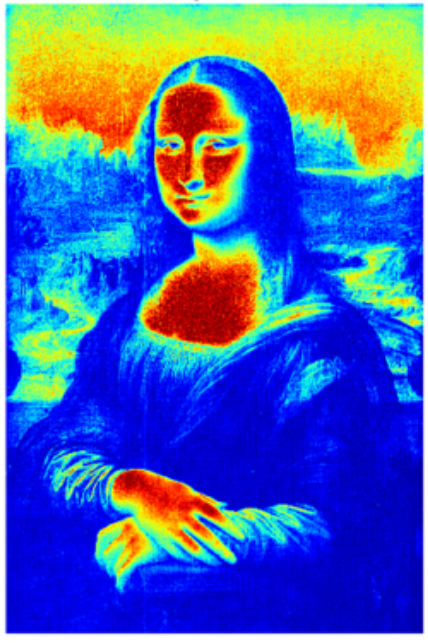


Rule 6b: Above all, do no harm!

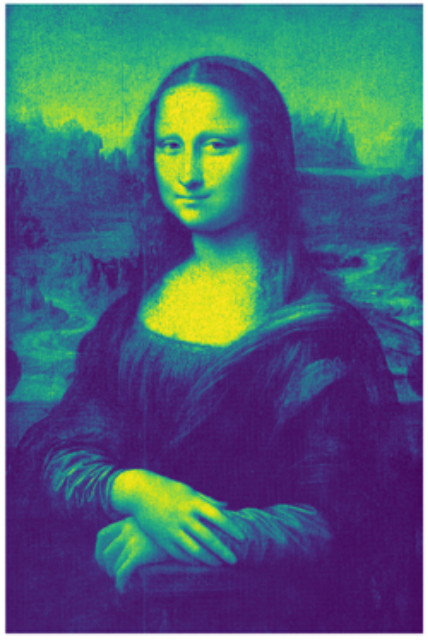
Colour



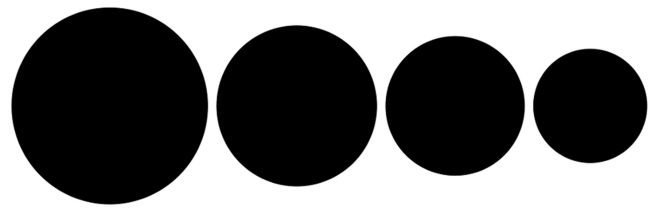
Jet



Viridis

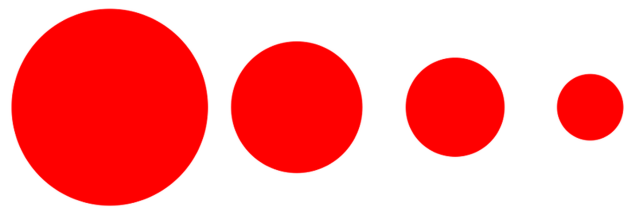


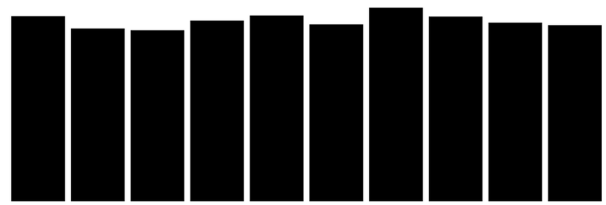
Rule 7: Do not mislead the reader



Relative size using disc area

Relative size using disc radius

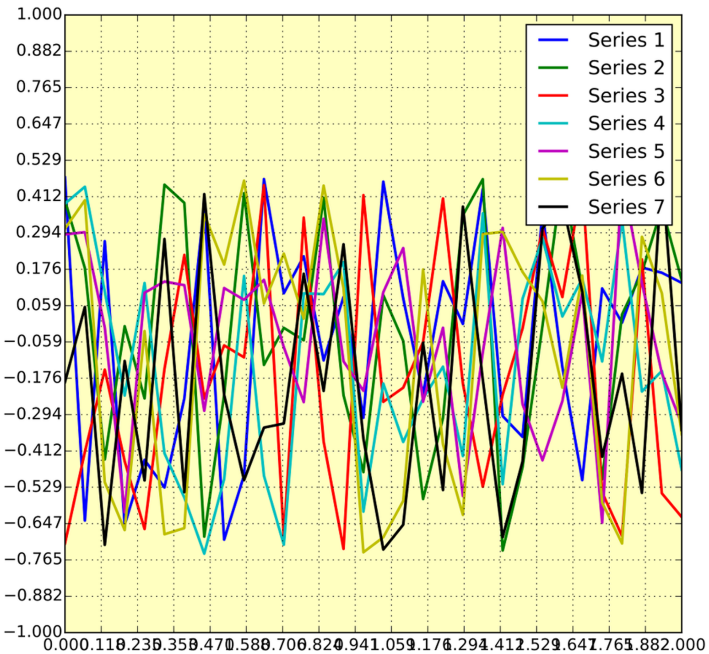


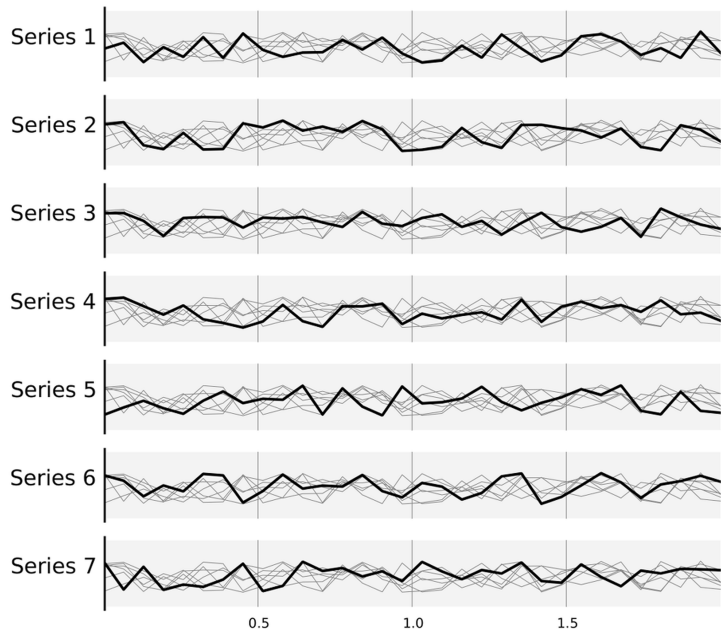


Relative size using full range

Relative size using partial range

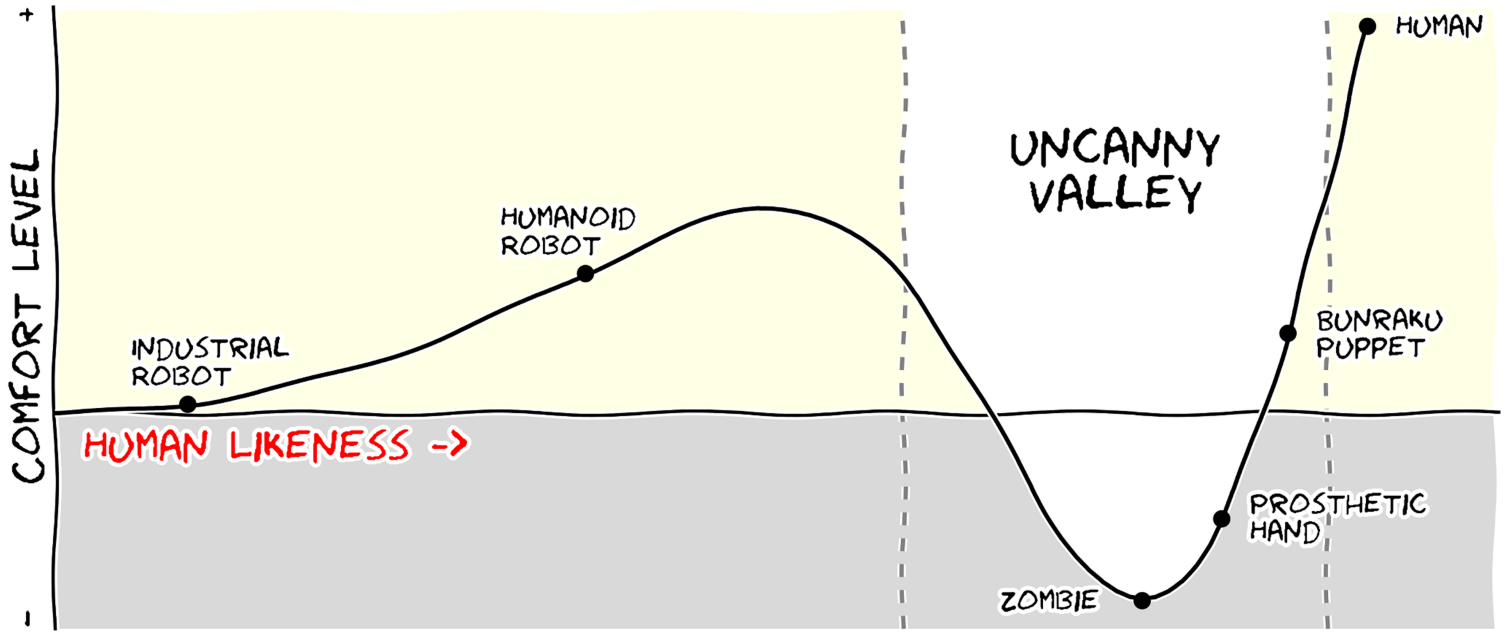
Rule 8: Avoid “chart junk”





Rule 8b: Less is more

Rule 9: Message trumps beauty



Rule 10: Get the right tool

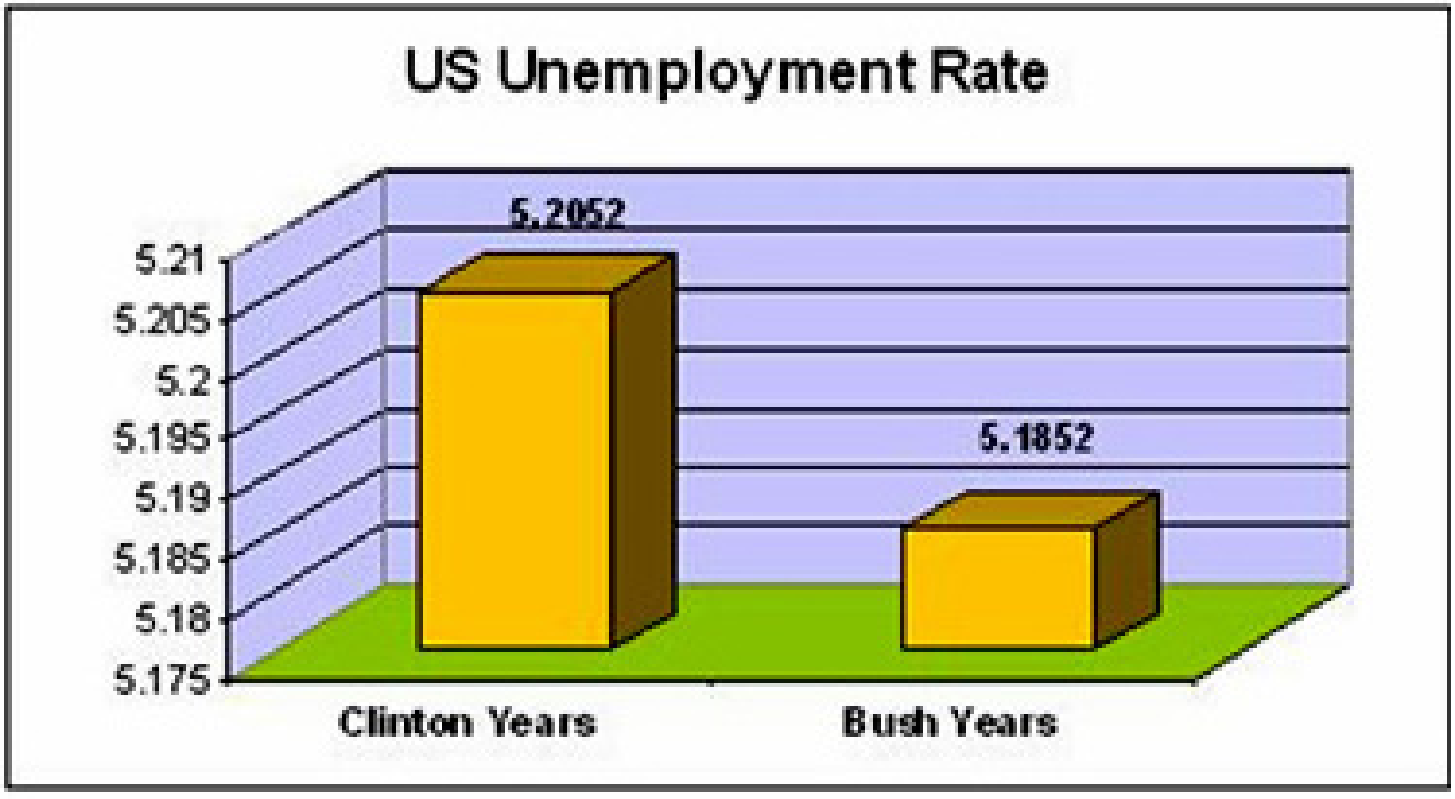
- PDFCrop (remove white borders)
  http://pdfcrop.sourceforge.net
- GraphViz (easy graph)
  http://www.graphviz.org
- ImageMagick (scripted image processing)
  http://www.imagemagick.org/script/index.php
- Gimp (bitmap image manipulation)
  https://www.gimp.org
- Inkscape (vector image manipulation)
  https://www.inkscape.org
- Tikz (scripted vector art)
  http://www.texample.net/tikz/examples/all/
- And many, many, many others

Enough theory, let's practice!

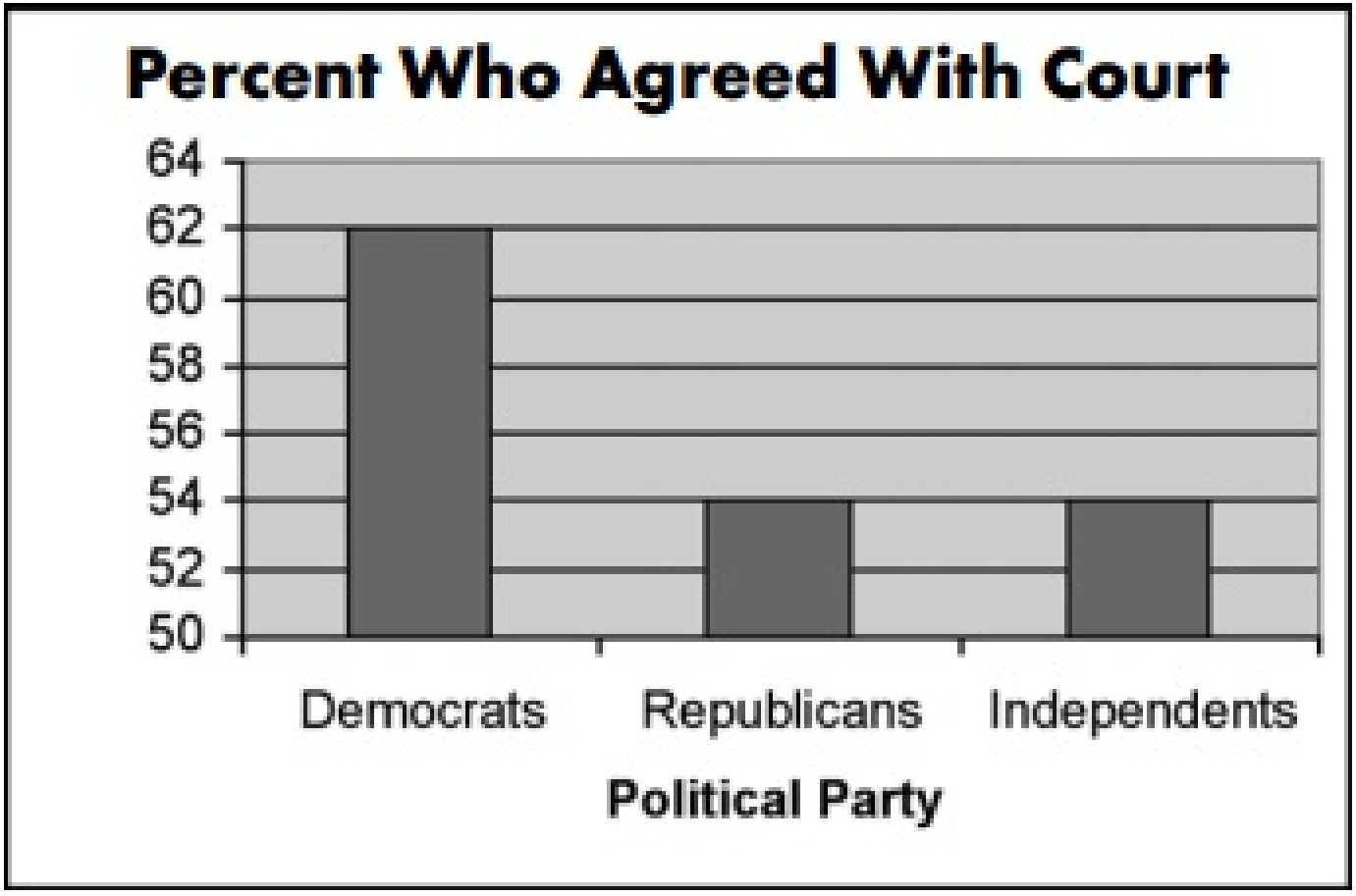
`https://www.stat.berkeley.edu/~nelle/teaching/2017-visualization/README.html`

Examples of misleading figures

Misleading figures



Misleading figures



Misleading figures