BLG 374E

Technical Communication for Computer Engineers

Week 8

Graphics

Lecture Notes

I'll be using lecture notes prepared by earlier instructors, including Esbie van Heerden, Damien Jade Duff, and probably others (though I may revise them).

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Lecture Contents:

- When to use what.
- Chart tips.
- Figures & text.
- Showing uncertainty.
- Table tips.
- Exercise.

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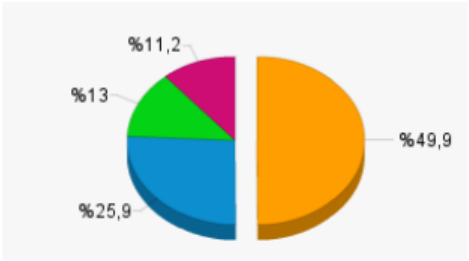
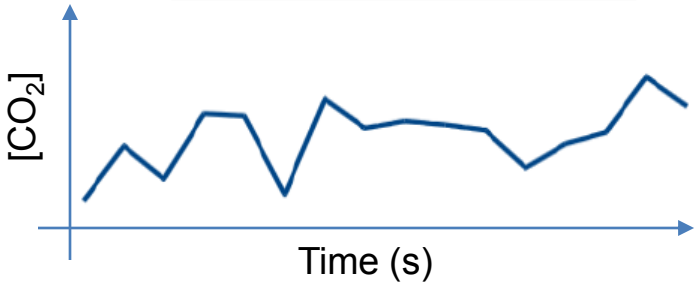
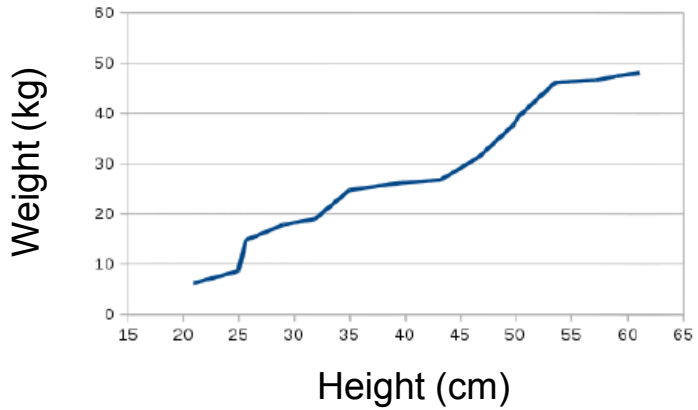
When to use what (usually)



- Pie charts: Numbers are part of a total.
  - Example: % votes.



- Line charts: there is a trend.
  - Example: CO2 concentration over time.



- Line charts: there is a continuous relationship.
  - Example: Weight v. height.

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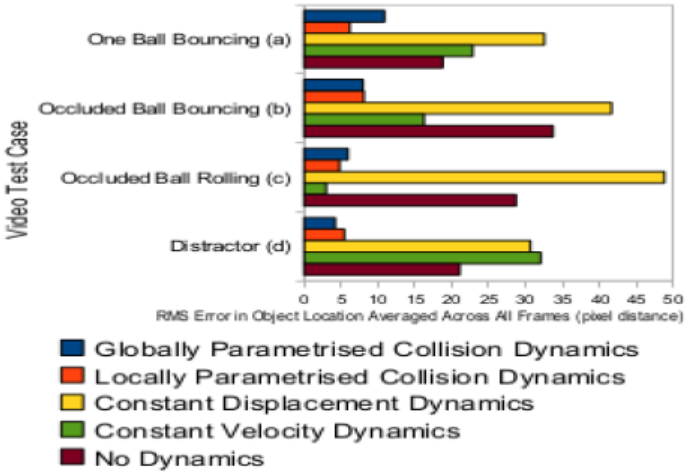
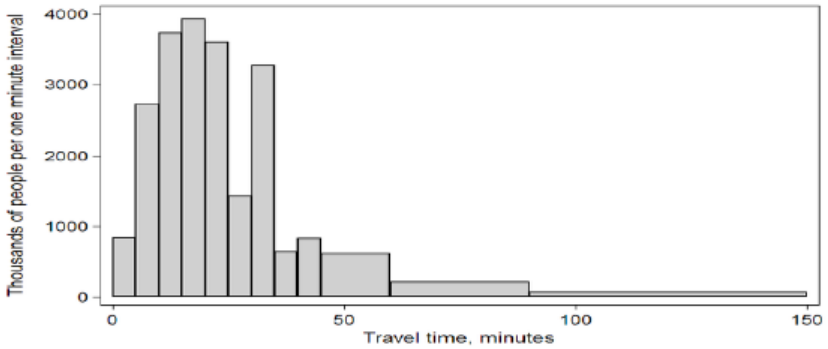
When to use what

- Column charts:
  - Discrete/ordinal categories.



- Histograms:
  - When the area of the bar has meaning.



https://en.wikipedia.org/wiki/Histogram

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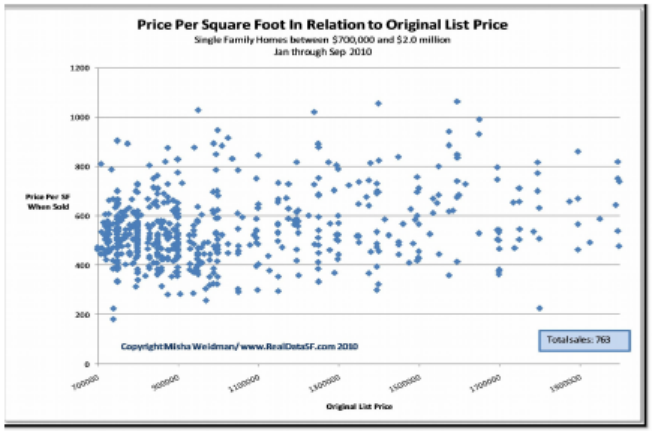
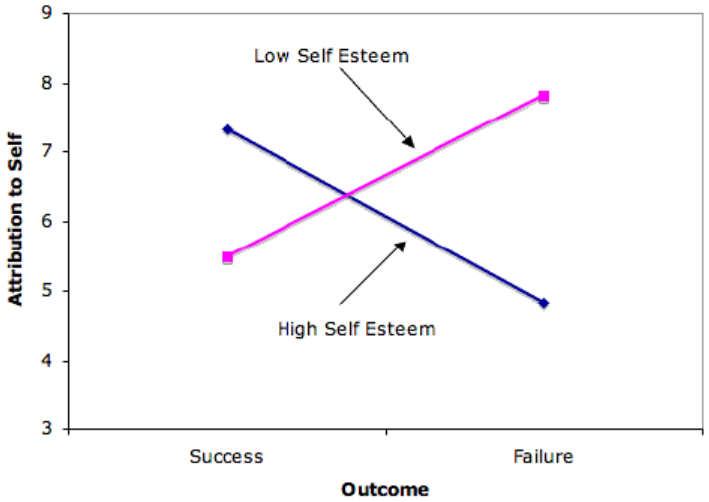
Other chart examples



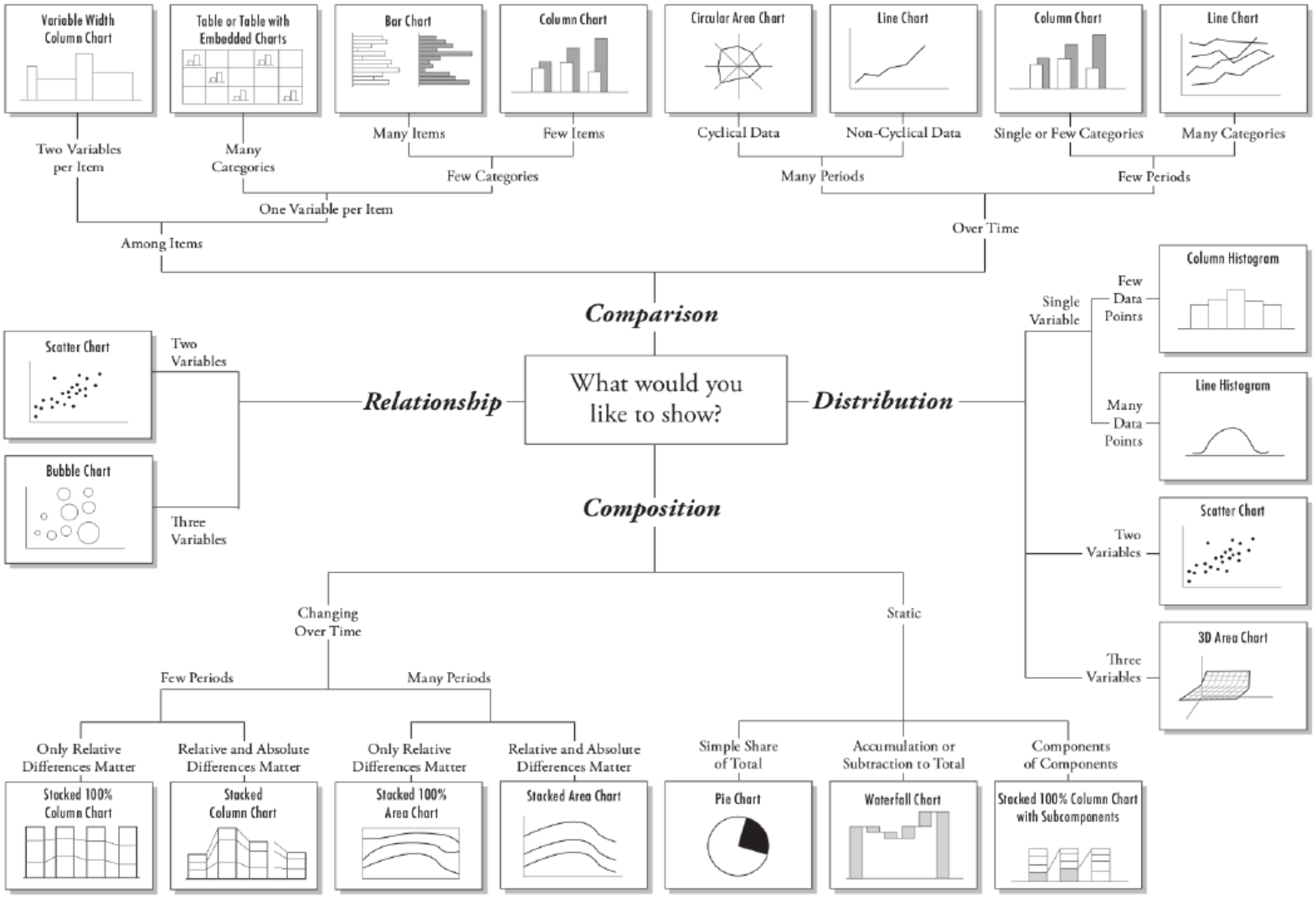
- Scatter plot.



- Line chart showing interactions.

Sources:
http://onlinestatbook.com/2/analysis_of_variance/multiway.html
http://www.mymarketresearchmethods.com/types-of-charts-choose/

Chart Suggestions—A Thought-Starter



See also http://labs.juiceanalytics.com/chartchooser/index.html

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What chart to use for?

- Number of participants aged 0-10,10-20,20-30,30-50,50-100?
- Performance of a solution over multiple datasets?
- Performance of a usability task over time?

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Always give a title and/or caption.

- Figure should be self-contained.
- Answer:
  - *"What is this about?"*
  - *"What does this mean?"*

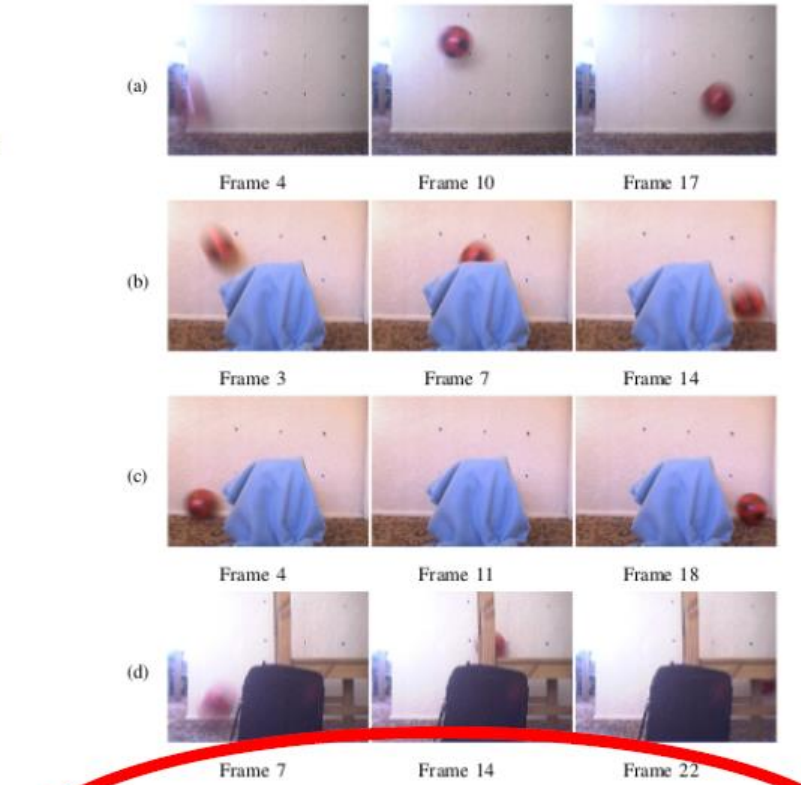

Fig. 3. Image sequences used to test 2D motion estimation. (a) A ball bounces across the field of view with glare, blur. (b) A ball bounces across the field of view, occluded by a stationary object mid-sequence. (c) A ball rolls across the field of view, again occluded by a stationary object. (d) A ball bounces across the field of view, with blur, glare, partial and full occlusion, and in the presence of a strong distractor.

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Figures should be self-explanatory

Readers will want to scan figures first.

→ Sometimes the captions need to be long.

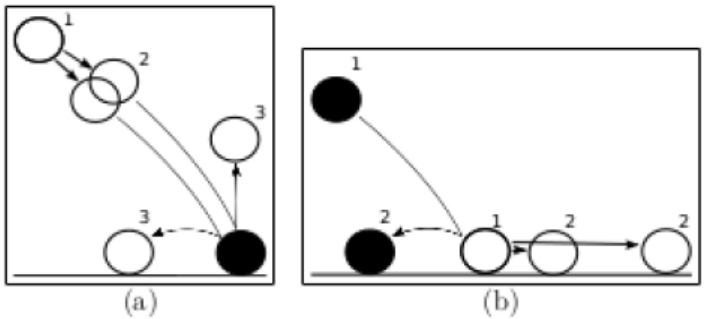

Figure 5.9: **Illustration (a)** illustrates how nonlinearity combined with some permuting noise can lead to large changes in reconstructed trajectory due to the nonlinearity of the dynamics model. If observations at time points 1 and 2 are used to calculate the trajectory of a ball and some permuting noise added to the observation at time 2 different resulting positions at time point 3 and later can be found. **Illustration (b)** shows one of many scenarios where a bad model fit can lead to incorrect reconstructed trajectory. If a trajectory is reconstructed incident on a stationary ball, that ball may roll different

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Always label axes

"What does this number mean?"

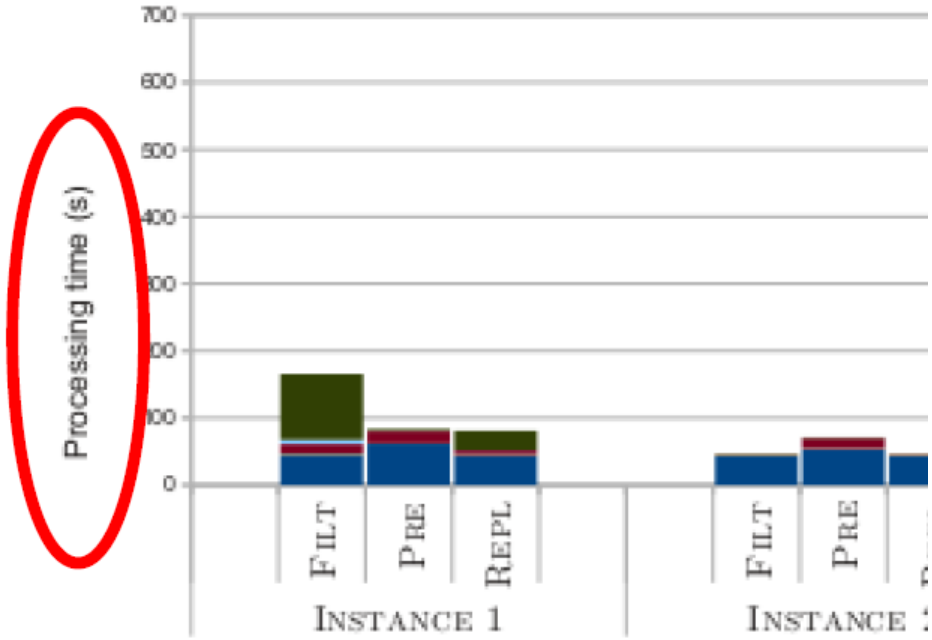

Fig. 3. Empirical computation time for compu

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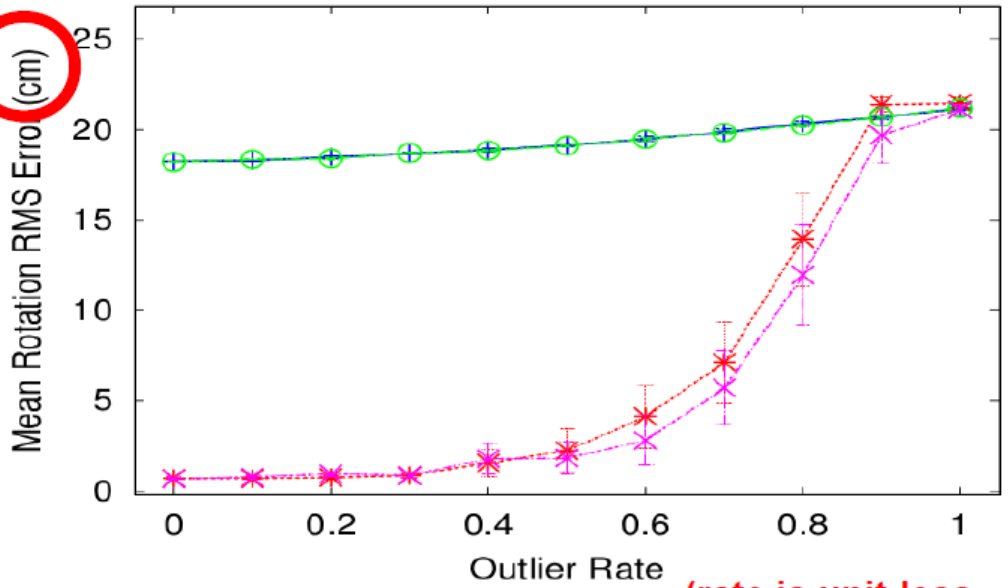
Always put units in figures and tables

"Is this 500 metres or 500 seconds?"



(rate is unit-less – 0 to 1)

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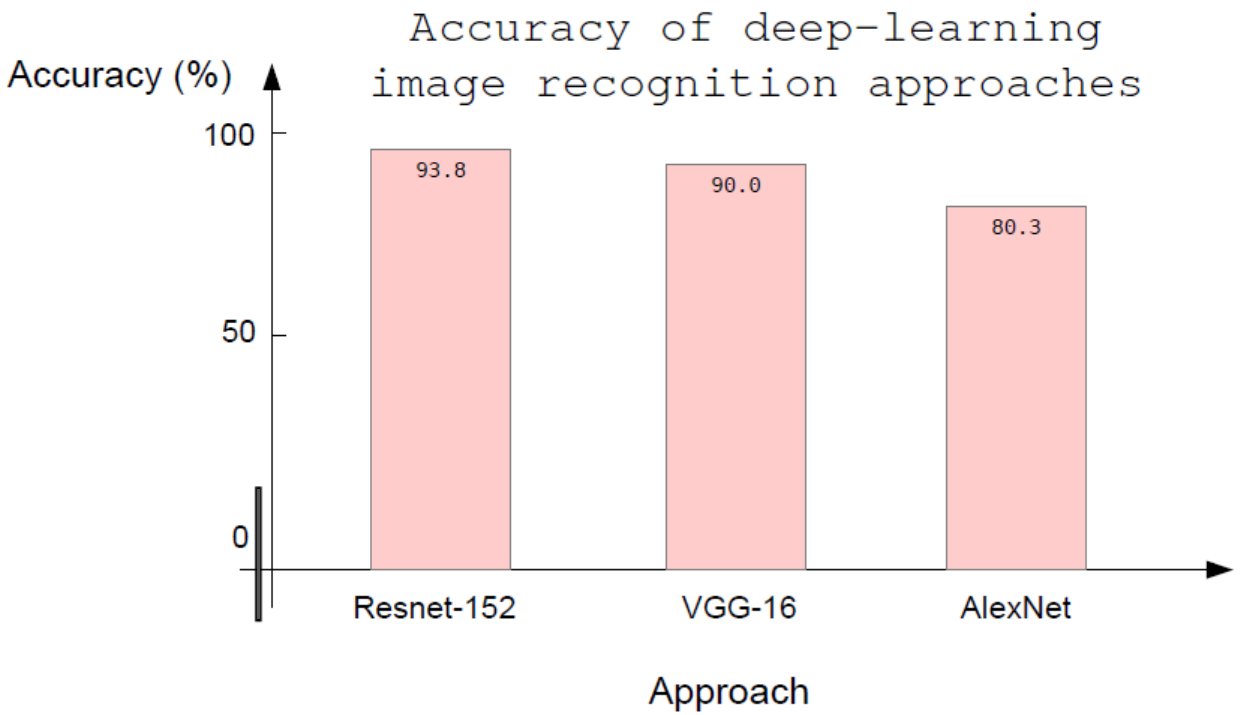
Axis scaling: Is this OK?



OK

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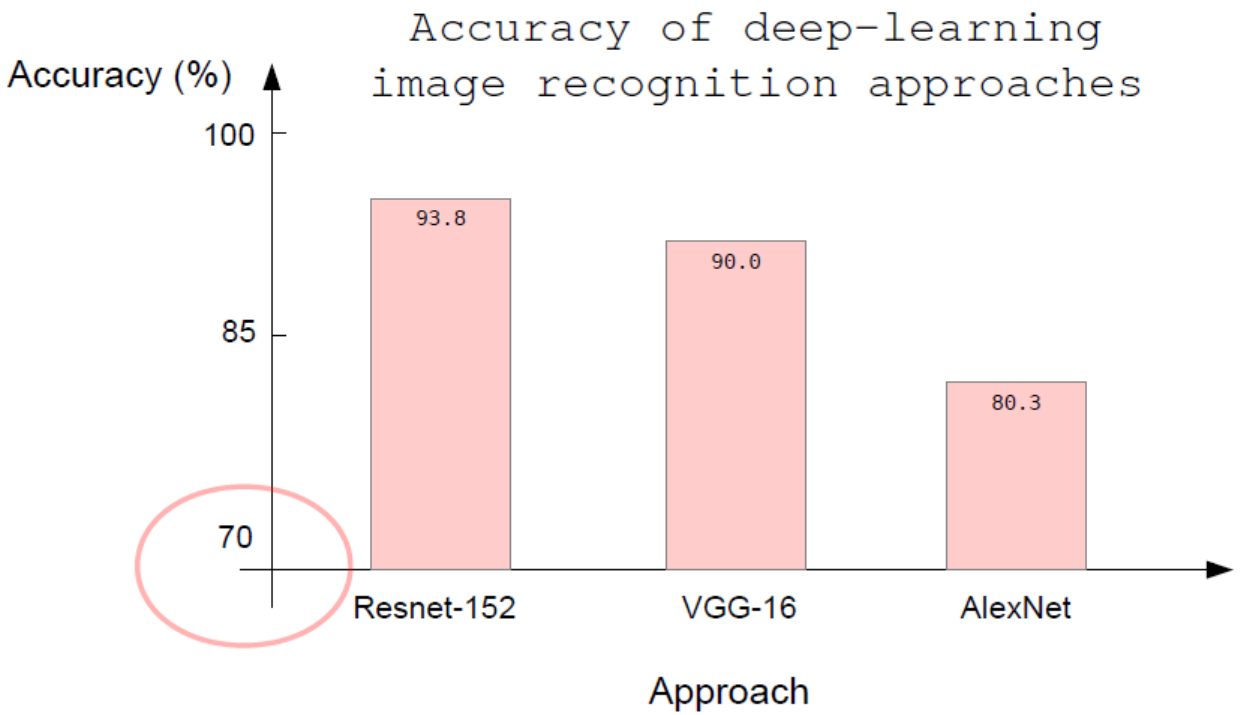
Axis scaling: Is this OK?



NOT OK

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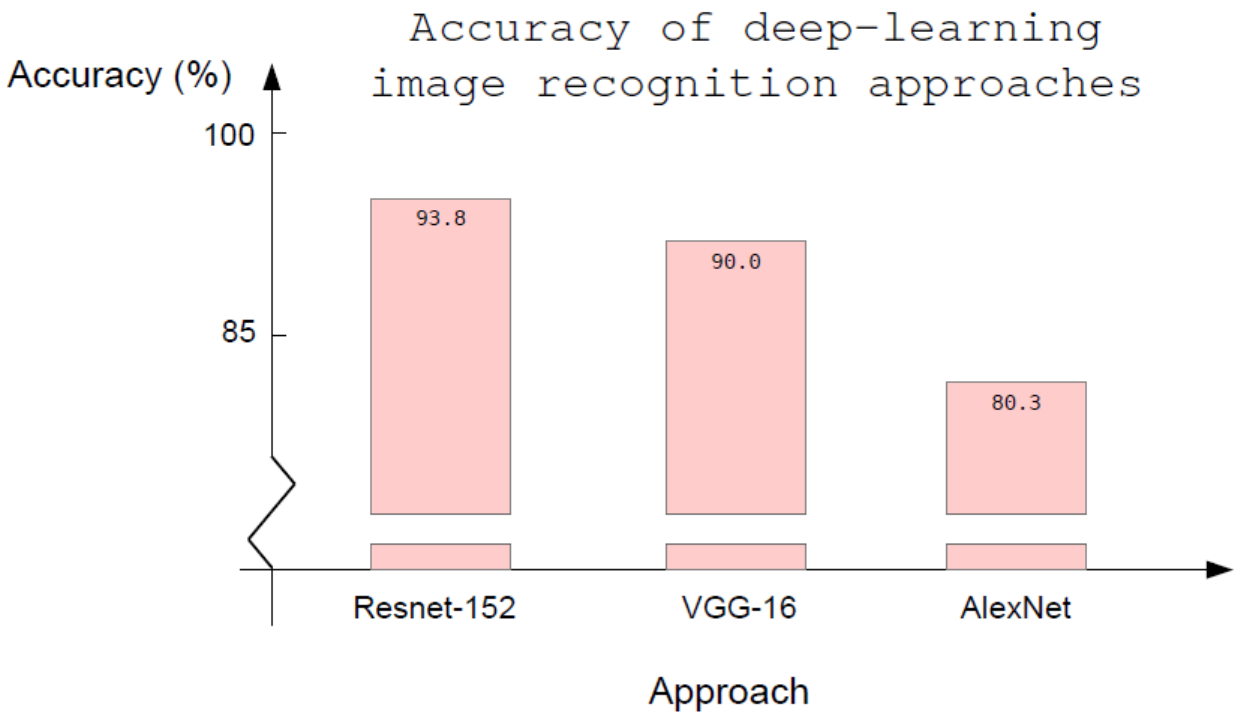
Axis scaling: Is this OK?



OK

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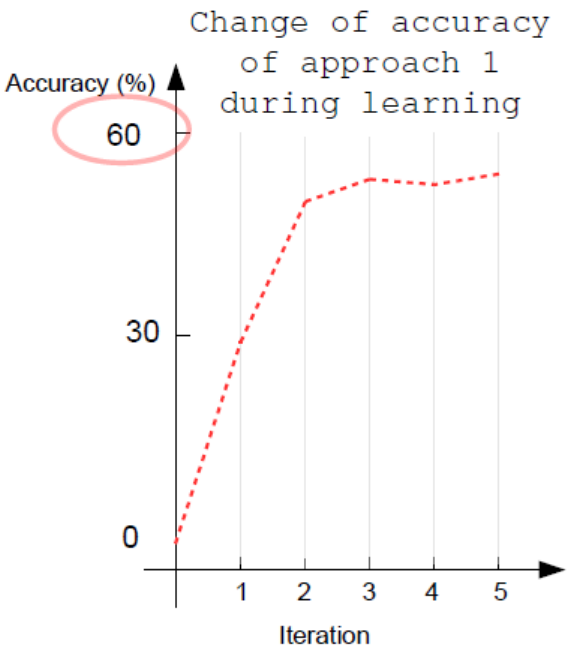
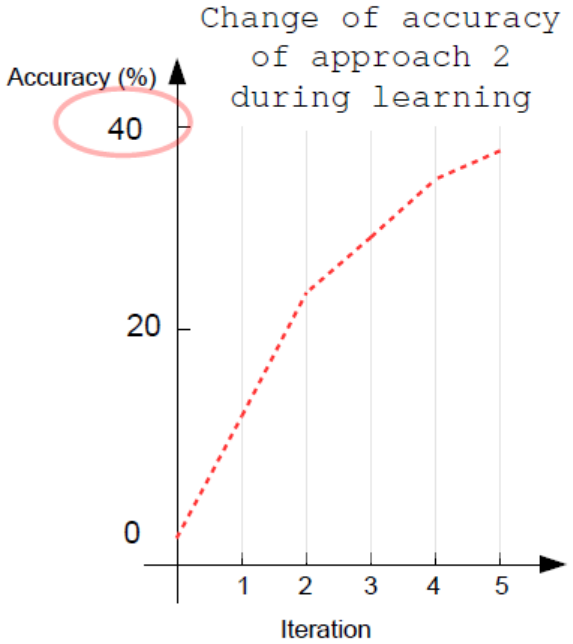
Axis scaling: Is this OK?





NOT OK

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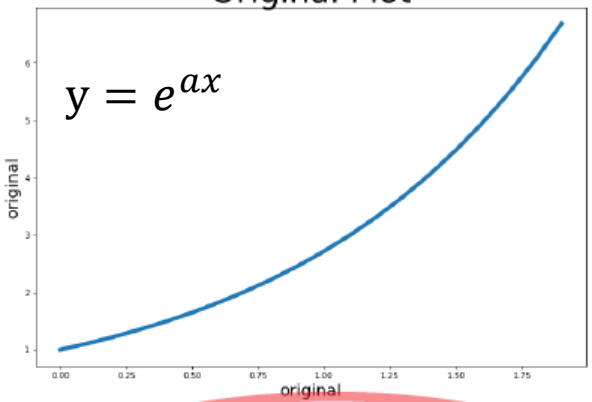
When to use a log scale?

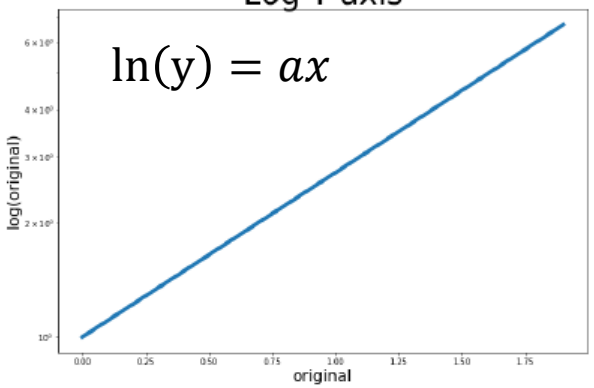
Original Plot

$y = e^{ax}$



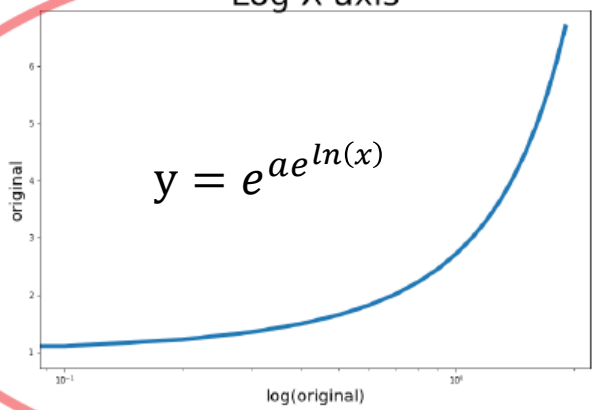
Log Y axis

$\ln(y) = ax$



Log X axis

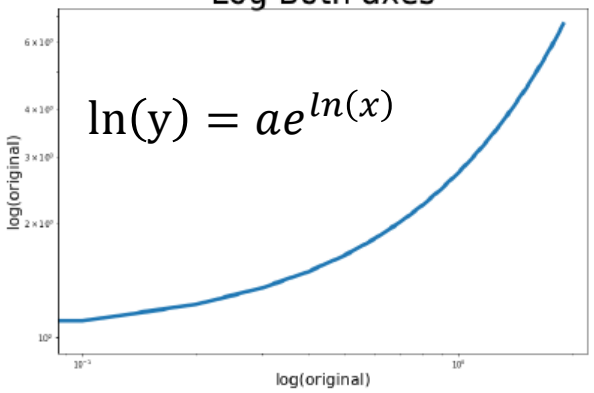
$y = e^{ae^{ln(x)}}$



Oops

Log Both axes

$\ln(y) = ae^{ln(x)}$



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Figures and text

- Give figures & tables a figure number.
- Refer to number in text.

- "Which figure is meant here?"
- "Where can I find more about this figure?"

Example of figure numbering

taken to be the Dirac delta $K(\boldsymbol{a}) = \delta(\boldsymbol{a})$[3]. This means that the approximated probability distribution has finite support[4].

Figure 6.2 contains a pictorial representation of such a set of particles.

Thus, the probability distribution over the current state given all observations to

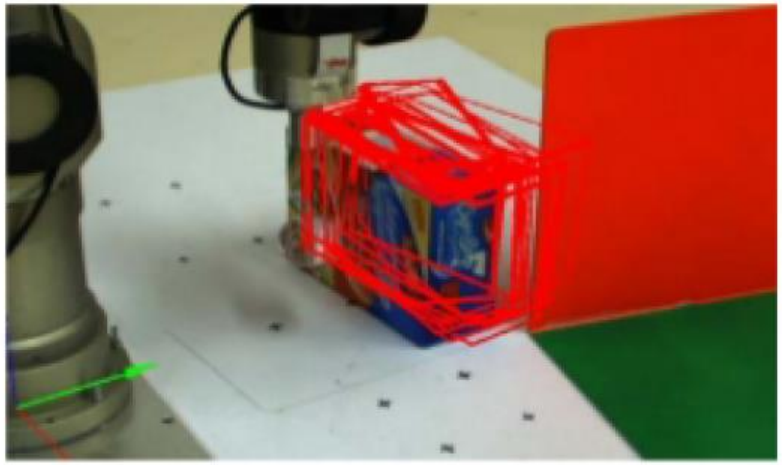

Figure 6.2: A pictorial representation of 20 particles representing 20 hypothesis poses.

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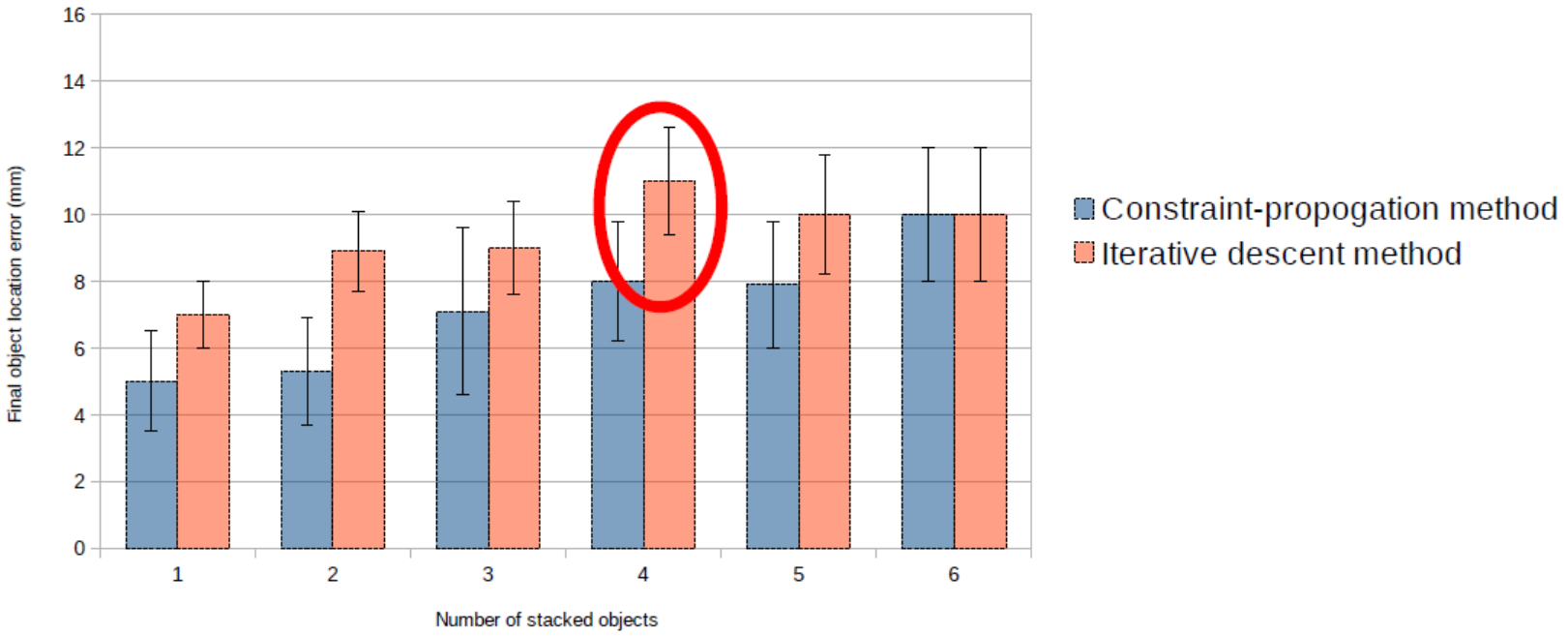
Showing uncertainty with charts: confidence interval

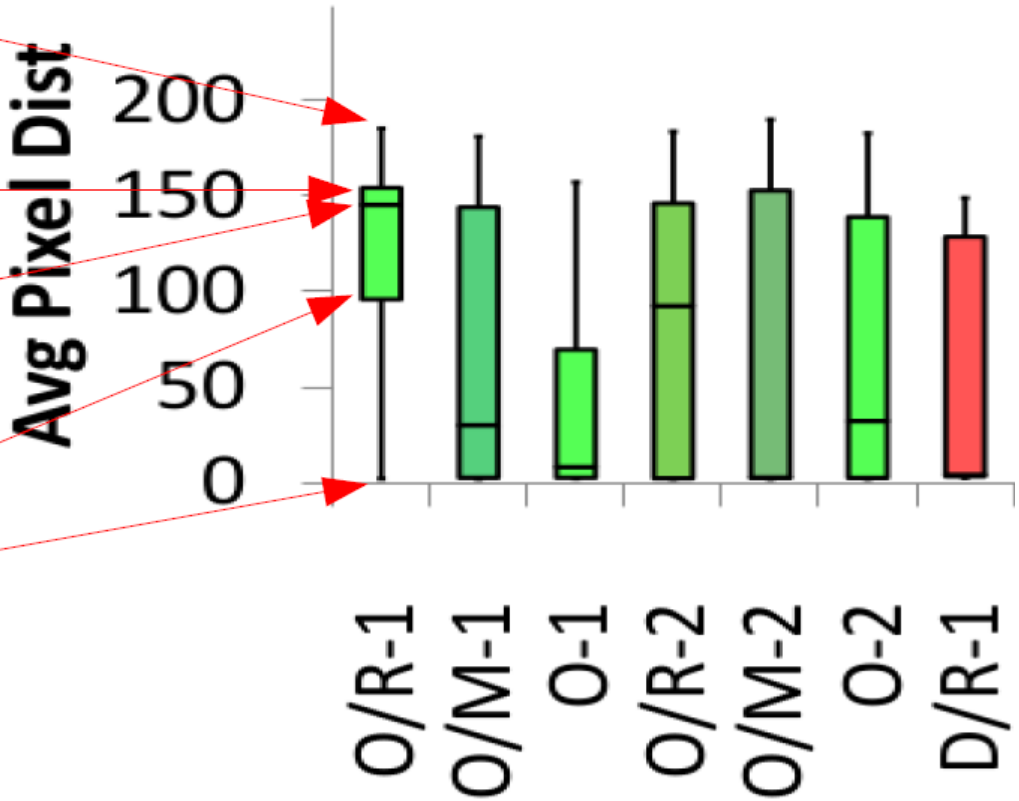
Error of simulation solution methods with increasing number of stacked objects

(with 95% confidence interval)



Showing uncertainty: box-whisker plots

- Maximum.
- Upper quartile.
- Median.
- Lower quartile.
- Minimum.



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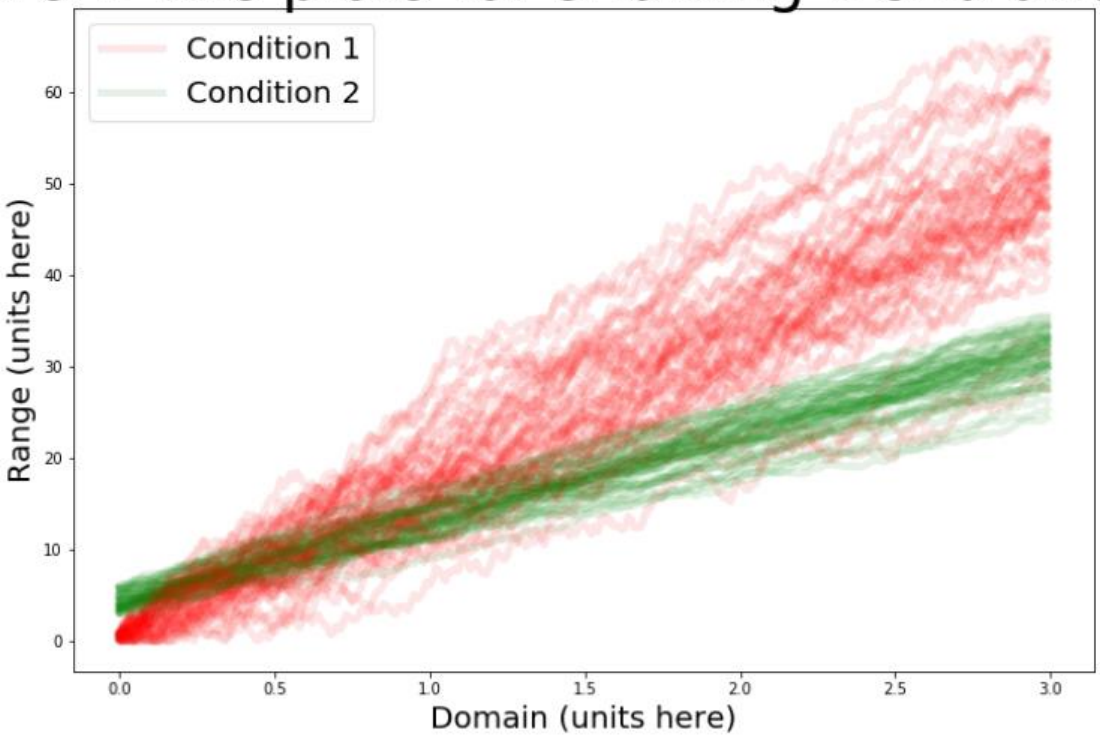
Trend+Variance

An idea

Transparent line plots for showing trend and variance



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DataViz Society 2022 Survey results

https://www.datavisualizationsociety.org/soti-report-2022

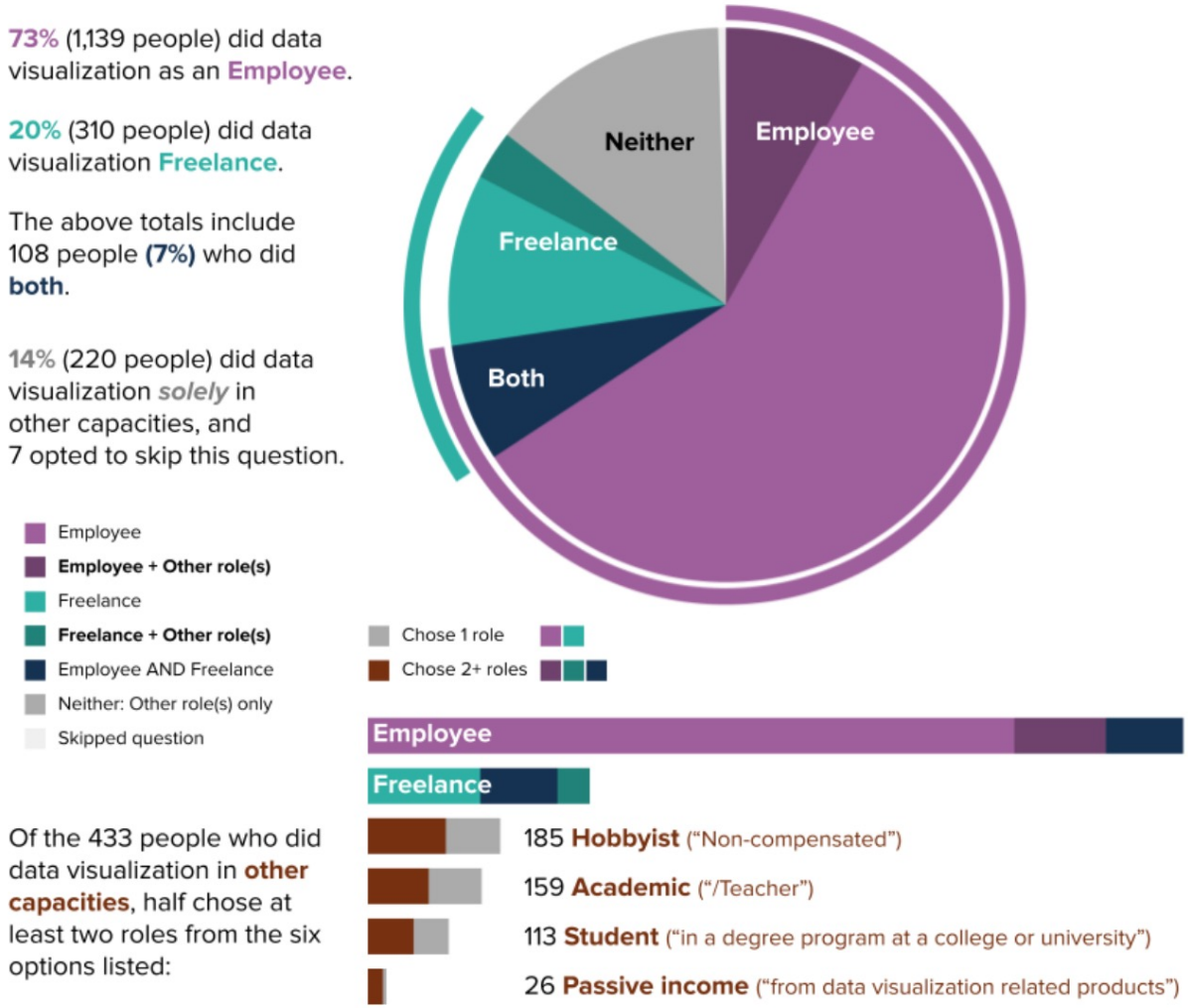

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Figure 6. Primacy of Data Visualization by Role Type (percents)

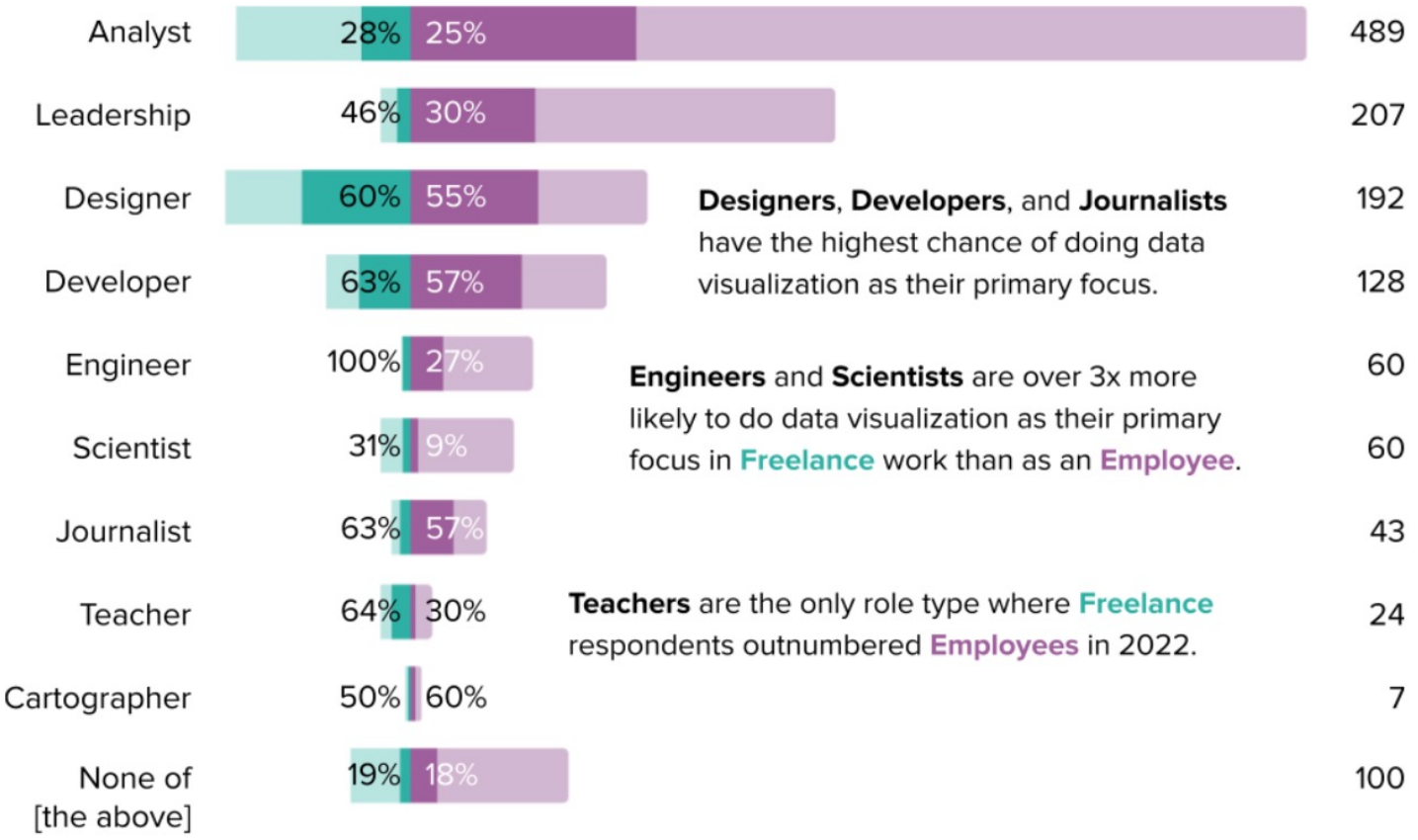

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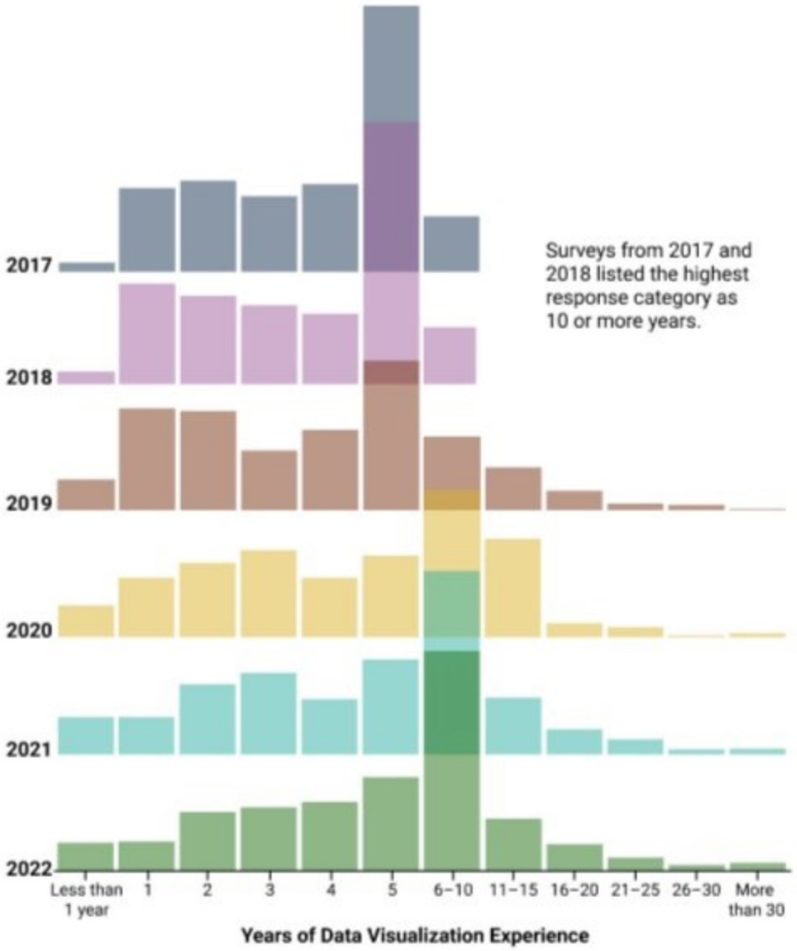
Figure 9. Years of Data Visualization Experience over Time (percents by year)



DataViz Society 2022 Survey results

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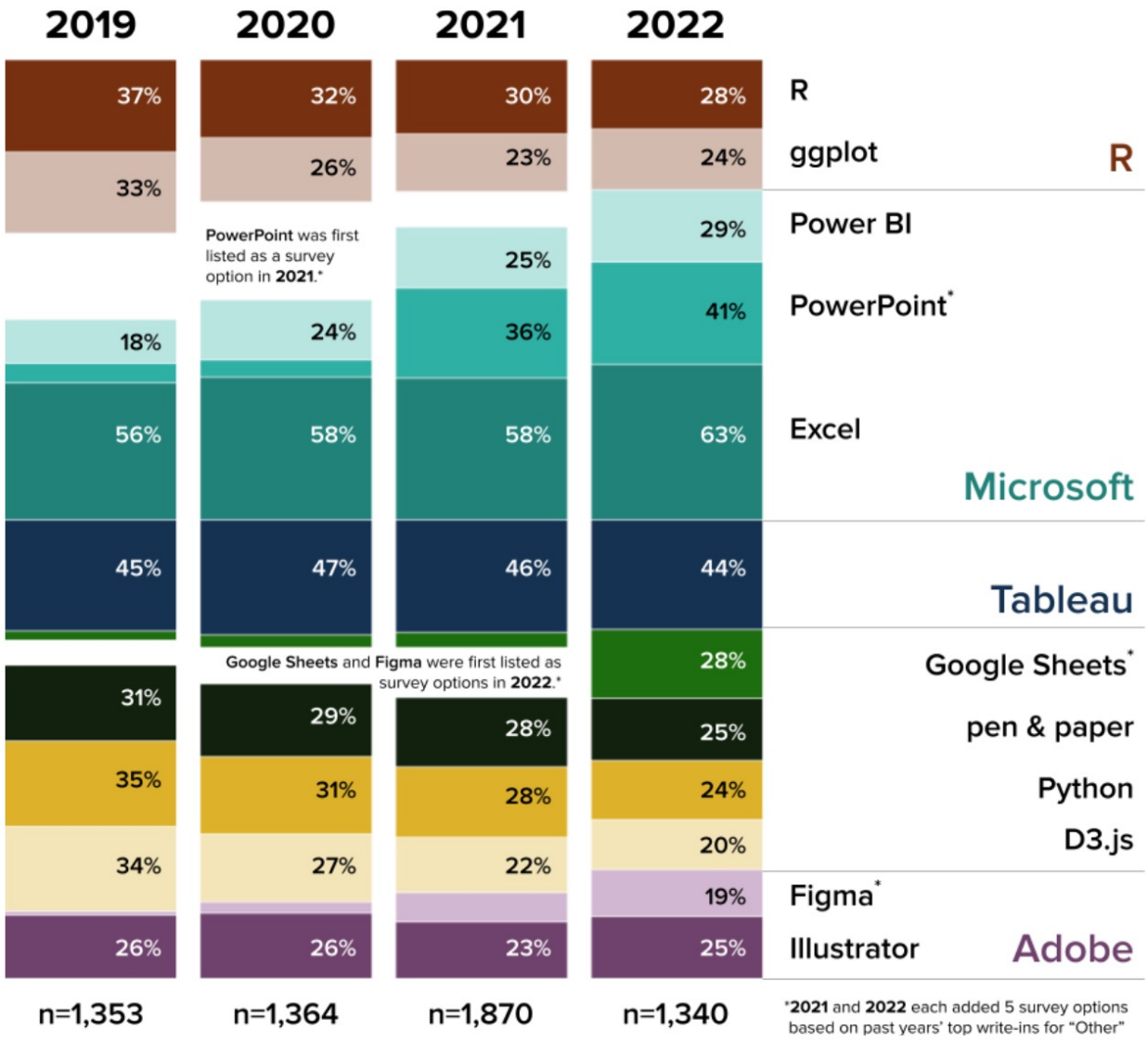
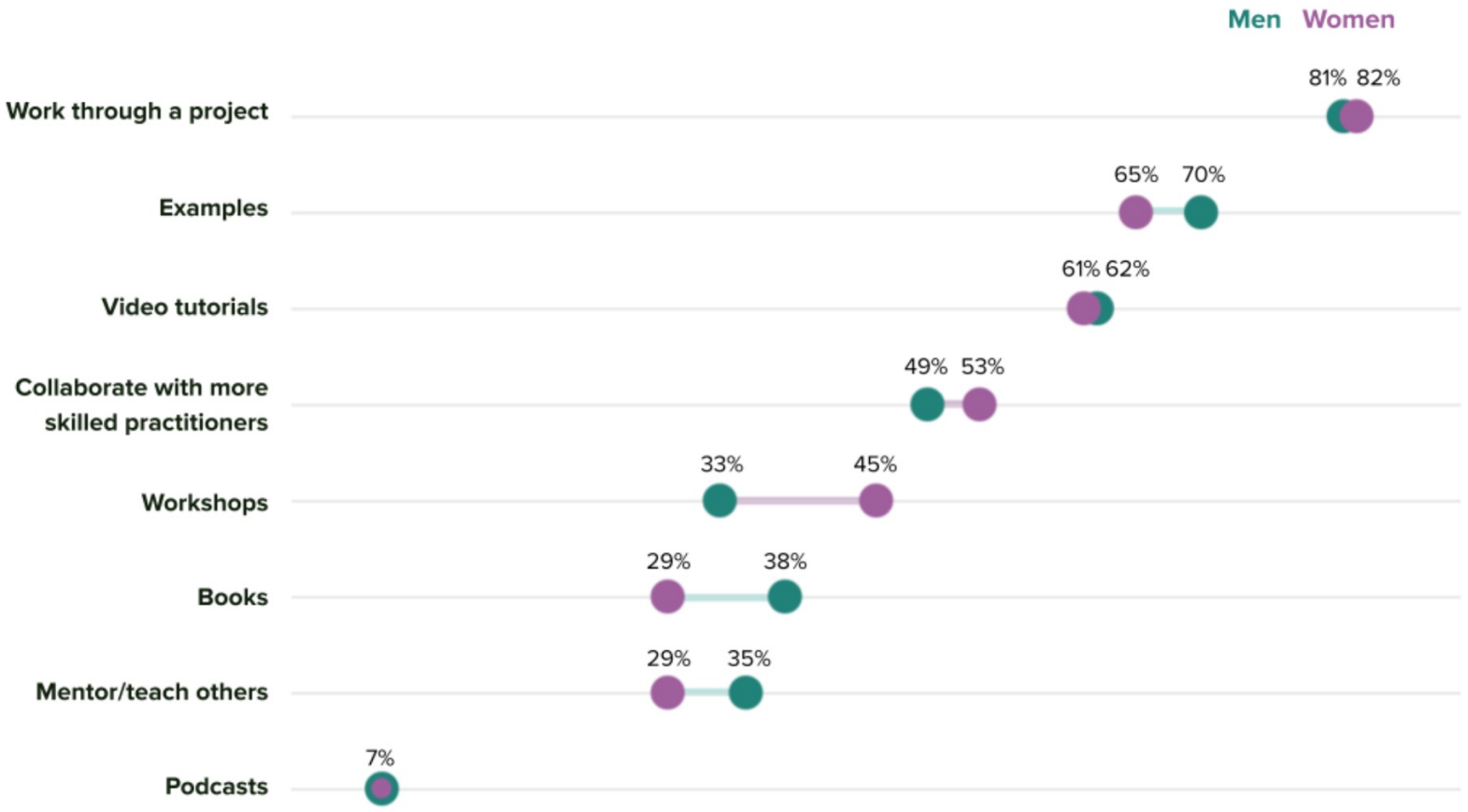


DataViz Society 2022 Survey results

https://www.datavisualizationsociety.org/soti-report-2022

Figure 19. Data Visualization Learning Preferences Compared by Gender (percents)



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Editorial

Ten Simple Rules for Better Figures

Nicolas P. Rougier[1,2,3]*, Michael Droettboom[4], Philip E. Bourne[5]

1 INRIA Bordeaux Sud-Ouest, Talence, France, **2** LaBRI, UMR 5800 CNRS, Talence, France, **3** Institute of Neurodegenerative Diseases, UMR 5293 CNRS, Bordeaux, France, **4** Space Telescope Science Institute, Baltimore, Maryland, United States of America, **5** Office of the Director, The National Institutes of Health, Bethesda, Maryland, United States of America

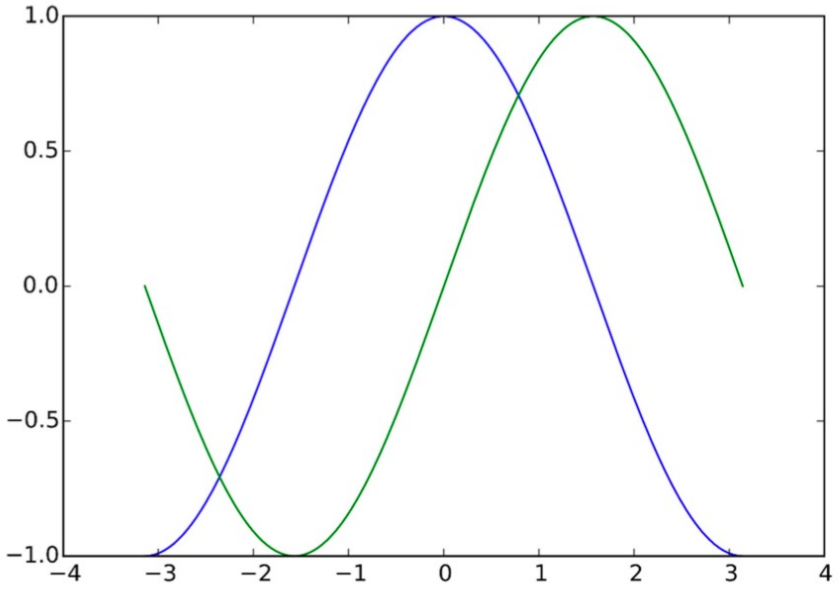
- Rule 1: Know Your Audience
- Rule 2: Identify Your Message
- Rule 3: Adapt the Figure to the Support Medium
- Rule 4: Captions Are Not Optional
- Rule 5: Do Not Trust the Defaults
- Rule 6: Use Color Effectively
- Rule 7: Do Not Mislead the Reader
- Rule 8: Avoid "Chartjunk"
- Rule 9: Message Trumps Beauty
- Rule 10: Get the Right Tool

Rule 3: Adapt the Figure to the Support Medium

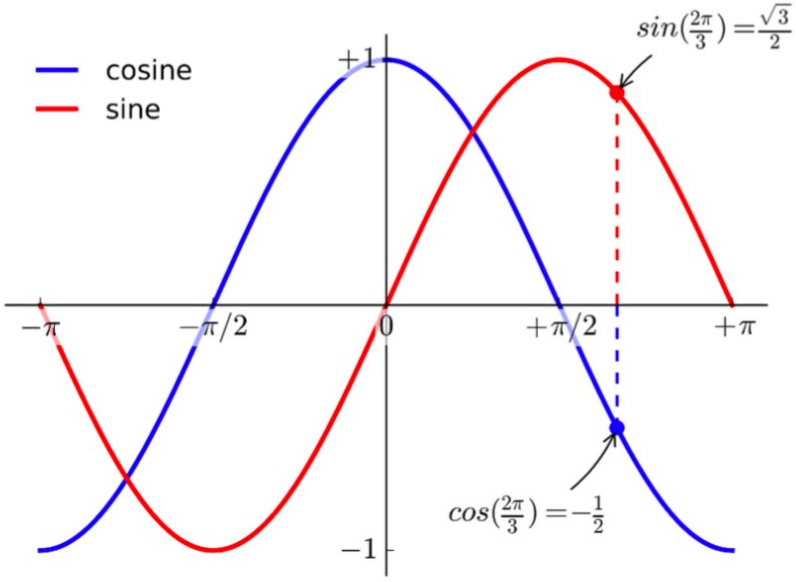
- A figure can be displayed on a variety of media, such as a poster, a computer monitor, a projection screen (as in an oral presentation)
- During an oral presentation, a figure will be displayed for a limited time.
- Thus, the viewer must quickly understand what is displayed and what it represents while still listening to your explanation.
- In such a situation, the figure must be kept simple and the message must be visually clear to attract attention
- It is also important to keep in mind that during oral presentations, figures will be video-projected and will be seen from a distance, and figure elements must consequently be made thicker (lines) or bigger (points, text), colors should have strong contrast, and vertical text should be avoided, etc.
- For a journal article or İn a written report, the situation is totally different, because the reader is able to view the figure as long as necessary

Rule 5: Do not trust the defaults

- Any plotting library or software comes with a set of default settings.
- When the end-user does not specify anything, these default settings are used to specify size, font, colors, styles, ticks, markers, etc
- Most of the plots require at least some manual tuning of the different settings to better express the message.

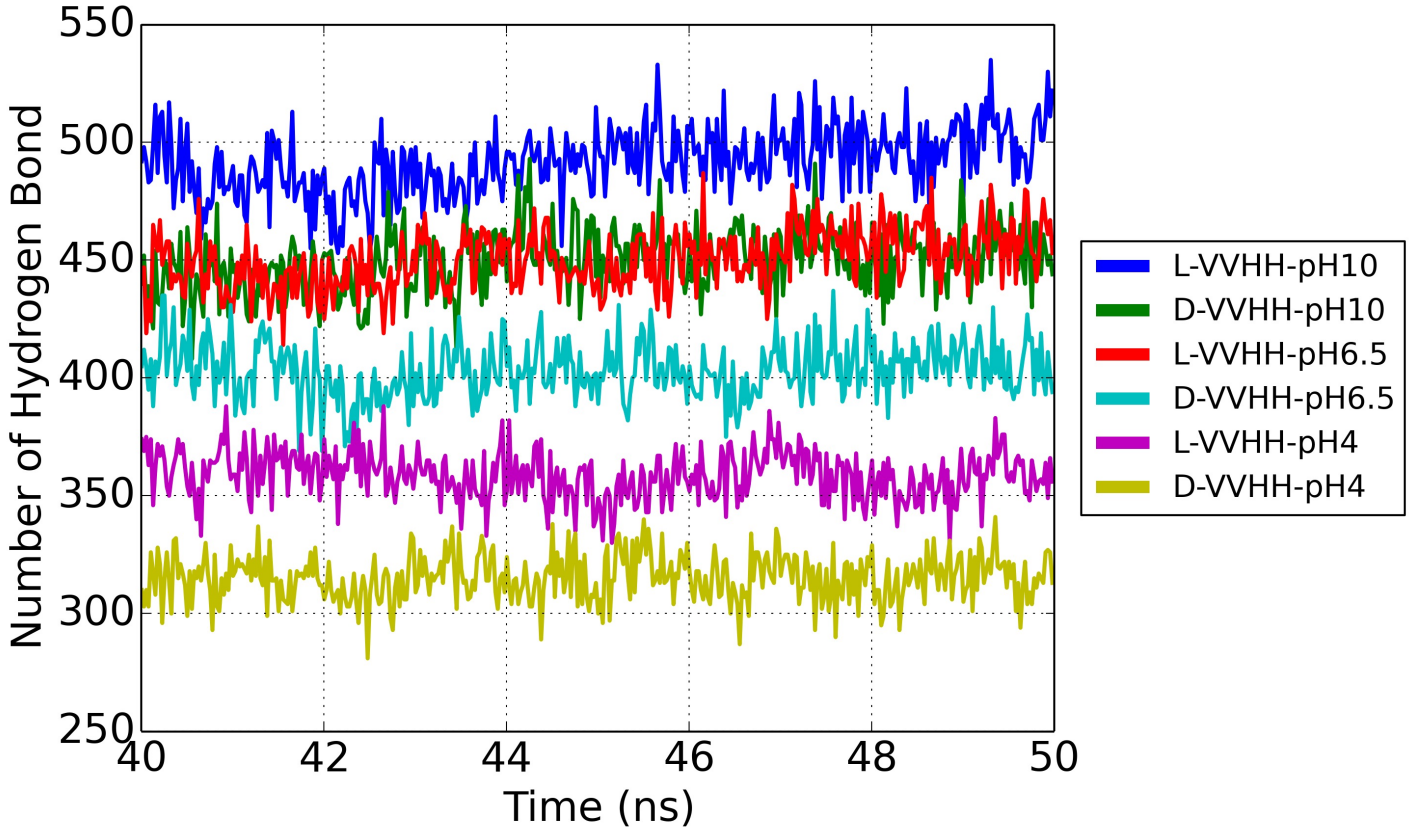


- sine and cosine functions as rendered by matplotlib using default settings



- While this figure is clear enough, it can be visually improved by tweaking the various available settings,

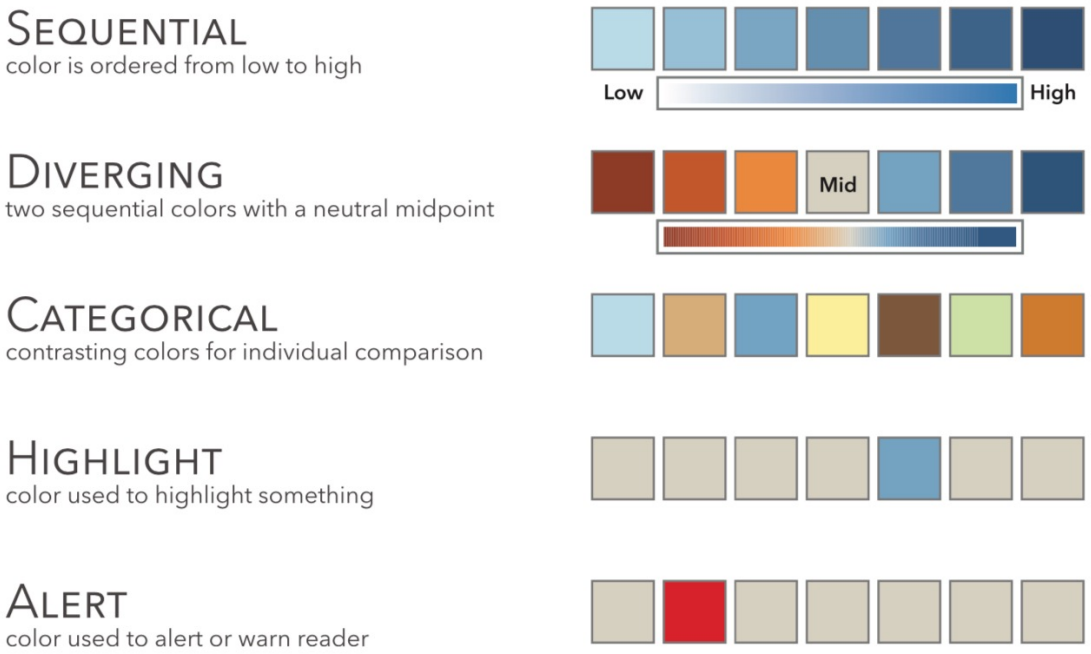
Examples




```
fig, ax1=plt.subplots()
plt.plot(40+timesim1[0:-1:5]*tseriesnormalization,hbondnumbersim1[0:-1:5],linewidth='2' ,label=str(sim1name))
plt.plot(40+timesim2[0:-1:5]*tseriesnormalization,hbondnumbersim2[0:-1:5],linewidth='2' ,label=str(sim2name))
plt.plot(40+timesim3[0:-1:5]*tseriesnormalization,hbondnumbersim3[0:-1:5],linewidth='2' ,label=str(sim3name))
plt.plot(40+timesim4[0:-1:5]*tseriesnormalization,hbondnumbersim4[0:-1:5],linewidth='2' ,label=str(sim4name))
plt.plot(40+timesim5[0:-1:5]*tseriesnormalization,hbondnumbersim5[0:-1:5],linewidth='2' ,label=str(sim5name))
plt.plot(40+timesim6[0:-1:5]*tseriesnormalization,hbondnumbersim6[0:-1:5],linewidth='2' ,label=str(sim6name))

lgd = ax1.legend( [ str(sim1name), str(sim2name), str(sim3name), str(sim4name), str(sim5name), str(sim6name)], loc='center right', bbox_to_anchor=(1.4, 0.5))
for label in lgd.get_lines():
    label.set_linewidth(6)  # the legend line width
for label in  lgd.get_texts():
    label.set_fontsize('15')

plt.xlabel("Time (ns)",fontsize='20')
plt.ylabel("Number of Hydrogen Bond",fontsize='20')

ax1.yaxis.set_tick_params(labelsize=20)
ax1.xaxis.set_tick_params(labelsize=20)
plt.grid(True)

fig.savefig('VVHH-l-d-different-ph-40-50ns.png', dpi=300, format='png', bbox_extra_artists=(lgd,), bbox_inches='tight')
```

Rule 6: Use Color Effectively

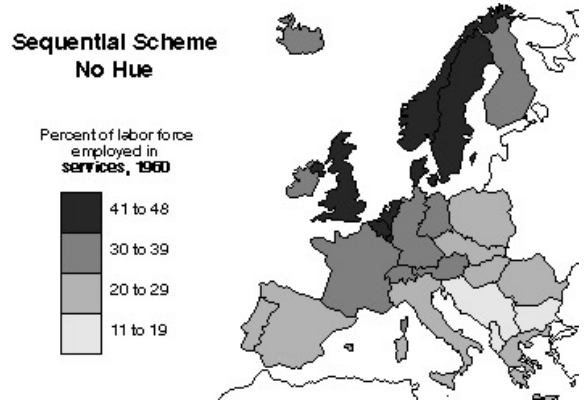
- We can plot variables using colormaps
- Sequential: one variation of a unique color, used for quantitative data varying from low to high.
- Diverging: variation from one color to another, used to highlight deviation from a median value.
- Qualitative: rapid variation of colors, used mainly for discrete or categorical data.

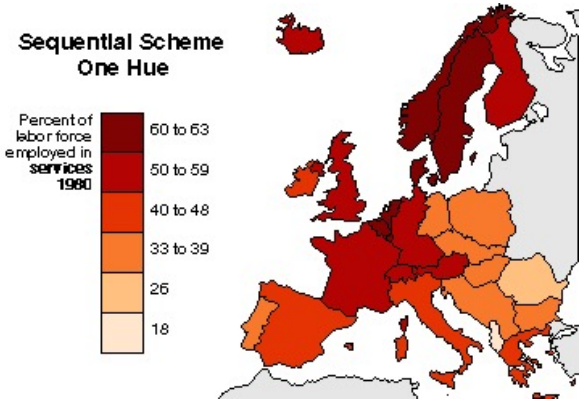


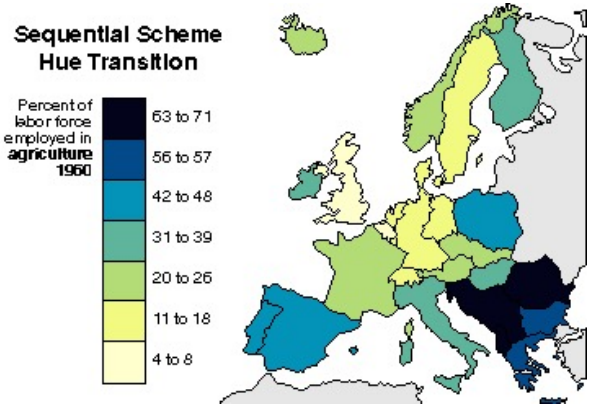
Rule 6: Use Color Effectively

Sequential Scheme Color Map

- Sequential schemes order data from high to low, accenting the highest as a dark shade and the lowest as a light shade (or vice versa).
- Sequential schemes are best if you are mapping quantitative data and do not want to focus on one particular range within your data.
- Lightness is used primarily to represent ordered data, but hue can be used as well.
- Low data values are usually represented by light colors and high values represented by dark colors.

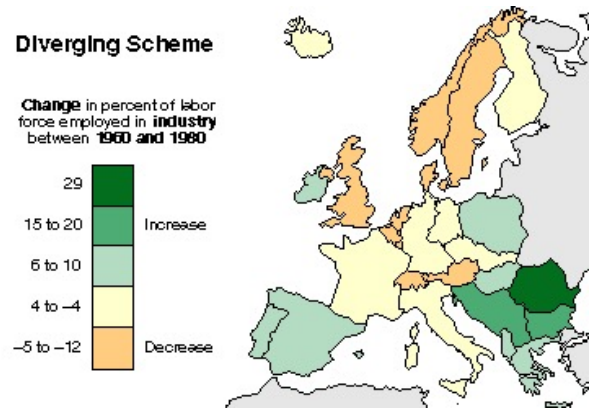


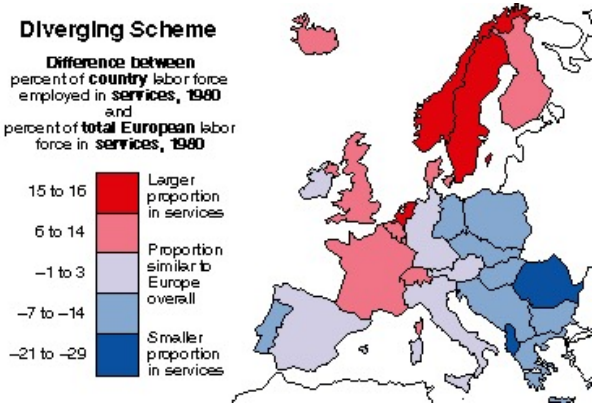


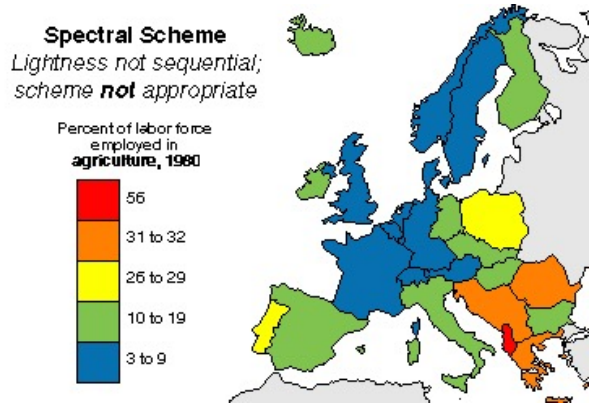


Diverging Scheme

- Divergent schemes are best at highlighting a particular middle range of quantitative data or looking at a trends in a single dimension.
- Pick two saturated contrasting colors for the extremes of the data, and the middle ranges blend into a lighter mix of the two.
- Colors are arranged symmetrically around a median, zero, or threshold value.
- Divergent color schemes emphasize both highs and lows by using variation in both hue and value.

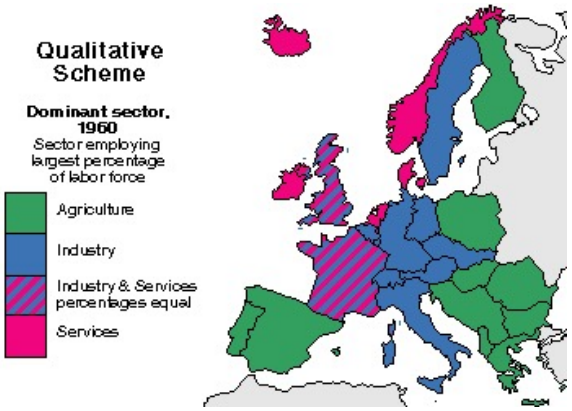






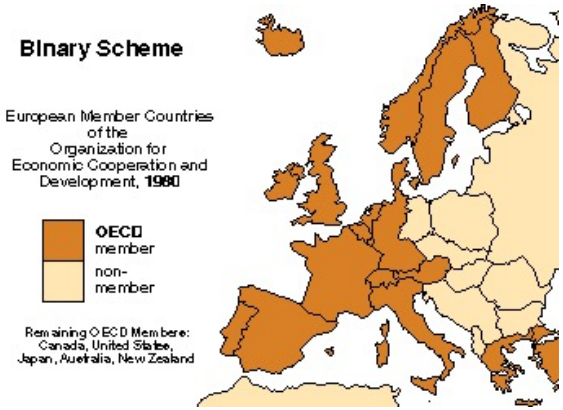
Qualitative Scheme

- Qualitative schemes use differences in hue to represent categorical differences in data
- Assign the lightest, darkest, and most saturated hues in the scheme to categories that warrant emphasis on the map.
- Use more intense colors to make smaller classes more visible

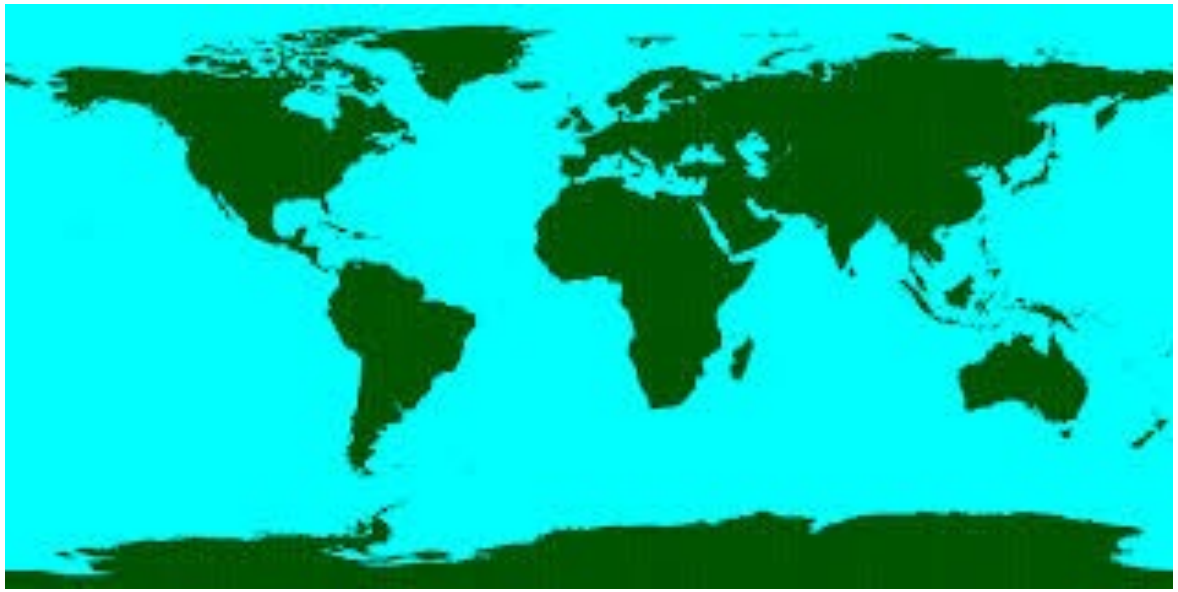


Binary Scheme

- Binary schemes show nominal differences that are divided into only two categories.
- The primary perceptual difference between the two categories of a binary scheme may be a lightness step, unlike the use of hue for multi-valued qualitative variables.



- Incorporated versus unincorporated urban areas are well represented by a binary color scheme.



Land-sea mask

Put more visual emphasis on one class if it is more important for the message of the map!

Color Blind friendly colors

- Based on research (Birch 1993), approximately 8 percent of males have color vision deficiency (CVD) compared to only 0.4 percent of females
- People suffering from CVD cannot distinguish colors in the same way as the rest of the population.
- The primary problem among people with CVD is with the colors red and green.
- This is why it is best to avoid using red and green together and, in general, to avoid the commonly used traffic light colors.
- Protanopia is one kind of CVD.

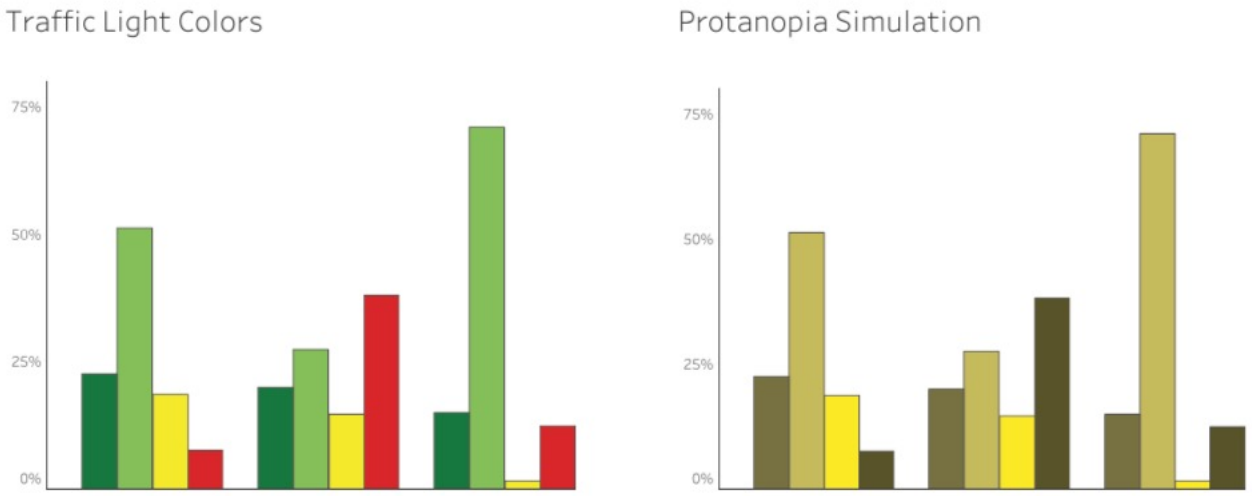


FIGURE 1.24 Bar chart using the traffic light colors and a protanopia simulation. Notice the red and green bars in the panel on the right are very difficult to differentiate from one another for a person with protanopia.

Color Blind friendly colors

- One common solution among data visualization practitioners is to use blue and orange.
- Using blue instead of green for good and orange instead of red for bad works well because almost everyone (with very rare exceptions) can distinguish blue and orange from each other.
- This blue-orange palette is often referred to as being "color-blind friendly."

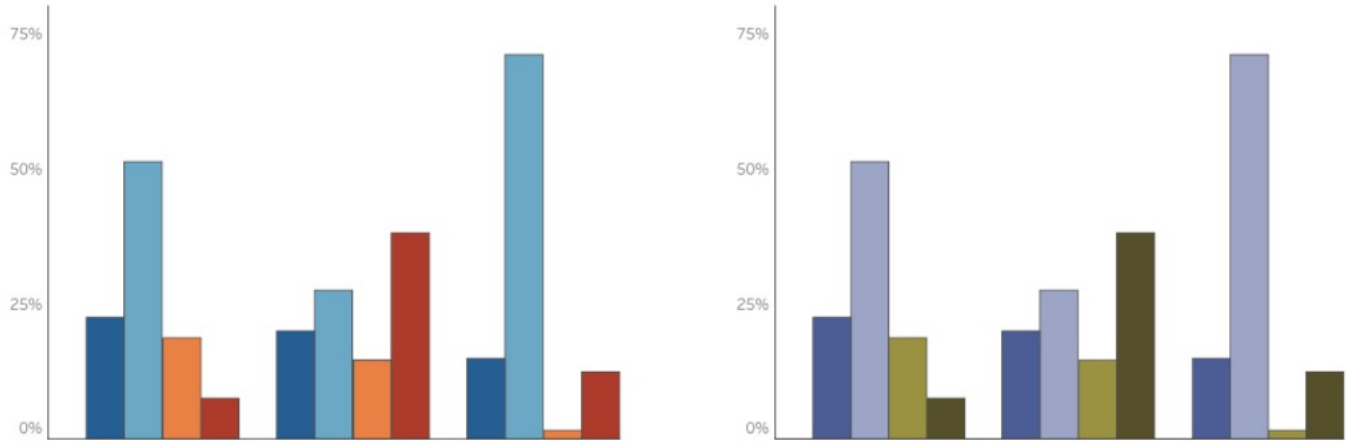
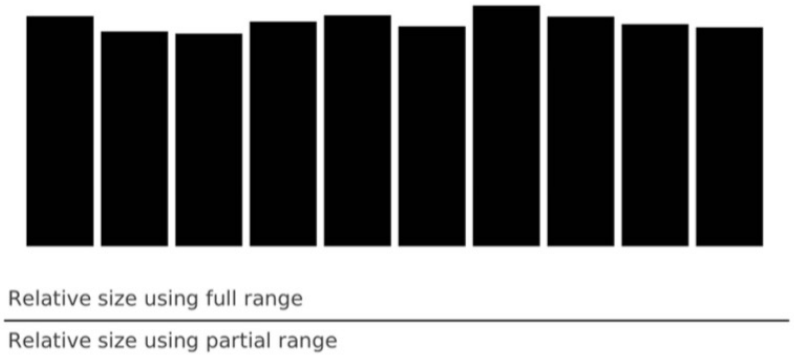


FIGURE 1.25 Bar chart using a color-blind-friendly blue and orange palette and a protanopia simulation.

Rule 7: Do Not Mislead the Reader

- We display a series of ten values using the full range for values on the top part or a partial range in the bottom part.
- We explicitly did not label the y-axis to enhance the confusion.
- The visual perception of the two series is totally different.
- In the top part (black series), we tend to interpret the values as very similar.
- While in the bottom part, we tend to believe there are significant differences

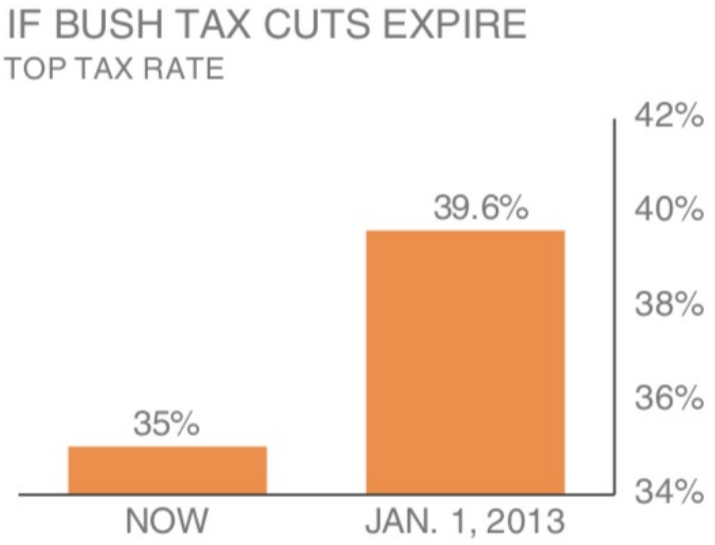


y axis goes from 0 to 100

y axis goes from 80 to 100

Rule 7: Do Not Mislead the Reader

Non-zero baseline: as originally graphed



Zero baseline: as it should be graphed

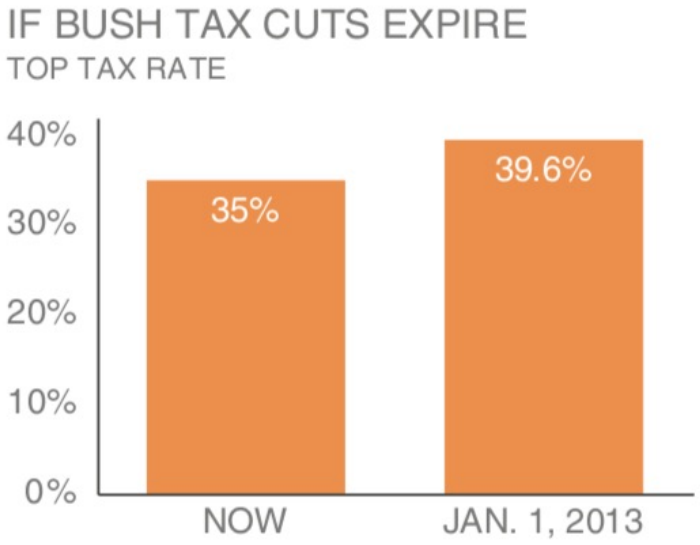
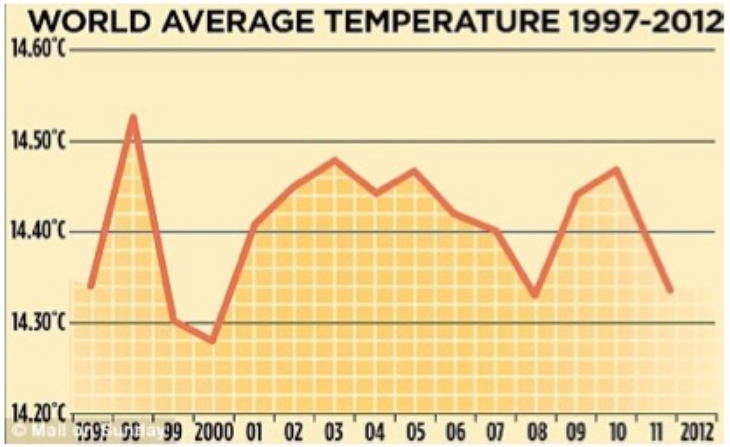


FIGURE 2.13 Bar charts must have a zero baseline

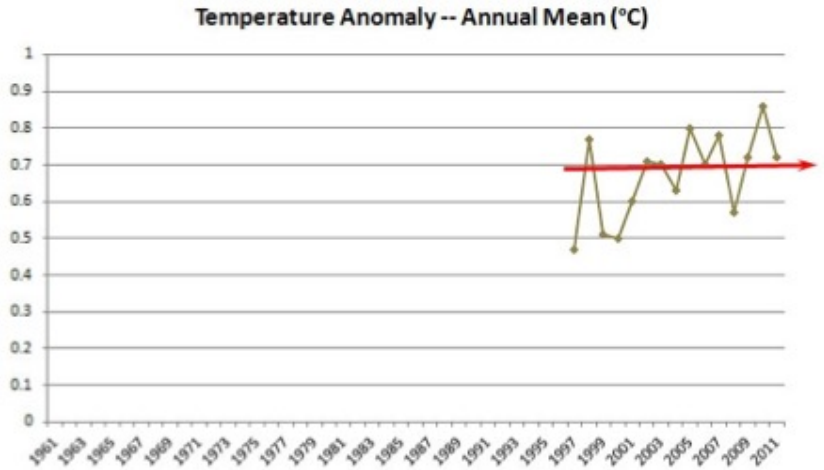
Do Not Mislead the Reader

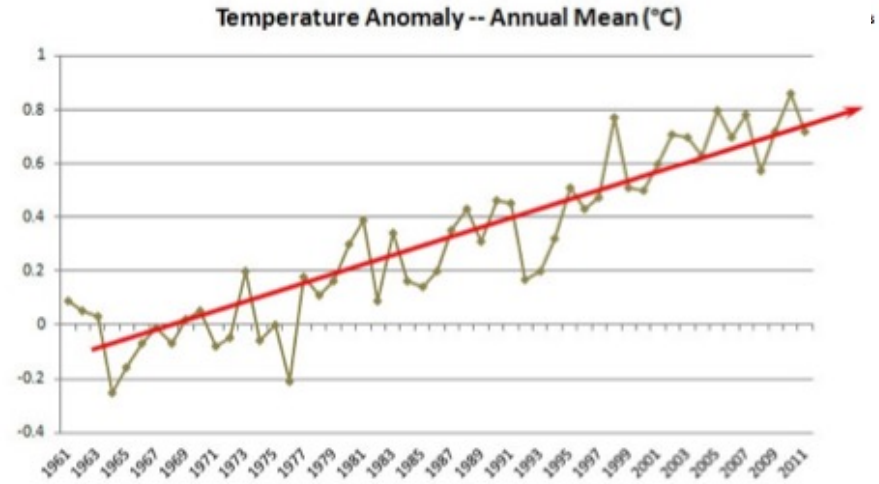
Scale Distortions …

- As it also shown in the previous example, scale is important!
- You can easily manipulate the results either deliberate or accidently.
- **Another Example: Global Warming?**



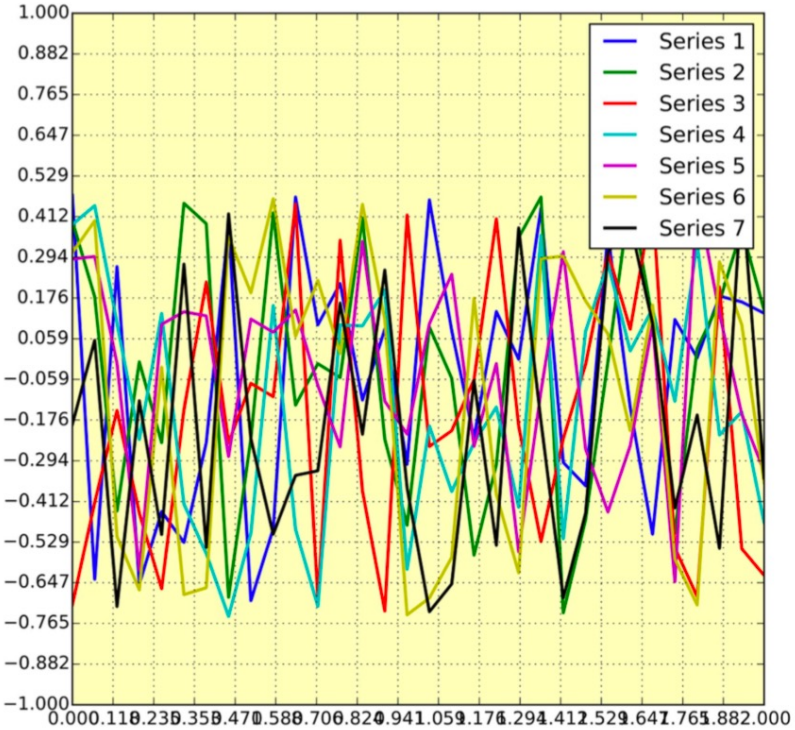
The Daily Mail, UK, Jan 2012

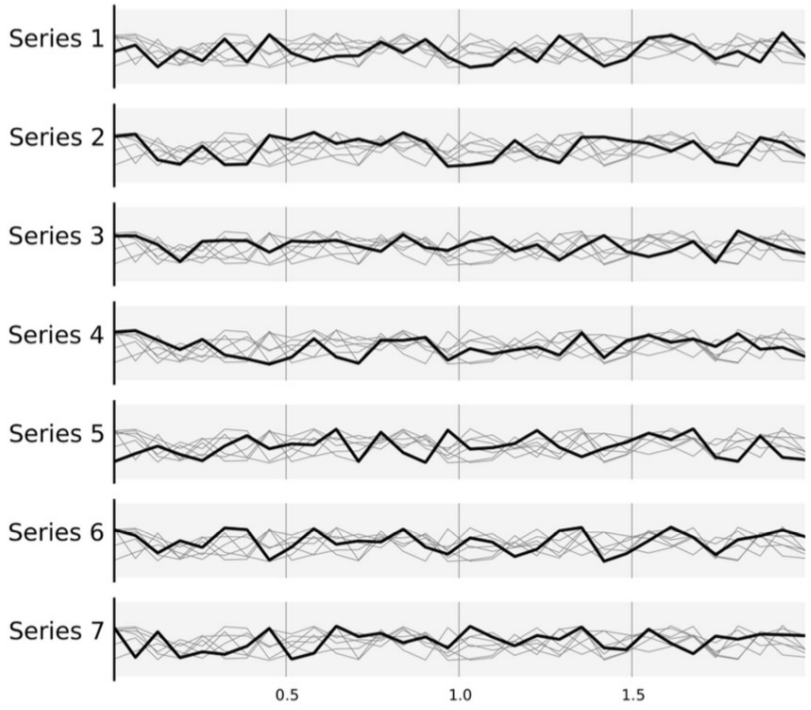




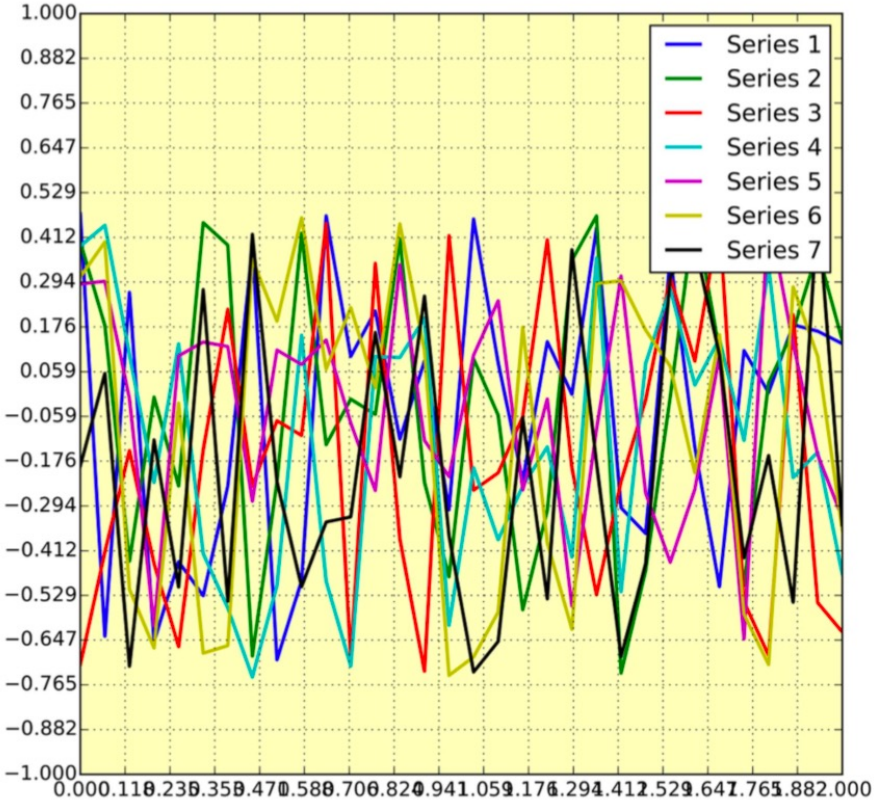
Rule 8: Avoid ‘‘Chartjunk’’

- Chartjunk: all the unnecessary or confusing visual elements found in a figure that do not improve the message (in the best case) or add confusion (in the worst case).



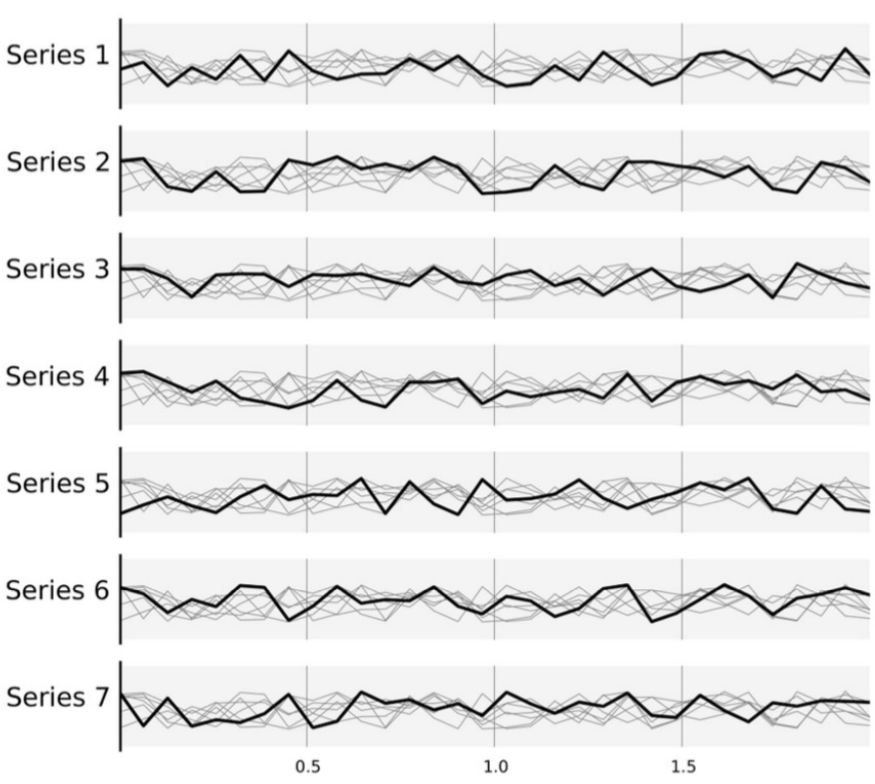


Rule 8: Avoid ‘‘Chartjunk’’



- one of the worst possible designs.
- All the curves cover each other and the different colors (that have been badly and automatically chosen by the software) do not help to distinguish them.
- The legend box overlaps part of the graphic, making it impossible to check if there is any interesting information in this area
- There are far too many ticks:
- x labels overlap each other,
- making them unreadable,
- the three-digit precision does not seem to carry any significant information.

Rule 8: Avoid ‘‘Chartjunk’’



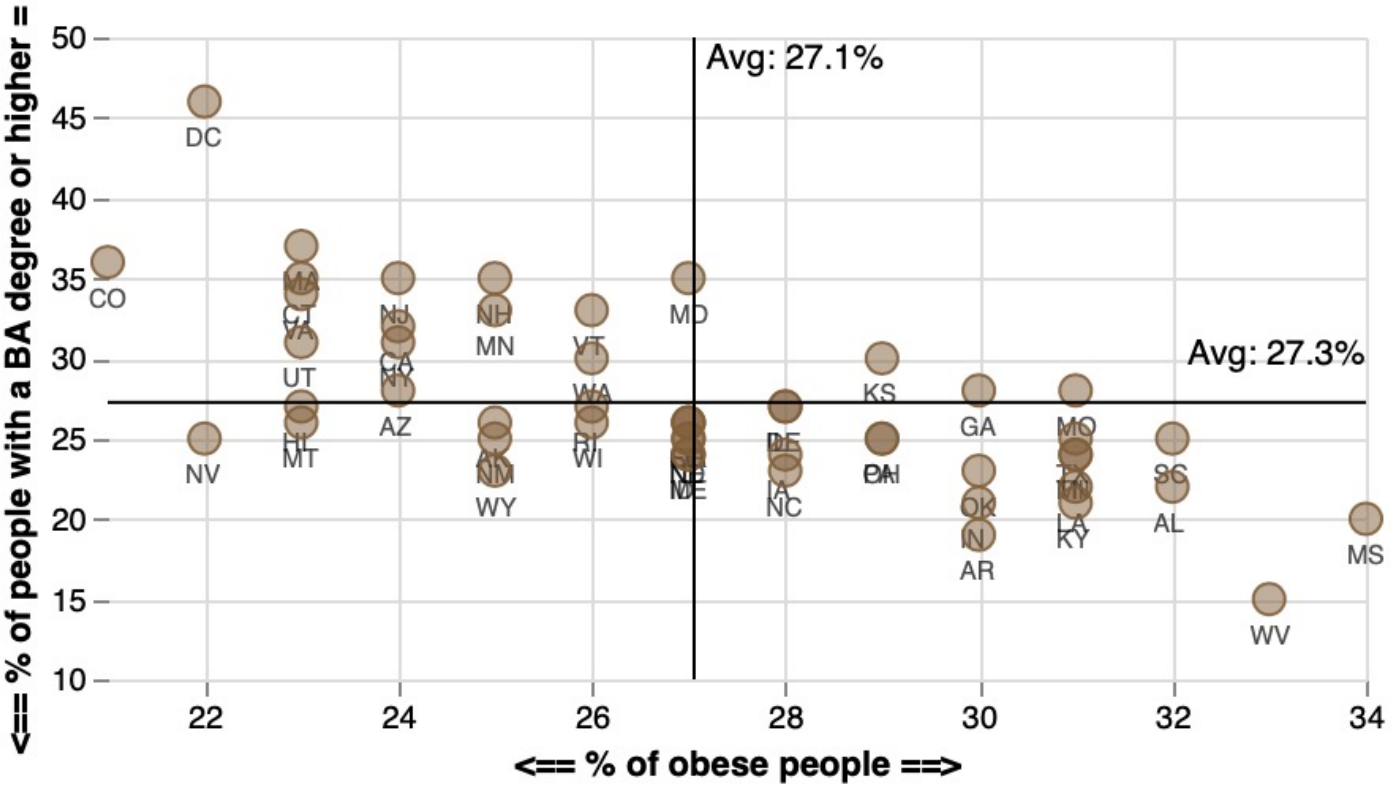
- Using the same area but smarter!
- Series have been split into seven plots
- Each of them showing one series
- While other series are drawn very lightly behind the main one.
- Series labels have been put on the left of each plot, avoiding the use of colors and a legend box.
- The number of x ticks has been reduced to three, and a thin line indicates these three values for all plot
- Finally, y ticks have been completely removed and the height of the gray background boxes indicate the [-1,+1] range

Visualization Types: Correlation

- https://gramener.github.io/visual-vocabulary-vega

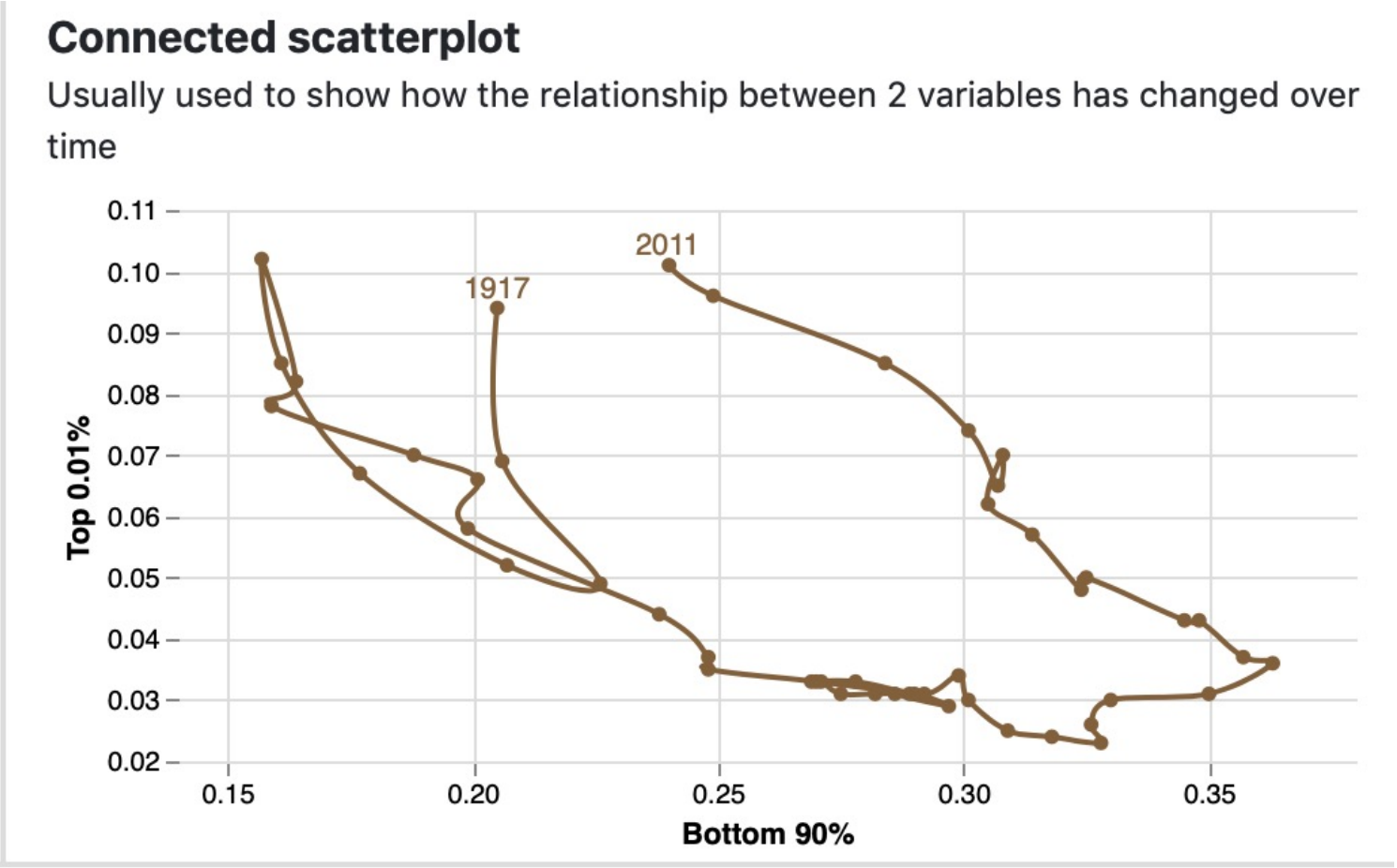
Scatterplot

The standard way to show the relationship between two variables, each of which has its own axis



Visualization Types: Correlation

- https://gramener.github.io/visual-vocabulary-vega

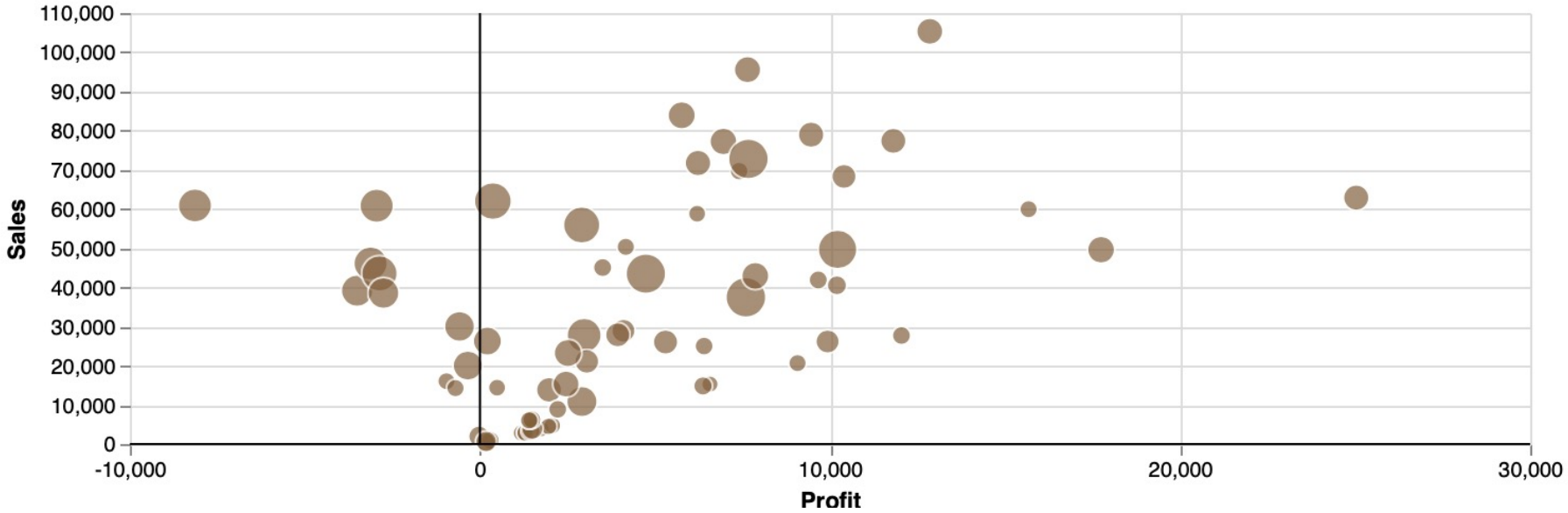


Visualization Types: Correlation

- https://gramener.github.io/visual-vocabulary-vega

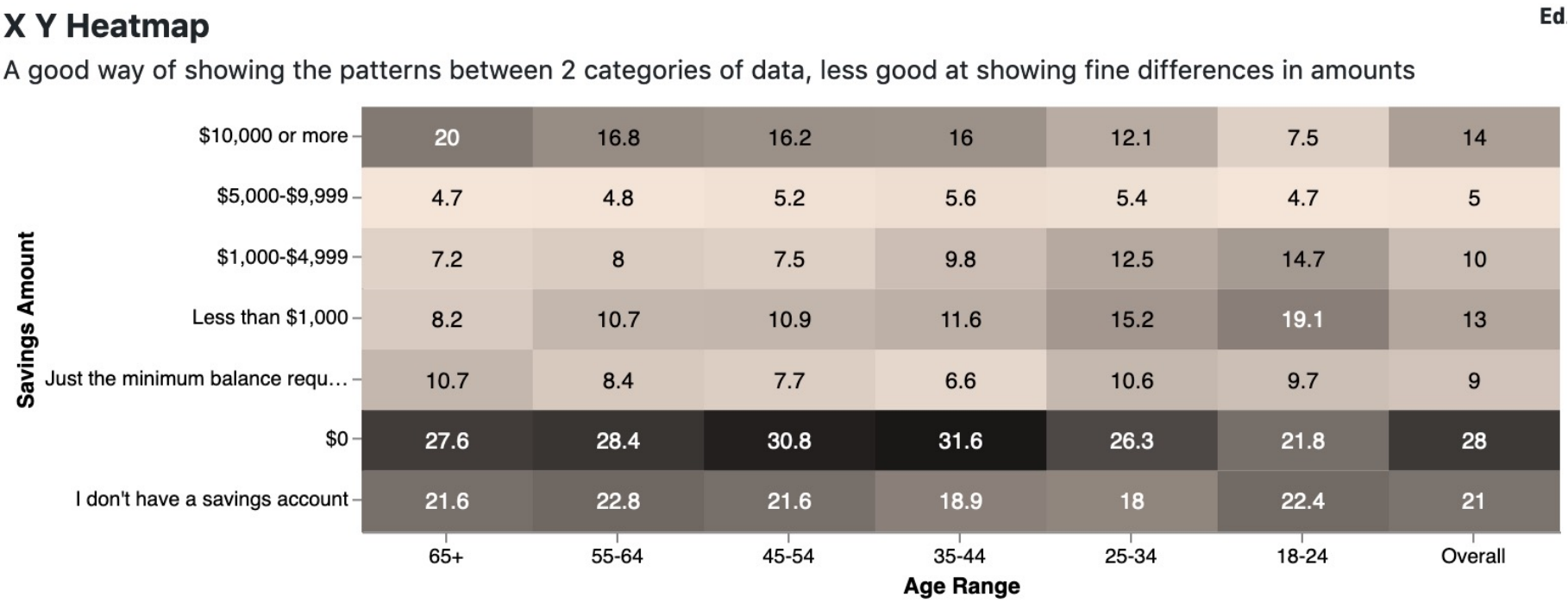
Bubble

Like a scatterplot, but adds additional detail by sizing the circles according to a third variable



Visualization Types: Correlation

- https://gramener.github.io/visual-vocabulary-vega



Visualization Types: Correlation

- We can use **color saturation** to reduce mental processing of the figure.
- This helps our eyes and brains more quickly target the potential points of interest.
- In the table on the right entitled "Heatmap," the higher saturation of blue, the higher the number.
- This makes the process of picking out the tails of the spectrum—the lowest number (11%) and highest number (58%)—an easier and faster process than it was in the original table where we didn't have any visual cues to help direct our attention.

Table

	A	B	C
Category 1	15%	22%	42%
Category 2	40%	36%	20%
Category 3	35%	17%	34%
Category 4	30%	29%	26%
Category 5	55%	30%	58%
Category 6	11%	25%	49%

Heatmap

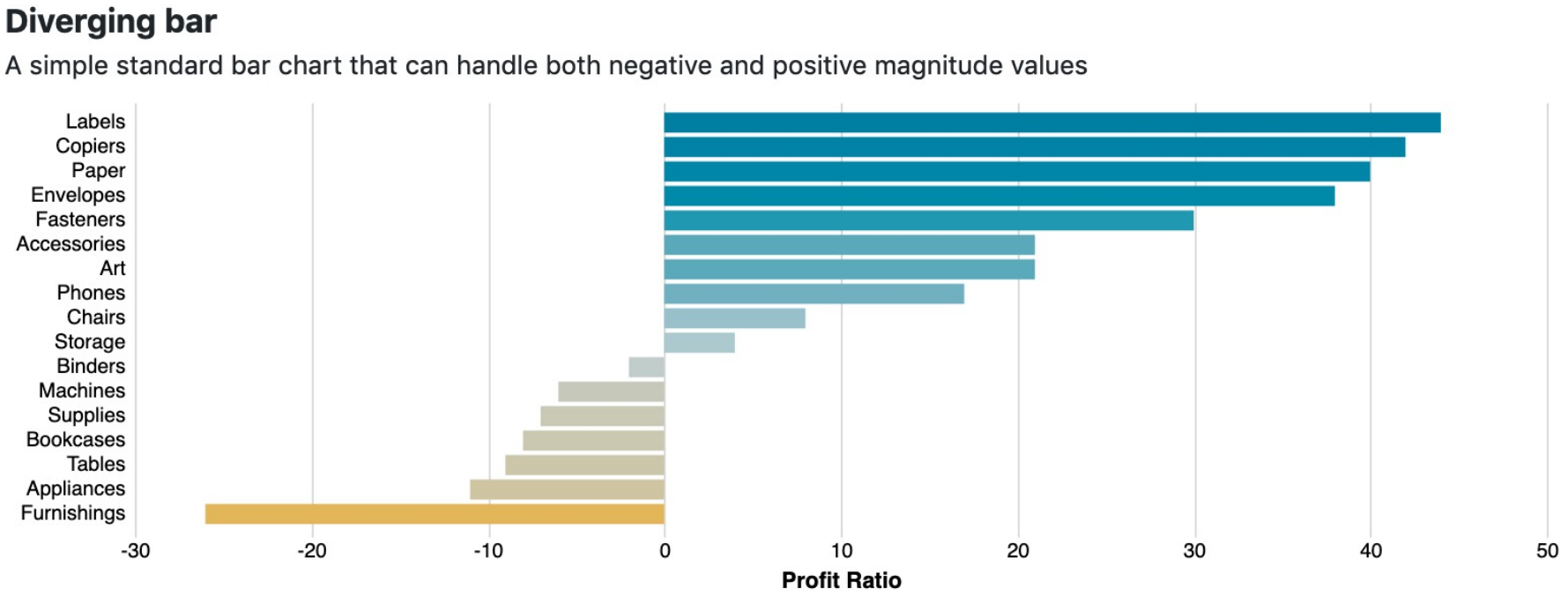
LOW-**HIGH**

	A	B	C
Category 1	15%	22%	42%
Category 2	40%	36%	20%
Category 3	35%	17%	34%
Category 4	30%	29%	26%
Category 5	55%	30%	58%
Category 6	11%	25%	49%

FIGURE 2.5 Two views of the same data

Visualization Types: Deviation

- https://gramener.github.io/visual-vocabulary-vega
- Emphasise variations (+/-) from a fixed reference point.
- Typically the reference point is zero but it can also be a target or a long-term average. Can also be used to show sentiment (positive/neutral/negative)



Visualization Types: Deviation

- https://gramener.github.io/visual-vocabulary-vega
- Emphasise variations (+/-) from a fixed reference point.
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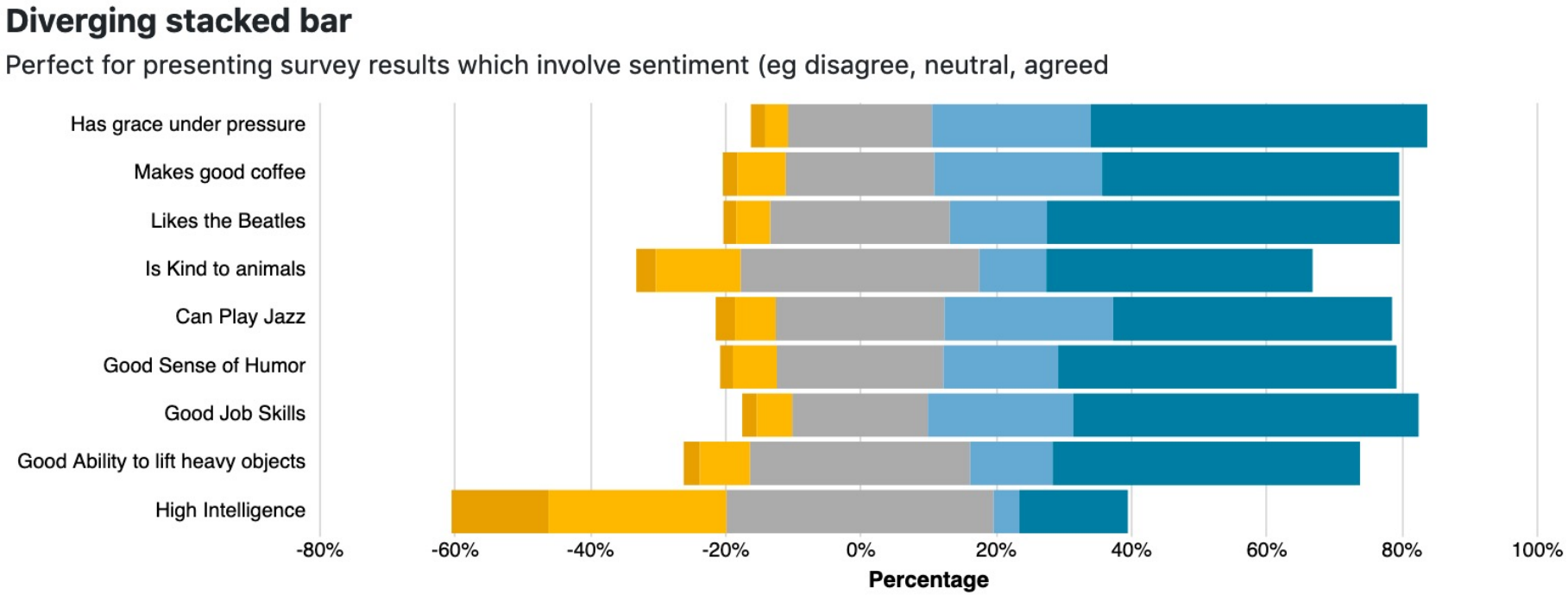

Visualization Types: Deviation

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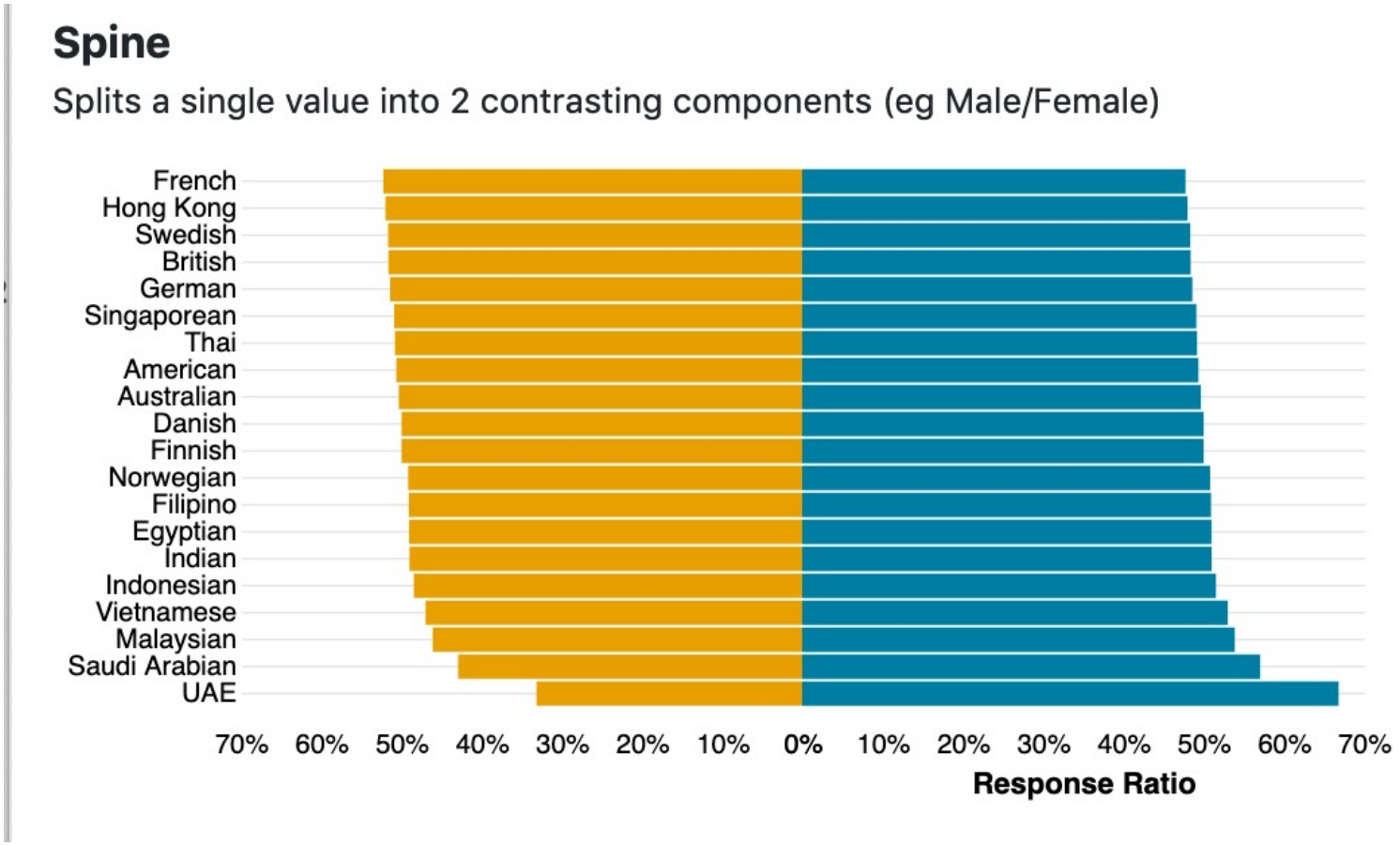

Visualization Types: Deviation

- https://gramener.github.io/visual-vocabulary-vega
- Emphasise variations (+/-) from a fixed reference point.
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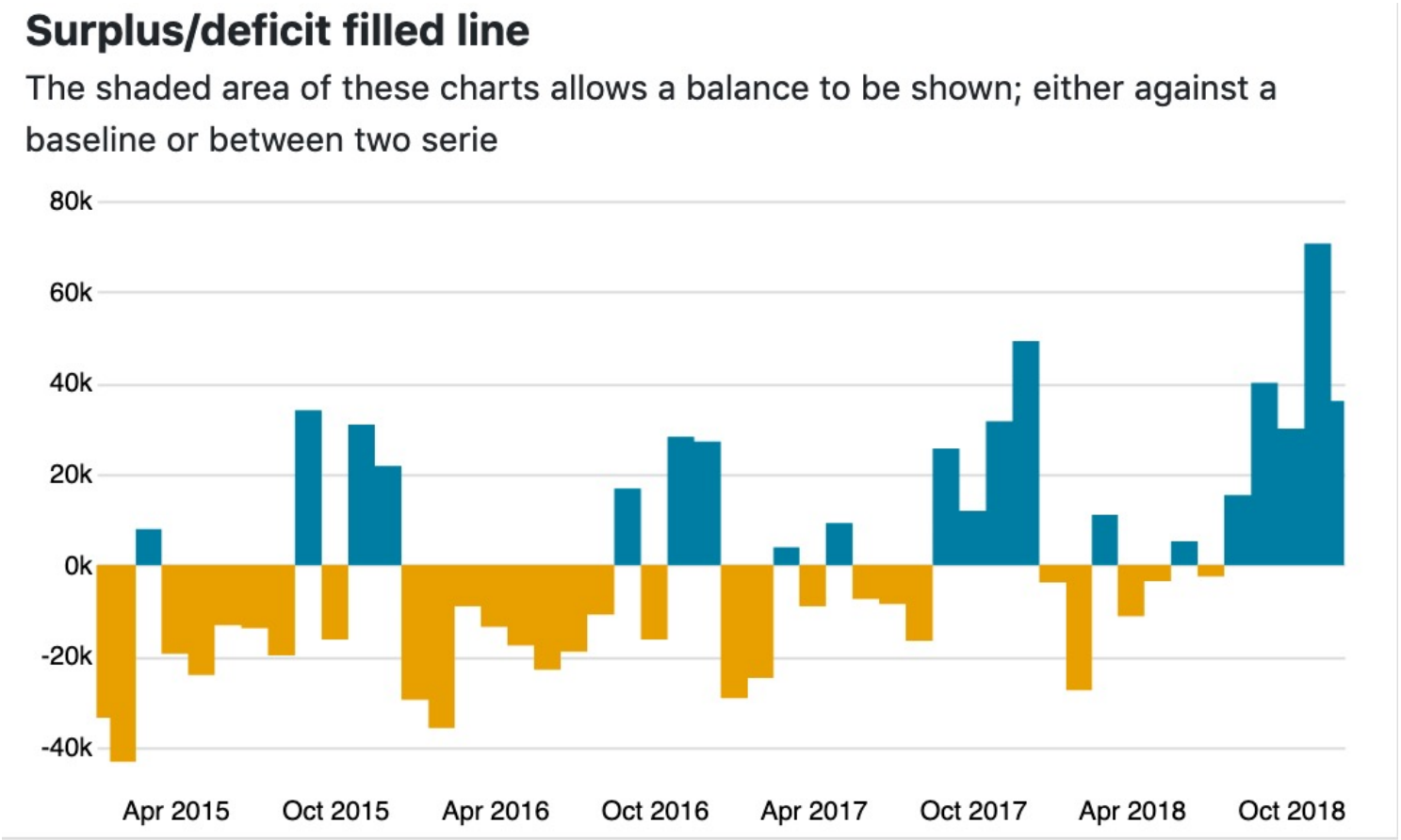
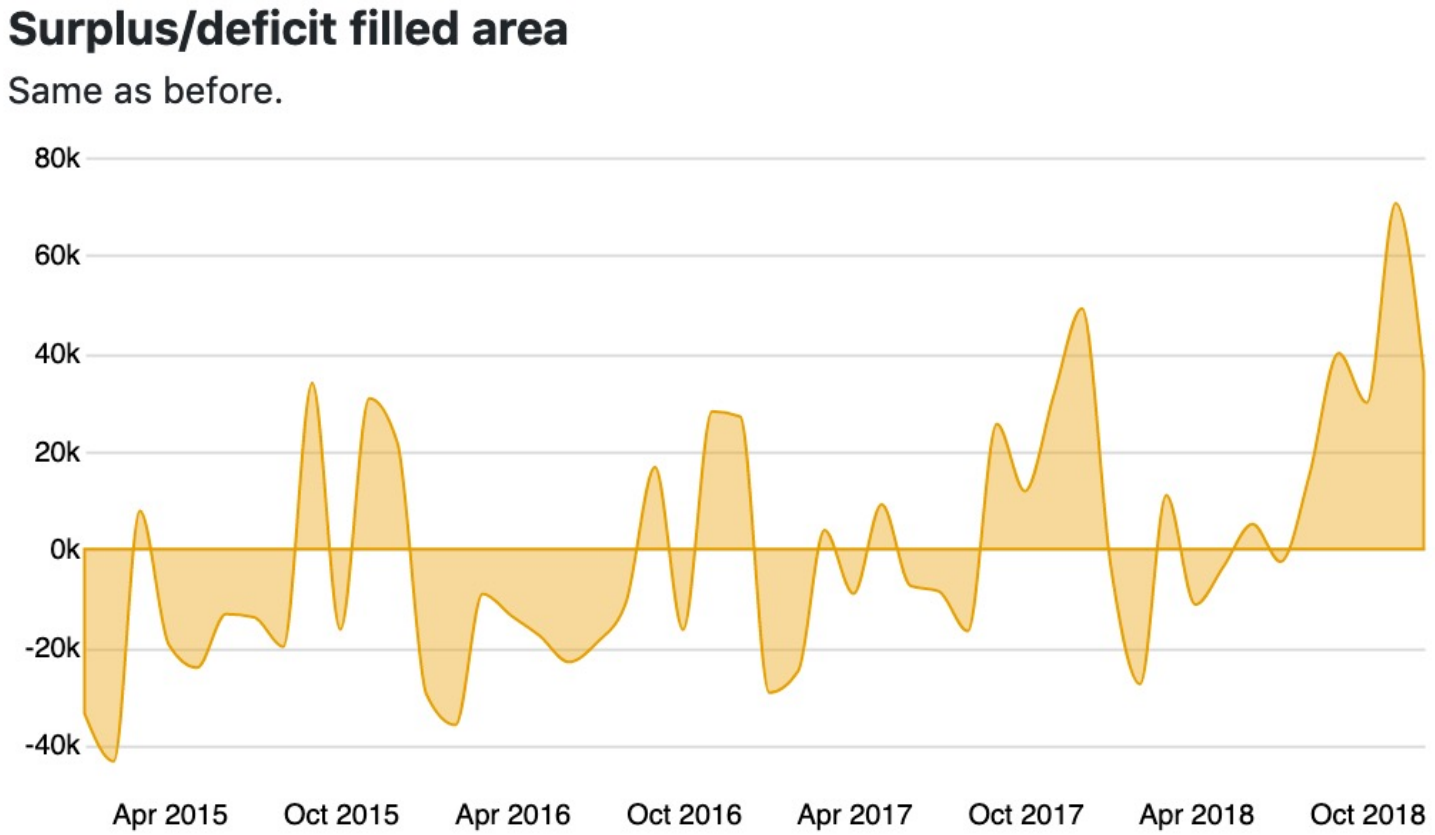


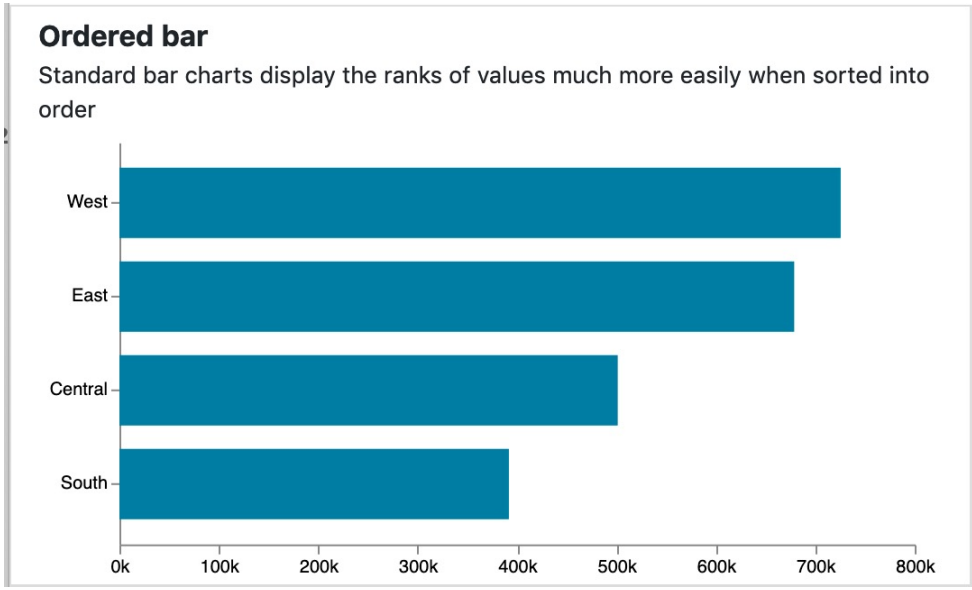
Visualization Types: Deviation

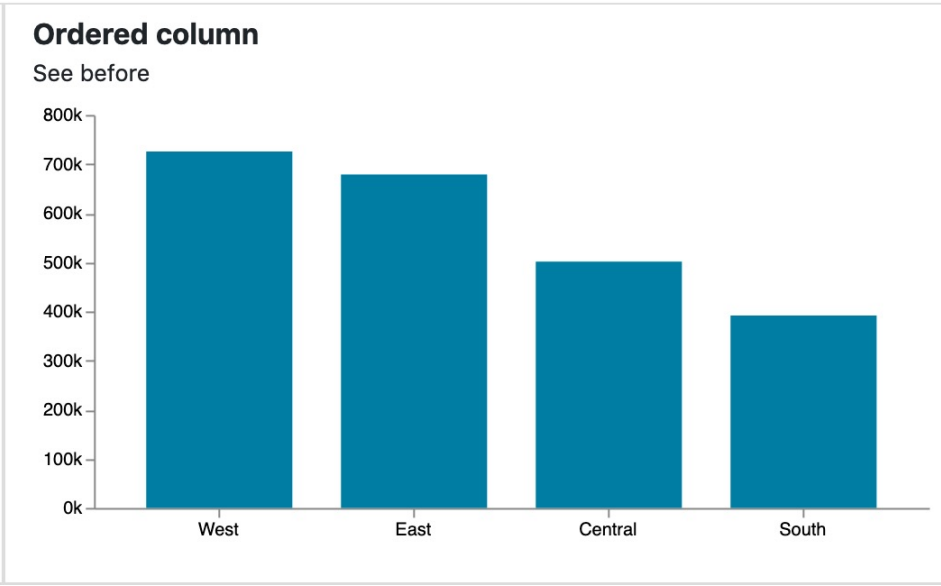
- https://gramener.github.io/visual-vocabulary-vega
- Emphasise variations (+/-) from a fixed reference point.
- Typically the reference point is zero but it can also be a target or a long-term average. Can also be used to show sentiment (positive/neutral/negative)



Visualization Types: Ranking

- Use where an item's position in an ordered list is more important than its absolute or relative value.
- Don't be afraid to highlight the points of interest.





Visualization Types: Ranking

- Use where an item's position in an ordered list is more important than its absolute or relative value.
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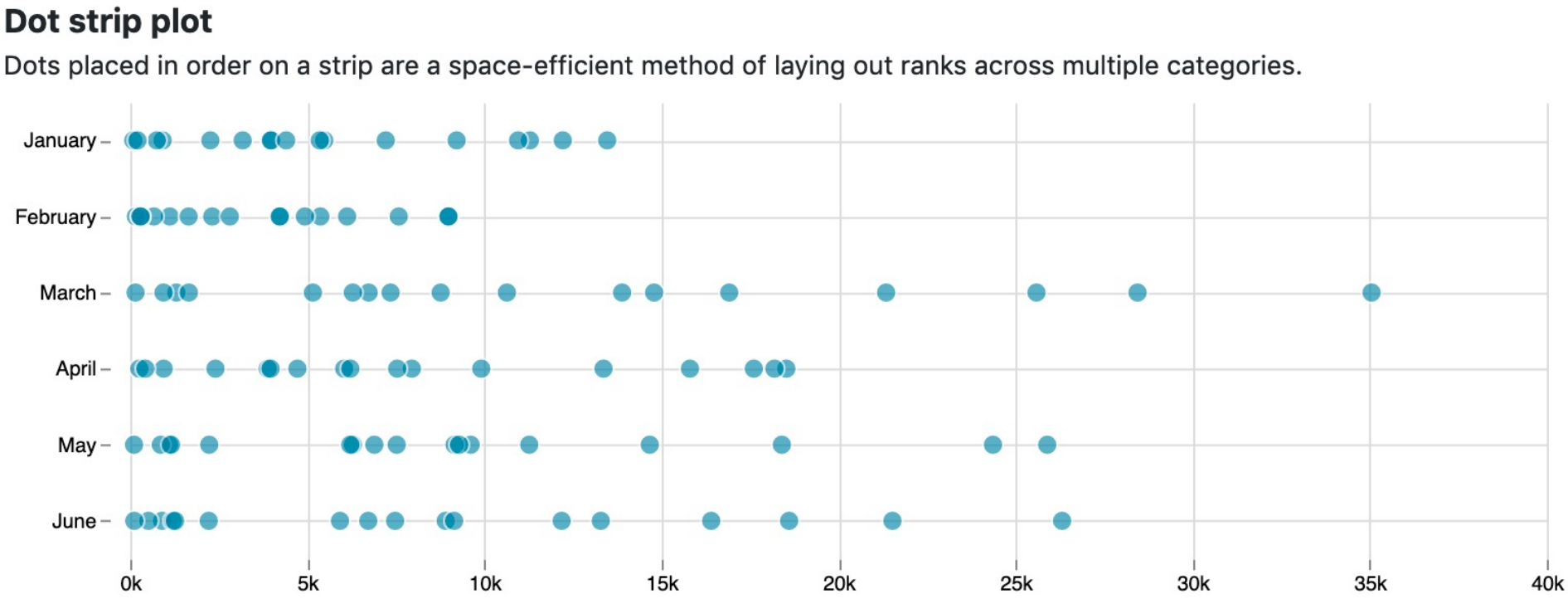
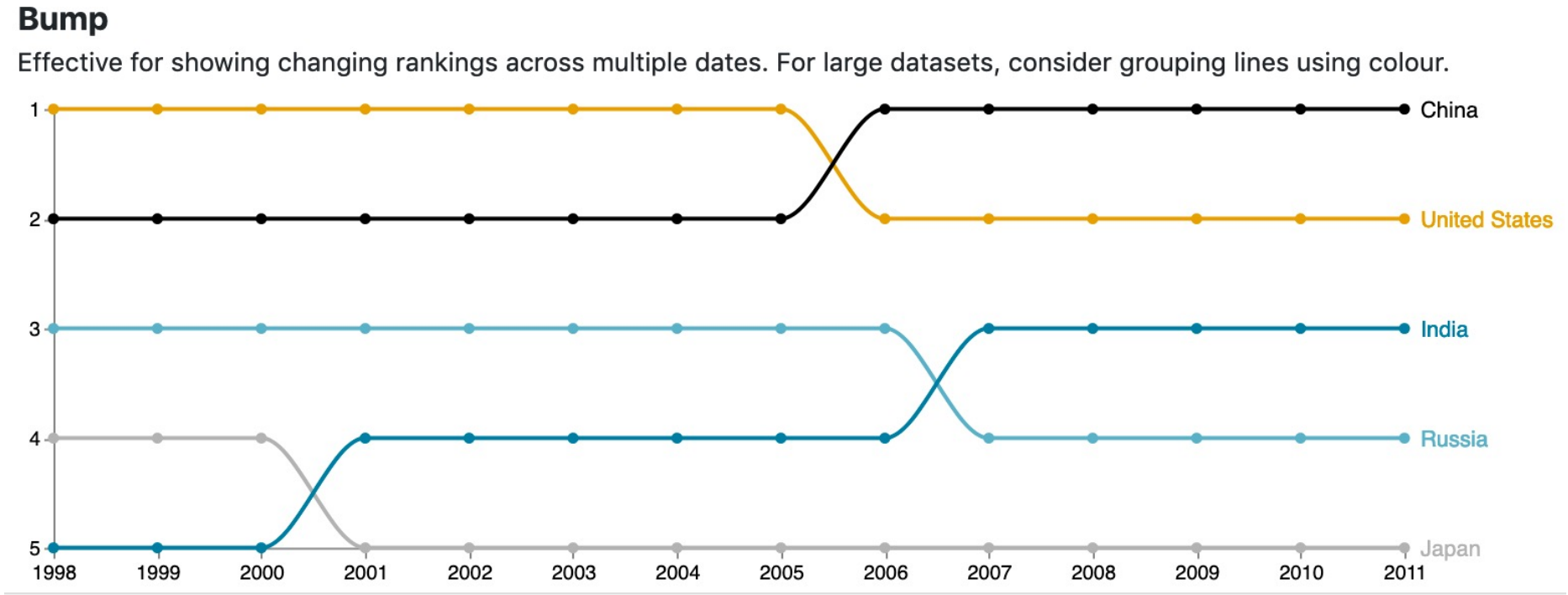


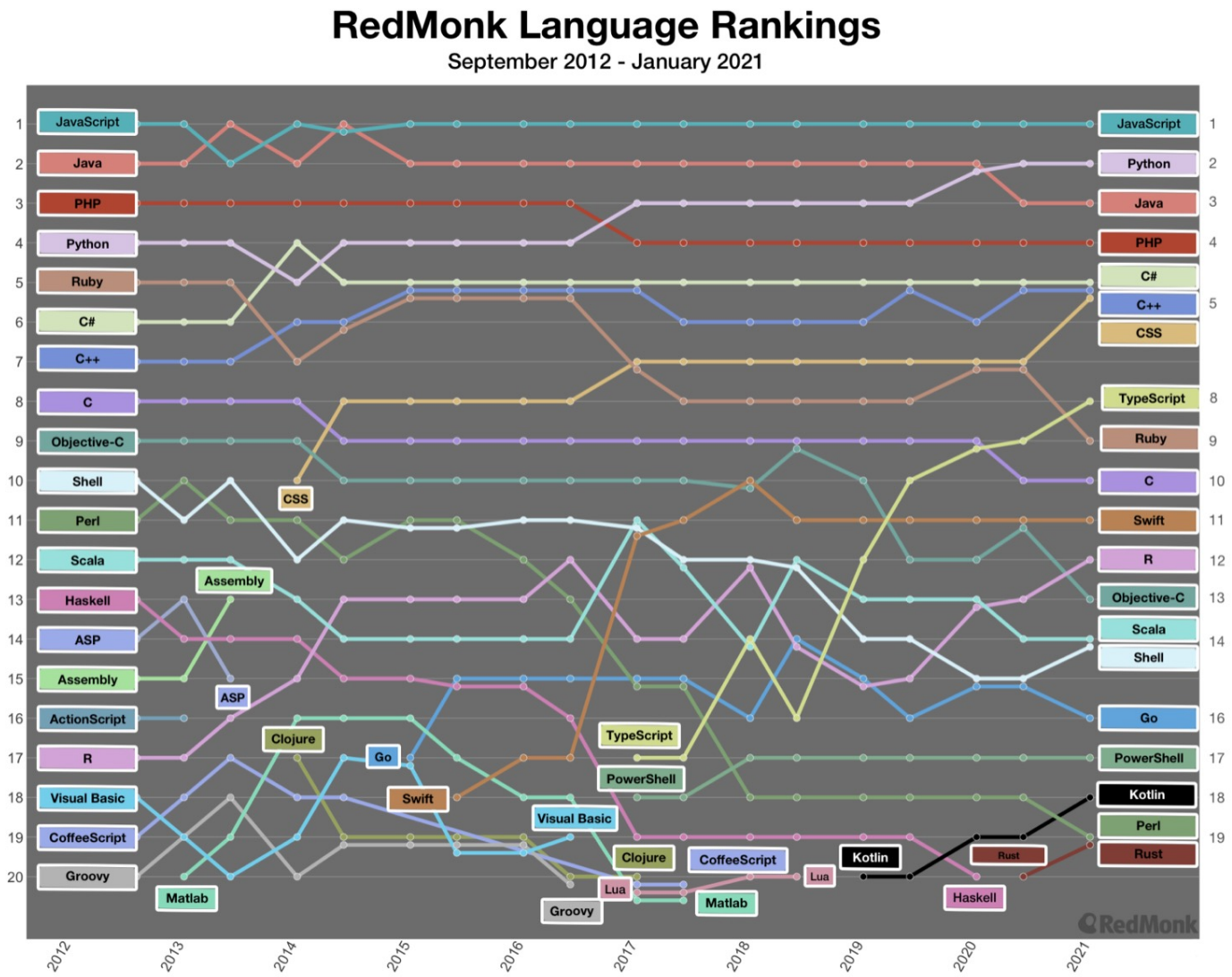
- Each marker is a sub-category

Visualization Types: Ranking

- Use where an item's position in an ordered list is more important than its absolute or relative value.
- Don't be afraid to highlight the points of interest.

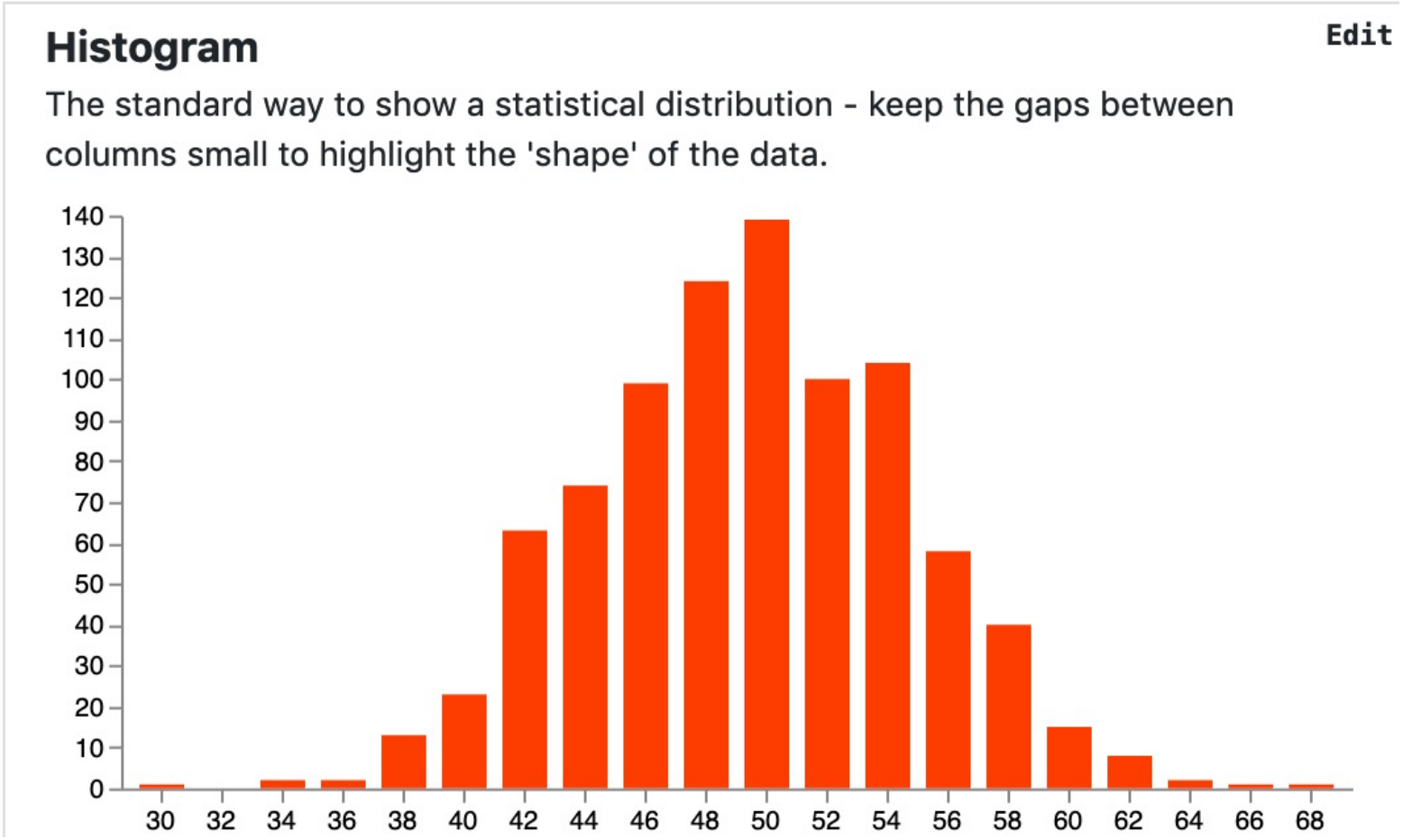


- https://insights.dice.com/2021/03/18/programming-languages-that-remain-popular-in-the-long-term/



Visualization Types: Distribution

- Show values in a dataset and how often they occur.
- The shape (or skew) of a distribution can be a memorable way of highlighting the lack of uniformity or equality in the data



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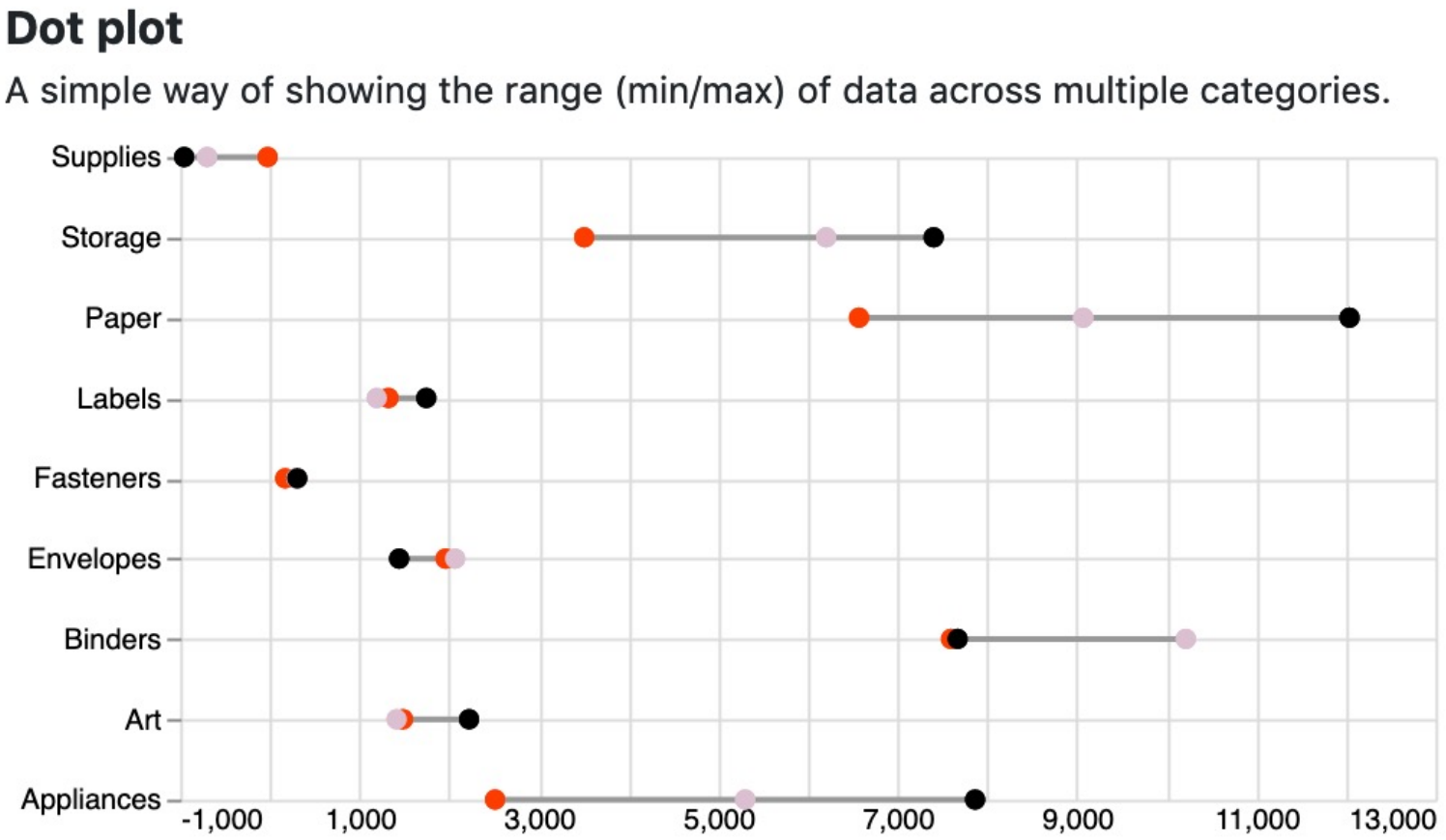

Visualization Types: Distribution

- Show values in a dataset and how often they occur.
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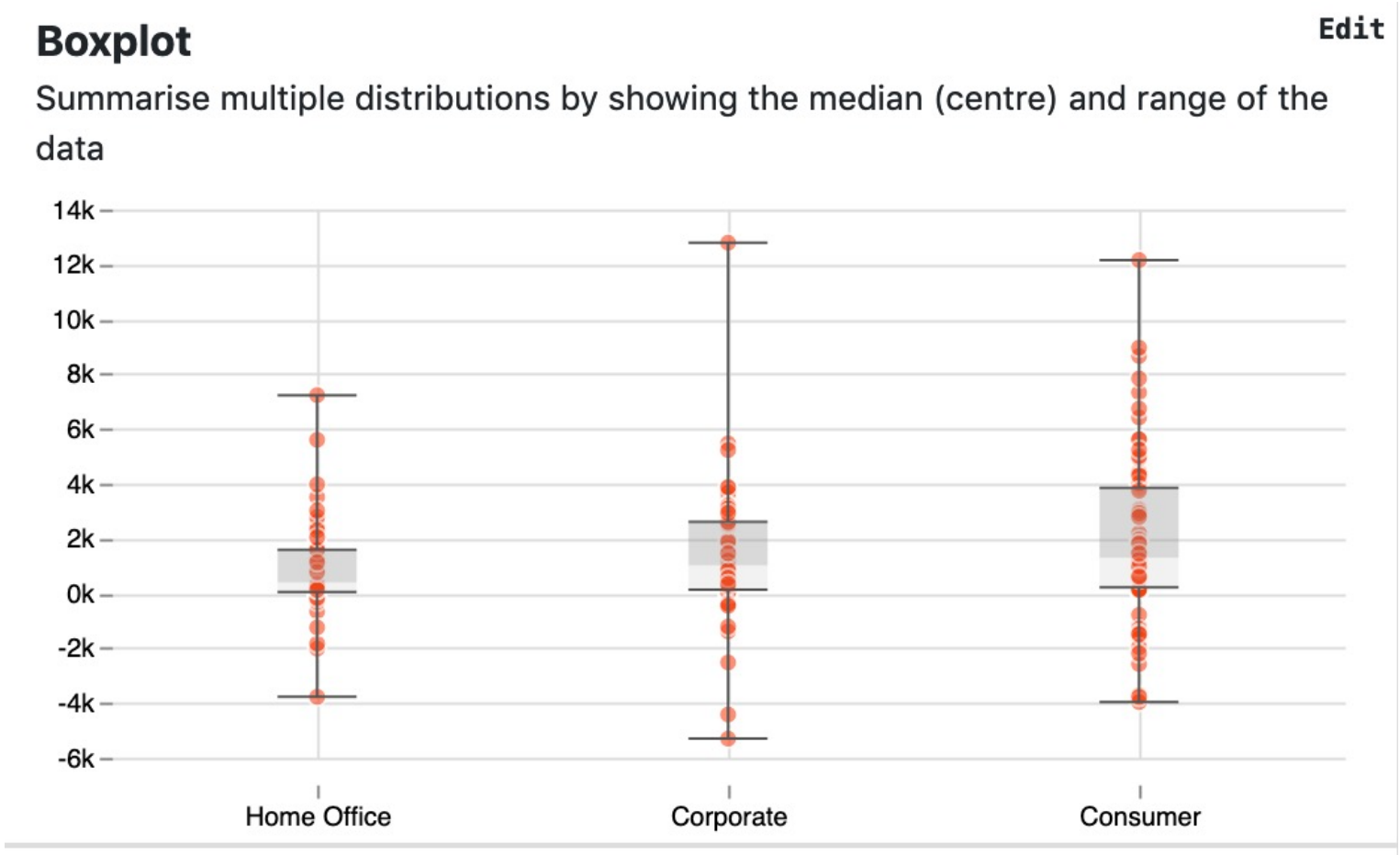
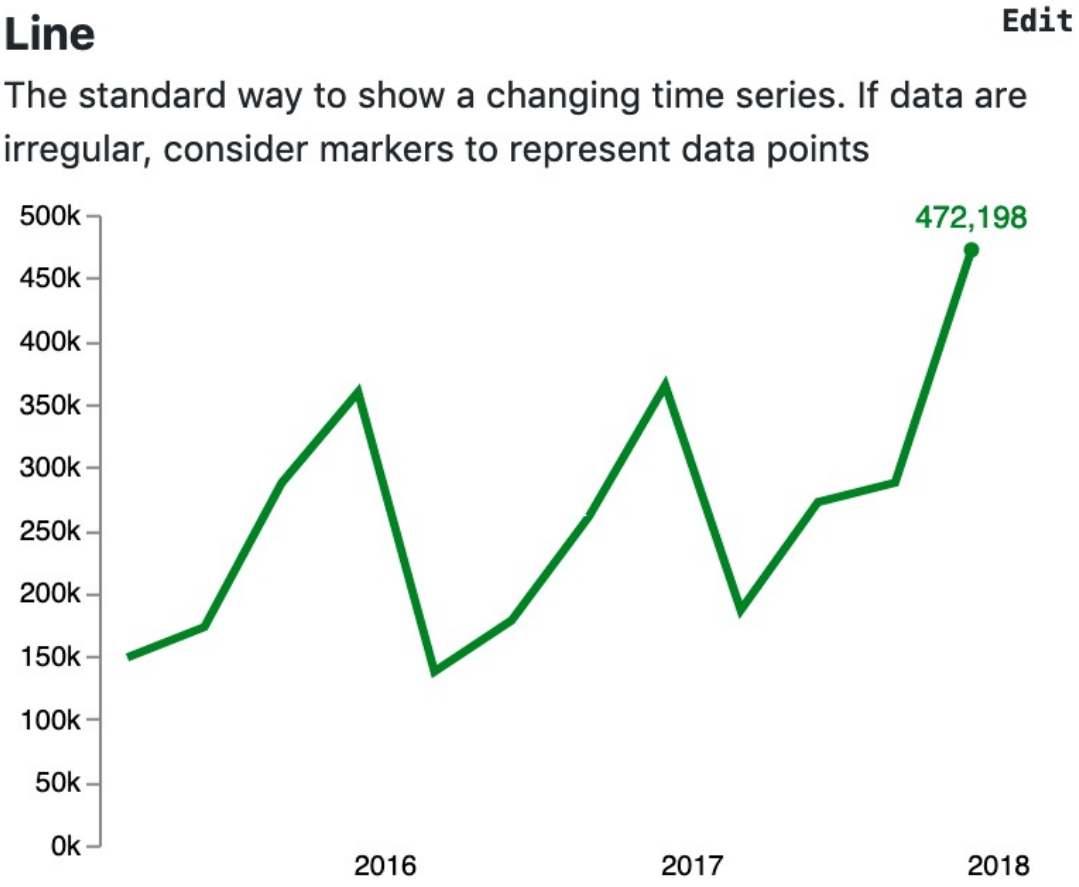


Visualization Types: Timeseries

- Give emphasis to changing trends.
- These can be short (intra-day) movements or extended series traversing decades or centuries:
- Choosing the correct time period is important to provide suitable context for the reader



Visualization Types: Timeseries

- Sometimes it is better to give additional statistics like max,min std on top of average values

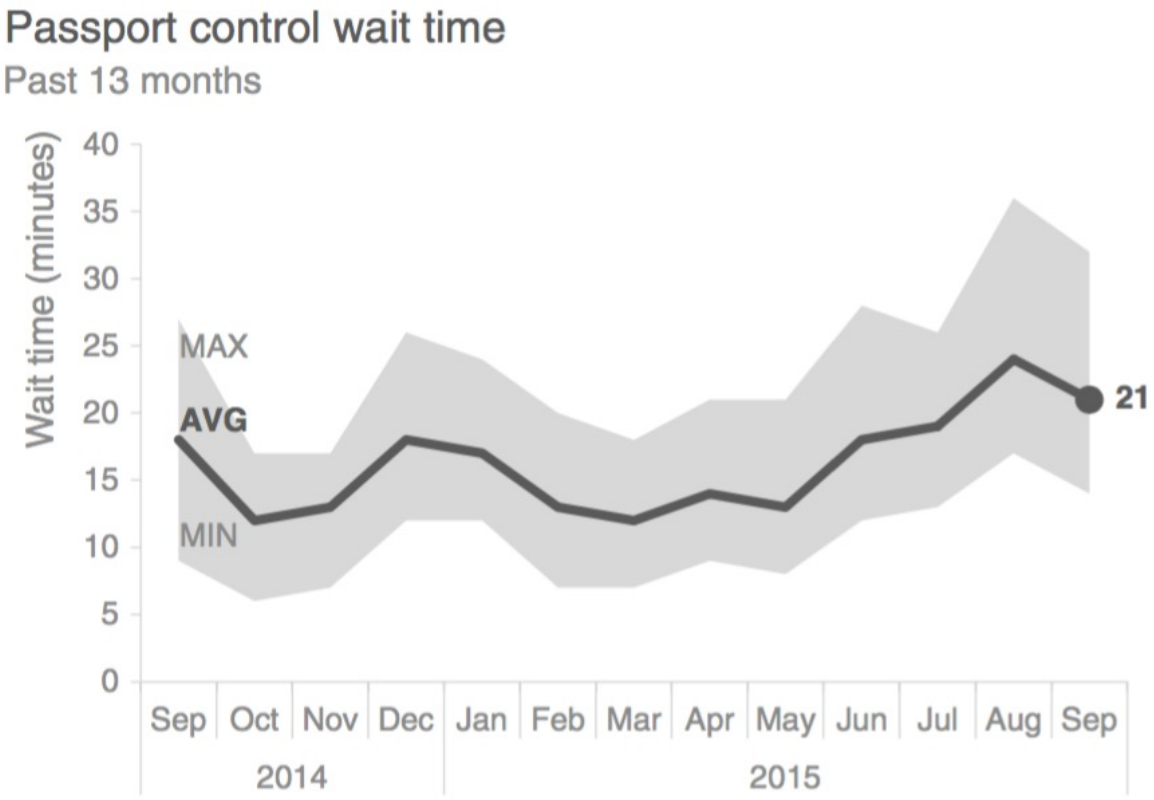
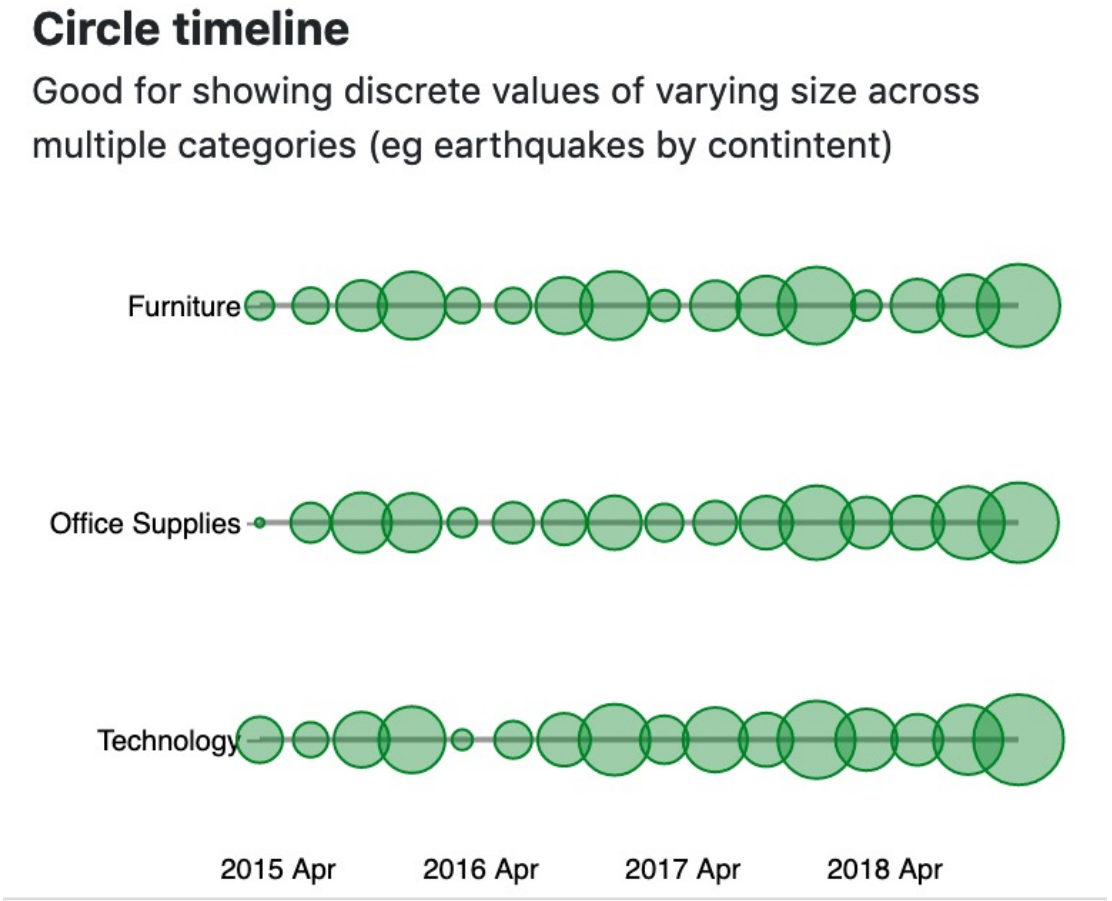


FIGURE 2.9 Showing average within a range in a line graph

Visualization Types: Timeseries

- Give emphasis to changing trends.
- These can be short (intra-day) movements or extended series traversing decades or centuries:
- Choosing the correct time period is important to provide suitable context for the reader



Visualization Types: Timeseries

- Give emphasis to changing trends.
- These can be short (intra-day) movements or extended series traversing decades or centuries:
- Choosing the correct time period is important to provide suitable context for the reader

Fan chart (projections)

Use to show the uncertainty in future projections - usually this grows the further forward to projection

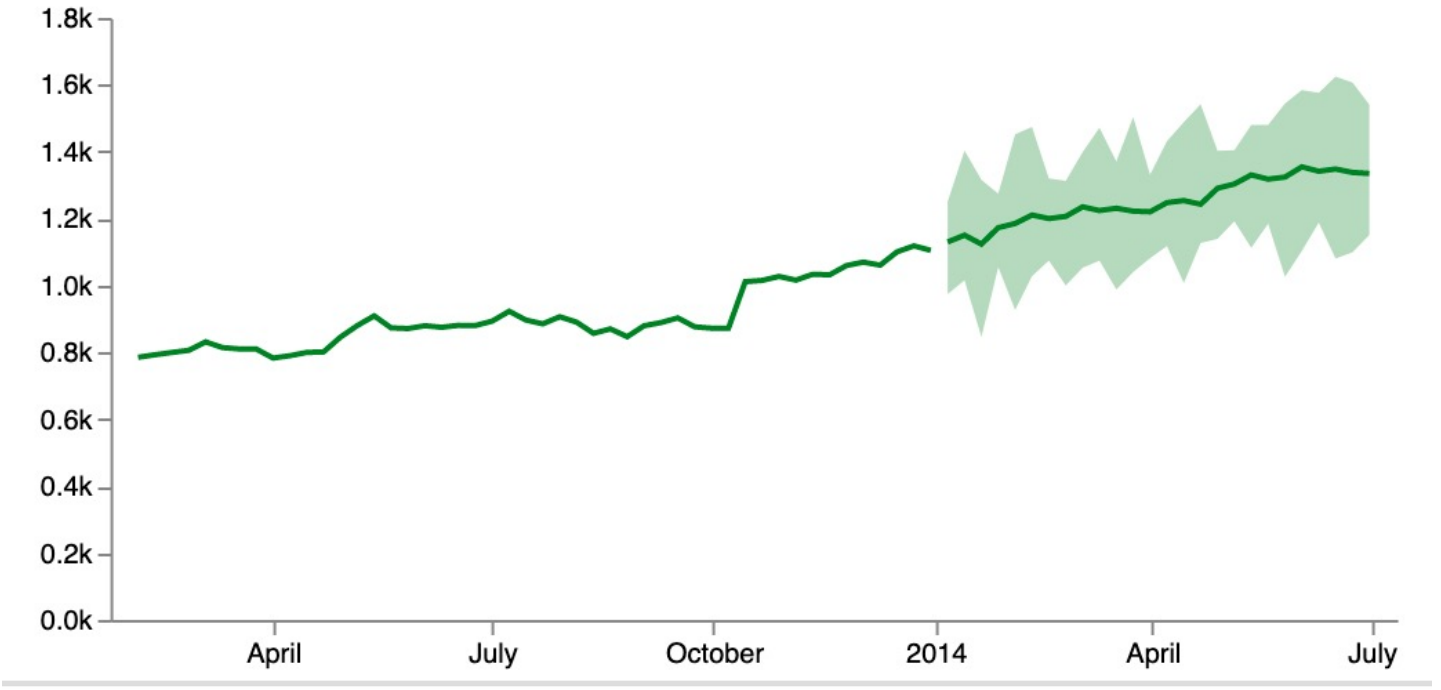


Table Tips

Sometimes, a table is better than text.

TABLE VI Summary and Comparison of Mainstream Deep Learning Libraries

Library	Low-Layer Language	Available Interface	Pros	Cons	Mobile Supported	Popularity	Upper-Level Library
Tensor-Flow	C++	Python, Java, C, C++, Go	• Large user community • Well-written document • Complete functionality • Provides visualization tool (TensorBoard) • Multiple interfaces support • Allows distributed training and model serving	• Difficult to debug • The package is heavy • Higher entry barrier for beginners	Yes	High	Keras, TensorLayer, Luminoth
Theano	Python	Python	• Flexible • Good running speed	• Difficult to learn • Long compilation time • No longer maintained	No	Low	Keras, Blocks, Lasagne
Caffe(2)	C++	Python, Matlab	• Fast runtime • Multiple platform s support	• Small user base • Modest documentation	Yes	Medium	None
(Py)Torch	Lua, C++	Lua, Python, C, C++	• Easy to build models • Flexible • Well documented • Easy to debug • Rich pretrained models available • Declarative data parallelism	• Has limited resource • Lacks model serving • Lacks visualization tools	Yes	High	None
MXNET	C++	C++, Python, Matlab, R	• Lightweight • Memory-efficient • Fast training • Simple model serving • Highly scalable	• Small user base • Difficult to learn	Yes	Low	Gluon

C. Zhang, P. Patras and H. Haddadi, "Deep Learning in Mobile and Wireless Networking: A Survey," in IEEE Communications Surveys & Tutorials, vol. 21, no. 3, pp. 2224-2287, thirdquarter 2019, doi: 10.1109/COMST.2019.2904897.

Graphics can be better than tables

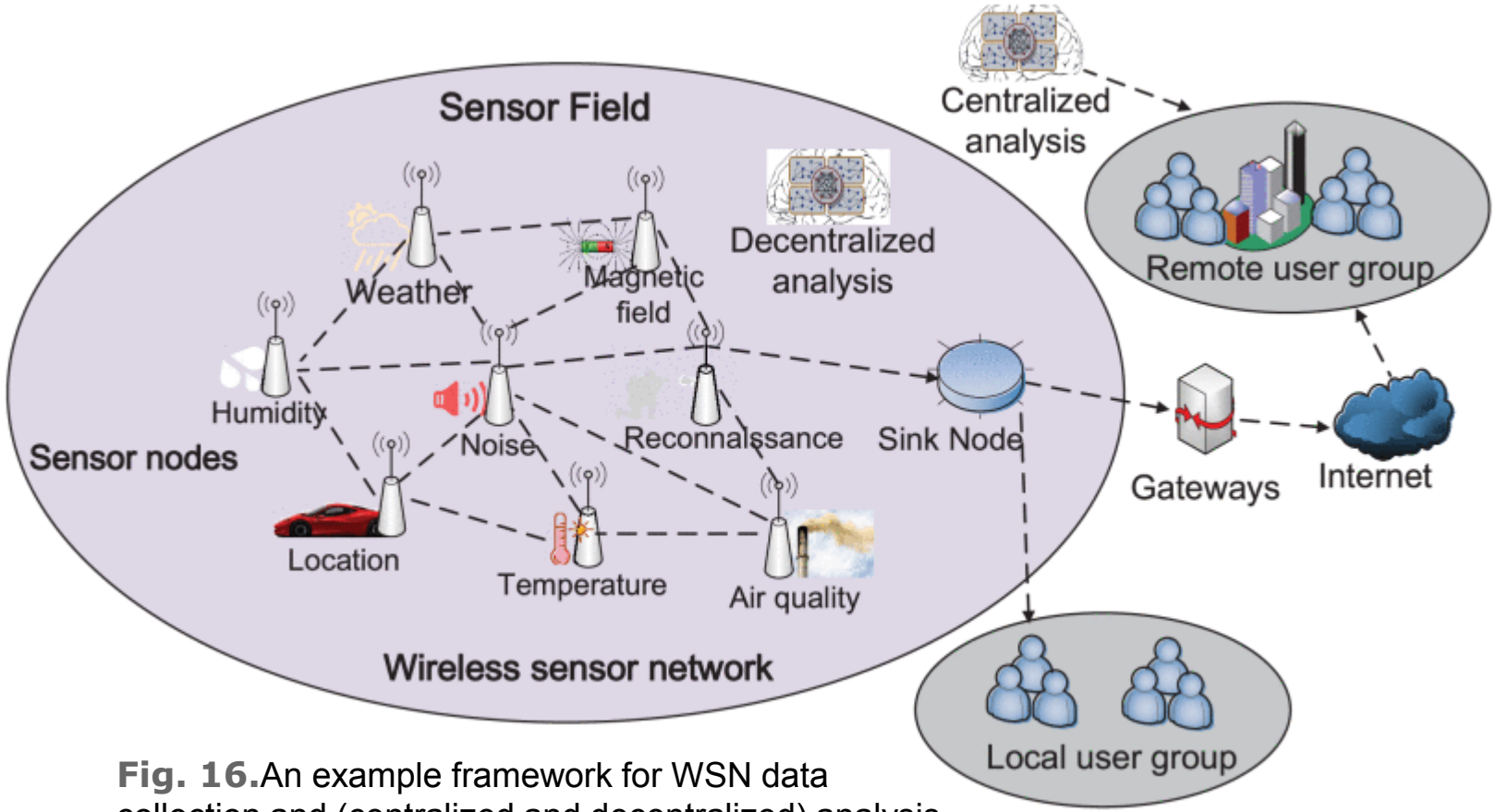


Fig. 16. An example framework for WSN data collection and (centralized and decentralized) analysis.

C. Zhang, P. Patras and H. Haddadi, "Deep Learning in Mobile and Wireless Networking: A Survey," in IEEE Communications Surveys & Tutorials, vol. 21, no. 3, pp. 2224-2287, thirdquarter 2019, doi: 10.1109/COMST.2019.2904897.

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Table tips

- Use column headings.
- Alignment:
  - Text: left.
  - Numbers: right.
    Align to decimal point!!
- Titles above tables (usually).

TABLE 3 Comparison of the VQE solution, obtained with an R_Y variational form of depth 3, a depth p=4 QAOA solution, and a diagonalization of the hamiltonian of the portfolio optimization problem

Assets selected	Energy	Probability
Diagonalization		
[1 0 1 0 1 0]	-0.0036	1.0000
VQE		
[0 1 0 0 1 1]	-0.0021	0.4431
[0 1 0 1 1 0]	-0.0021	0.3660
[1 1 0 0 1 0]	-0.0036	0.1154
QAOA	0.01	0.01
[1 1 0 0 1 0]	-0.0036	0.0487
[1 0 1 0 1 0]	-0.0036	0.0486
[1 0 0 1 1 0]	-0.0031	0.0485

D. J. Egger et al., "Quantum Computing for Finance: State-of-the-Art and Future Prospects," in IEEE Transactions on Quantum Engineering, vol. 1, pp. 1-24, 2020, Art no. 3101724, doi: 10.1109/TQE.2020.3030314.

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Table tips

- Cite source.

Table 1

Numbers of Boys and Girls by Age Group

Grade	Boys	Girls
4	115	126
5	130	119
6	117	124
Total	362	369

Note. Adapted from *Example Book*, by J. Smith, 2016, p. 115. Copyright 2016 by Scribbr.

https://www.scribbr.com/apa-style/6th-edition/archived-tables-and-figures/

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Graphics

Lecture Contents:

- When to use what.
- Chart tips.
- Figures & text.
- Showing uncertainty.
- Table tips.
- Exercise.

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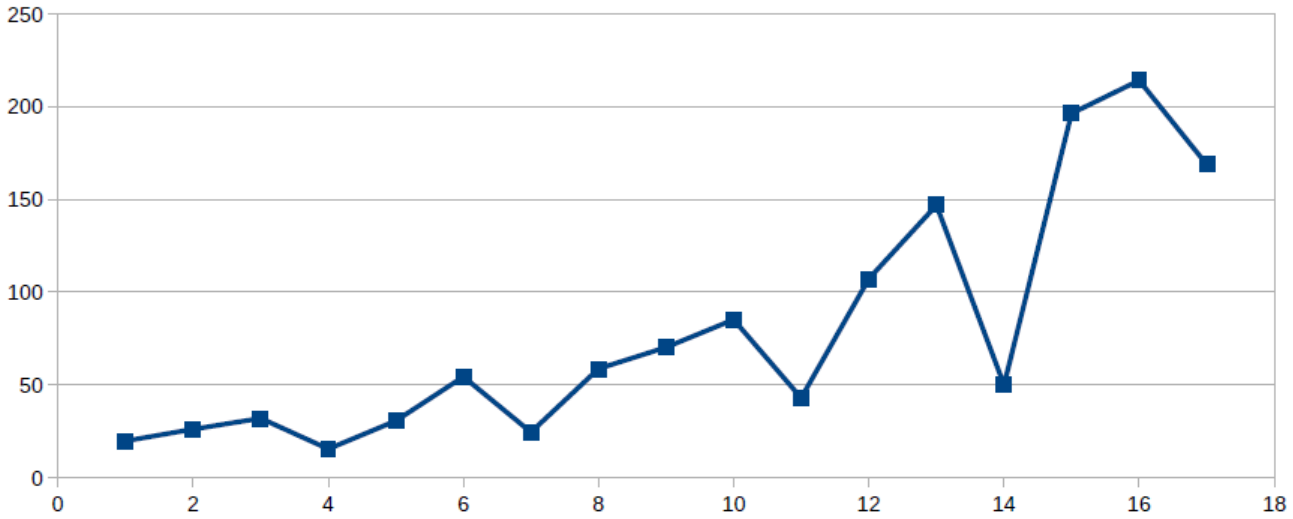
Exercise: what is wrong here?



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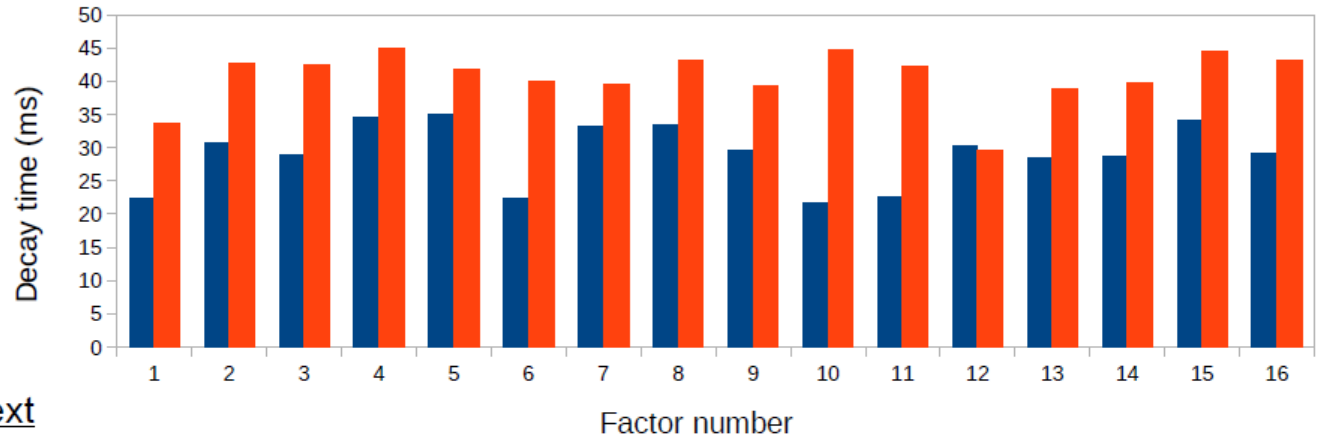
Exercise: what is wrong here?

Figure 2: Impact of protein factors on decomposition rate



Text

The figure shows the decay time with respect to introduced protein factors via:

- in vivo introduction.
- in vitro introduction.

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Exercise: make a chart

Amount of time to create a video montage in seconds (successive trials, one individual):

- 325.7, 415.6, 210.4, 56.6, 57.6, 45.5, 51.3, 45.7, 44.4, 51.6.

Exercise: Create:

- A chart showing trend over time.
- Accompanying text.

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Exercise: make a chart

Two groups of 10 subjects each used video editing software A vs B to create a video montage in one attempt.

Time taken by group A in minutes : 47 64 56 83 36 38 51 49 69 75 60
Time taken by group B in minutes : 77 69 42 58 89 59 79 70 82 93 86

Create a chart that compares the time taken by each group, indicating the 95% CI of the mean duration in each group.

Are the durations significantly different?

Hint: Use two-sample t-test with unequal variances.

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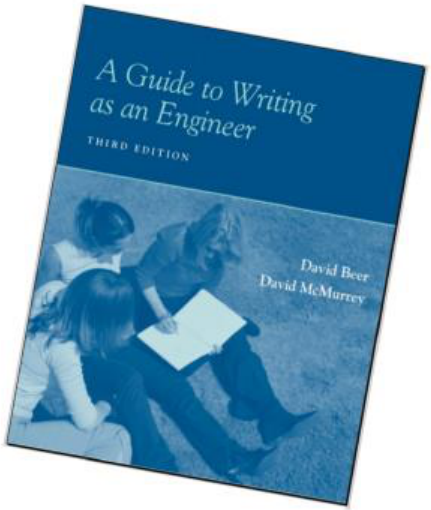
Reading



Beer & McMurrey Chapter 7.

"Constructing Engineering Tables and Graphics"