Principles of Visualization

3 February 2020

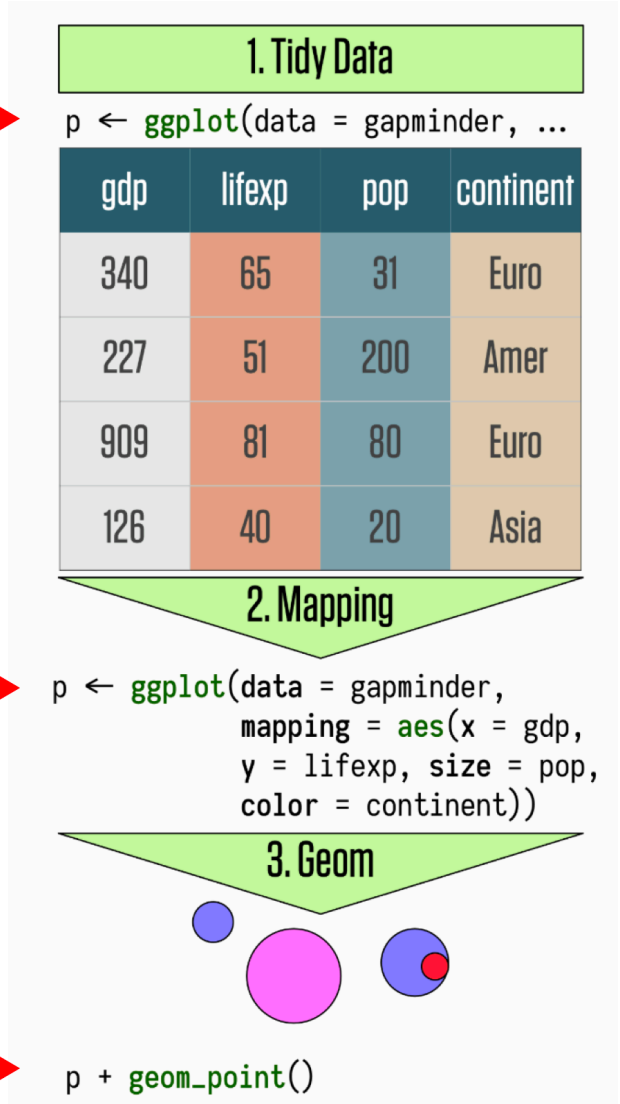
Modern Research Methods

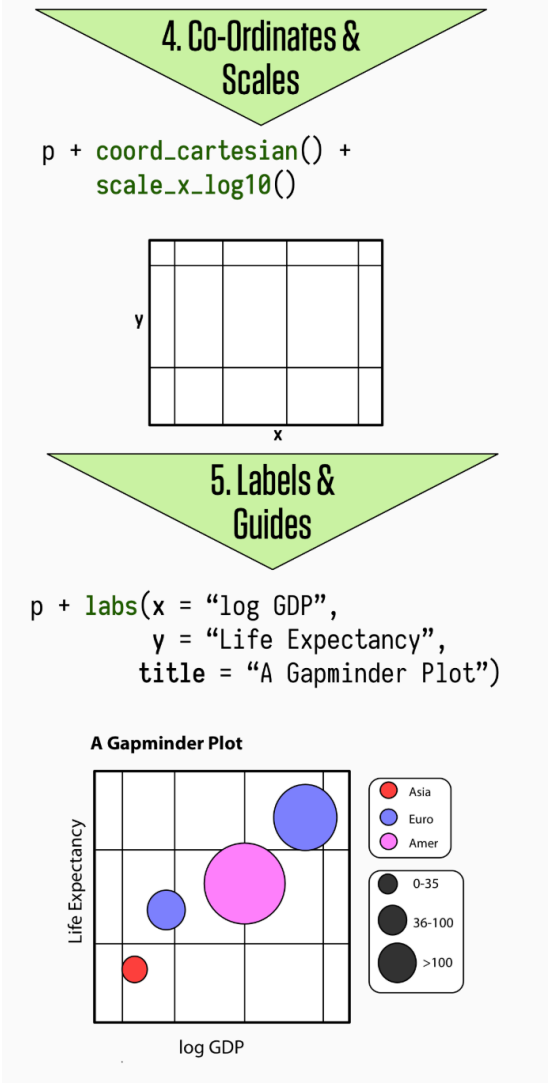
Last Time: Plotting with ggplot

What data do you want to plot?

Map variables to aesthetics (parts) of plot

What kind of plot do you want

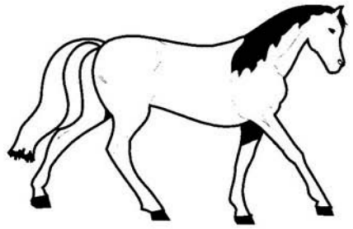




Last Time: Plotting with ggplot

	word	mean_complexity_rating	complexity_type	word_class	n_chars	n_syllables	n_phonemes	concreteness	familiarity	imageability	frequency
1	a	1.375	low	closed	1	1	1	201	632	217	410.55
2	about	3.9375	high	closed	5	2	4	227	593	225	193.97
3	ache	2.88235294117647	low	open	4	1	3	443	523	443	8.23
4	affirmation	5.83333333333333	high	open	11	4	8	242	332	313	4.25
5	after	2.23076923076923	low	closed	5	2	4	242	575	217	93.85
6	age	2.17647058823529	low	open	3	1	2	390	582	468	36.83
7	aid	1.625	low	open	3	1	2	372	536	413	17.31
8	all	2.66666666666667	low	closed	3	1	2	267	582	332	225.97
9	ally	3.23076923076923	low	open	4	2	3	485	410	453	
10	alphabet	3.57142857142857	high	open	8	3	7	449	493	499	8.23

“The linguistic sign is arbitrary” – Saussure (1916)



horse

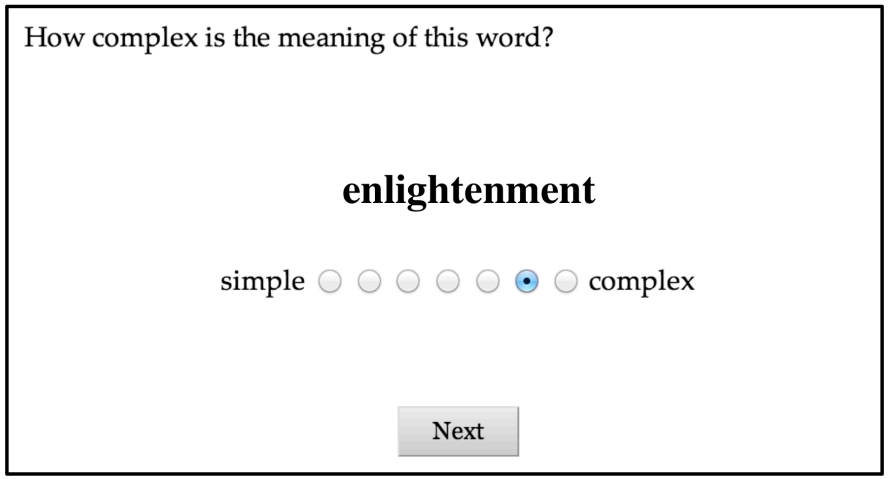
kalë حصان ձի at zaldi конь घाड़ा konj кон cavall kabayo 马 馬 konj
kůň hest paard ĉevalo hobune kabayo hevonen cheval cabalo
Pferd άλογο ઘોડો chwal doki סוס घोड़ा nees ló hestur anyịnya kuda
capall cavallo 馬 jaran ಕುದುರೆ ม้า 말씀 equo zirgs arklys коњ kuda
hoiho ઘોડા адуу ઘોડા hest اسب koń cavalo ঘোড়া cal лошадь коњ kôň
konj faras caballo farasi häst குதிரை గుర్రము ม๊า кінь گھوڑا ngựa ceffyl

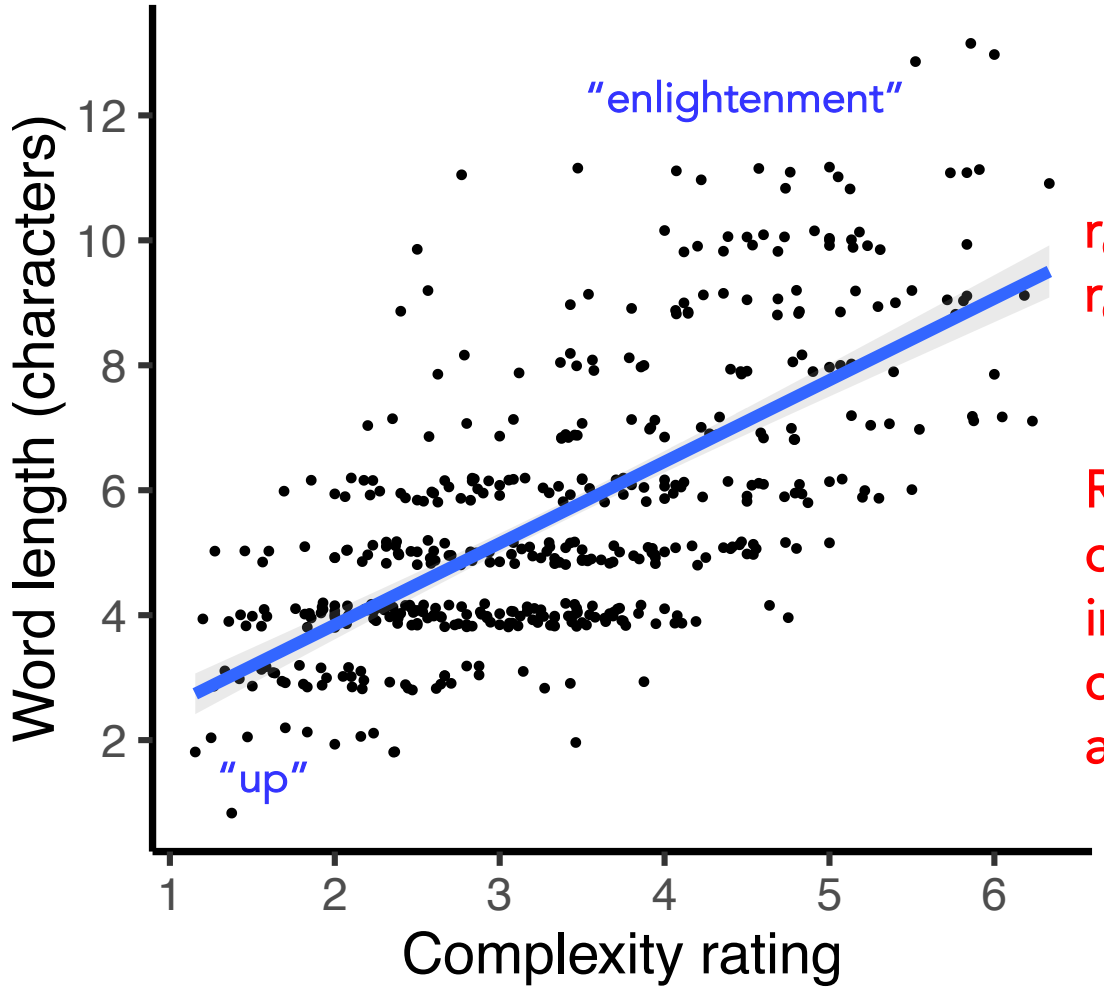
However, limits to arbitrariness

(Köhler, 1929; Maurer, et al., 2006; Ramachandran & Hubbard, 2001; Farmer, Christiansen, & Monaghan, 2006; Zipf, 1936; Piantadosi, Tily, & Gibson, 2011)

Complexity Bias in natural language

Participants rated 499 words for conceptual complexity
(Lewis & Frank, 2016)





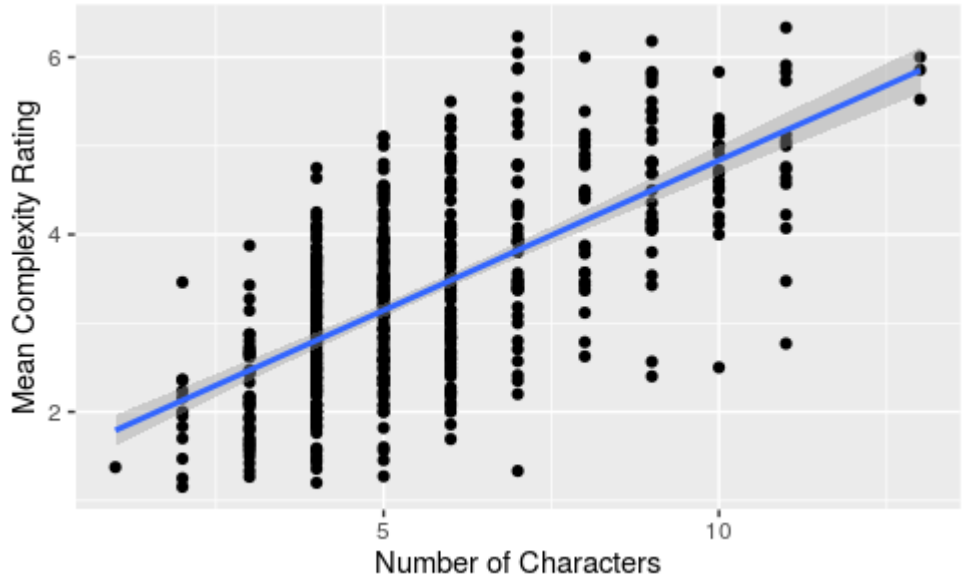
$r_{CL} = .69$
$r_{CL \bullet F} = .60$

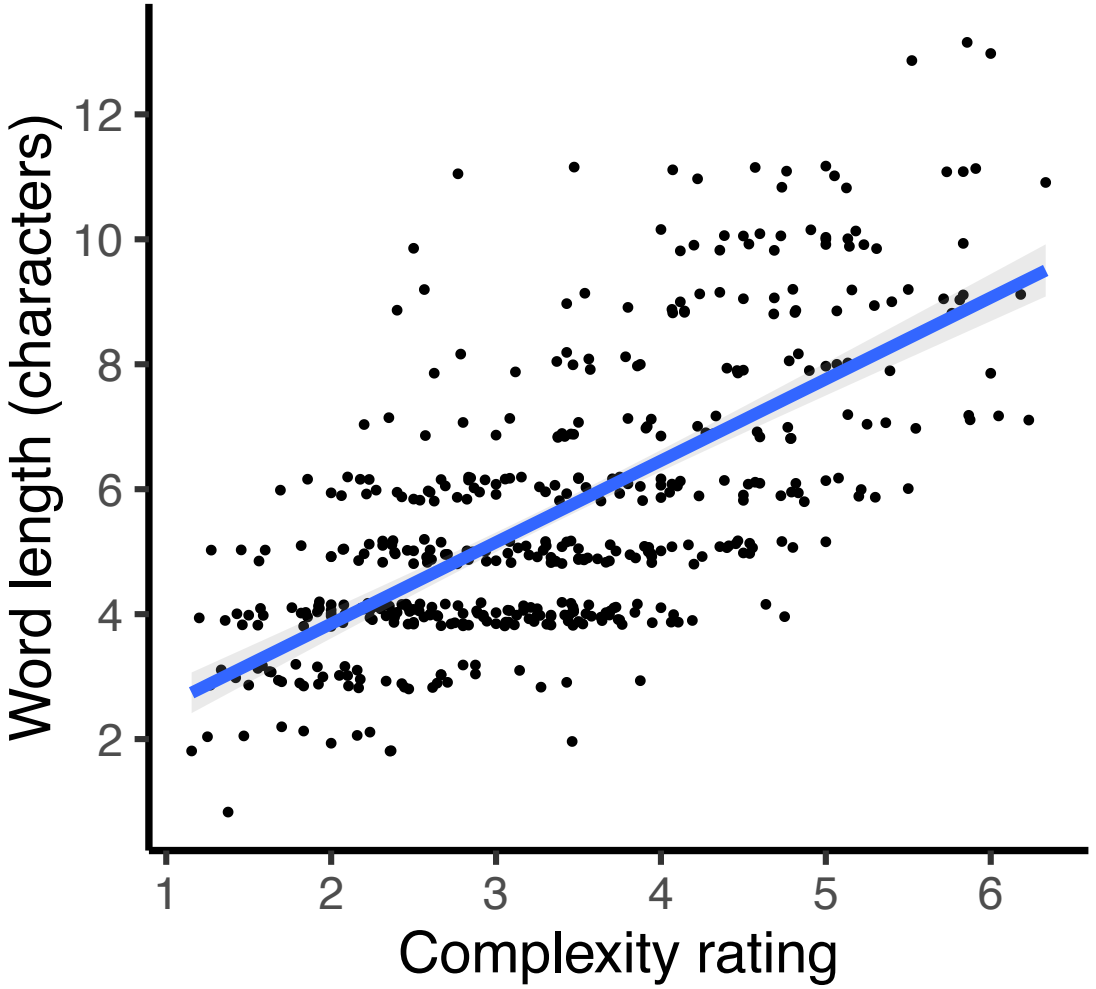
Reliable controlling for imageability, concreteness, and familiarity

$N = 250$

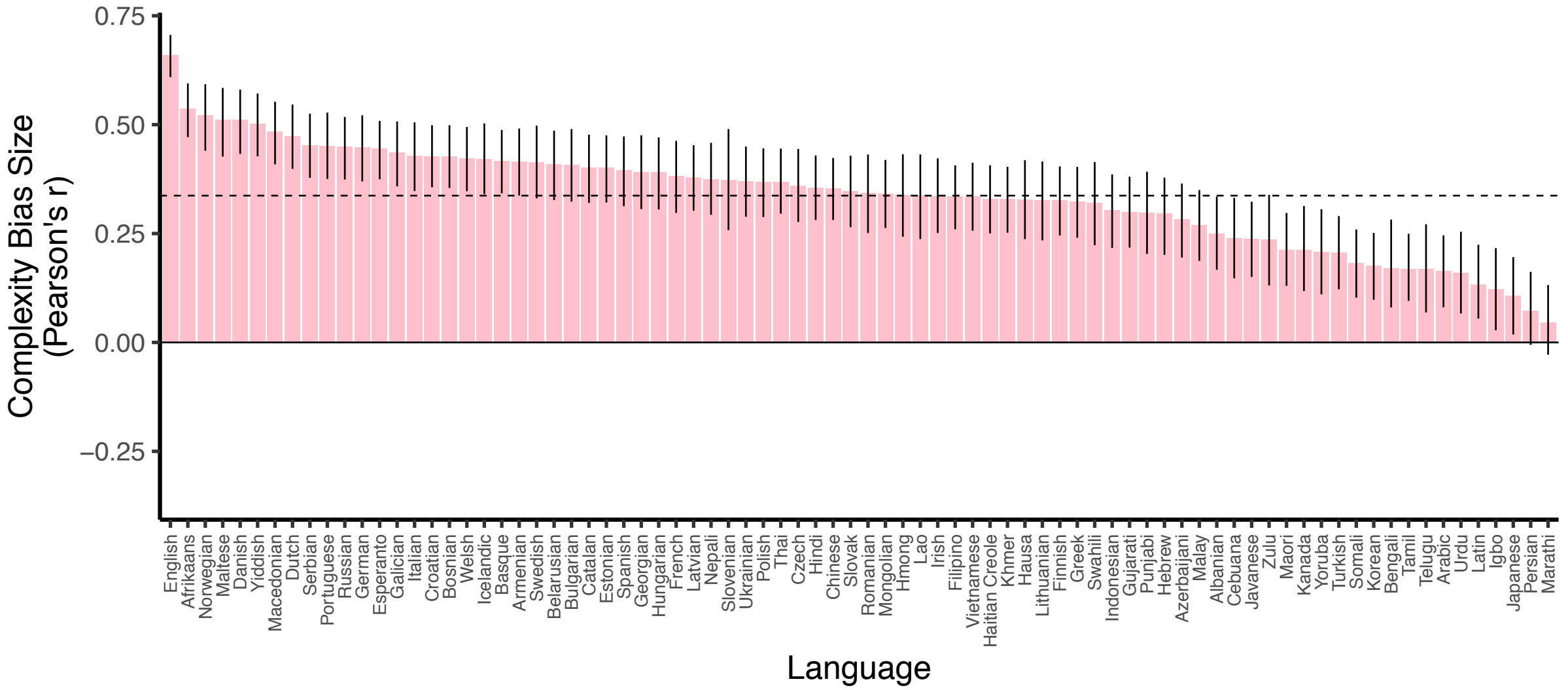
Complexity Bias in natural language

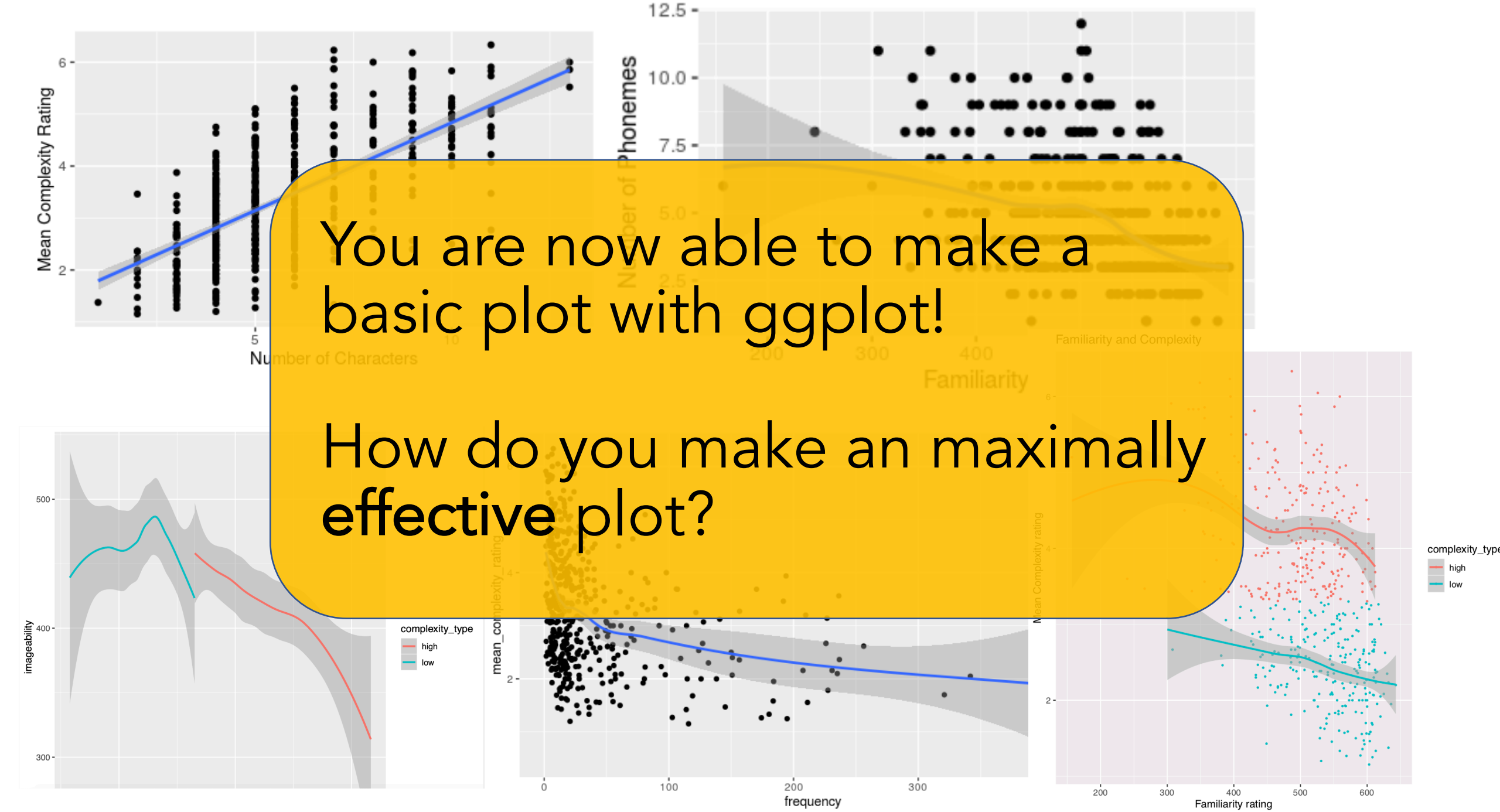
Plot by Nicole Hsing and Nicole Casey





Complexity bias cross-linguistically





You are now able to make a basic plot with ggplot!

How do you make an maximally **effective** plot?

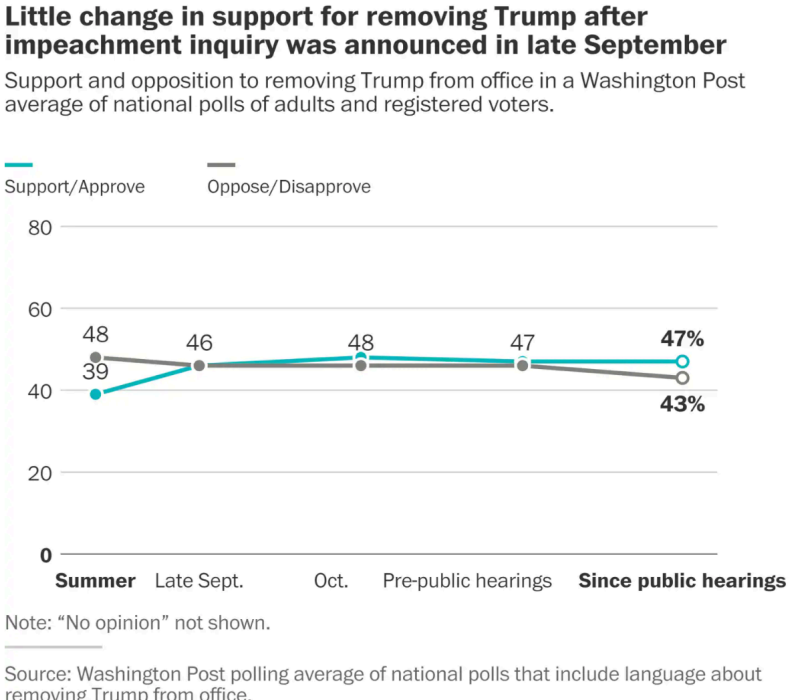
Principles of Data Visualization

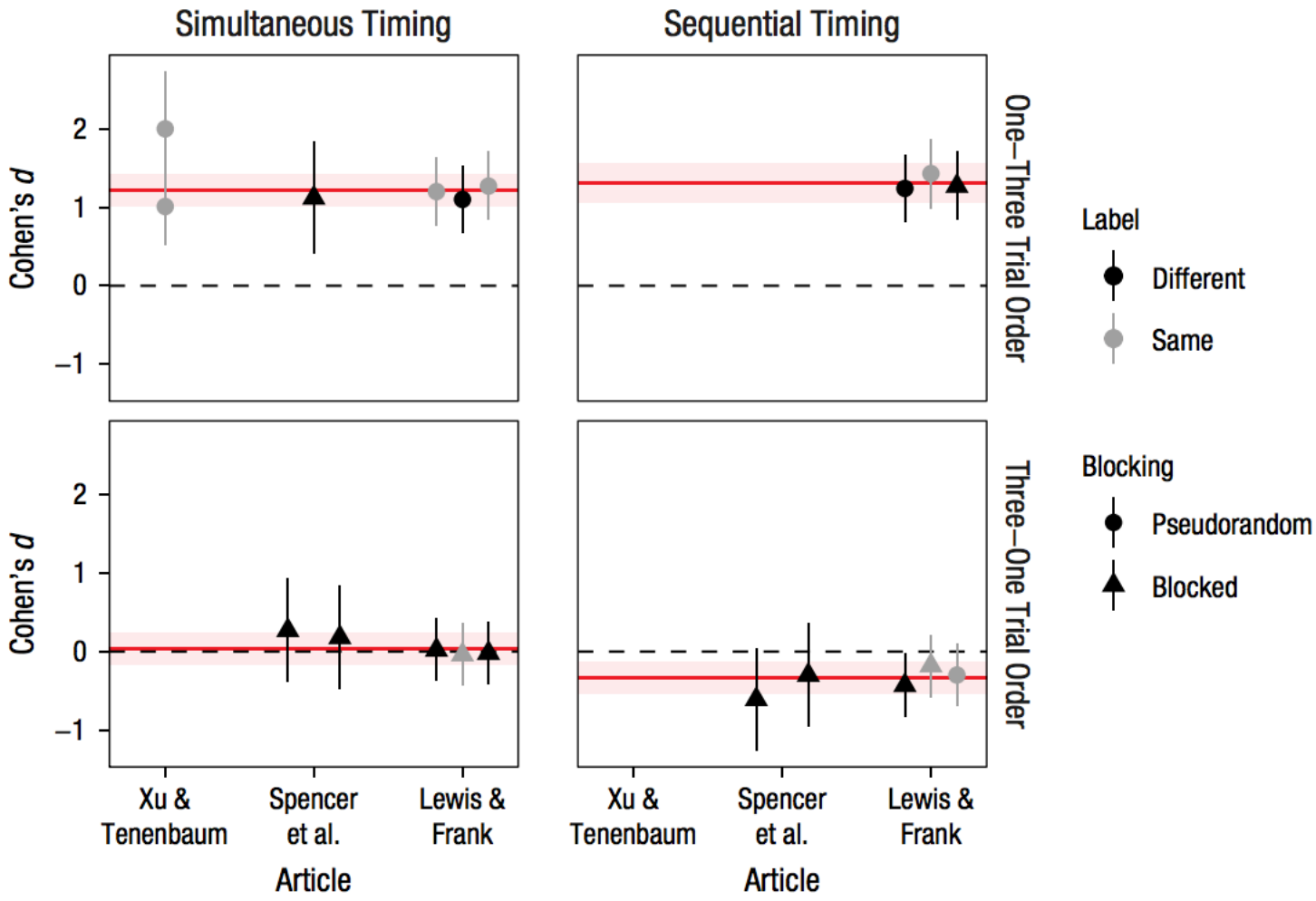
- Visualization as **communication**
  - There is no list of rules for what makes a good visualization
  - Design depends on the message you want to communicate
  - And, who your audience is.

- Your goal is to make it as easy as possible for your audience to understand your message.
- Too much detail/information means your audience might not get the intended message.

Kinds of Audiences

- You, exploring data
- Newspaper
- Journal Article
- Poster Presentation





(Lewis & Frank, 2018)

Some Guidelines

1. Get rid of "chart junk" – maximize info to ink ratio

(image source: Healy, 2018)

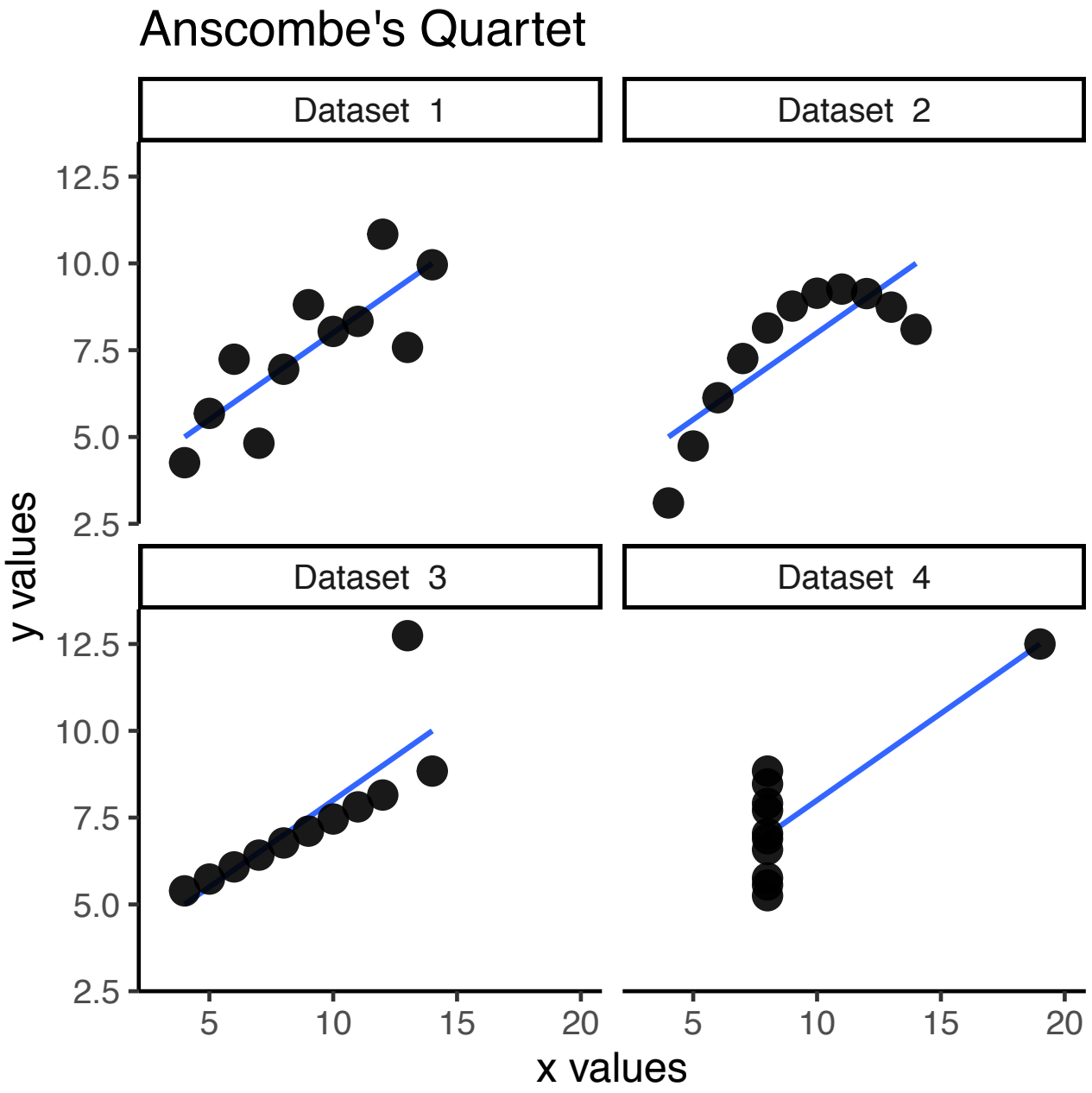
Some Guidelines

1. Get rid of “chart junk” – maximize info to ink ratio

2. Don’t be deceptive – show the raw data when possible

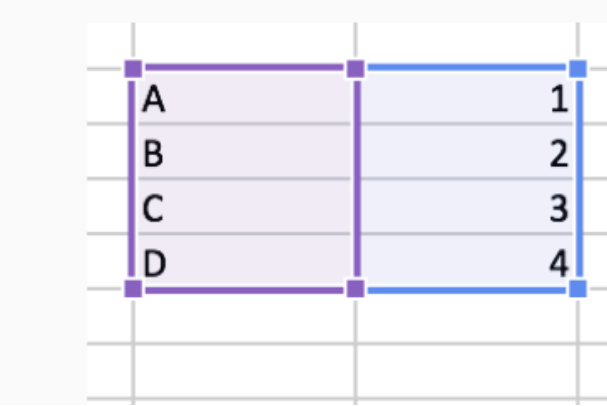
Anscombe's quartet

I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84



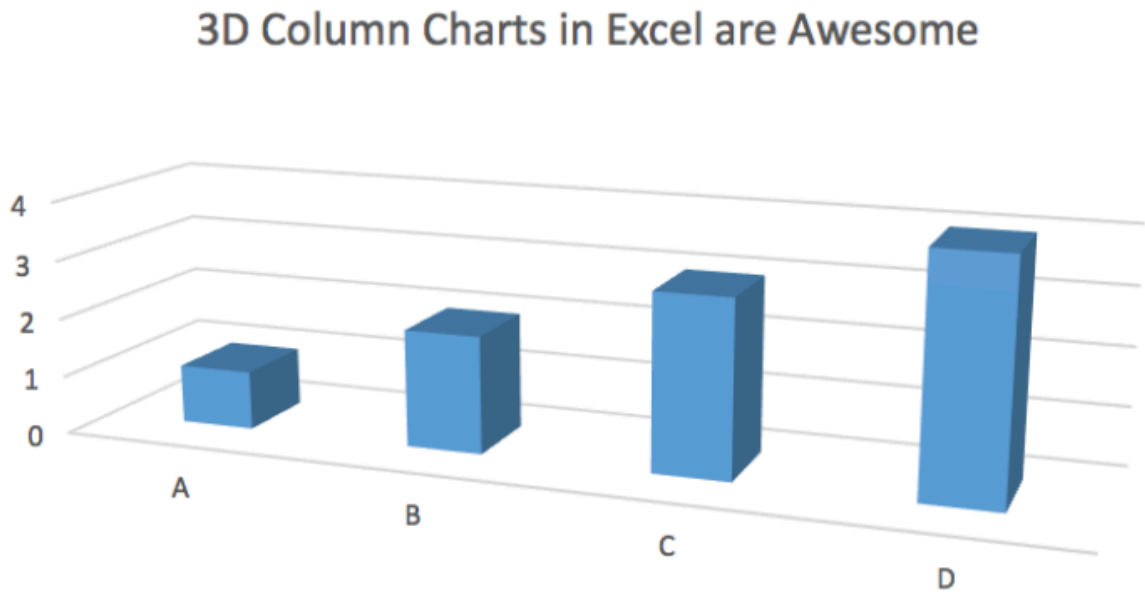
Some Guidelines

1. Get rid of “chart junk” – maximize info to ink ratio



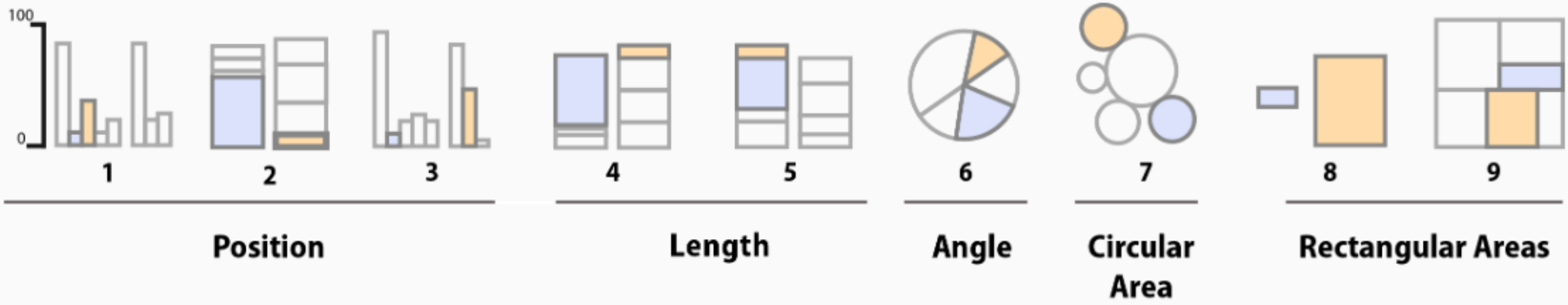
2. Don’t be deceptive – show the raw data when possible

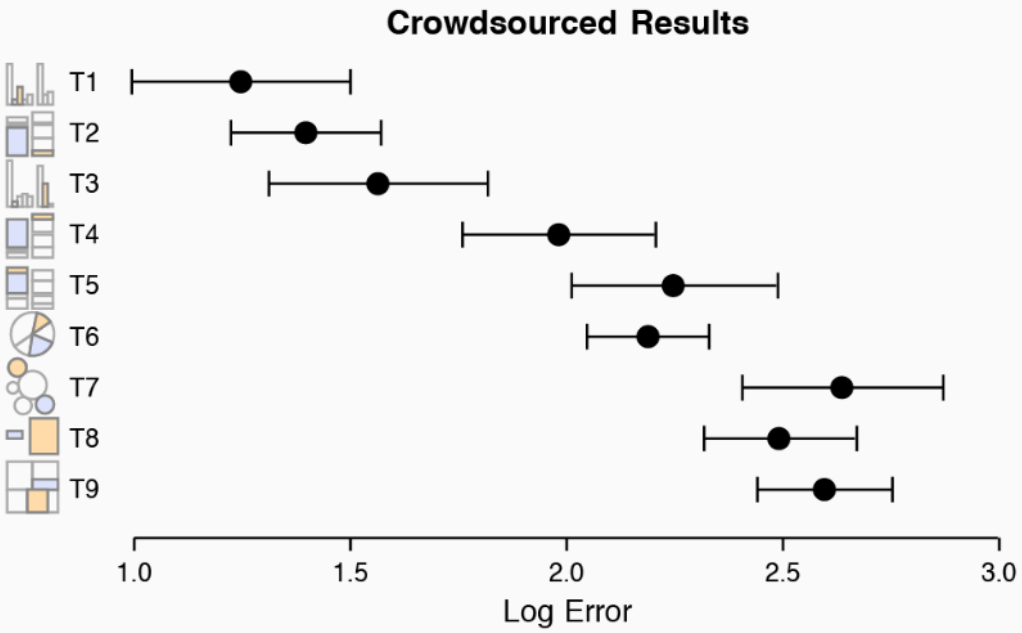
3. Think about human perception.



(image source: Healy, 2018)

Some things are easier to perceive than others!

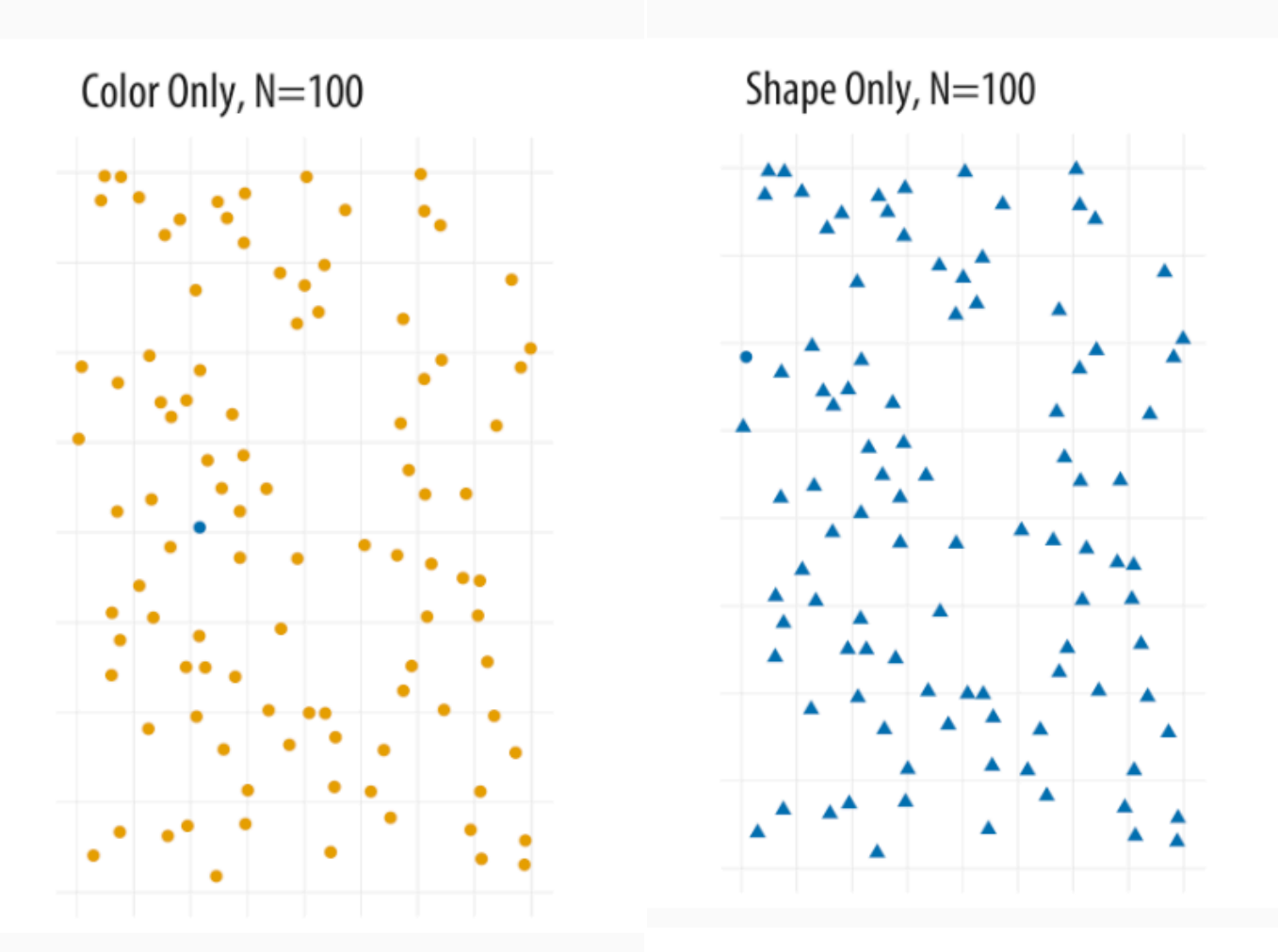




Position and length are easiest for the human perceptual system to distinguish.

Heer & Bostock (2010);
image source: Healy, 2018

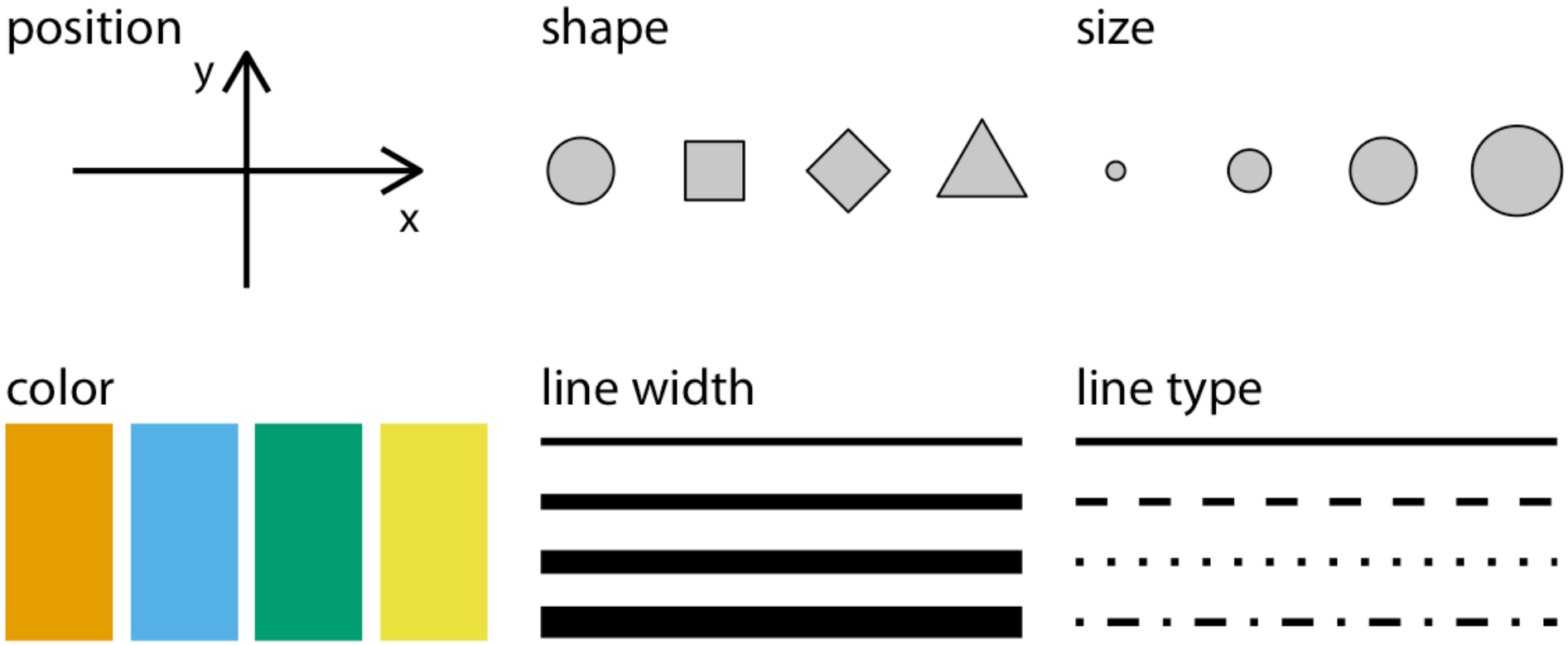
Attentional “pop”



Attentional “pop” is stronger for color than for shape.

(image source: Healy, 2018)

Main channels available in ggplot

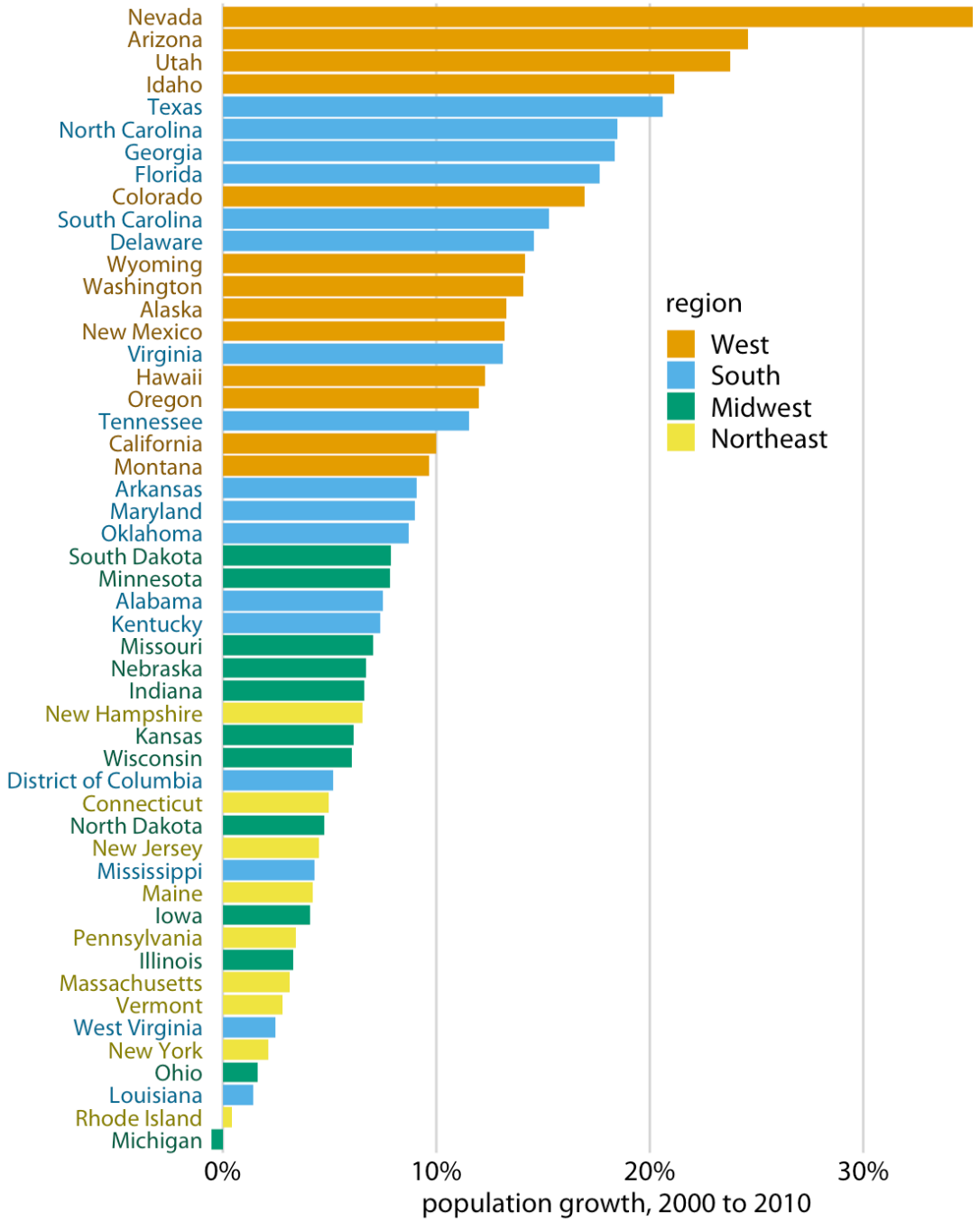


(image source: Wilke, *Fundamentals of Data Visualization*)

Color Channel

Color for **qualitative** variables

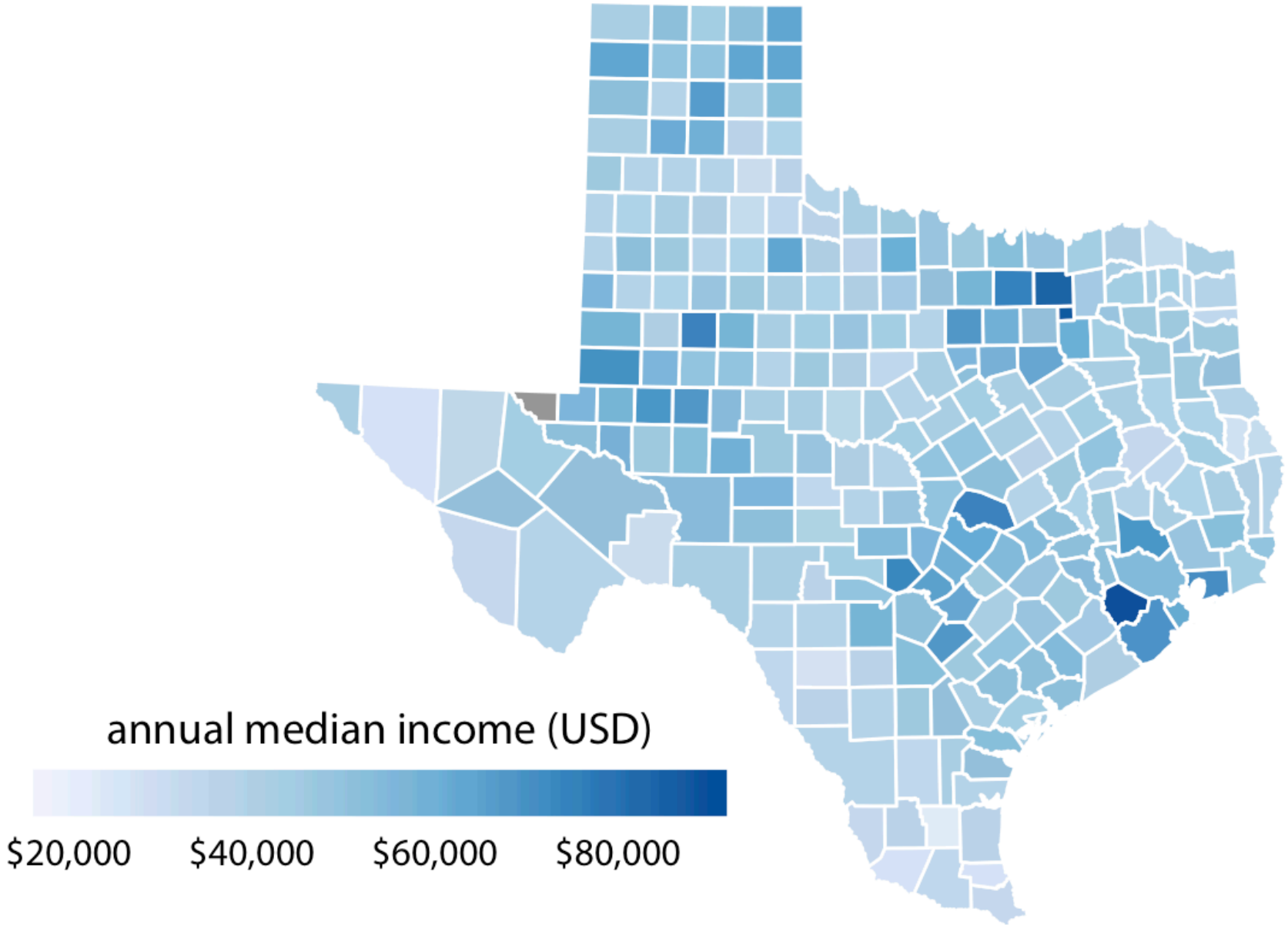
- Color as a tool to distinguish
- Colors clearly distinct from each other
- No one color should stand out relative to the others
- No impression of order



(image source: Wilke, *Fundamentals of Data Visualization*)

Color for **quantitative** variables

- Color indicates which values are larger/smaller
- How distant two values are from each other



(image source: Wilke, *Fundamentals of Data Visualization*)

Working with color in ggplot

Can change the palette of colors used by ggplot.

* = aesthetic

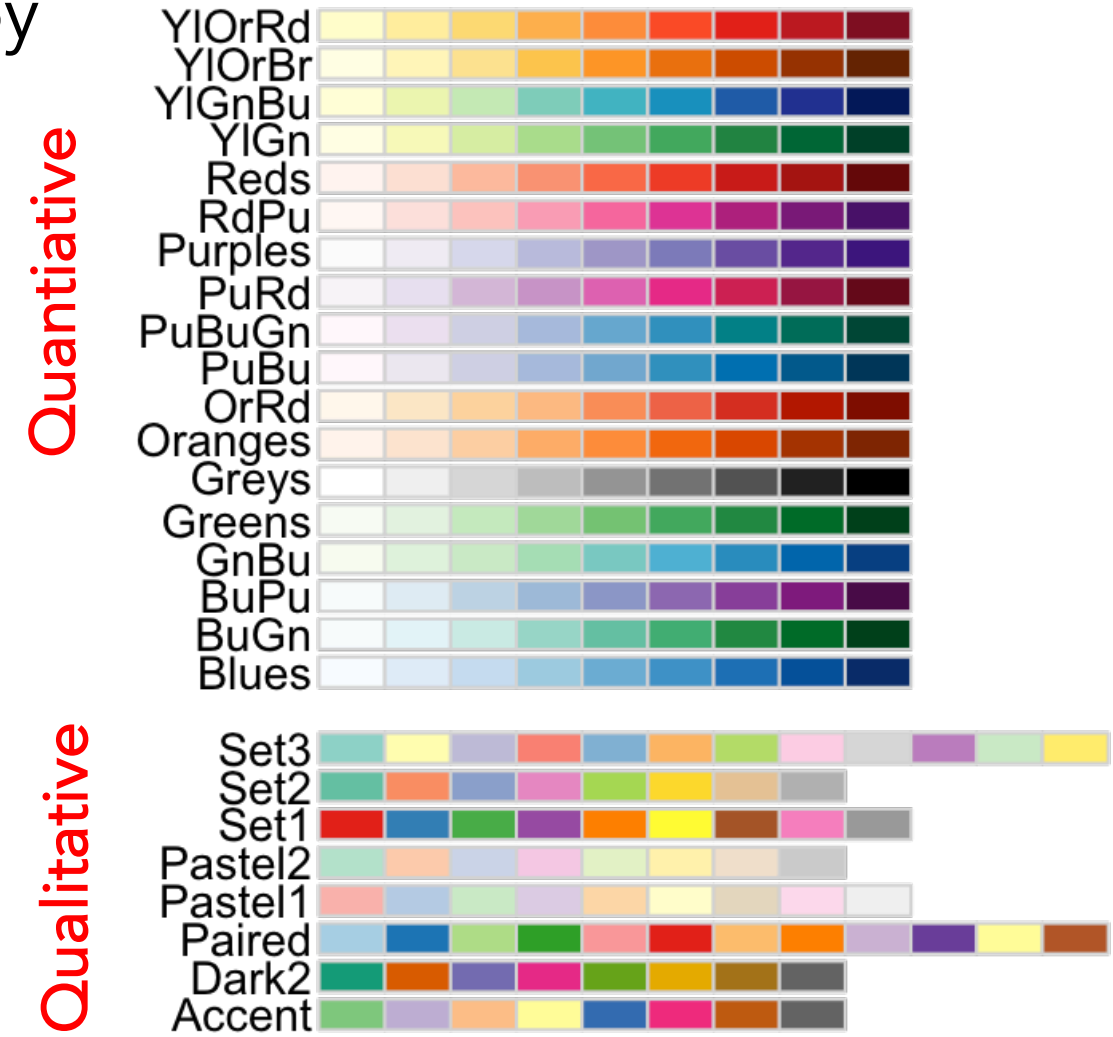
scale_*_brewer(palette = “YlOrRd”)

scale_*_manual(values =
c("#000000", "#E69F00”)

hex color

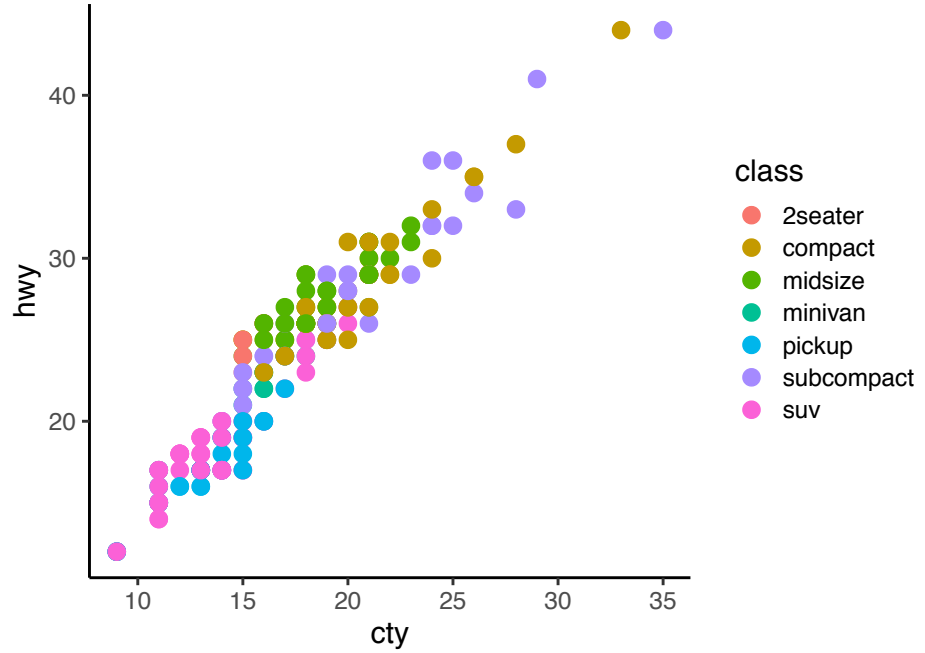
https://htmlcolorcodes.com/

Brewer Color Palette



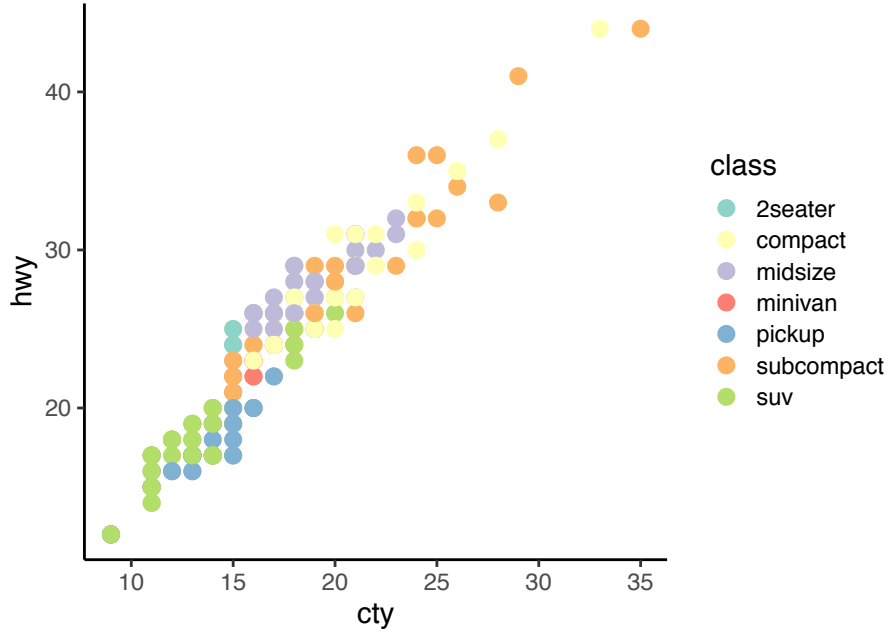
Default

```
ggplot(data = mpg, aes(x = cty, y = hwy)) +
    geom_point(aes(color = class), size = 4) +
     theme_classic(base_size = 16)
```



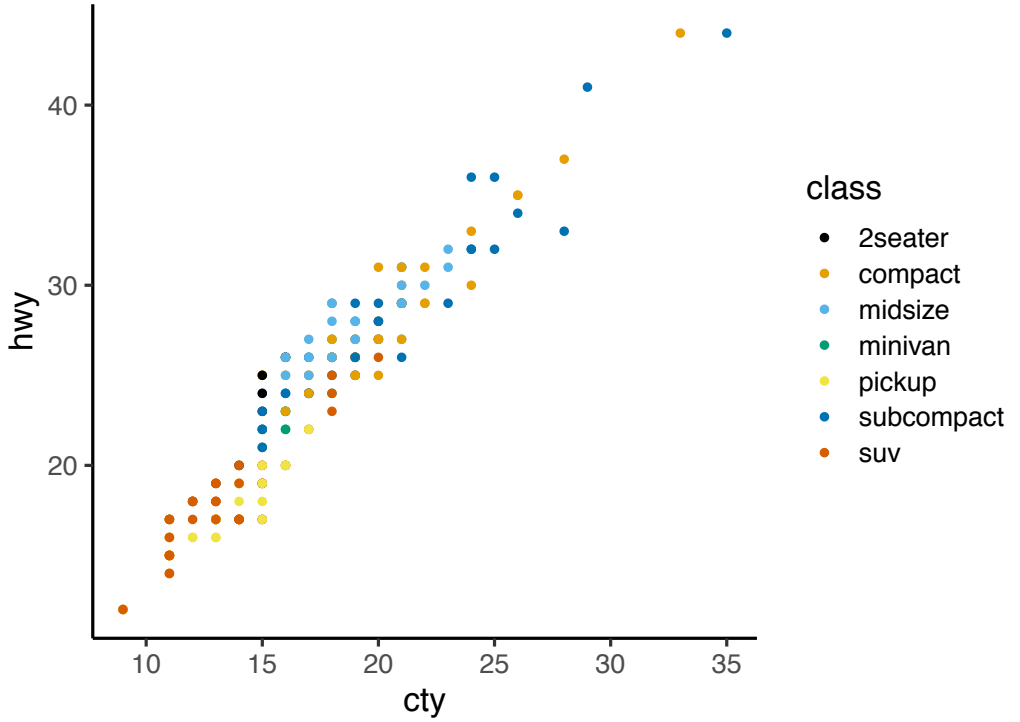
Brewer palette

```
ggplot(data = mpg, aes(x = cty, y = hwy)) +
  geom_point(aes(color = class), size = 4) +
  scale_color_brewer(palette = "Set3") +
  theme_classic(base_size = 16)
```



Manual palette

```
ggplot(data = mpg, aes(x = cty, y = hwy)) +
  geom_point(aes(color = class)) +
  scale_color_manual(values = c("#000000", "#E69F00", "#56B4E9",
                                "#009E73", "#F0E442", "#0072B2",
                                "#D55E00", "#CC79A7")) +
  theme_classic(base_size = 16)
```

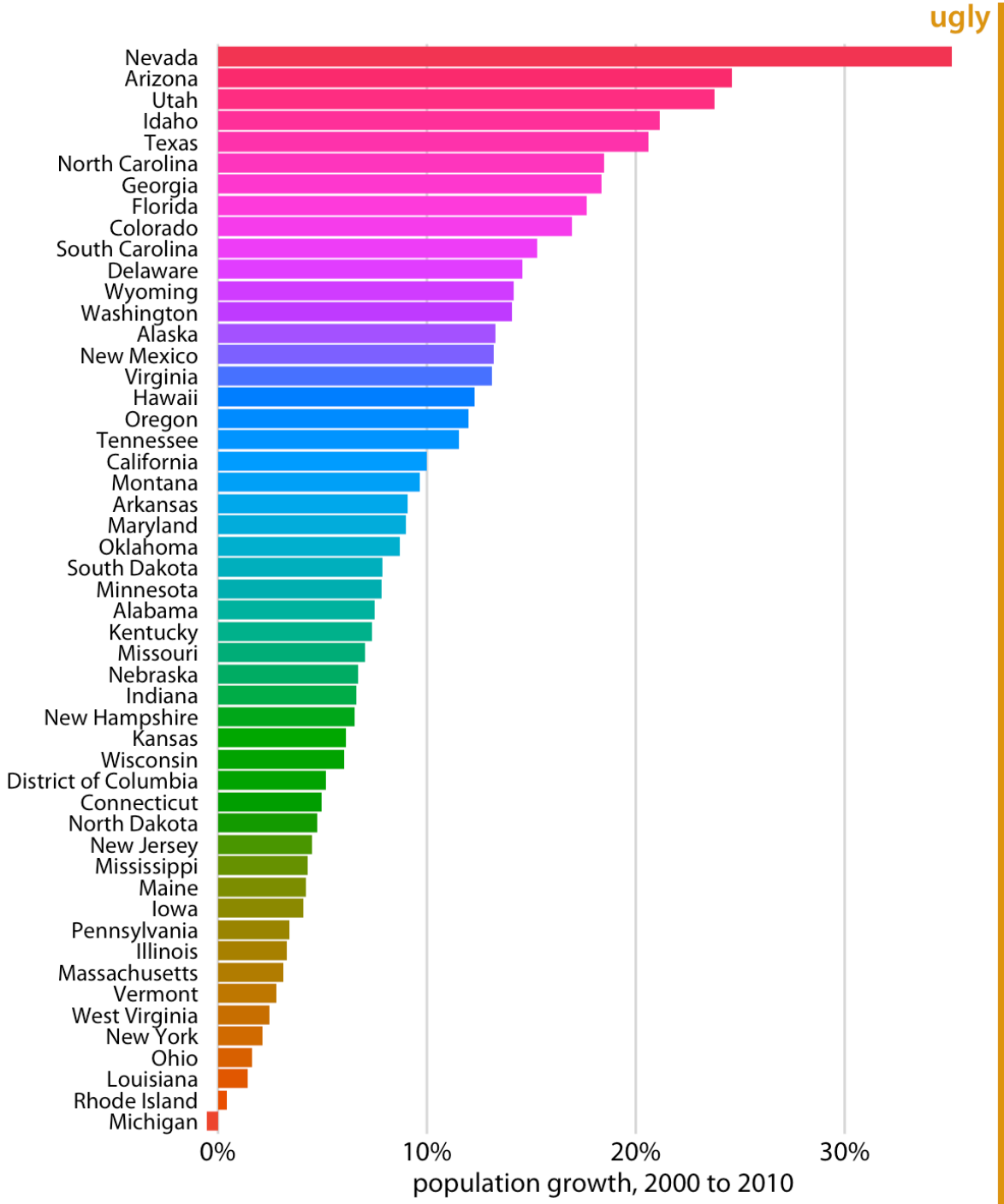


More plotting guidelines

Use colors to communicate something

Avoid using color for the sake of color

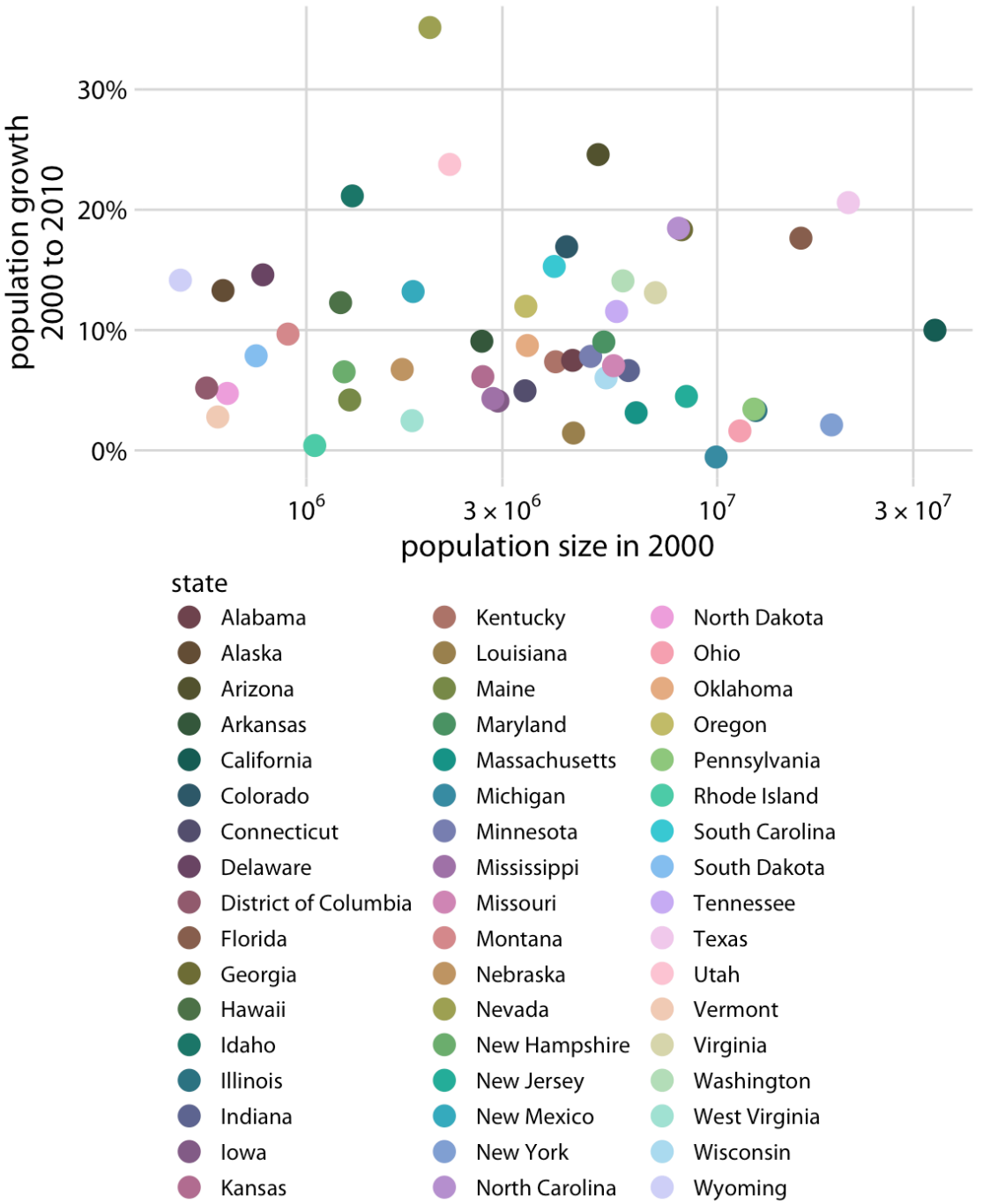
= chart junk!



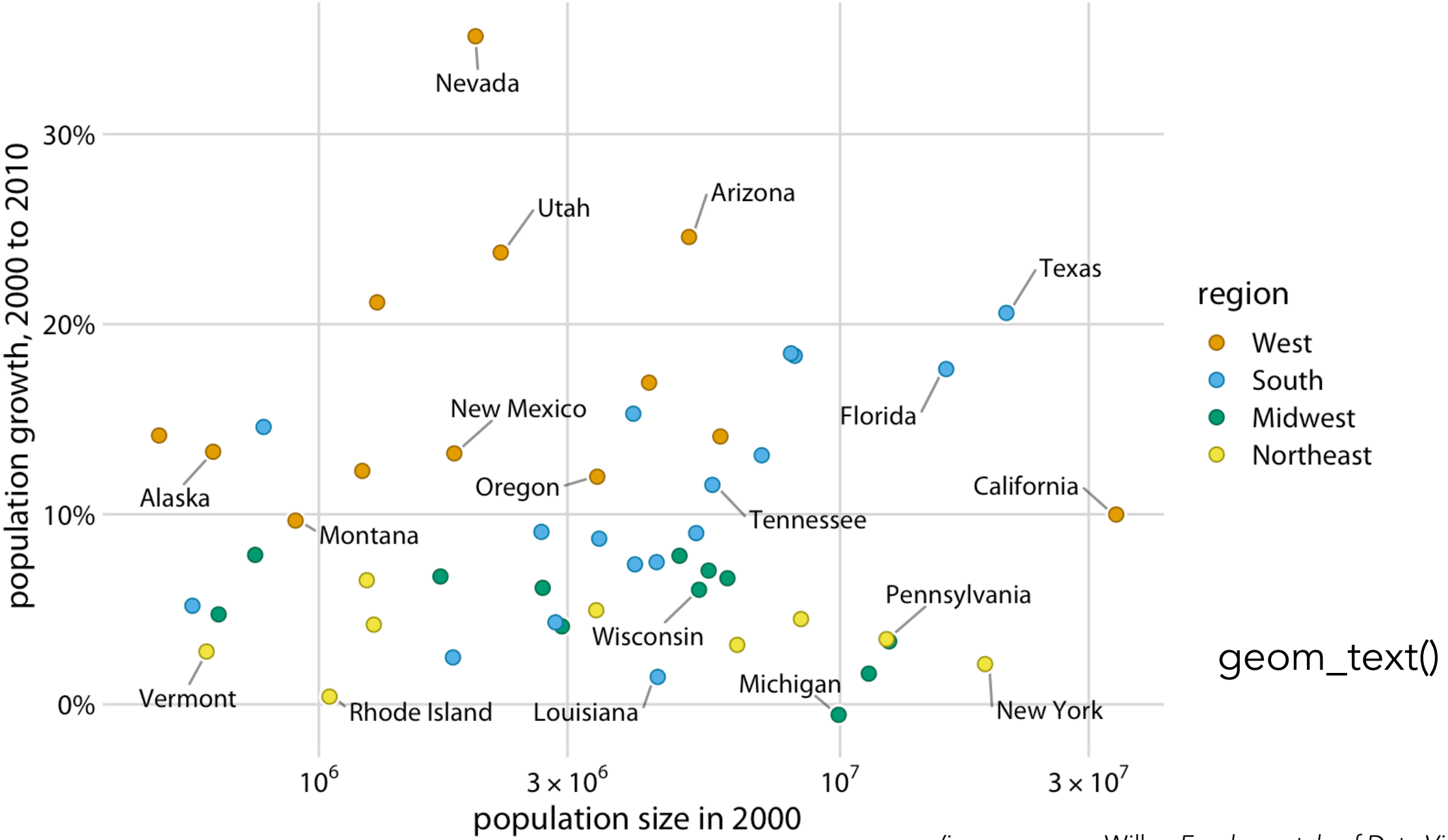
(image source: Wilke, *Fundamentals of Data Visualization*)

Avoid encoding too much/ irrelevant information

Use direct labeling to distinguish >8 qualitative variables.



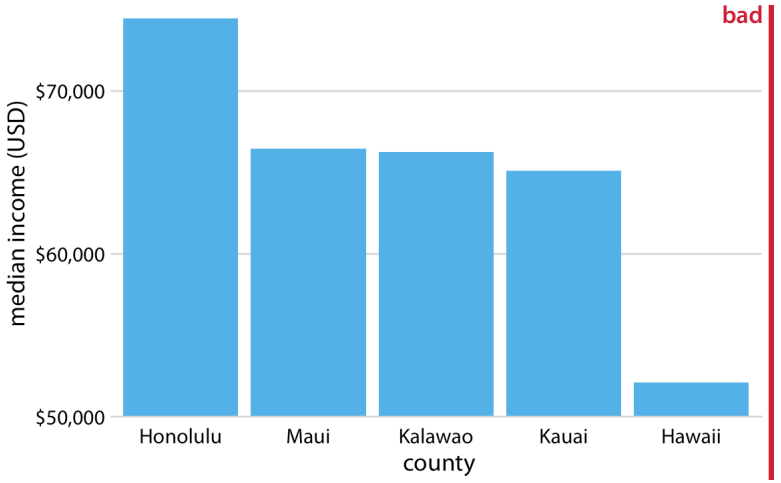
(image source: Wilke, *Fundamentals of Data Visualization*)

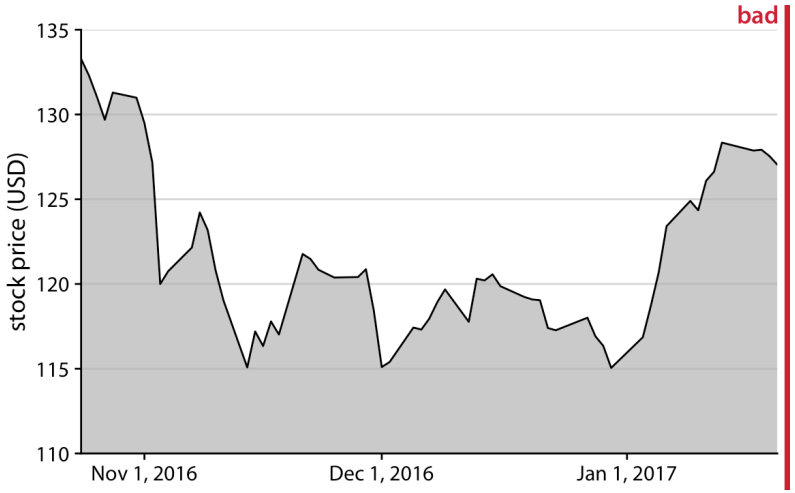


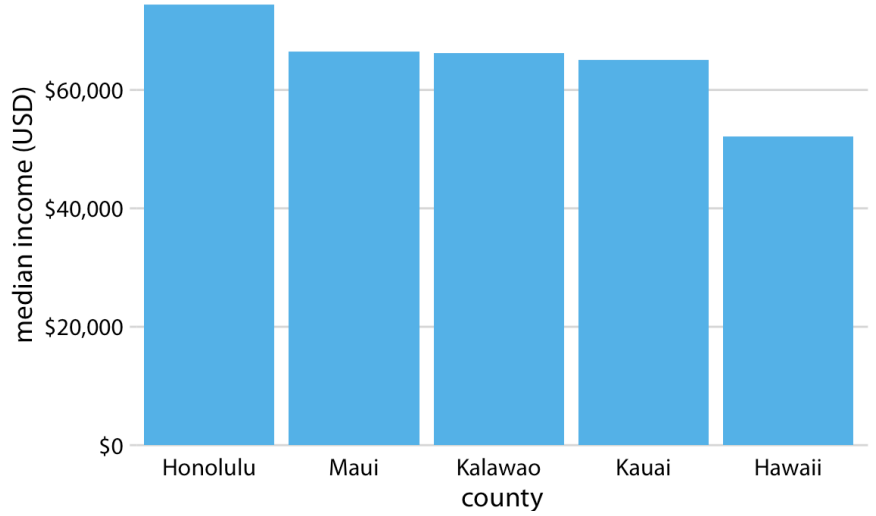
geom_text()

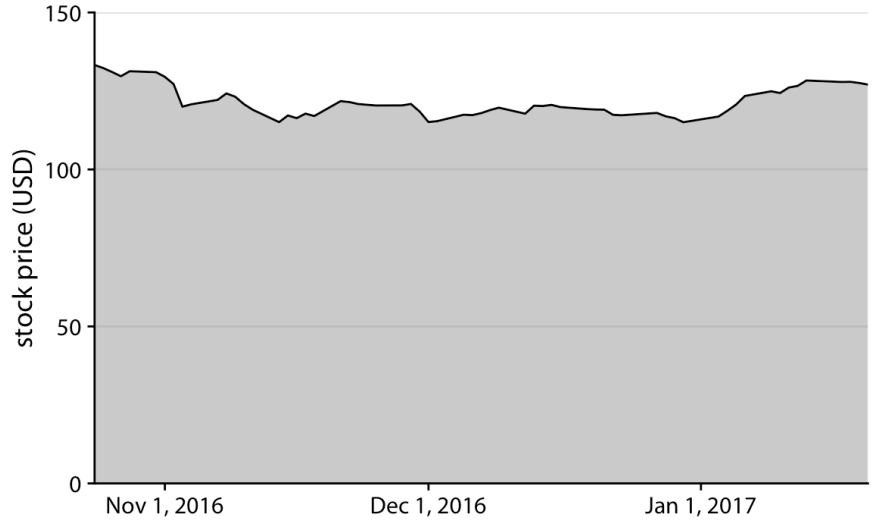
(image source: Wilke, *Fundamentals of Data Visualization*)

Axes should start at 0 (ggplot does this by default)



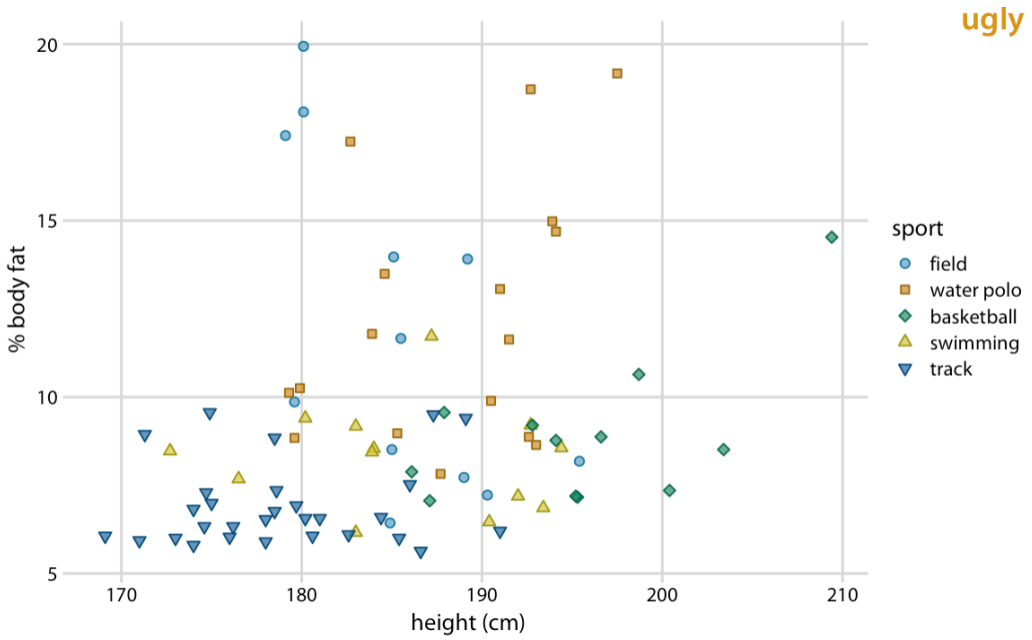


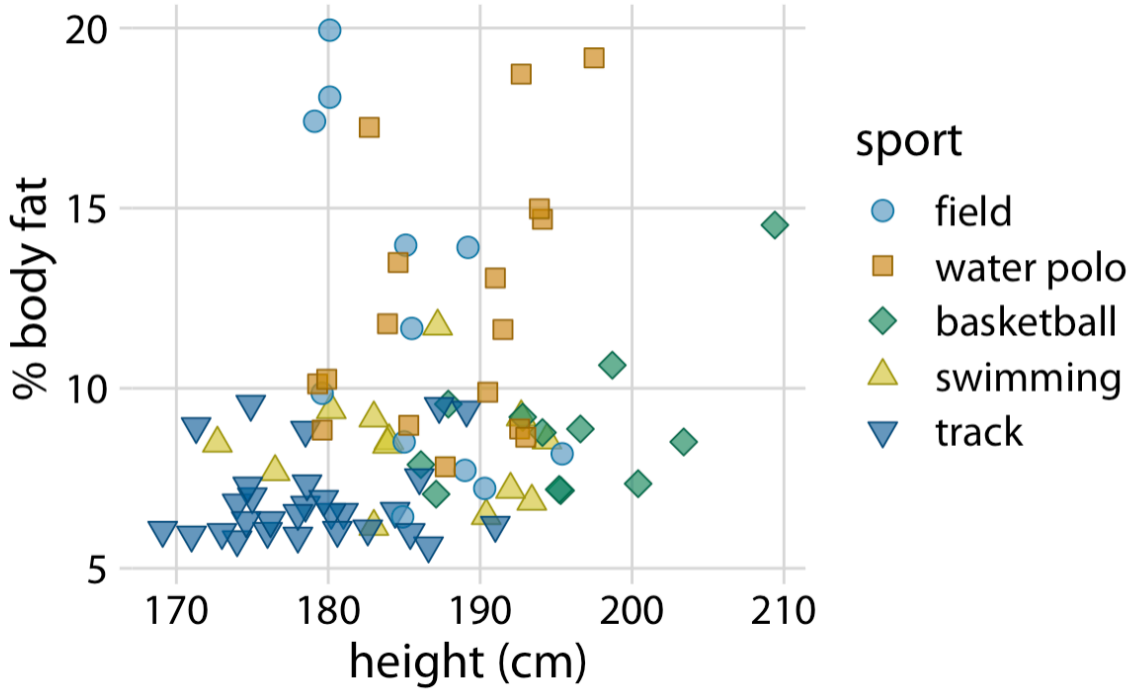




(image source: Wilke, *Fundamentals of Data Visualization*)

Make text readable by increasing font size





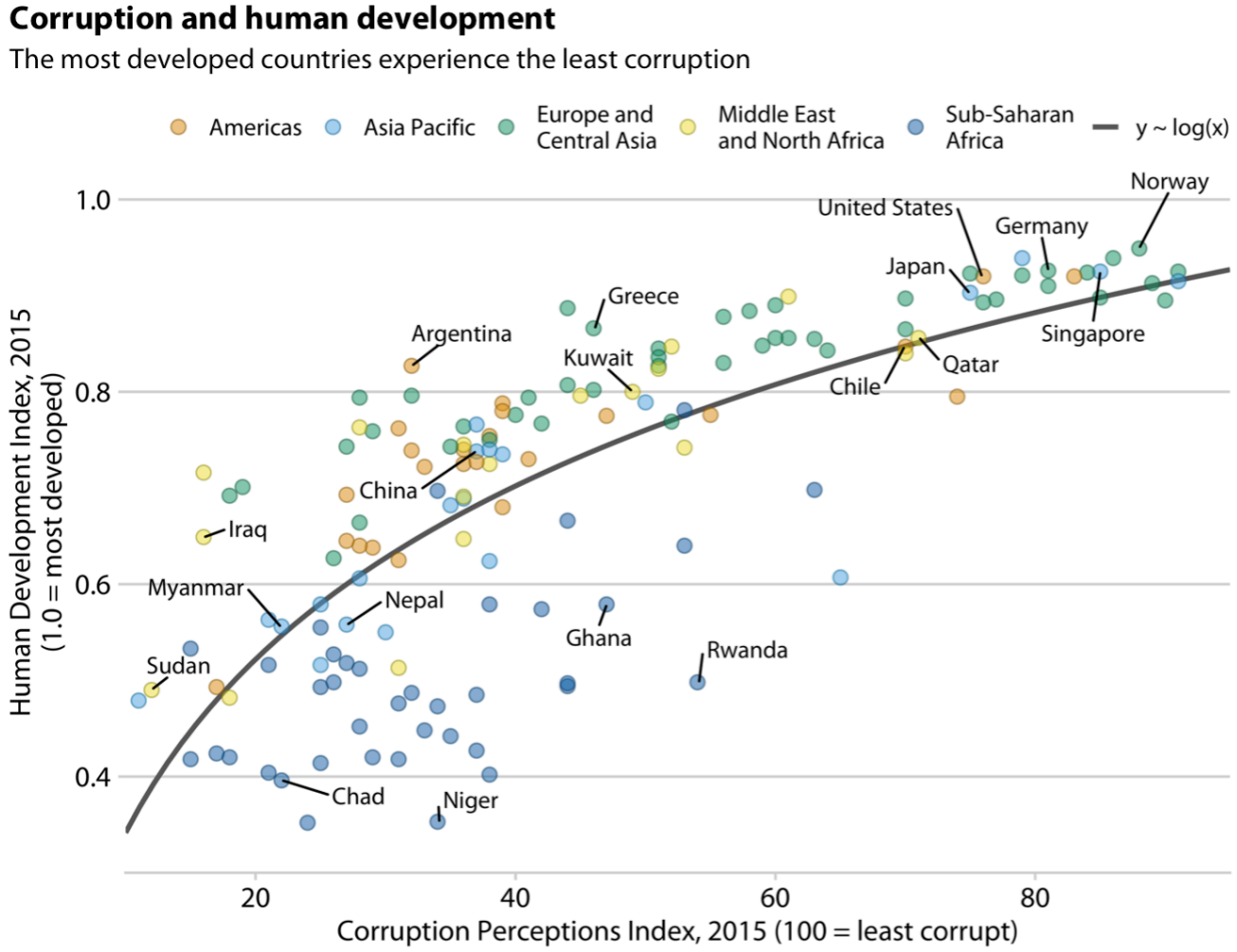
theme_classic(base_size = 16)

(image source: Wilke, *Fundamentals of Data Visualization*)

Add interpretable labels

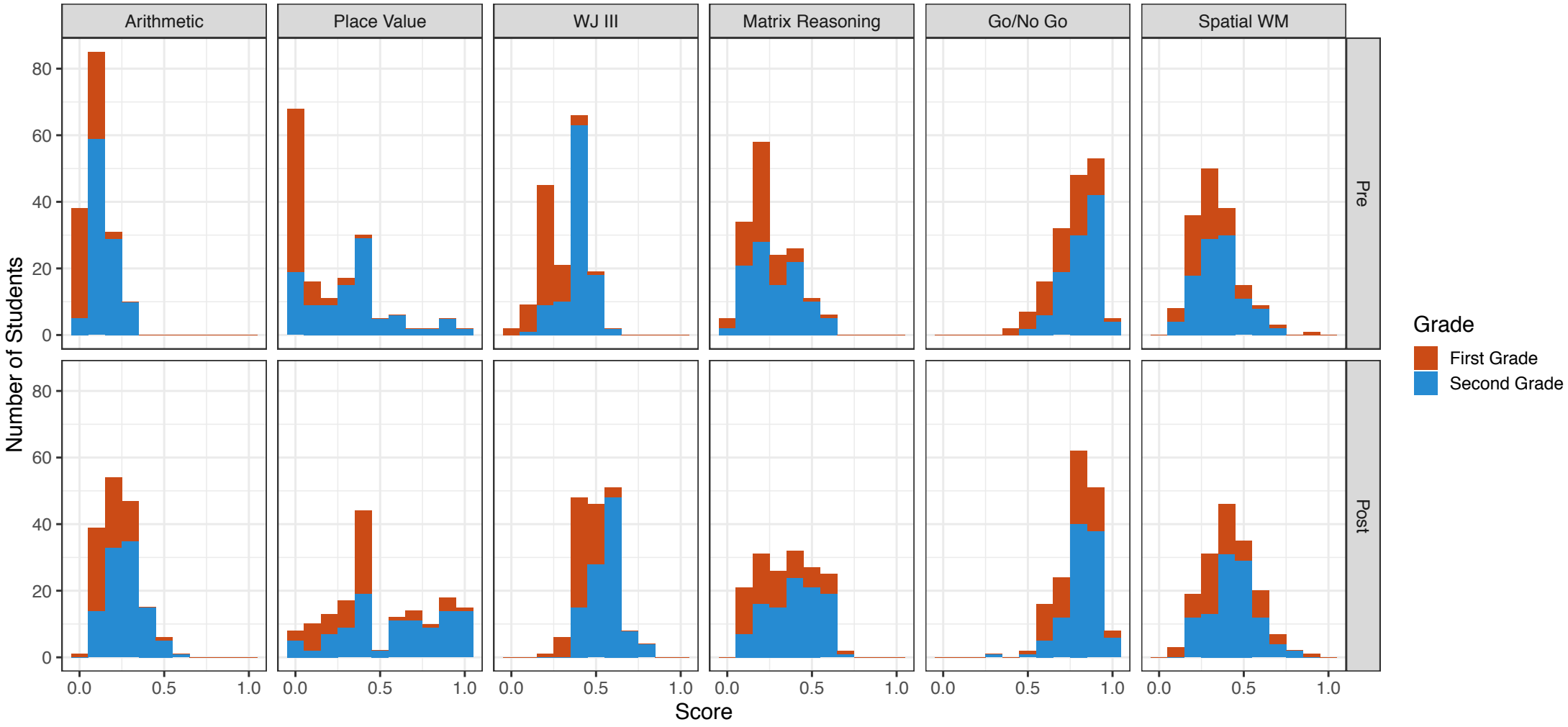
Title and axis labels

```
ggtitle(
      label = " Corruption and human
      development",
      subtitle = "The most developed countries
      experience the least corruption"
)

xlab("Corrpution Perceptions Index, 2015
(100 = least corrupt)")

ylab("Human Development Index, 2015
(1.0 = most developed)")
```



(image source: Wilke, *Fundamentals of Data Visualization*)

Use “facets” for large data

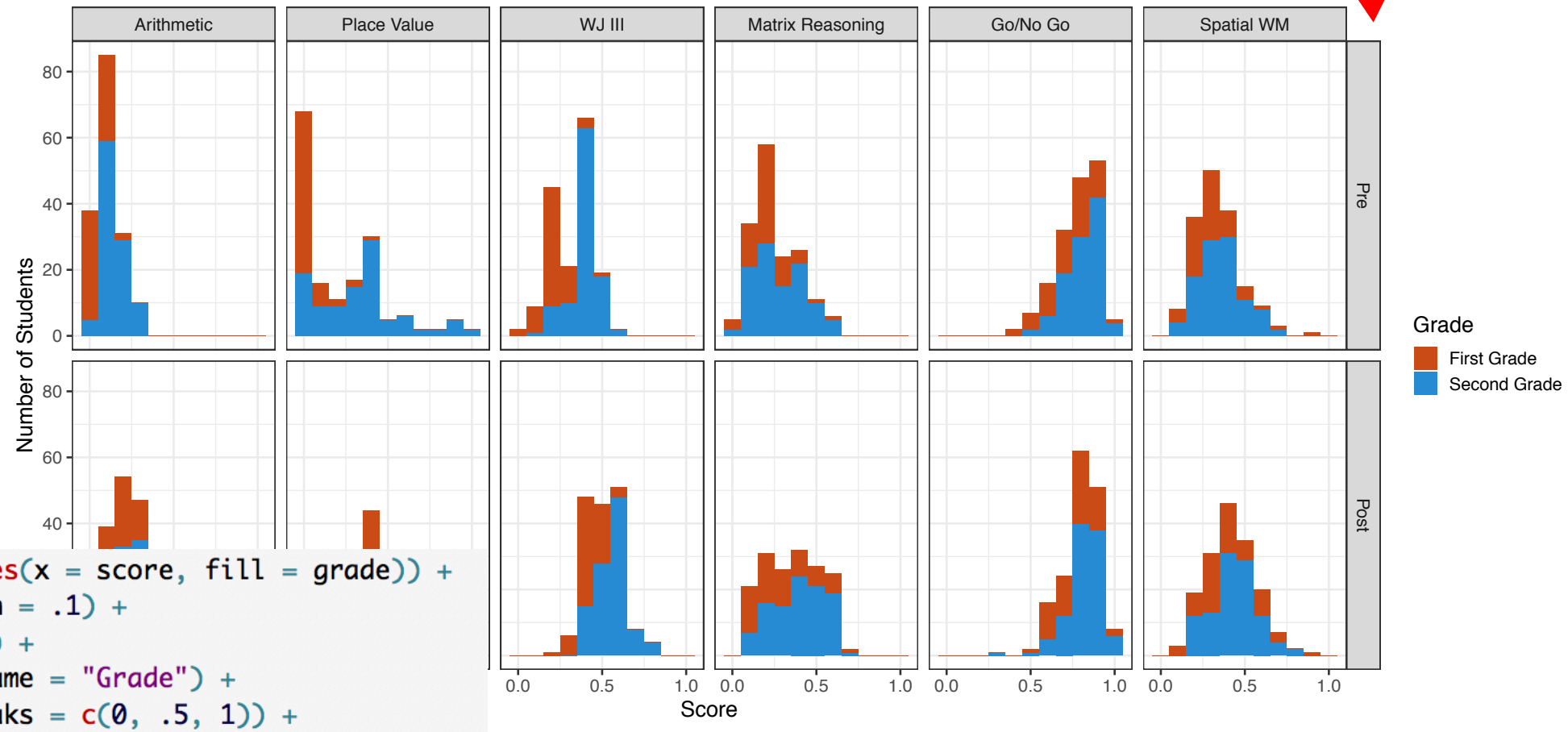


(Barner et al, 2017)

facet_grid()

Task →

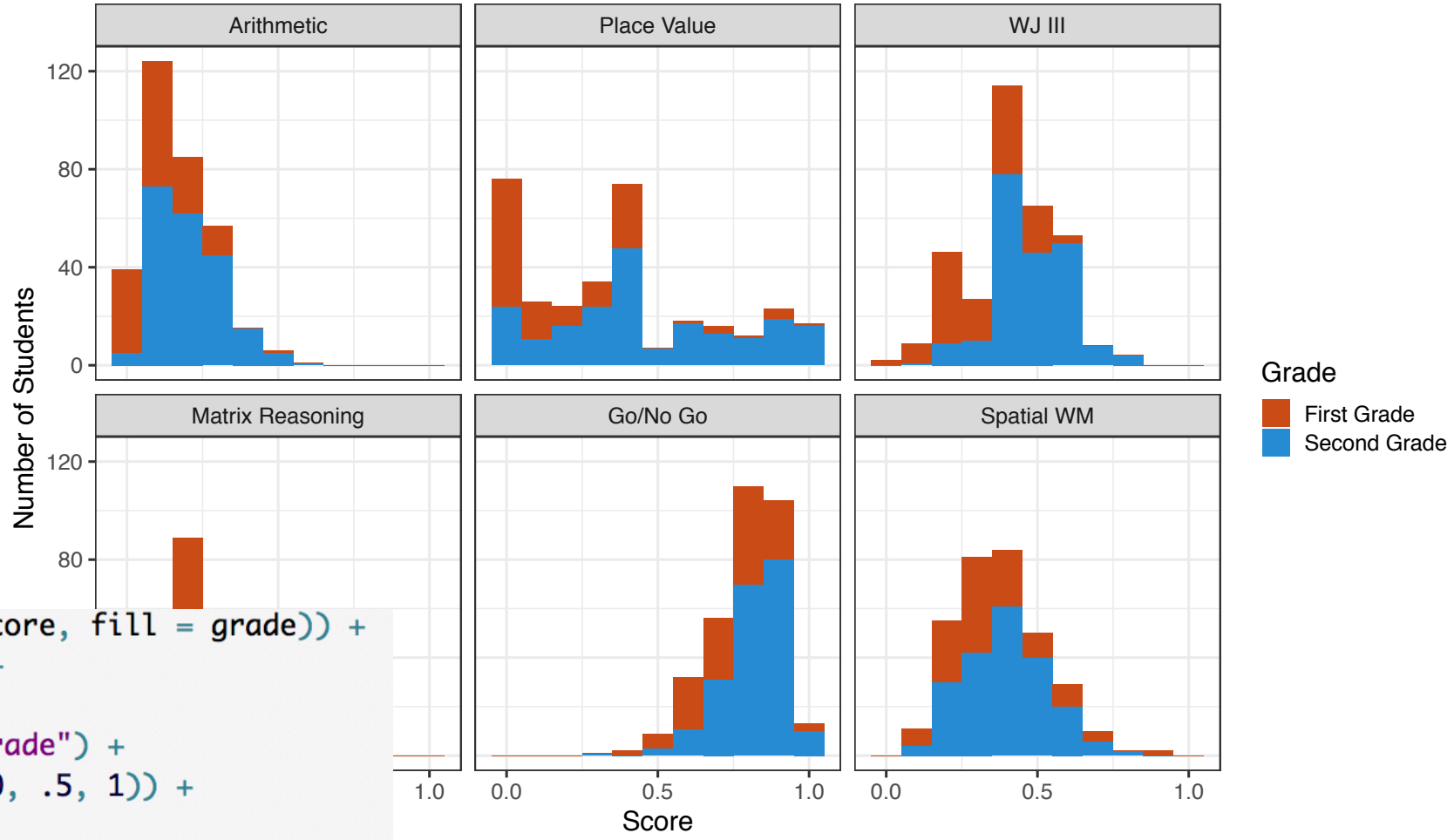
Time ↓




```
ggplot(student_scores, aes(x = score, fill = grade)) +
  geom_histogram(binwidth = .1) +
  facet_grid(time ~ task) +
  scale_fill_solarized(name = "Grade") +
  scale_x_continuous(breaks = c(0, .5, 1)) +
  xlab("Score") +
  ylab("Number of Students") +
  theme_bw(base_size = 16)
```

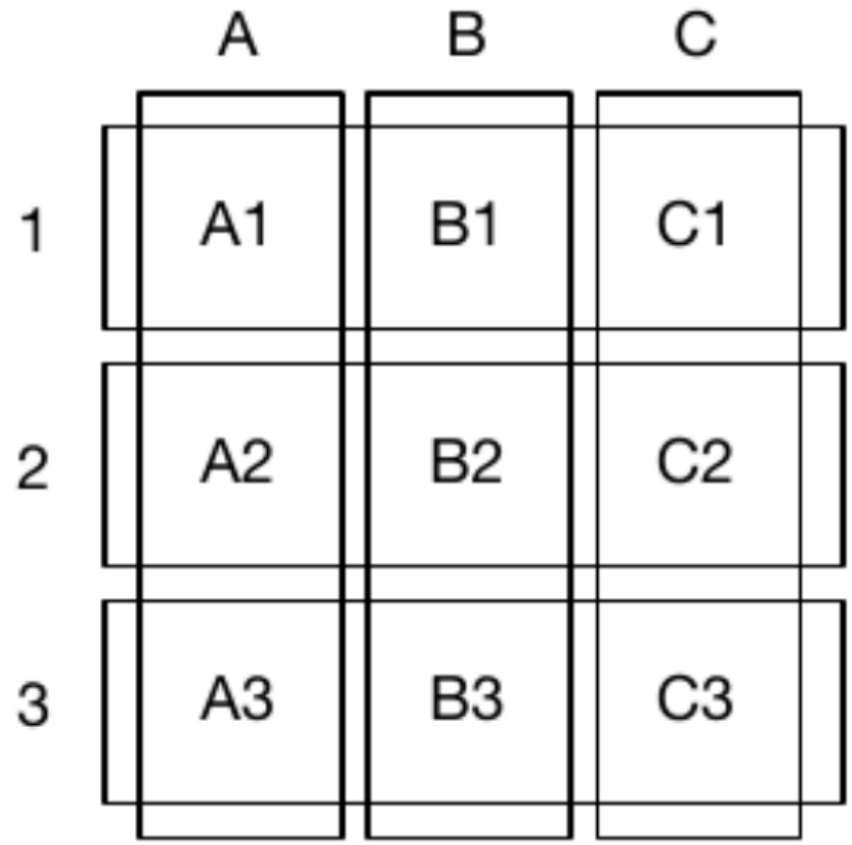
facet_wrap()

Task →

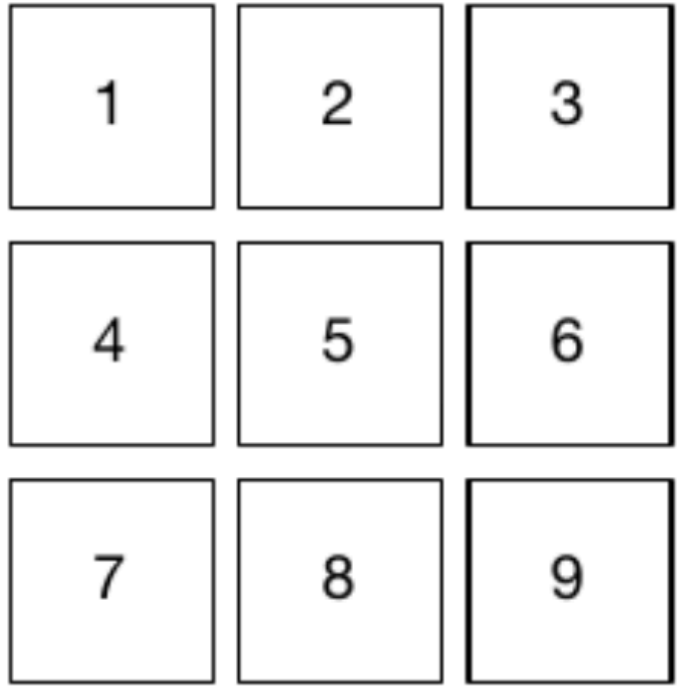



```
ggplot(student_scores, aes(x = score, fill = grade)) +
  geom_histogram(binwidth = .1) +
  facet_wrap(~ task) +
  scale_fill_solarized(name = "Grade") +
  scale_x_continuous(breaks = c(0, .5, 1)) +
  xlab("Score") +
  ylab("Number of Students") +
  theme_bw(base_size = 16)
```

facet_grid() vs. facet_wrap()



facet_grid

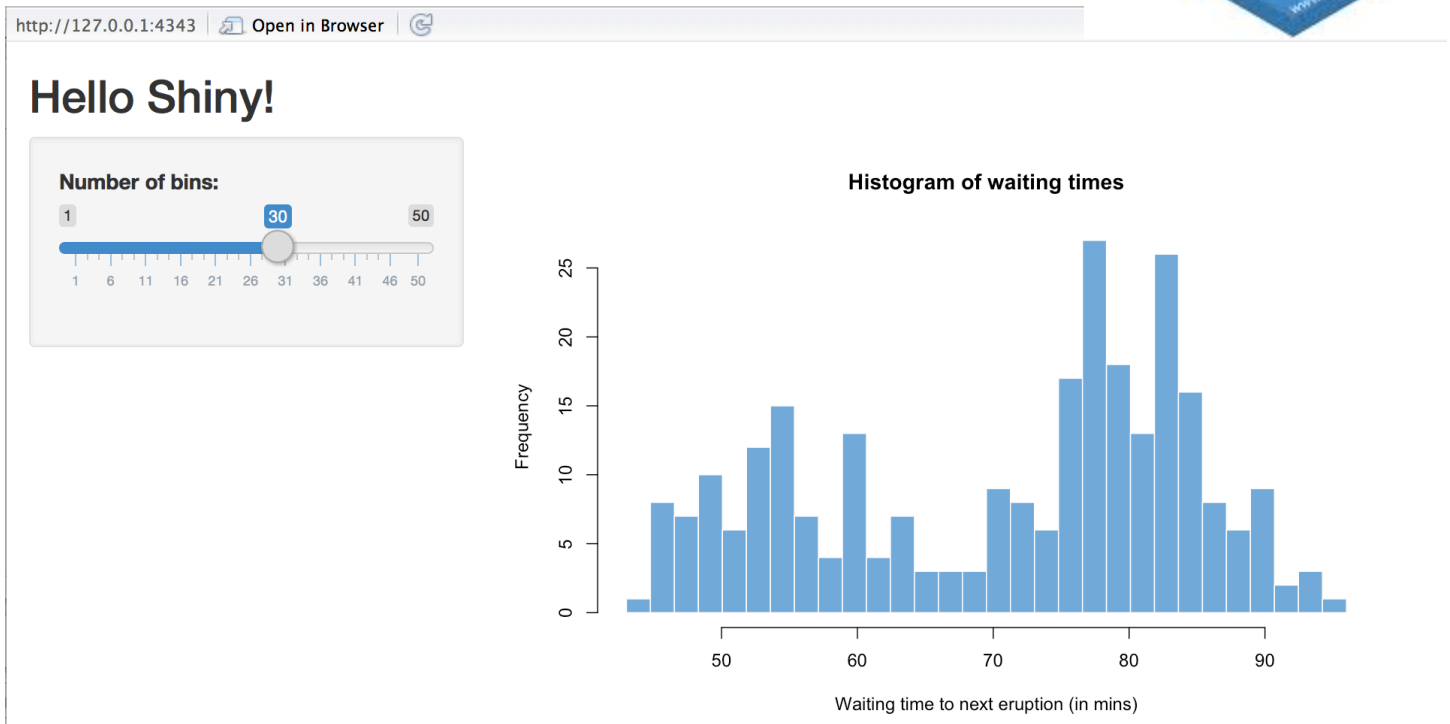


facet_wrap

https://ggplot2-book.org/

Interactive visualizations

- Campaign Donors: https://www.nytimes.com/interactive/2020/02/01/us/politics/democratic-presidential-campaign-donors.html
- Hair styles: https://pudding.cool/2019/11/big-hair/
- Built with Shiny:
  - https://mlewis.shinyapps.io/lnhBrowser/
  - https://mlewis.shinyapps.io/SI_KIDBOOK/



Shiny Tutorial: https://shiny.rstudio.com/tutorial

Summary of Principles of Visualization

- Think of plotting as communication – you want to maximize the likelihood that your audience gets your message
- How do you do that?
  - Get rid of "chart junk" – maximize info to ink ratio
  - Don't be deceptive – show the raw data when possible
  - Think about human perception.
- ggplot is powerful – you have lots of control!
- ggplot defaults are pretty good, but often you need to make choices/tweak things for your specific plot
- Use appropriate color scale and make axes readable

Next Time

- Review of tidyverse verbs (summarize, mutate, group_by, arrange, ggplot, etc.)
- Evaluating plots

Office Hours:

Jaeah 1:00-3pm **today** (Psych Lounge);

Molly 4:30-6:30pm Wednesday (Porter 223A)

Acknowledgements

Images on slides 11-35 adapted from
http://socviz.co/lookatdata.html (Healy, 2018) and
https://serialmentor.com/dataviz/ (Wilke)